

R E C O R D S
OF THE
ZOOLOGICAL SURVEY
OF INDIA

(A Journal of Indian Zoology)
(Continuation of the *Records of the Indian Museum*)
Abbreviation : *Rec. zool. Surv. India*

Vol. 65, Parts 1-4

1967

Pages 1-270



Edited by the Director, Zoological Survey of India

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PRINTED BY M/S. N. K. GOSSAIN & CO. (PVT.) LTD., CALCUTTA-4 AND
PUBLISHED BY THE MANAGER OF PUBLICATIONS, CIVIL LINES, DELHI, 1971

PUBLISHED : DECEMBER, 1971

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ON SOME FRESHWATER RHIZOPODA AND HELIOZOA (PROTOZOA) FROM CALCUTTA AND ITS ENVIRONS. PART I.

By

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(With 3 Text-figures)

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I—INTRODUCTION

The first record of a Rhizopod in Calcutta is found in the work of Cantor (1842). Wallich (1864) in discussing the principal causes of structural variations among *Diffugia* Leclerc refers about four species of this genus collected from Gangetic Sundarbans of Lower Bengal without citing any specific locality. Simmons (1891) records a reticulated Amoeba (*Biomyxa vagans* n. sp.) from Calcutta. Ghosh (1923) refers about the peculiarities of *Arcella vulgaris* var. *gibbosa* West.

Even though there are a few references about the Rhizopodan fauna of this place, it seems that the study of this fauna has not received adequate attention from the earlier workers. In the present paper, an account of twenty-nine species of Rhizopoda and Heliozoa collected by the authors from the ponds in and around Calcutta is given. The major part of the material was collected during the years 1965 to 1967. The name of the localities, habitats and the date of collection are given in the systematic account under each species.

II—MATERIAL AND METHODS

The water samples with the flocculent matter amongst the submerged and floating vegetation and the surface ooze of the bottom of the various ponds were brought to the laboratory and examined from time to time for the Rhizopods and Heliozoans. The living specimens were isolated and examined by keeping them in a drop of natural medium. For making permanent preparations, the specimens were fixed in Bouin's fluid or Schaudinn's fluid. For staining Delafield's haematoxylin, Heidenhain's iron haematoxylin and borax carmine were used. The empty tests, very frequently met with in abundance in the bottom ooze, were isolated, air-dried after two or three washings in absolute alcohol and mounted in Canada balsam. To avoid crushing of the delicate tests, tiny pieces of broken cover slips were kept a little away from the specimens to support the cover slip.

III—ACKNOWLEDGEMENTS

Our sincere thanks are due to Dr. B. S. Chauhan, Deputy Director, Zoological Survey of India for the encouragement and the helpful suggestions given during the course of this work. We are highly grateful to the Director, Zoological Survey of India for the facilities provided to carry out this study.

IV—LIST OF THE SPECIES

Phylum PROTOZOA

Class SARCODINA

Order AMOEBIDA Ehrenberg

Family AMOEBIDAE Bronn

1. *Amoeba vespertilio* Penard
2. *Amoeba discoides* Schaeffer
3. *Amoeba radiosa* Ehrenberg
4. *Pelomyxa palustris* Greeff.

Order TESTACIDA Schultze

Family ARCELLIDAE Schultze

5. *Arcella vulgaris* Ehrenberg
6. *Arcella gibbosa* Penard
7. *Arcella discoides* Ehrenberg
8. *Lesquereusia spiralis* (Ehrenberg)
9. *Lesquereusia modesta* Rhumbler

Family DIFFLUGIIDAE Taránek

10. *Diffugia lobostoma* Leidy
11. *Diffugia urceolata* Carter

12. *Diffugia corona* Wallich
13. *Diffugia oblonga* Ehrenberg
14. *Diffugia acuminata* Ehrenberg
15. *Diffugia curvicaulis* Penard
16. *Diffugia pyriformis* Perty
17. *Diffugia tuberculata* (Wallich)
18. *Diffugia muriformis* Gauthier-Lievre & Thomas
19. *Centropyxis aculeata* (Ehrenberg)
20. *Centropyxis ecornis* (Ehrenberg)
21. *Centropyxis spinosa* (Cash & Hopkinson)

Family EUGLYPHIDAE Wallich

22. *Euglypha acanthophora* (Ehrenberg)
23. *Euglypha tuberculata* Dujardin
24. *Placocista lens* Penard
25. *Trinema enchelys* (Ehrenberg)
26. *Trinema lineare* Penard

Subclass 2. ACTINOPODA Calkins

Order HELIOZOIDA Haeckel

Family ACTINOPHRYIDAE Claus

27. *Actinophrys sol* Ehrenberg

Family ACANTHOCYSTIDAE Claus

28. *Acanthocystis spinifera* Greeff

Family CLATHRULINIDAE Claus

29. *Clathrulina elegans* Cienkowski

V—SYSTEMATIC ACCOUNT

1. *Amoeba vespertilio* Penard

(TEXT-FIG. 1A)

1901. *Amoeba vespertilio* Penard, *Rev. Suisse Zool.*, 9, p. 237.

1919. *Amoeba vespertilio*: Cash and Hopkinson, *The Brit. Fresh-water Rhiz. & Heliozoa*, 4, p. 10, pl. 58, fig. 2 & pl. 59, figs 1-3.

Habitat & Locality.—Amongst pond vegetation and the surface scum; Botanical Garden, Sibpur (Howrah Dist.); 21-9-1961.

Remarks.—Small *Amoeba* displaying clear web like expansion of cytoplasm in between the pseudopodia during active locomotion. Number of pseudopodia varies from four to six. Few food vacuoles and granules are seen concentrated in the central portion bearing

nucleus. Size—52-62 μ diameter, varying slightly depending on the range of expansion.

2. *Amoeba discoides* Schaeffer (TEXT-FIG. 1 B)

1916. *Amoeba discoides* Schaeffer, *Arch. Protistenk.*, Jena, 37, pp. 218-223, fig. 5a, b.

Habitat & Locality.—Amongst pond vegetation in still water; Shahid Colony, Paikpara (Calcutta); 5-11-1962. Kalyani (Nadia Dist.); 9-11-1964.

Remarks.—One of the big *Amoeba* of the region having plenty of granules distributed all over the endoplasm, rendering the observation of nucleus very difficult. In suspended condition resembles a big sized *Amoeba radiosa*, but the true palmate nature of pseudopodia is observed while creeping on the slide.

The specimens observed are small ranging 264-338 μ in maximum extended condition.

3. *Amoeba radiosa* Ehrenberg (TEXT-FIG. 1 C)

1830. *Amoeba radiosa* Ehrenberg, *Abh. preuss Akad. Wiss.*, Berlin, p. 39.

1879. *Amoeba radiosa* : Leidy, *Rept. U.S. geol. Surv.*, 12, pp. 59-62, pl. 4, figs. 1-18.

Habitat & Locality.—Amongst pond vegetation and surface scum in clear water; Botanical Garden, Sibpur (Dist. Howrah); 20-11-1961. Barasat (Dist. 24-Parganas); 6-12-1965. Rabindra Sarobar (Calcutta); 8-12-1965.

Remarks.—Small to medium sized *Amoeba* with a spherical central mass on which more or less long straight pseudopodia are usually seen. While creeping it resembles a true amoeba.

The local specimens are of average size measuring 36 μ diameter with pseudopodia as long as three to four times the body diameter.

4. *Pelomyxa palustris* Greeff (TEXT-FIG. 1 D)

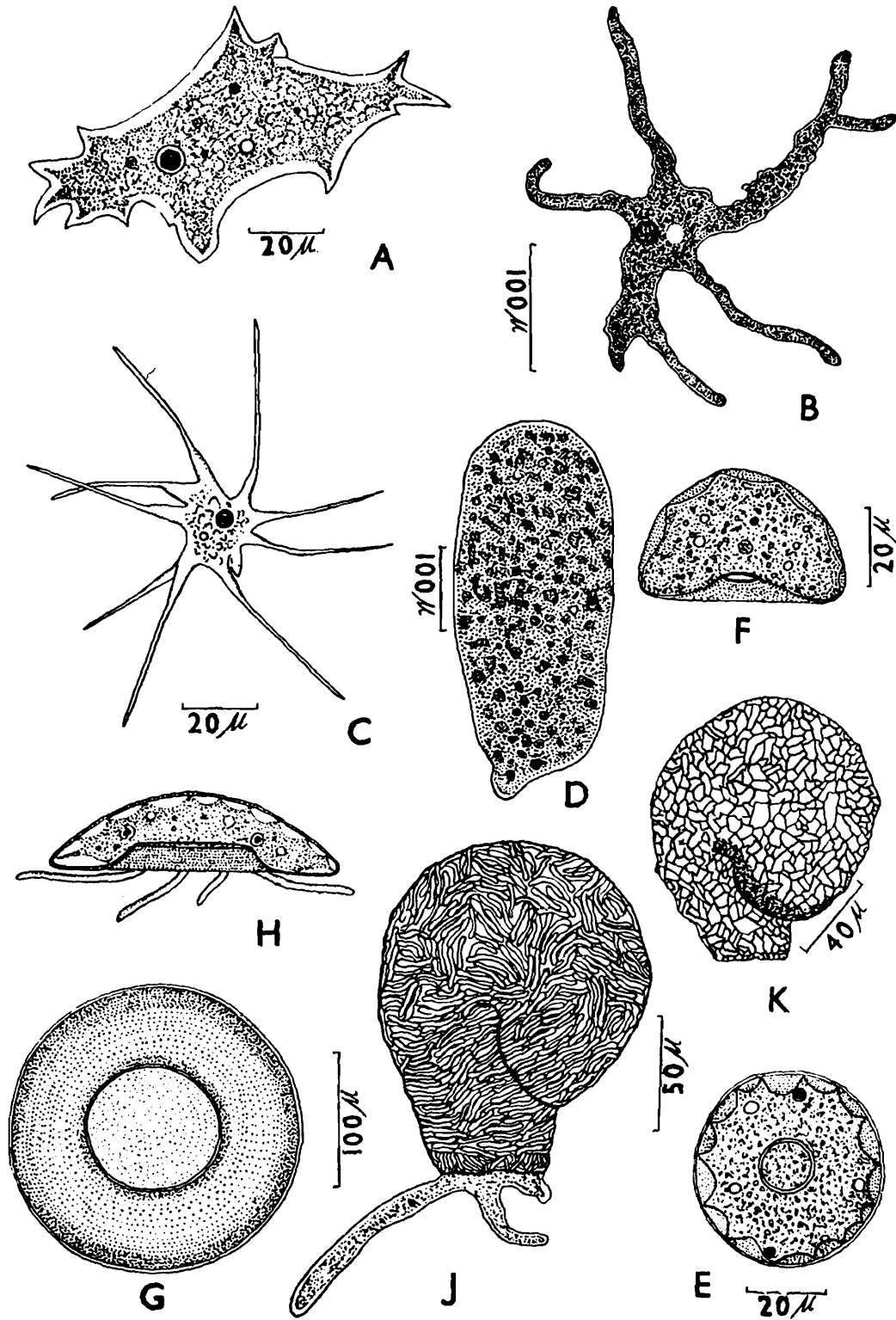
1874. *Pelomyxa palustris* Greeff, *Arch. f. mikr. Anat.*, 10, p. 51, pls. 3-5.

1905. *Pelomyxa palustris* : Cash & Hopkinson, *The Brit. Fresh-water Rhiz. & Heliozoa*, 1, pp. 74-79.

Habitat & Locality.—From the bottom ooze of ponds; Garia (Dist. 24-Parganas); 8-2-1965.

Remarks.—Usually seen as a big opaque mass of protoplasm possessing a lot of assorted types of crystals, broken algal filaments and rod-shaped bacteria. In locomotion changes to rod-shape with a prominent pseudopodium in the front. At times the protuberance of a pseudopodium on the sides is also seen. The contractile vacuoles and the nuclei are not easy to detect.

The local specimens are of average size ranging 150-569 μ while in locomotion. The 'villi' are not very prominent in these specimens.



TEXT-FIG. 1. A. *Amoeba vespertilio* Penard; B. *Amoeba discoides* Schaeffer; C. *Amoeba radiosa* Ehrenberg; D. *Pelomyxa palustris* Greeff; E. *Arcella vulgaris* Ehrenberg (ventral view); F. *Arcella gibbosa* Penard (lateral view of test); G. *Arcella discoides* Ehrenberg (apertural view of test); H. *Arcella discoides* Ehrenberg (lateral view); J. *Lesquereusia spiralis* (Ehrenberg) (lateral view); K. *Lesquereusia modesta* Rhumbler (lateral view of test).

5. *Arcella vulgaris* Ehrenberg.

(TEXT-FIG. 1 E)

1832. *Arcella vulgaris* Ehrenberg, *Abh. K. Akad. Wiss.*, Berlin, p. 40, pl. 1, fig. 6.
 1905. *Arcella vulgaris* : Cash & Hopkinson, *The Brit. Fresh-water Rhiz. & Heliozoa*, 1, pp. 118-121, pl. 15, figs. 1-3, 13-15, text-figs. 17 & 18.
 1928. *Arcella vulgaris* : Deflandre, *Arch. Protistenk.*, Jena, 64, pp. 219-221, figs, 156-164.

Habitat & Locality.—Amongst the pond vegetation and on the surface scum, empty tests common in the bottom ooze. Jagannathpur, Falta (Dist. 24-Parganas); 11-6-1967. Burdwan (Dist. Burdwan); 12-11-1965. Gopal Nagar, Lakshmikantapur (Dist. 24-Parganas); 2-11-1966.

Remarks.—Typical specimens with varying size range are quite commonly met with in water samples. The young ones are having colourless test gradually changing from yellow to brown depending on the age.

Among the specimens the tests referable to variety *angulosa* and forma *undulata* are also observed.

Local specimens have test diameter ranging from 43-74. μ .

6. *Arcella gibbosa* Penard

(TEXT-FIG. 1 F)

1890. *Arcella gibbosa* Penard, *Mem. Soc. Phys. Geneve*, 31 (2), p. 155, pl. 5, figs. 96-99, pl. 6, fig. 1.

Habitat & Locality.—Amongst the submerged pond vegetation, Jagannathpur, Falta (Dist. 24-Parganas); 11-7-1967.

Remarks.—Except for the gibbous nature of the test, the specimens are similar to the previous species. Very rare, the local specimens are smaller in size having diameter 45-50 μ . The circular depressions on the surface of the test are very shallow.

7. *Arcella discoides* Ehrenberg

(TEXT-FIG. 1 G, H)

1843. *Arcella discoides* Ehrenberg, *Abh. preuss. Akad. Wiss.*, Berlin. p. 139.
 1928. *Arcella discoides*: Deflandre, *Arch. Protistenk.*, Jena, 64, pp. 256-257, figs, 324-326.

Habitat & Locality.—The living specimens in the flocculent matter amongst pond vegetation, empty tests are plenty in the bottom ooze. Himsagar, Kalyani (Dist. Nadia); 29-9-1965; Tribeni, (Dist Hooghly), 5-1-1967, 12-12-1967.

Remarks.—Empty tests are usually seen on the bottom ooze of ponds; the living animals are very rare. The local specimens are medium sized to big, ranging 104 to 220 μ in diameter, and the diameter of the mouth from 44-117 μ . Height of the dome $\frac{1}{4}$ to $\frac{1}{3}$ of the diameter of test.

8. *Lesquereusia spiralis* (Ehrenberg)

(TEXT-FIG. 1 J)

1840. *Diffugia spiralis* Ehrenberg, *Monatsb. Akad. Wiss.* Berlin, p. 199.

Habitat & Locality.—Empty tests on the bottom ooze, living specimens very rare amongst the pond vegetation. Kalyani (Dist. Nadia); 7-12-1964.

Remarks.—The spherical part and the tubular neck of the test are composed of vermiform pellets arranged very closely. The tests are transparent allowing the plasma to be seen very clearly. The pseudopodia are long, finger-shaped and branched.

The local specimens averaging 148-158 μ by 115-132 μ in size are bigger than the specimens recorded from British Isles.

9. *Lesquereusia modesta* Rhumbler

(TEXT-FIG. 1 K)

1895. *Lesquereusia modesta* Rhumbler, *Zeits. Wiss. Zool.*, 61 (1), p. 101, pl. 4, fig. 2.

Habitat & Locality.—Empty tests on the bottom ooze of ponds. The living specimens are rare and seen amongst the aquatic vegetation. Kalyani (Dist. Nadia); 14-9-1964. Diamond Harbour (Dist. 24-Parganas); 4-9-1964.

Remarks.—Very similar to the preceding species in shape but with encrustation of quartz crystals on the test instead of vermiform pellets. The test is opaque and the details of the nucleus and contractile vacuole are not easy to make out.

The local specimens are bigger in size measuring 112-122 μ by 89-102 μ than the specimens described from the British Isles.

10. *Diffugia lobostoma* Leidy

(TEXT-FIG. 2 A)

1879. *Diffugia lobostoma* Leidy, *Fresh water Rhiz. N. America*, p. 112, pl. 15, figs. 1-14, 20-24, pl. 16, figs. 25-29.

Habitat & Locality.—The living ones amongst the pond vegetation and empty tests are commonly seen in the bottom ooze. Bandel (Dist. Hooghly); 9-11-1964. Tribeni (Dist. Hooghly); 12-12-1966. Burdwan (Dist. Burdwan); 14-11-1966. Krishna Sayar (Dist. Burdwan); 9-8-1966.

Remarks.—The tests of the local specimens are generally ovoidal in shape, medium sized with small angular quartz crystals covering the test. All the specimens observed are with trilobed pseudostome. Size 63-119 μ by 46-106 μ .

11. *Diffugia urceolata* Carter

(TEXT-FIG. 2 B)

1864. *Diffugia urceolata* Carter, *Ann. Mag. nat. Hist.*, (3) 13, pp. 27, 37, pl. 1, fig. 7.

Habitat & Locality.—In the bottom ooze of ponds. Kalyani (Dist. Nadia); 7-12-1964. Akna village, Bandel (Dist. Hooghly), 9-11-1964.

Remarks.—The tests of the specimens observed are spherical with a broad reflected rim around the pseudostome. The test and the rim surfaces are quite smooth. The angular quartz crystals on the rim are smaller than the ones on the spherical part.

One of the biggest *Diffugia* observed in this place. The local specimens are of average size, measuring $165\text{--}317\ \mu$ by $115\text{--}314\ \mu$.

12. *Diffugia corona* Wallich

(TEXT-FIGS. 2 C, D)

1864. *Diffugia corona* Wallich, *Ann. Mag. nat. Hist.*, (3) 13, p. 244, pl. 15, figs. 4 b, c, pl. 16, figs. 19, 20.

Habitat & Locality.—Amongst the pond vegetation and the bottom ooze. Empty tests are quite common in the ooze of ponds, the living ones are very rare. Manohar Das tadak (Calcutta); 8-10-1963. Ghosh para, Kalyani (Dist. Nadia); 14-9-1964. Naihati (Dist. 24-Parganas); 4-9-1964. Barasat (Dist. 24-Parganas); 6-12-1965.

Remarks.—The tests of the local specimens are spherical in shape with five pointed spines on the periphery of the fundus. The surfaces of the test and the spines are smooth, formed by quartz crystals. The pseudostome characteristically crenulated, crenulation varying from 10-12 in number.

The local specimens are smaller, measuring $109\text{--}147\ \mu$ in diameter of test and $50\text{--}60\ \mu$ in diameter of the pseudostome, than the specimens reported from British Isles.

13. *Diffugia oblonga* Ehrenberg

(TEXT-FIG. 2 E)

1838. *Diffugia oblonga* Ehrenberg, *Infusionsthierchen*, p. 131, pl. 2, fig. 3 a-d.

Habitat & Locality.—In the bottom ooze of ponds. Himsagar, Kalyani (Dist. Nadia); 9-11-1964.

Remarks.—The test is typically oblong with smooth surface, composed of big angular quartz crystals. The empty tests are only observed measuring $360\text{--}426\ \mu$ by $138\ \mu$.

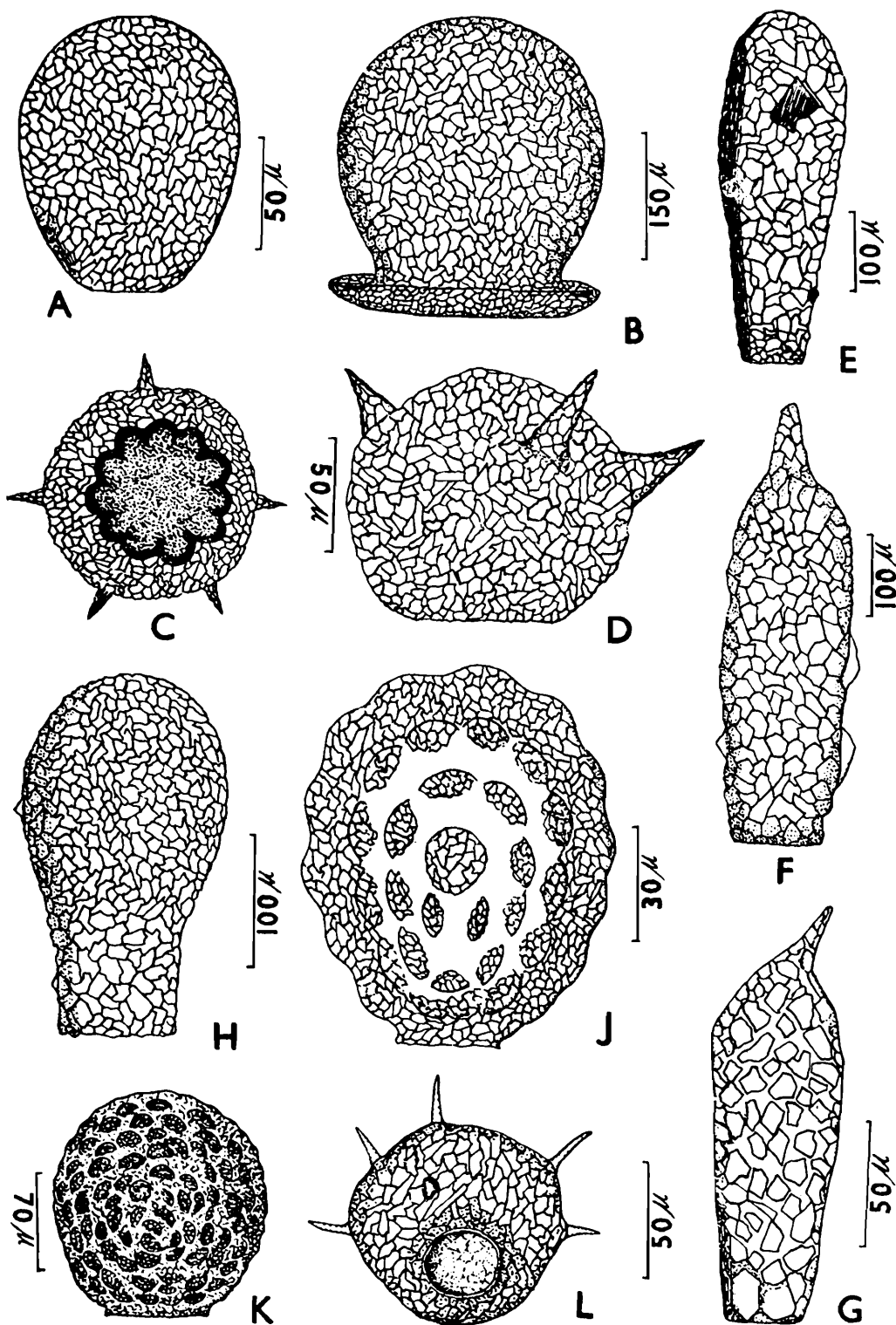
The specimens collected are bigger in size than the specimens reported from British Isles.

14. *Diffugia acuminata* Ehrenberg

(TEXT-FIG. 2 F)

1838. *Diffugia acuminata* Ehrenberg, *Infusionsthierchen*, p. 131, pl. 9, fig. 3.

Habitat & Locality.—In the bottom ooze of ponds. Kalyani (Dist. Nadia), 14-9-1964, 17-12-1964. Diamond Harbour (Dist. 24-Parganas); 10-8-1964. Pathipukur (Dist. 24-Parganas); 21-4-1964. Gopal Nagar, Adisaptagram (Dist. Hooghly); 5-1-1967.



TEXT-FIG. 2. A. *Diffugia lobostoma* Leidy (lateral view of test); B. *Diffugia urceolata* Carter (lateral view of test); C. *Diffugia corona* Wallich (Apertural view of test); D. *Diffugia corona* Wallich (lateral view of test); E. *Diffugia oblonga* Ehrenberg (lateral view of test); F. *Diffugia acuminata* Ehrenberg (lateral view of test); G. *Diffugia curvicaulis* Penard (lateral view of test); H. *Diffugia pyriformis* Perty (lateral view of test); J. *Diffugia tuberculata* (Wallich) (lateral view of test); K. *Diffugia muriformis* Gauthier - Lievre & Thomas (lateral view of test); L. *Centropyxis aculeata* (Ehrenberg) (apertural view of test).

Remarks.—One of the species of *Diffugia* showing a considerable size range, from small sized to giant sized tests with a pointed tubular extension at the apex of the fundus. The quartz. crystals of the test are

big and some of them project out of the margin of the test giving an irregular appearance to the border.

Size ranging from 184-338 μ by 59-96 μ . The specimens are medium sized when compared to the measurement of specimens (338-390 μ by 90-100 μ) reported by Gauthier-Lievre & Thomas (1958).

15. *Diffugia curvicaulis* Penard

(TEXT-FIG. 2 G)

1899. *Diffugia curvicaulis* Penard, *Rev. Suisse Zool.*, 7 (1), p. 36, pl. 3, figs. 2-6.

Habitat & Locality.—In the bottom ooze of ponds, Naihati (Dist. 24-Parganas); 17-10-1966.

Remarks.—The texture and shape of the test are very similar to *D. acuminata* except for curved prolongation on the fundus and the transparent nature of the test. The crystals on the chitinous tests are scanty and the gradual narrowing of the test towards the pseudostome is not seen in the specimens.

These specimens are doubtfully referred to this species here.

16. *Diffugia pyriformis* Perty

(TEXT-FIG. 2 H)

1848. *Diffugia pyriformis* Perty, *Mittheil. Naturf. Gesells.*, Bern, p. 168.

Habitat and Locality.—In the bottom ooze of ponds, the living specimens are very rare, the empty tests are seen in good number. Diamond Harbour (Dist. 24-Parganas); 18-8-1964. Kalyani (Dist. Nadia); 14-9-1964. Burdwan (Dist. Burdwan); 14-2-1966.

Remarks.—The shape of the test is characteristically pyriform with smooth margins, small angular quartz crystals and mud particles encrusted on the chitinous membrane.

Local specimens are of average size measuring 181-301 μ by 99-181 μ .

17. *Diffugia tuberculata* (Wallich)

(TEXT-FIG. 2 J)

1864. *Diffugia proteiformes* subsp. *globularis* var. *tuberculata*, Wallich, *Ann. Mag. nat. Hist.*, (3) 13, p. 241, pl. 15, fig. 48 and pl. 16, fig. 18.

Habitat & Locality.—Empty shells are seen in the bottom ooze of ponds, very rare. Garia (Dist. 24-Parganas); 5-10-1964. Barrackpore (Dist. 24-Parganas); 25-1-1967.

Remarks.—Test ovoidal in shape with pseudostome hexagonal in outline with obtuse angles. The tubercles on the test of the local specimens are of very feeble amplitude.

The specimens are of average size measuring 100-133 μ by 79-100 μ in size.

18. *Diffugia muriformis* Gauthier-Leivre & Thomas

(TEXT-FIG. 2 K)

1958. *Diffugia muriformis* Gauthier-Lievre & Thomas, *Arch. Protistenk.*, Jena. 103 (2), p. 271, pl. 10, fig. a-c.

Habitat & Locality.—In the bottom ooze of ponds; only empty tests are observed. Kalyani (Dist. Nadia); 7-12-1964. Bandel (Dist. Hooghly); 9-11-1964.

Remarks.—The test is spherical with a small collar around the pseudostome, the pseudostome is trilobed, the test bearing evenly distributed small disc-shaped protuberances of feeble amplitude on it. In this character these specimens very clearly resemble the description of *D. muriformis* Gauthier-Lievre and Thomas (1958).

The local specimens are bigger in size measuring 172-210 μ by 158-178 μ than the size reported by Gauthier-Lievre and Thomas (1958).

19. *Centropyxis aculeata* (Ehrenberg)

(TEXT-FIG. 2 L)

1832. *Arcella aculeata* Ehrenberg, *Abh. preuss. Akad. Wiss.*, Berlin, p. 40.

Habitat & Locality.—The living animals usually amongst the pond vegetation, empty tests quite frequent on the bottom ooze. Diamond Harbour (Dist. 24-Parganas); 31-8-1964. Bandel (Dist. Hooghly); 9-11-1964. Garia (Dist. 24-Parganas); 8-2-1965. Krishna Sayar (Dist. Burdwan); 7-8-1965. Barasat (Dist. 24-Parganas); 6-9-1965 & 6-12-1965. Naihati (Dist. 24-Parganas); 17-10-1966.

Remarks.—The size of the specimens varies considerably, usually with quartz crystals on the test, the specimens with admixture of diatoms, fistules and sand particles are very common.

The specimens collected are of medium size to big ones ranging from 88-250 μ in diameter of test and the pseudostome 33-99 μ . The spines number varies from four to six; the spines are devoid of crystals and diatom encrustation.

20. *Centropyxis ecornis* (Ehrenberg)

(TEXT-FIG. 3 A)

1843. *Arcella ecornis* Ehrenberg, *Abh. preuss. Akad. Wiss.*, Berlin, p. 368, pl. 1, fig. 9, pl. 3, fig. 46.

Habitat & Locality.—Amongst the pond vegetation and on the bottom ooze. Bandel (Dist. Hooghly); 17-11-1964. Diamond Harbour (Dist. 24-Parganas); 31-8-1964. Garia (Dist. 24-Parganas); 8-2-1965.

Remarks.—Very similar to *Centropyxis aculeata* in nature and texture of the test, but devoid of spines. The pseudostome is circular and placed eccentrically.

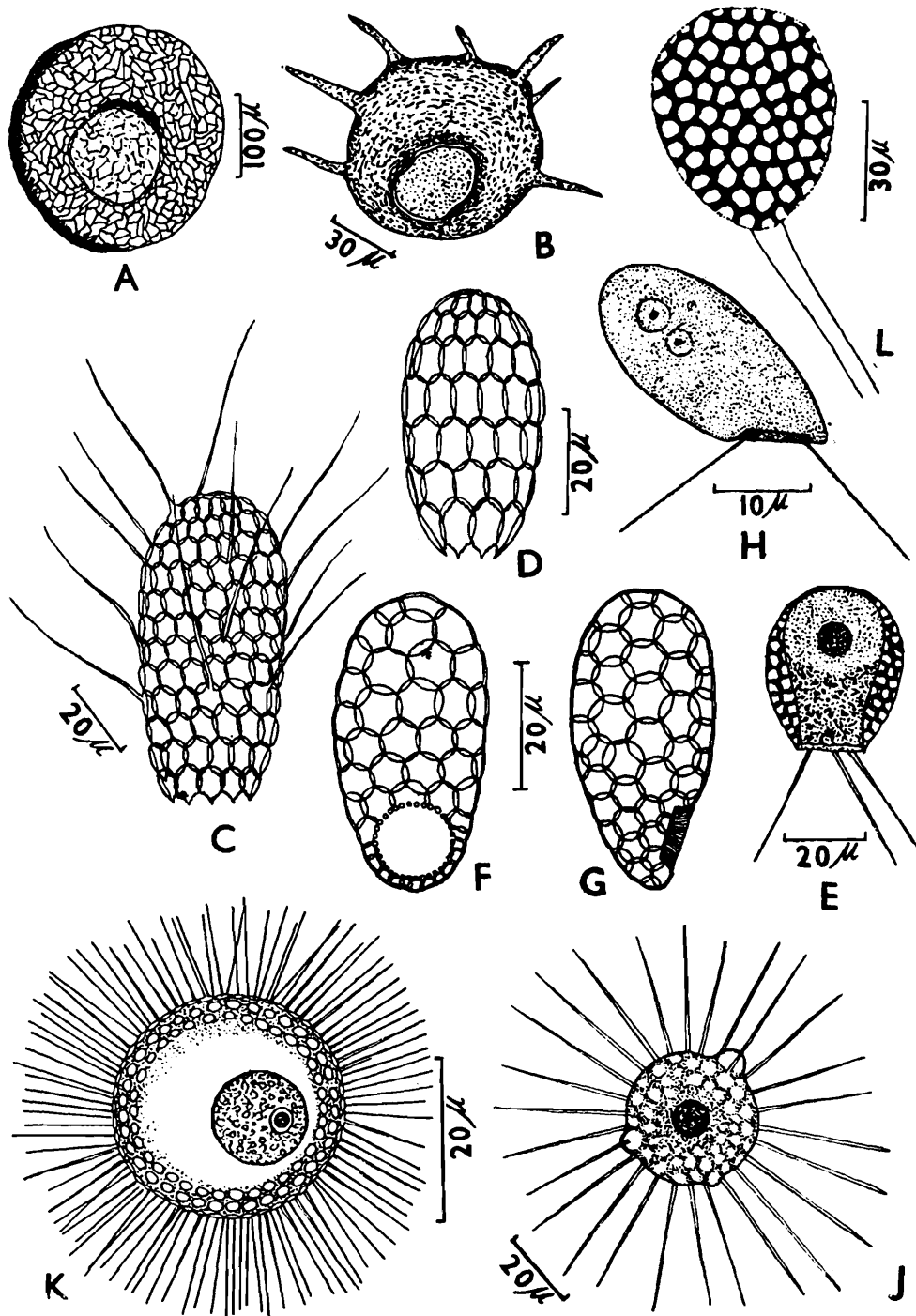
Size 195-267 μ in diameter and the height of the test on the non-depressed border ranges from 85-102 μ .

21. *Centropyxis spinosa* (Cash & Hopkinson)

(TEXT-FIG. 3 B)

1905. *Centropyxis aculeata* var. *spinosa* Cash & Hopkinson, *The British Fresh-water Rhiz. & Heliozoa*, 1, p. 135, pl. 16, fig. 15 and text-fig. 26.

Habitat & Locality.—Amongst the pond vegetation and the surface scum. Krishna Sayar, Burdwan (Dist. Burdwan); 9-8-1965.



TEXT-FIG. 3. A. *Centropyxis ecornis* (Ehrenberg) (apertural view of test); B. *Centropyxis spinosa* (Cash & Hopkinson) (apertural view of test); C. *Euglypha acanthophora* (Ehrenberg) (lateral view of test); D. *Euglypha tuberculata* Dujardin (lateral view of test); E. *Placocista lens* Penard (broad side view); F. *Trinema enchelys* (Ehrenberg) (apertural view of test); G. *Trinema enchelys* (Ehrenberg) (lateral view of test); H. *Trinema lineare* Penard (lateral view); I. *Actinophrys sol* Ehrenberg; J. *Acanthocystis spinifera* Greeff; K. *Acanthocystis spinifera* Greeff; L. *Clathrulina elegans* Cienkowski (lateral view of a capsule)

Remarks.—The test is chitinous and with very few crystals of quartz or diatom fistules encrusting on it. The spines vary from six to eight and arranged on two levels on the periphery of the broader end. The pseudostome is irregularly circular in shape, with invaginated borders. Size: $86\ \mu$ in diameter, mouth $46\ \mu$ in diameter and spine length varies from $30\text{--}41\ \mu$. The local specimens are of smaller size than those recorded by Cash and Hopkinson (1905) who give $120\text{--}140\ \mu$ diameter.

22. *Euglypha acanthophora* (Ehrenberg)

(TEXT-FIG. 3 C)

1842. *Diffugia acanthophora* Ehrenberg, *Abh. Acad. Berlin*, pp. 413, 414, pl. 4, 1 fig. 36.

Habitat & Locality.—Amongst the pond vegetation and on the bottom ooze of ponds. Hridayapur, Barasat (Dist. 24-Parganas); 6-9-1965, 6-12-1965. Adisaptagram (Dist. Hooghly); 5-1-1967.

Remarks.—The test is ovoidal and very closely resembles the descriptions of the species by Cash & Wailes (1915) in the nature of spines, the serrated apical scales bordering the pseudostome and in the shape and structure of the plasma.

Size $53\text{--}73\ \mu$ by $22\text{--}33\ \mu$, spines five to six varying from $18\text{--}32\ \mu$ in length.

The specimens referable to *E. acanthophora* var. *flexuosa* Penard are also quite common in the water samples. Except for the flexuous nature of the spines, these specimens agree in other respects with the typical forms. The specimens with two to three tiers of flexuous spines at varying intervals are also present in the collection. Size of these specimens ranges from $53\text{--}56\ \mu$ by $26\ \mu$.

23. *Euglypha tuberculata* Dujardin

(TEXT-FIG. 3 D)

1841. *Euglypha tuberculata* Dujardin, *Zooph. Infus.*, pp. 251-252.

Habitat & Locality.—Amongst the pond vegetation and the bottom ooze. Barasat (Dist. 24-Parganas); 6-9-1965. Barrackpore (Dist. 24-Parganas); 25-1-1967.

Remarks.—The test is oval in shape, composed of oval shaped silicious scales, regularly imbricated. The apical scales are serrated and the pseudostome is circular. Size of the test $56\text{--}58\ \mu$ by $23\text{--}26\ \mu$.

24. *Placocista lens* Penard

(TEXT-FIG. 3 E)

1902. *Placocista lens* Penard, *Faune Rhiz. Leman*, pp. 514-515, 3 figs.

Habitat & Locality.—The bottom ooze of ponds. Gopalnagar, Lakshmikantapur (Dist. Hooghly); 2-11-1966.

Remarks.—The test is broadly oval in shape, made of small oval shaped silicious scales; very much compressed hence the plasma is seen very clearly, the pseudostome is bordered by a very delicate membrane.

Size 40-46 μ by 33 μ in the broad view and the maximum thickness in side profile 10-15 μ . The local specimens are smaller in size than the ones reported from the British Isles. It is of considerable interest to note that this species has been reported from deep lakes in Europe.

25. *Trinema enchelys* (Ehrenberg)

(TEXT-FIGS. 3 F, G)

1838. *Diffugia enchelys* Ehrenberg, *Infusionsthierchen*, p. 132, pl. 9, fig. 4 a, b.

Habitat & Locality.—Amongst the pond vegetation and the bottom ooze of ponds. Barasat (Dist. 24-Parganas); 6-12-1965. Adisaptagram (Dist. Hooghly); 5-1-1967.

Remarks.—Very common in the ponds, the scales are circular and imbricated, the pseudostome is circular bordered by small incurved silicious plates.

Size 49.5 μ by 23-28 μ , the diameter of the pseudostome 10-12 μ .

26. *Trinema lineare* Penard

(TEXT-FIG. 3 H)

1890. *Trinema lineare* Penard, *Mem. Soc. Geneve.*, 31 (1 & 2), p. 187, pl. 11, figs. 5-17.

Habitat & Locality.—On the bottom ooze of ponds with *Trinema enchelys* specimens. Barasat (Dist. 24-Parganas); 6-12-1965.

Remarks.—The shape of the test is very similar to the previous species, but the silicious scales of the test are not very distinct, and the size of the specimens is very small not exceeding 25 μ in length. The living specimens in conjugation are usually seen in the collections.

27. *Actinophrys sol* Ehrenberg

(TEXT-FIG. 3 J)

1830. *Actinophrys sol* Ehrenberg, *Abh. preuss. Akad.*, Berlin, p. 42, pl. 2, fig. 4.

Habitat & Locality.—In long standing still water, amongst the pond vegetation. Wellington square fountain pond (Calcutta); 2-5-1959. Indian Museum Pond (Calcutta); 18-1-1960. Botanical Garden, Sibpur (Dist. Howrah); 4-2-1960. Adisaptagram (Dist. Hooghly); 28-2-1967.

Remarks.—Very common heliozoan usually seen in all the ponds of the locality. Size of the specimens varies according to the habitat and age differences.

28. *Acanthocystis spinifera* Greeff

(TEXT-FIG. 3 K)

1869. *Acanthocystis spinifera* Greeff, *Arch. mikr. Anat.*, 5, p. 493, pl. 27, figs. 20-23.

Habitat & Locality.—Adisaptagram (Dist. Hooghly); 5-1-1967.

Remarks.—The body is spherical with numerous, slightly curved spines of unequal length on the entire surface. The nucleus is eccentrically placed. The axopodia are not observed in these specimens. Size 26-33 μ diameter, spine length varying from 3-8 μ . The specimens are of small to medium size.

29. *Clathrulina elegans* Cienkowski
(TEXT-FIG. 3 L)

1867. *Clathrulina elegans* Cienkowski, *Arch. mikr. Anat.*, 3, p. 311, pl. 18, figs. 1-15.

Habitat & Locality.—On the submerged vegetation of ponds. Bandel (Dist. Hooghly); 5-12-1964. Barasat (Dist. 24-Parganas); 6-12-1965.

Remarks.—Solitary individuals and colonies with 8 to 10 individuals are commonly seen.

The length of each stalk 191-285 μ , diameter of each capsule 43-53 μ , each pore having diameter 3.5-4.5 μ .

The capsule of the local specimens are spherical and smaller in size than those reported from Europe and N. America.

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PATTERNS OF SECONDARY GROWTH AND A REVISION OF THE SYSTEMATICS IN *MICROCOTYLOIDEA* AND *GASTROCOTYLIDAE* (MONOGENOIDEA)

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(With 7 Text-figures)

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I—INTRODUCTION

An analysis of the dynamics of axial growth potentials in the hind-body of the higher Monogenoidea; particularly those showing secon-

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The author is grateful to Miss Nora G. Sproston for the discussions he had with her on the preparation of this paper.

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dary growth, was suggested by the wealth of the variety displayed in recently discovered forms from fishes in tropical seas. This naturally led to a re-examination of their relationships.

The systematic scheme presented here for the higher monogeneans is consciously a temporary one, and its main feature is the re-introduction of superfamily taxa, absent in the welcome expansion of the scheme by Bychowsky. Bychowsky (1957) provided three orders each for the subclasses Polyonchoinea Bych., 1937, and Oligonchoinea Bych., 1937, and the order Mazocraeidea Bych., 1957 has 7 families. I agree with the American workers (Hargis, 1959, Price, 1959) that superfamilies are again necessary to accommodate the strange variety of forms discovered since Bychowsky's great work went to press. I have suggested 6 superfamilies for Discocotylinea, and elaborated the schemata for two of them: Microcotyloidea (Unnithan, 1957) *s. str. emend.*, in respect of the families Axinidae Unnithan, 1957 and Heteromicrocotylidae (Yamaguti, 1963) *s. str. emend.* (an analysis of the Microcotylidae *s. str.* will follow), and Gastrocotyloidea Price, 1959, in respect of Gastrocotylidae (a study of Opisthogynidae Unnithan, 1962 appears elsewhere).

The revision is an attempt to rationalize the classification in the light of comparative anatomy of the clamps, and also of an analysis of the dynamics of the axial growth potentials of the haptor region. The opportunity has been taken to make some corrections in the out-of-date synopsis of Sproston (1946), and to clarify and emend certain definitions in the paper on Axinidae (Unnithan, 1957): in this, only passing reference was made to the systematics of species related to the new forms, even when they were affected by recent findings. Accordingly, each species has been reconsidered at lengths proportionate to their interest in the present inquiry. Substantial contributions on Monogeneoidea by Price (1962) and Yamaguti (1963) have appeared since the first draft of this paper was ready. Though their rationale is on different lines, portions found to be helpful from these two have also been incorporated in the present paper.

Note on terminology: 'Haptor' is used in preference to Dawes' 'opisthohaptor' for the whole of the posterior adhesive complex in all Monogeneoidea; 'Protohaptor' for the ventral terminal lobe of the larval haptor bearing two dissimilar pairs of anchors and usually a terminal pair of larval hooklets: all or some of these structures may be retained by the adults. The 'euhaptor' is the definitive haptor of the adult, and in forms without secondary growth comprises only the remodelled larval haptor, but in forms with secondary growth includes in addition all clamp-bearing regions produced by anadromous metamerism. 'Metahaptor' is an anterior extension of the euhaptor, ventrally to the body axis and bearing clamps produced by a katadromous metamerism from the anterior side of the dichotomized formative zone—the euhaptor being formed from the posterior moiety of this zone. The metahaptor may be a unilateral flange or a bilateral lobe, always physically if not qualitatively continuous with the euhaptor.

MICROCOTYLOIDEA (Unnithan, 1957) *s. str. emend.*

The present emendation is the removal of Gastrocotylidae from the superfamily as constituted by Unnithan (1957: 41). The superfamily is now defined as Discocotylinea Bychowsky, 1957, in which the clamps are basically discocotyloid, with no extra sclerites entering into their essential mechanism, and in which there is a secondary replication of the four primary pairs of clamps of the larval haptor: the growth of the euhaptor so formed is potentially unlimited throughout life.

II — SOME PATTERNS OF SECONDARY GROWTH IN THE HAPTOR OF MICROCOTYLOIDEA (AND GASTROCOTYLIDAE)

The potentially unlimited growth of the euhaptor may be modified by secondary inhibitory influences operating differentially in the various growth-axes of the euhaptor, being imposed along the body/haptor-axis, either, or both, of the lateral longitudinal replication axes; or more rarely, along the lateral (transverse) axes of the haptor itself. These inhibitory influences are responsible for the more striking degrees and kinds of asymmetry of the haptor. In addition, there may be secondary stimulative influences along these axes, inducing both qualitative and quantitative changes in growth. These positive influences are less evident in those axes where negative influences have been strong. Secondary stimulation is usually persistent in an axis, at its original intensity, both qualitatively and quantitatively. If this involves remodelling of the clamp sclerites at some level of the axis, the new form appears abruptly — except where the remodelling is extreme, as in Pyragraphorinae, where it is gradually developed. Stimulative effects, once achieved, are maintained in subsequent replications: in contrast to inhibitory effects which, unless they are absolute at the outset, increase gradually along the growth axis, *e.g.* *Heteraxine* spp. clamps of the short row are formed in a gradually diminishing series, and are produced more and more slowly compared with the less inhibited row.

Quantitative stimulation has two manifestations: (a) the clamps themselves increase in size, and (b) there is an accelerated replication rate, and this is nearly always accompanied by a *dichotomy of the axes of growth*. This is necessary after a certain threshold of stimulation, since a haptor growing much faster than the body/haptor-axis would lack space for development.

In the simplest instances this does not occur till late in life (proximal region of the haptor), when there is a longitudinal scission in the formative zone, resulting in a *lateral dichotomy* of the axis of replication (perhaps irrevocably), so that two clamps are formed side by side instead of in single file: *e.g.* in *Microcotyle priacanthi* Meserve, *M. pomatomi* Goto: (and in Gastrocotylidae, *Chauhanea madrasensis* Ramalingam, *Gotocotyla secunda* (Tripathi) etc. In all these and in similar instances of lateral dichotomy in the proximal (younger) sector of the euhaptor-rows, the stimulus is bilateral, but

in instances of a second dichotomy in the same plane, resulting in three parallel rows, this may not occur at the same level on both flanks, or one flank may not have a secondary or tertiary dichotomy at all; but more data are required to confirm this. It seems to be a character of secondary stimulation (accelerated growth) to affect both lateral axes equally, or to be discernible on one side only: no example appears to be known of a marked acceleration on one side, and a minor (similarly abrupt) acceleration on the other, a character in marked contrast to the manifestations of inhibitory influences.

A more highly evolved expression of growth stimuli is seen in the metahaptor: a secondary haptoral lobe produced anteriorly to the euhaptor and growing forwards (morphologically) ventral to the body proper. Functionally, as a postural effect, the body is pivoted more or less at right angles to it, and away laterally in the vertical plane, in the direction of the cibo-respiratory current over the gill-surface of the fish-host: an habitual posture of all larger monogeneans. This fact is well known, but has been nicely illustrated by Llewellyn (1956 *a*: 113) though it was probably outside the intended scope of his paper to emphasize that the resulting torque on any organs in the hind-body embraced by the haptoral frills or flanges, is often effective in bringing about significant displacements among them, and also relative to the body-axis. *Somatic asymmetry* occurs when the pivoting axis is within the gonad-zone, the least resilient part of the body; this is more marked when the body/haptor axis is shortened or aborted, that is, when the euhaptor flanges are adherent to the sides of the body, *e.g.* in *Thoracocotyle ovalis* Tripathi. A thickened cuticle and body-wall developed in Vallisiinae and Protomicrocotylidae are additional causes for their gross asymmetry in the gonad-zone (all these are Gastrocotyloidea).

In the simple euhaptor, the first secondary clamps are produced from a formative zone immediately anterior to the proximal (most anterior) pair of primary clamps, as is shown conclusively in Bychowsky's figures (1957: figs. 252, 253) of *Prosomicrocotyla gotoi*. Thus, throughout life, new clamps are added at the anterior end of the euhaptor. When there is a dichotomy and a dual zone of replication is formed, however, the secondary clamps forming anterior to this are pushed over ventrally and anteriorly, and particularly if the dichotomy has affected both lateral axes, they carry with them part of the median axial tissues of the haptor, and a bud is formed. The type of tissue or organ carried outwards in the metahaptoral bud is, of course, dependent on the depth of the dichotomy organoleptically.

The level of the dichotomy in the larval haptor can be found at any time by counting the number of diminutive clamps on the anterior end of the metahaptor. In highly modified clamp forms, the number on the posterior end of the euhaptor may be more difficult to assess, nor are we certain that in some cases the posterior primary clamps are not lost with the protohaptor—the lappet bearing the larval anchors, the loss of which occurs spasmodically in genera throughout the order Mazocraeidea Bychowsky, 1957. In the extreme instance of *Pricea* spp. (Gastrocotyloidea: (Gastrocotylidae) the dichotomy

evidently takes place in the proto-haptoral zone of the larval haptor, and between the two pairs of anchors. This is witnessed by the presence of the proximal pair of anchors on the end of the body proper, at the level where the metahaptor leaves it. They remain attached (*in situ*) owing to their longitudinal muscles being continued into the body proper. The shallowness of the dichotomy in this group involves only the more superficial tissues, as it does in some species of *Microcotyle sensu lato*.

Though the euhaptor and metahaptor grow out from juxtaposed formative zones, they are immediately separate entities, and nearly always seem to show a different degree of acceleration of axial growth: sometimes the euhaptor is the longer as in *Pricea*, and perhaps *Microcotyle cepolae* Yamaguti (1938: xix, fig. 32), and *M. gimpo* Yamaguti (1958: liii, fig. 15); sometimes about equally long as in *Pyragraphorus pyragraphorus* (Mac Callum & Mac Callum, 1913), and perhaps in *Microcotyle branchiostegi*, Yamaguti (1938: xvii, fig. 1) *M. sebastisci* Yamaguti (1938: xvii, fig. 13); but sometimes the metahaptor has a sustained higher growth acceleration than the euhaptor, as in *Hargisiella hippos* (Hargis, 1956: x, fig. 19) gen. n., also in the unilateral metahaptor of *Cemocotyle carangis* MacCallum, 1913), and perhaps in *Microcotyle leiognathi* Tripathi (1959, fig. 53). In *Microcotyle (sensu lato)* spp. just mentioned, there is no qualitative difference in the clamps of the metahaptor, nor is there in *Hargisiella* or *Pricea*, but the secondary stimuli producing the metahaptor in *Pyragraphorus* are accompanied by other positive influences which cause an extreme remodelling of the clamps, and the same is true to a lesser degree in *Cemocotyle*, *Xureliphilus elongata* (Meserve, 1938, figs. 53, 57) gen. n., and *Tripathiana minuta* (Tripathi, 1959, fig. 55) the last three having only a unilateral metahaptor.

In Microcotyloidea: Axinidae, characterized by various degrees of inhibition exerted on their potentially unlimited clamp replication, it is not surprising that when these inhibitory influences are exerted at least on one of the clamp-rows, the other row is so far never known to receive a secondary stimulation. And when the inhibition (total) is exerted only on the median body-haptor axis, as in Axininae Unnithan, there is only a slight differential inhibition exerted on the lateral replication axes (except in *Oligapta* Unnithan, where it is equally strong). There is one very interesting instance in Axininae of the development of a unilateral metahaptor namely in *Chlamydaxine truncata* (Hargis, 1956: xi, fig. 5), (Unnithan, 1957, fig. 4) at first glance difficult to interpret, because owing to the total inhibition of the longitudinal axis of the haptor/body but not of the "longitudinal" clamp-replication axes, the clamps accumulate in two lateral rows, the formative zone turning ventral to the larval haptor: at least the anchors (protohaptor) persist (always on the dorsal side of the adult haptor, (Unnithan, 1957: 82, 88, 101, 114). As a further complication in *Chlamydaxine*, there has been a unilateral dichotomy of the formative zone on one side, resulting in a short ventral lobe turning anteriorly, bearing much larger clamps as it does so. An interesting point here is that as a result of this secondary stimulation, the metahaptor has

overcome the inhibition on longitudinal growth, and carries the deeper body-organs, intestinal rami and a few vitellaria forwards with it.

The secondary growth rhythms, in the haptor of Microcotyloidea, including their inhibitions and stimulations as discussed above, apply also to the definition of Gastrocotyloidea: Gastrocotylidae, which also have a potentially unlimited power of clamp replication. But there is a fundamental difference (or one which is not a dynamic character in the growth-vector sense, but is qualitative and therefore more appealing to comparative morphologists) and this consists of the presence of at least one pair of extra sclerites in the clamp capsule, at least originally playing an essential role in the clamp mechanism. These are the oblique braces in the posterior (distal) part of the capsule in Gastrocotylinae, Priceinae, and Gotocotylinae: in Thoracocotylinae they are jettisoned from the capsule which has become remodelled as a clamp-sucker but they persist along with the dorsal jaw rami outside its effective frame (Text-fig. 6 A-G). Other sclerites are developed in other subfamilies, from rudiments which are frequently to be seen in even the simple microcotylid clamps of Microcotylidae and Axinidae, but where they play no essential part in the mechanics of the clamp.

In families without this secondary replication of the primary four pairs of clamps, namely families in which the clamp pairs are limited to the four pairs of the larval haptor, the clamp structure becomes a more important taxonomic criterion. In fact it is true, that in general, those having extra sclerites of the basic "gastrocotylid type of clamp" do have other uniting (somatic) characters in combinations not found in the simpler Discocotylinae, and in general they are apparently more highly evolved.

Moreover, Gastrocotyloidea are more frequently (but by no means always) found on the more highly evolved families of fishes, a characteristic shared by the most highly evolved Microcotylids, the Heteromicrocotylidae. Soviet colleagues have pursued many ramifications of the hypothesis of the host/parasite parallelism in evolution, and have even ventured to attribute various parasites, including Monogenea, to their putative geological horizon *vis-a-vis* the fossil evidence for their present-day hosts, on the one hand, and on the other, the propinquity in the relationships of the known species of parasites of correspondingly related genera of fishes. The generally accepted rule is that the parasite evolves less rapidly than the host, but in many instances it could be cited that the reverse may be true, at least for Monogenea, where two or more related species are found in the same host exclusively of other "likely" hosts elsewhere. Whereas in other instances we certainly have some very archaic forms living to-day on descendants of very primitive fish stocks, I am more inclined to lay stress on Dollfus' warning (1957 : 184, 269; and elsewhere) that parasites of primitive fishes are by no means always primitive, and the corollary that infection by a relatively modern stock may have taken place in relatively recent geological times. Environmental propinquity of historically very different hosts, particularly if these are shoaling in rather closed waters may, chiefly for statistical reasons, favour the establishment of a new host-parasite relationship.

III—THE REINTRODUCTION OF SUPERFAMILIES INTO THE SYSTEMATIC SCHEME OF DISCOCOTYLINA BYCHOWSKY 1957

The peculiar characters of secondary growth revealed by some well-known, and several newly discovered, members of this suborder are herein considered, criteria of taxonomic rank second only to basic clamp-architecture.

Accordingly, the superfamily Microcotyloidea, *sensu emend. nov.* represents forms with secondary haptoral growth involving clamps of the simple 'discocotyloid' type, and Gastrocotylidae *sensu emend.* those with 'gastrocotylid' clamps (with additional sclerites in their mechanism). The difference in taxonomic rank is due to the exigencies of the logical scheme of the suborder, accepted provisionally pending further knowledge of the ontogenies of Gastrocotyloidea Price, 1959.

Since the first draft of this paper was written, I have found support for the reintroduction of superfamilies in papers by Hargis (1959) and Price (1959), the latter already having erected my intended Gastrocotyloidea, though its internal grouping is unlike the present, its criteria based on additional clampsclerites, are identical. Price makes no mention of Bychowsky's works, and his rationale is not clear when he unites genera with limited haptoral growth in the same family with *Gastrocotyle*, (those now placed in the new family Opisthogynidae Unnithan, 1962); moreover, he retains Priceinae Chauhan, in its original context, thus separating *Pseudaxine* from *Neothoracocotyle*, and *Thoracocotyle* from *Amphipolycotyle*, pairs of genera with fundamentally similar clamps.

While emphasizing the importance of the pattern of growth-potentials throughout the haptoral region, I have given prior taxonomic rank to basic clamp-type, preserved at superfamily level, since it is the main criterion for the higher taxa of the subclass Oligonchoinea Bychowsky, 1937. Consistency appears to fail in the case of Protomicrocotylidae Poche, since recent authors have described species of *Protomicrocotyle*, *sensu lato*, with sometimes microcotylid and sometimes gastrocotylid clamps; for this reason, and for the peculiar somatic asymmetry and unique haptor, I reserve a separate superfamily for it (see Unnithan, 1962). For logical consistency, I have raised three other of Bychowsky's family groups to superfamily rank. His 1957 scheme, with these emendations for Discocotylinea is set out below.

Class: MONOGENOIDEA (Beneden) Bychowsky, 1937.

Subclass: POLYONCHOINEA Bychowsky, 1937.

Order: DACTYLOGYRIDEA Bychowsky, 1937.

Suborder: DACTYLOGYRINEA Bychowsky, 1937.

Family: DACTYLOGYRIDAE Bychowsky, 1933.

Subfamily: DACTYLOGYRINAE Bychowsky, 1933.

- Subfamily: ANCYROCEPHALINAE Bychowsky, 1937.
- Subfamily: LINGUADACTYLINAE Bychowsky, 1957.
- Family: DIPLECTANIDAE Bychowsky, 1957.
- Subfamily: DIPLECTANINAE Monticelli, 1903.
- Subfamily: RHAMNOCERCINAE Monaco, Wood & Mizelle, 1954.
- Family: PROTOGYRODACTYLIDAE Johnston & Tiegs, 1922.
- Family: CALCEOSTOMATIDAE (Par. & Per. 1890) Price, 1937.
- Suborder: *MONOPISTHOCOTYLINAE* (Odhner, 1912)
Bychowsky, 1937.
- Family: MONOCOTYLIDAE Taschenberg, 1879.
- Subfamily: MONOCOTYLINAE Gamble, 1896.
- Subfamily: DASYBATOTREMINAE Bychowsky, 1957.
- Subfamily: CALICOTYLINAE Monticelli, 1903.
- Subfamily: MBRIZOCOTYLINAE Johnston & Tiegs, 1922.
- Family: LOIMOIDAE Bychowsky, 1957.
- Family: DIONCHIDAE Bychowsky, 1957.
- Family: CAPSALIDAE Baird, 1853.
- Subfamily: CAPSALINAE Johnston, 1929.
- Subfamily: MEGALOCOTYLINAE Bychowsky, 1957.
- Subfamily: TROCHOPODINAE (Price, 1936) Sproston, 1946.
- Subfamily: ENTOBDELLINAE Bychowsky, 1957.
- Subfamily: ENCOTYLLABINAE Monticelli, 1892.
- Subfamily: NITZSCHIINAE Johnston, 1931.
- Family: ACANTHOCOTYLIDAE Price, 1936.
- Subfamily: ACANTHOCOTYLINAE Monticelli, 1903.
- Subfamily: ENOPLOCOTYLINAE Tagliani, 1912.
- Family: MICROBOTHRIIDAE Price, 1936.
- Order: TETRAONCHIDEA Bychowsky, 1957.
- Family: TETRAONCHIDAE Bychowsky, 1937.
- Family: AMPHIBDELLATIDAE (Carus, 1885) Bychowsky, 1957.
- Family: TETRAONCHOIDIDEA Bychowsky, 1951.
- Family: BOTHITREMATIDAE Bychowsky, 1957.
- Order: GYRODACTYLIDEA Bychowsky, 1937.
- Suborder: *GYRODACTYLINAE* Bychowsky, 1937.

- Family: GYRODACTYLIDAE (v. Ben. & Hesse, 1863) Cobbold, 1864.
Suborder: *POLYOPISTHOCOTYLINA* (Odhner, 1912)
Bychowsky, 1937.
Family: POLYSTOMATIDAE (Carus, 1936) Gamble, 1896.
Family: SPHYRANURIDAE Poche, 1926.
Subclass: *OLIGONCHOINEA* Bychowsky, 1937.

Order: DICLYBOTHRIIDEA Bychowsky, 1957.
Family: DICLYBOTHRIIDAE Bychowsky & Gussew, 1950.
Family: HEXABOTHRIIDAE Price, 1942.

Order: CHIMAERICOLIDEA (Brinkmann, 1952) Bychowsky, 1957.
Family: CHIMAERICOLIDAE Brinkmann, 1942.

Order: MAZOCRAEIDEA Bychowsky, 1957.
Suborder: *PTERINOTREMATINEA* Bychowsky & Nagibina, 1959.
Family: PTERINOTREMATIDAE Bychowsky & Nagibina, 1959.
Subfamily: PTERINOTREMATINAE Caballero & Bravo Hollis, 1955.
Suborder: *MAZOCRAEINEA* Bychowsky, 1957.
Family: MAZOCRAEIDAE Price, 1936.
Family: HEXOSTOMATIDAE Price, 1936.
Suborder: *DISCOCOTYLINA* Bychowsky, 1957.
Superfamily: DISCOCOTYLOIDEA superfam. nov.
Family: DISCOCOTYLIDAE (Price, 1936) Tripathi, 1959.
Family: DIPLOZOOIDAE Tripathi, 1959.
Superfamily: PLECTANOCOTYLOIDEA superfam. nov.
Family: PLECTANOCOTYLIDAE Poche, 1926.
Superfamily: DICLIDOPHOROIDEA (Price, 1936) *sensu stricto*, emend.
Family: DICLIDOPHORIDAE Fuhrmann, 1928.
Superfamily: MICROCOTYLOIDEA (Unnithan, 1957) *s. str.*, emend.
Family: MICROCOTYLIDAE (Taschenberg, 1879) *s. str.*, emend.

Family: AXINIDAE Unnithan, 1957.
Subfamily: AXININAE Monticelli, 1903.
Subfamily: HETERAXININAE Unnithan, 1957.
Subfamily: MONAXININAE Unnithan, 1957.
Family: HETEROMICROCOTYLIDAE (Yamaguti, 1963) *s. str.*, emend.
Subfamily: HETEROMICROCOTYLINAE subfam. nov.
Subfamily: CEMOCOTYLINAE subfam. nov.
Subfamily: PYRAGRAPHORINAE subfam. nov.
Superfamily: PROTOMICROCOTYLOIDEA Unnithan, 1962.
Family: PROTOMICROCOTYLIDAE Poche, 1926.
Sumfamily: PROTOMICROCOTYLINAE Johnston & Tiegs, 1922.

- Subfamily: ABORTIPEDINAE Unnithan, 1962.
- Subfamily: LETHACOTYLINAE Unnithan, 1962
- Superfamily: GASTROCOTYLOIDEA Price, 1959.
- Family: GASTROCOTYLIDAE Price, 1943.
- Subfamily: GASTROCOTYLINAE (Sproston, 1946) *s. str.*, emend.
- Subfamily: THORACOCOTYLINAE subfam. nov.
- Subfamily: PRICEINAE (Chauhan, 1953) *s. str.*, emend.
- Subfamily: ENGRAULICOLINAE subfam. nov.
- Subfamily: GOTOCOTYLINAE subfam. nov.
- Family: ANTHOCOTYLIDAE Bychowsky, 1957.
- Family: OPISTHOGYNIDAE Unnithan, 1962.
- Subfamily: OPISTHOGYNINAE Unnithan, 1962.
- Subfamily: PENTATRINAE Unnithan, 1962.
- Subfamily: VALLISIINAE (Price, 1943) *s. str.*, emend, in Unnithan, 1962.
- Family: GEPHYROCOTYLIDAE Unnithan, 1966.

The emendations made in the families Axinidae, Heteromicrocotylidae, and Gastrocotylidae in this paper, and in Opisthogynidae Unnithan (1962), elsewhere, (erected for gastrocotyloid worms with no additions to the 4 primary pairs of clamps, and in which the ovary lies behind the main testicular zone), are open to criticism in their being perhaps too "open": several genera, for example, are monotypic. My defence is that the great variety of structure presented by these newly discovered forms demands taxonomic separation to at least the degrees suggested, when the array is compared with the degrees of structural variation found in Polyonchoinea. The rate at which new genera are being discovered, now that attention is directed to fishes of tropical waters in various parts of the world, would suggest that only a tithe of existing forms are yet known. Considering the narrow host-specificity of Monogenoidea and that many host-species harbour four or more different monogeneans, added to the fact that there are over 20,000 species of fishes known to science, the great majority of which have not been searched for monogeneans, the present attempts to expand the systematic schemata may very soon appear less extravagant.

In the sections which follow, each family (and in Gastrocotylinae, subfamily) will be preceded by a general discussion of the range of structural variation it displays, evolutionary trends in modifications of the basic clamp-sclerites, and peculiarities in secondary growth phenomena, where of particular interest generic characters are similarly reviewed. All species known to me are cited, usually with some diagnostic notes; several emendations are made in orthography of specific names consonant with their present genus, and some corrections have been made in host-nomenclature. Only recent synonyms are cited: several, in some American and Indian publications, being due to inadequate proof-correction, a remediable source of confusion.

IV — SECONDARY GROWTH PHENOMENA AND CLAMP MODIFICATION AS SYSTEMATIC CRITERIA

MICROCOTYLOIDEA Unnithan, 1957, *sensu stricto*: Discocotylinea, in which there is a potentially unlimited replication of the clamps, which are basically of discocotyloid type.

MICROCOTYLIDAE Taschenberg, 1879, *s. str.*—Microcotyloidea, in which the usually very numerous clamps are small and delicate versions of the typical discocotyloid clamp. Very rarely there is a slight secondary inhibition in the replication, and the two lateral axes are practically equally affected, but a secondary stimulus is far more common. Quantitatively, in the clamps themselves, there may be an increase in size anteriorly in the series; rarely, a stimulus for qualitative change—an adaptive remodelling of the abaxial jaw-rami, so that the right and left counterpart clamps are mirror-images, as in *Microcotyle mormyri* Lorenz—discovered by Bychowsky (1957, fig. 309). Quantitative replication-stimuli are frequently imposed, sometimes late in life there is a lateral dichotomy in the axes, when two or more rows of clamps are formed along each side of the more proximal (anterior) region of the euhaptor. The double row on each side of *M. pomatomi* Goto, 1900, has been confirmed by Hargis (1956, X:440). The euhaptor is practically symmetrical in all species—the shorter side never having less than 90% of the clamps of the longer: greater discrepancies in number, and in length of sides have been transferred to Axinidae as evidence of an arbitrarily significant secondary differential inhibition. Sometimes there is an earlier and stronger replication stimulus resulting in an anterior-posterior dichotomy of the replication-axes, involving more or less of the body-haptor axis medially, so that a firm metahaptor is formed: its growth-rate differing more or less from that of the euhaptor, but it is always bilaterally symmetrical. There is a great diversity in the form of the genital terminalia, but the ovary is always pretesticular and its distal limb descends, often forming a double arch. The prothaptor never persists in the adult. The sub-family taxa have been studied in detail for the whole range, including some new tropical species (cf. Unnithan, 1967). At present it is necessary to mention only two groups of transitional species: (1) Replication-stimulus is weak on both lateral axes (the number of clamps on each side in parenthesis) in *Microcotyle trachini* Par. & Per., 1889, from *Trachinus radiatus* (8-10) and in Bychowsky, 1957, fig. 308 (8 each side, increasing gradually in size proximally); *Diplasiocotyle johnstoni* Sandars, 1944, from the mullet *Agonostomus forsteri* (7 pedunculated); and in *M. truncata* Goto, 1894—now placed in Gastrocotylinae in the new genus *Yamaguticotyla* Price, 1959, from *Pristipoma japonicum* (10) and *Parapristipoma trilineatum* (11).

(2) Transition to Heteraxinae-type of haptor, showing unequal stimuli for clamp-replication in the two axes is expressed here by the numerical percentage of the shorter to the longer row. There is, however, no evidence of inhibition in any of these instances, the clamps are neither absolutely nor progressively smaller in the shorter row, so I interpret this condition as differential stimulation: *Microcotyle heteracantha* Manter, 1938, from the sciaenid *Cynoscion nebulosus* (according to Hargis 1956, X: 438, on *C. regalis* also)—84%—89%; *M.*

pseudoheteracantha Hargis, 1956 (X:440) from *Cynoscion nothus*—according to his fig. 1, about 87%; *M. pamae* Tripathi, 1956, from *Pama pama*, a fluviatile sciaenid—82%—84.5%. All these from sciaenids have a single filament on the egg, and in the first and the third it is in the form of a short stalked cup. The eggs are unknown in *M. sciaenae* Goto, 1894, from *Nivea schlegelii*—80%, and re-examined by Yamaguti (1958, liii: 80) recording 87 to 97.5% “asymmetry” In these sciaenid spp. the genital atrium includes muscular bulbs and at least 2 kinds of spines, one set slender and slightly wavy, but there are marked differences in the vaginae. In *M. scorpiis* Sandars, 1944, from *Scorpiis aequipinnis* the “asymmetry” is 59%, and even more pronounced in *Gonoplasius carangis* Sandars, 1944, from *Caranx georgianus*—50%.

The asymmetry in *M. seriolae* Yamaguti, 1940, is accompanied by the clamp-rows being adherent to the body proper and by peculiar union of the vaginae, and it has been removed to Heteraxininae: *Zeuxapta* Unnithan, 1957 (see below for emendation). *Microcotyle reticulata* Goto, has been similarly transferred to *Dictydenteron* gen. n. (see below); but *Prosomicrocotyla gotoi* (Yamaguti, 1934) Yamaguti 1958, (liii: 83), and *P. chiri* (Goto, 1894) Yamaguti, 1958, are retained in Microcotylidae owing to their equal clamp-frills being quite separate in the adult, on either side of the body proper: the complete ontogeny has been studied in the genotype by Bychowsky (1957: 210, figs. 125, 248-256). The partition of the genus *Microcotyle*, *sensu lato*, as attempted by Tripathi (1956: 239), while being a useful analysis, is perhaps too arbitrary to be adopted without considerable modification.

AXINIDAE Unnithan (1957: 41) — Microcotyloidea in which the asymmetry of the haptoral region is associated with inhibitions imposed differentially on at least three of the growth-axes: the right and left longitudinal replication axes, and the median body/haptor axis. The clamps themselves show very little modification from the microcotylid type: there may be a fibrous thickening of the capsule wall but secondary cuticularizations are absent (no ribs), but an appendix on the dorsal end of the median spring may be present as in some Microcotylidae. The armature is variously developed on the genital terminalia, and a true cirrus is not developed, only a protrusible penis. There are three subfamilies distinguished by different patterns of this secondary inhibition in the growth-axes of the hind-body.

AXININAE Monticelli 1903, *sensu* Unnithan, 1957: with 7 genera—*Axine* Abildgaard, 1794, *Axinoides* Yamaguti, 1938, *Chlamydaxine* Unnithan, 1957, *Loxura* Unnithan, 1957, *Loxuroides* Price, 1962 *emend.*, *Oligapta* Unnithan, 1957, and *Indocotyle* Tripathi, 1959 (Text-fig. 1A-C).

HETERAXININAE Unnithan, 1957: with 6 genera—*Heteraxine* Yamaguti, 1938, *Gonoplasius* Sandars, 1944, *Zeuxapta* Unnithan, 1957, *Axinoa* gen. n., *Kannaphallus* Unnithan, 1957 and *Heteraxinoides* Yamaguti, 1963.

MONAXININAE Unnithan, 1957: with 7 genera—*Monaxine* Unnithan, 1957, *Crotalaxine* Unnithan, 1957, *Neoaxine* Price, 1945 (= *Amonaxine*

Unnithan, 1957), *Uraxine* Unnithan, 1957, *Allopseudaxine* Yamaguti, 1943 (Text-fig. 2B, 3C-D), *Monaxinoides* Yamaguti, 1963 and *Leuresthiicola* Price, 1962. Yamaguti (1963) proposes 3 more subfamilies which are based on characters different from those used in the present rationale.

AXININAE Monticelli 1903—Axinidae in which there is a total inhibition imposed on the median axis of the haptor, while its lateral replication axes are rarely affected, though secondary stimulation is exceptionally absent (*Oligapta* and *Indocotyle*), and the two co-linear rows consist of only the 4 pairs of primary clamps. This absolute inhibition of the median axis affects to some extent the lateral growth of one side of the body at the hind end: the result is that the body is obliquely truncated at a sharp angle and the morphological posterior end faces to one side, edged with a straight row of clamps; near the middle, dorsally, is the intact protohaptor with the persistent larval anchors, and ventrally to it is the combined right and left formative zone for replication of clamps, from which new clamps move slightly distally to take their place in the co-linear rows, their older fellows being pushed laterally so that the oldest clamps are at the outer ends of the rows. The rows are seldom precisely equal, replication being faster on one side than on the other. In Axininae the distal part of the ovary is ascending; the vagina is always single, and in a separate pocket near the 'vulva' there is always a peg-like structure (penis dilator?) with its own muscles. The eggs have filaments at both poles except in *Oligapta*, which has no filaments. The protohaptor with typically two pairs of larval anchors is invariably retained by the adults. Type genus: *Axine* Abildgaard.

Axininae is a remarkably homogeneous group: all of the 17 valid species, except one, occur on Belonidae or Exocoetidae. The well developed vaginal apparatus is unique, and correlated with the lack of strong musculature subservient to protrusion of the male terminalia, and though the latter are often elaborately armoured, there is a truly muscular penis only in *Axinoides*, and doubtfully in *Indocotyle* but in the closely related genus *Oligapta*, and also in *Axine*, the genital atrium has a very characteristic structure: there is a pair of lateral comb-like crescents, a single or double circle of prong-like spines on a muscular ring round the aperture, and the end of the vas deferens carries another crown of spines. When in repose the latter is simply far behind the atrium near the base of a thin roomy sac which is surrounded by masses of prostatic cells, some of which are large with chromophobic cytoplasm and a central nucleus, like the loosely scattered cells round the 'vulva', others are in bunches and more typically "prostatic" (chromophile) the former I would call "hydraulic" cells.

Hydraulic cells are present in all genera I have examined, and particularly well developed in *Loxura* and *Loxuroides*. The atrium is normally much wider than the diameter of the resting penis, and the diameter of the vulval region of the vagina is correspondingly very large, suggesting that the hydraulic turgor of the male duct is explosively destroyed by the ram-like action of the vaginal peg. At the

side of the peg-sac in several forms there is a blind pocket leading distally from the vaginal canal proper (both Yamaguti and Hargis have remarked on this problematic duct or sac), and I think that it is obviously to take the pressure-jet at the time of copulation. A similar device is found in the spermathaecae in *Argulus*, and even in other monogeneans; it is an internal safety-valve. Numerous similar "hydraulic-cells" surround the vaginal region in all the Axininae. Another parallel hydraulic or "water-vascular-system" is also developed in this family, (and in others with relatively weak clamp musculature, and also correlated with rapidly swimming hosts, e.g. Opisthogyninae on *Sphyræna* spp.) but this haptoral system has already been referred to in appropriate place by Unnithan (1957). To increase the very necessary firm hold on the gills of these leaping and flying fishes, the delicate clamps are permitted to get a more extensive grip on the filaments by the ventral jaw-rami being hinged near their outer angles: in *Axinoides* both jaws may be hinged in this way, and sometimes two hinges are formed in one ramus.

Axine Abildgaard — Axininae with a marginal vagina and a 3-partite armature of the atrium masculinum and single penis-crown; the vulva often contains a cuticularized plaque against which the peg can operate when the male organ is in place. The long co-linear rows of clamps act as a rule as a single row.

Except perhaps in *A. inada*, where the arrangement is like that in *Heteraxine*, but it is retained in this genus on account of the highly typical genital terminalia, and the ascending ovary, a decision neither supported by its Carangid host nor by the single-filamented egg. In Axininae where the clamps are co-linear and are similarly orientated throughout, it was unfortunate that Llewellyn (1956 a: 125) made an ambiguous statement which might imply that Sproston (1946: 452) found them right and left mirror-images in the two rows: there is no need to expect this as a corollary of shortened median haptor axis (shortened to extinction), the two halves of the row are morphologically right and left of course, but the colinear posture being imposed at an early age would affect the shape of even the primary clamps, or at least the later formed pairs on the larval haptor: the early influence on all four pairs of primary clamps is striking in *Oligapta* and *Indocotyle* (Text-fig. 1A). The 7 species of *Axine* considered valid are:—

A. belones Abildgaard, 1794 (Genotype) on *Belone belone* (L.); and from *B. belone euxini* (Günther). Strelkov (1953) obtained his material for ontogenetic studies (see also in Bychowsky, 1957: 214, figs. 257-260, who also reports that according to Palombi there are other hosts belonging to related genera, but I have not examined the evidence).

A. cypseluri (Meserve, 1938) Price, 1945, on *Cypselurus callopterus* from Galapagos, and on *C. agoo* from Japan (Syn. *A. japonicum* Price, 1945).

A. yamagutii (Meserve, 1938) Price, 1945, on a flying fish off Pacific coast of Mexico.

A. parawa Unnithan, 1957, on *Cypselurus bahiensis* (Ranz.) from Trivandrum, S. India.

A. hemirhamphae Unnithan, 1957, *orthog. emend.* (Syn. *A. hemiramphae* Unn., 1957: non *Axine hemirhamphae* Tripathi, 1959 on *Hemirhamphus xanthopterus* Val., from Trivandrum: distinguished by the haptor being tilted only at about 45° to the body-axis, and only slightly wider than the rather evenly wide body, in contrast to the fore-going spp. in which the haptor besides being about twice the width of the body, is tilted nearly parallel.

A. tripathii (Tripathi, 1959) Yamaguti 1963 pro *A. hemirhamphae* Tripathi, 1959 (homonym but not synonym of *A. hemirhamphae* Unnithan, 1957, on *Hemirhamphus georgii* Val. from the Hooghly River, W. Bengal, and Puri, Orissa, Bay of Bengal: distinguished, *inter alia*, by the haptor being at right angles to the body-axis but stretching away to one side, causing the whole animal to be 'L'-shaped, and its length $4\frac{1}{2}$ times the body-width—the latter is the more important since the former may be a transient posture; an unusual character is the single row of relatively very large testes.

A. inada, Ishii & Sawarda, 1938, on the Caraangid *Seriola quinquiradiata* from Japan: exceptional in the asymmetrical clamp-rows, the shorter being only 6% of the longer, and the egg having a single polar filament (characteristic of *Heteraxine* spp., but the vagina and atrium are like those of *A. belones*: a transitional species of special interest).

Axinoides Yamaguti, 1938 emend.—Axininae in which the clamps do not have an appendix on the dorsal end of the median spring, but in which the ventral, at least, of the jaw-rami are jointed near their mid-length; vaginal apparatus as in *Axine*, but never marginal (dorsal, median or laterally placed); atrium masculinum never armed. Genotype: *Axinoides tylosuri* Yamaguti, 1938, on *Tylosurus schismatorhynchus* from Japan. 4 other species considered valid:—

Axinoides gracilis (Linton, 1940) Sproston, 1946 on *Tylosurus marinus* (Walb.) from W. Atlantic at Woods Hole and Florida: recently rediscovered by Hargis (1956:xi: 155), he confirms the protohaptor and on the basis of the very variable position of the vagina from mid-dorsal to nearly supramarginal, he emends the generic diagnosis.

A. raphidoma Hargis, 1956 on *Tylosurus raphidoma* (Ranz.) from Florida: Hargis (xi: fig. 1) shows the anchors (protohaptor) as we find them in other species, on the dorsal side, the clamps are fewer than usual: 5+12 on the left (posterior lobe) and right respectively; the crown of a muscular penis is shown reduced to cuticularized papillae; vagina obliquely median-dorsal; crura not confluent.

A. kola Unnithan, 1957 on *Athlennes hians* (Val.), from Trivandrum, S. W. India: vagina median with cuticularized papillae in funnel much longer than in the genotype; muscular penis with ejaculatory bulb also similar, but clamps (25-27+37-41) are enclosed in hardened fibrous capsules which are jointed laterally and posteriorly,

like the ventral jaw-rami but not opposite to these hinges, and the anteriormost clamps are longer with long reflected ventral jaw-rami; the intestinal crura are confluent.

A. sebastisci Yamaguti, 1958, from *Sebastiscus marmoratus* from Japan: there is a constriction at the base of the very narrow neck opposite to the mid-dorsal vagina; the 38-42 clamps are described but not figured in detail, nor are anchors mentioned.

Species incertae sedis: *Axine resplendens* Caballero, Bravo & Grocott, 1954, on *Tylosurus fodiator* from Eastern Pacific: according to the remarks of Hargis it may belong here, but I have not yet seen this paper.

Chlamydaxine Unnithan, 1957 emend.—*Axininae* unique in having a metahaptor, developed on one side only, growing laterally then anteriorly on the ventral side; body flattened to a broad triangle and cuticle with transverse rows of delicate papillae; vaginal apparatus with a well developed peg and caecum, vaginal duct thick walled and with cuticularized lining, all marginal at level of atrium: penis not strongly muscular with a minute head of papillae; intestinal crura confluent, a few branches entering the metahaptor. Monotypic with *C. truncata* (Hargis, 1956) Unnithan, 1957, *orthogr. emend.*

Hargis placed this species in *Axinoides* but it is excluded by the thickened papillose cuticle, the marginal vagina, and the clamp jaw-rami being unjointed laterally, but predominantly by the unique unilateral metahaptor. On the gills of *Tylosurus raphidoma* (Ranz.) from Florida, S.E. USA. (Text-fig. 2A).

Loxura Unnithan, 1957, *s. str. emend.* Monotypic with *L. ananaphallus* Unnithan, 1957, on *Tylosurus leiurus* (Blkr.) from Mandapam, S. India: Generic characters related to *Axinoides*: dorsal vagina in the lateral field but not marginal, numerous hydraulic cells surround the vulva, peg slender, no receptaculum seminis, but wide canal apparently distensible; unique pine-apple like penis beset with close-packed pointed spines with notched bases, musculature weak for this huge organ (occupying a larger field than the ovary) but surrounded by a sheath of prostatic cells extending from the atrium to mid-body (thought to be hydraulic in function); atrium unarmed but apparently extensive surrounding the penis and opening in a muscular ring with a dentate soft internal rim; testicular zone remarkably short, only about half the body-width in length, testes in double row; crura end bluntly well above haptor, which has a clear "water-vascular canal" in two arms from a median stem. Haptor margin in two wide curves projecting beyond the body at each side, numbers of clamps practically equal; clamps increase in size medially; very slender sclerites, only ventral jaw-rami jointed, no spring-appendix, about twice as wide as long, capsule not thickened, but finely fibrous. Only one pair of rather large anchors found; egg with two short thick filaments.

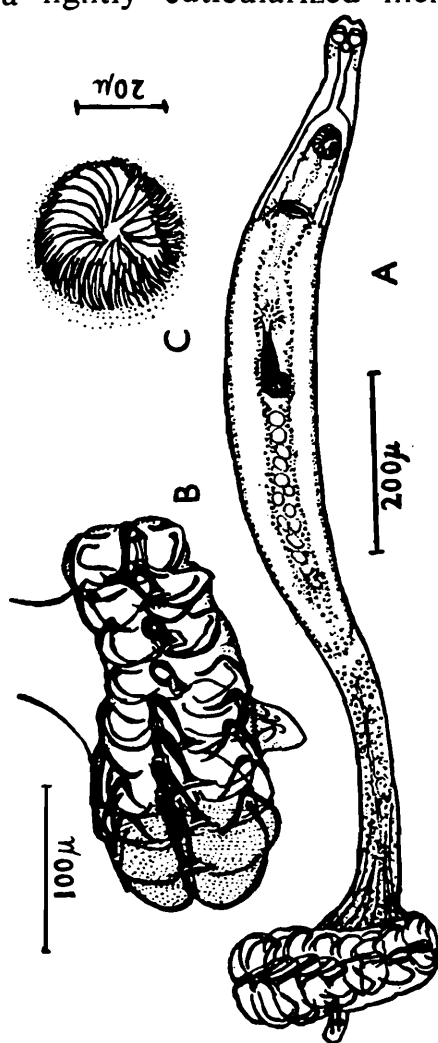
Loxuroides Price, 1962, *emend.*, for *Loxura sasikala* Unnithan (1957 p. 105, figs. 11 a-m) on *Cypselurus oligolepis* (Blkr.), from Mandapam, S. India. Generic criteria now seen to be quite distinct from *Loxura*: unlike the last 3 genera, the genital atrium has a characteristic armature, not in 3 parts as in *Axine*, but a single diadem-like

open circlet of highly muscular or other radial fibres as a thick rim holding a double row of peculiar broad spines with curved tips : radial extrinsic muscles could apparently pull open the ring to admit the emergence of a swollen penis head, which in repose lies at the base of this roomy atrium, its head of spines, like a sun-flower bud when not erected, are dagger-shaped on broad imbedded bases set on the intrinsic muscles of the head : extrinsic muscles absent and correlated with the hydraulic cells surrounding the atrium ; vesicula seminalis large proximal ; vaginal apparatus in the same relative lateral position as in *Loxura*, well behind the atrium ; the peg is a broad cone with notched tip, there is a large cuticular pad, the vaginal field is very wide and surrounded by hydraulic cells—a field of comparable size to that of the atrium masculinum ; a large receptaculum seminis is developed half way down the vaginal canal which opens independently into the ootype. In contrast to *Loxura*, the testicular field in *Loxuroides sasikala* occupies at least half the body-length, the more numerous follicles being in about 4 rows. The haptor-margin is nearly parallel with the body-axis, it is not in two curves, but it has a similar “water-vascular system” Right and left clamp rows are nearly equal, but only the “posterior” row projects beyond the body-edge and the crus of this side is much longer. The clamps are longer than wide, both jaw-rami are hinged and the ventral is the shorter jaw, there may be an appendix on the end of the spring. Both pairs of larval anchors slender with long roots.

Oligapta Unnithan, 1957 — Monotypic with *O. oligapta* Unnithan, 1957 on *Hemirhamphus georgii* (Val.) from Mandapam, S. India. This curious species was the first of its kind to be described : at first sight not Microcotyloidea, because there are only 4 pairs of clamps, but they are co-linear and are orientated in the same direction, and separated by two pairs of anchors, and there is a marginal vaginal apparatus as well as a tri-partite hook-bearing apparatus in the genital atrium — all characters of *Axine* Abildgaard. The second of this kind of Microcotyloid was in fact discovered over two years previously but not published till later, by Tripathi (1959), curiously on the same host-species, but from the opposite corner of India. Being unaware of *Oligapta* when going to Press, he created a new subfamily for it in Discocotylidae, a pardonable error since the typical axinid vaginal peg was not found. The numerous differences are instructive and will be noted below. In *Oligapta oligapta* the whole internal organization is precisely that of *Axine* : there is one unique feature of the genital system : the median vitelline canal gives off an accessory branch to the intestine of the right side (the normal vitello-intestinal canal passes into the same crus straight from the ootype-oviduct junction as usual) and also, the eggs are without polar filaments. The clamp-spring lacks an appendix but the ventral jaw-rami are jointed the proximal anterior shoulder-wings of the latter have a wide flange of muscle fibres and the whole of these large clamps is enclosed in a thick fibrous capsule. The absence of any secondary replication of the clamps is an interesting exception in Microcotyloidea and alone is sufficient to separate the genus from *Axine*.

Indocotyle Tripathi, 1959, Monotypic with *I. hemirhamphae* Tripathi, 1959, on *Hemirhamphus georgii* (Val.), from the Bay of

Bengal at Puri, Orissa, and from the River Hooghly, Calcutta region, India. The lack of detail in the description and figures have been remedied by the kind loan of original material (Text-fig. 1A-C). The fili-form body is more than one-third haptoral peduncle, and one-quarter is "neck" (in extended specimens). Clamps are in a graded row, obliquely to nearly perpendicular to the body/stem axis, the more posterior clamps are the larger in the living attitude, but the morphologically posterior clamps are of course, in the middle of the co-linear row; a small protohaptor projects from the dorsal posterior margin between the middle pair, bearing two pairs of anchors with sharply recurved points at least half as long as their shafts (the roots are partly hidden by the clamps in the present material). The clamps are extremely delicate, though the haptor is stout, and they appear sessile; the ventral end of the spring-loop has a narrow horizontal accessory piece suspended by a lightly cuticularized membrane which extends



TEXT-FIG. 1. *Indocotyle hemirhamphi* Tripathi, 1959. A. Whole animal, ventral view; B. Haptor with 8 clamps and posterior-dorsal proto-haptor with anchors, ventral view; C. Genital corona, ventral view (Original, from specimen on loan from Dr. Y. R. Tripathi).

laterally to connect with the distal tips of the ventral jaw-rami — these are articulated at about half their length; the dorsal arm of the median spring is short but connected with a double rib-like cuticularized support to the distal edge of the dorsal capsule wall making a tenuous

connection with the dorsal jaw-rami, which are in a single piece. The haptoral peduncle is packed with small gland-cells draining into a median duct, but distally it becomes confused by a dense granular mass of different glandular tissue. The ends of the intestinal crura were hidden in the vitelline mass. The lips of the vagina are broad and cuticularized, but just within, the vulva is finely corrugated, apparently hardened but stains differently: there are two lateral ducts which become obscured in the lateral vitellaria. There is a double circle of genital hooks: the outer, probably belong to the atrium and are extremely fine (about 48 of them) projecting ventrally, the inner (about 14) are much wider, and in repose point inwards and dorsally, probably attached to the tip of the penis. No eggs were observed in any specimen. (Text-figs. 1A-C).

HETERAXININAE Unnithan (1957), *emend.*—Axinidae in which the differential inhibition on secondary haptoral growth is most strongly imposed on the lateral clamp rows, though there is always some inhibitory influence on the growth of the body/haptor axis, so that the clamp-rows are more or less adherent to the sides of the body, and their unequal length results in a lateral torque (in the habitual posture of the worm along a gill-filament, *vis-a-vis* the more or less oblique posterior-anterior streaming of the cibo-respiratory current of the fish) so that the body-axis is inclined towards the shorter line of fixation.

As the short row approaches extinction (in *H. karavoli* and *Axinoa*) the body appears to "stand on" the long row (tilted over to nearly 90°), but the lateral nature of this now posterior haptor is seen in the intestinal crus following it to its morphological posterior end at the origin of the short side: the anchored protohaptor is always lost in the adults of Heteraxininae. As a result of this torque imposed from very early life, the whole of the gonad field tends to be curved with the convex side towards the long row (as in *H. heterocerca*). This is in marked contrast to Axininae where the gonad-field and body are straight: because from early life the clamp rows have been added practically two by two on either side of the median axis of the body, albeit in a straight line, and the torque has been applied very gradually as the body-axis bends nearly parallel to its straight haptor. In Axininae the level of tilting is *behind* the gonad-zone, so the alignment and symmetry is not affected at all, whereas in Heteraxininae where the clamp-rows are free to grow up the sides of the body, the longer row holds the hinder half of the gonad-zone and crural branches of that side, while the rest is tilted away with the bending body: the level of tilting being *within* the testicular zone. The degree of asymmetry, as in Gastrocotylinae, depending on the length of gonad-zone embraced by the clamp-row(s), and on their *inequality*. In *Zeuxapta* and *Dictydenteron* the right and left clamp-rows are not very different in length (in spite of the differences in numbers of clamp-units in the latter), and what is more important, they have been built up on wide flanges which allow of some independent movement of the body, though the latter is restricted by the nearly equal "pull" from each side of its hind end: in fact as published figures show, the level of flexing is even higher up the gonad-zone—at its *anterior* limit in these genera and in *H. oligoplitis*, but behind the gonad-zone in *Kannaphallus* and *Axinoa*, which

accounts for the lack of somatic involvement in their postural tilting, except for the intestinal branches which always point to the origin of the clamp-rows : more or less medially in direct extension of the body-axis in Axininae and also in Heteraxininae, where the rows are sub-equal ("V" — Shaped), and laterally in Heteraxininae in which there is a marked differential inhibition in the clamp-rows. No metahaptor is ever developed.

In Heteraxininae the distal end of the ovary is descending as in Microcotylidae, to which they are in many respects related: transitional genera being *Gonoplasius* and *Zeuxapta*. The eggs usually have a fine filament at the anopercular pole only. The vaginal apparatus is various but never with a peg, and the male terminalia muscular, but never an eversible cirrus; the spination of the atrium is various but never axinid, and may be absent. The clamps are sometimes in graded sizes in the longer row, or in uniformly different sizes in the two rows, but they are not adaptively remodelled from the microcotylid pattern, nor are the jaw-rami broken by hinges, but an appendix often occurs on the end of the spring (Text-fig. 3A). The 5 genera are distinguished by internal characters, and *Heteraxine* Yamaguti, the type genus, may be composite; *Axinoa* is perhaps transitory from Axininae, and of uncertain position, its hosts being beloniform fishes whereas the others are from Carangidae, Serranidae, and Sciaenidae.

HETERAXINE Yamaguti, 1938, *emend.*—Heteraxininae in which the number of clamps in the inhibited row are usually less than 40% (exceptionally about 62%) of the longer row and the length of the shorter less than 20% (exceptionally about 60%). The vagina is unarmed mid-dorsal. Genotype: *H. heterocerca* (Goto, 1894) on *Seriola quinqueradiata* (= *S. aureovittata* T. & S.) from Japan.

Other species are: *H. seriolae* (Ishii, 1936) Yamaguti, 1938 on *Seriola aureovittata* T. & S., from Japan: (Text-figs. 2C, 3A) clamp-rows length of the shorter (also with about 9-10 clamps) 17%, numerically 36-39%; testes over 50?; vaginal structure identical with last; eggs 149-166 μ long, one filament.

H. carangis (MacCallum, 1918) Yamaguti, 1938 on *Caranx hippos* (L.), from U.S.A., E. Coast: clamps in short row 19 (28% of longer); atrium with two lateral spine-rows and penis spiny; mid-dorsal vagina encircled by spines; testes 40-50; egg with 2 filaments.

H. scomberomori Koratha, 1955 is known to have a spiny vagina, but otherwise this species is insufficiently documented.

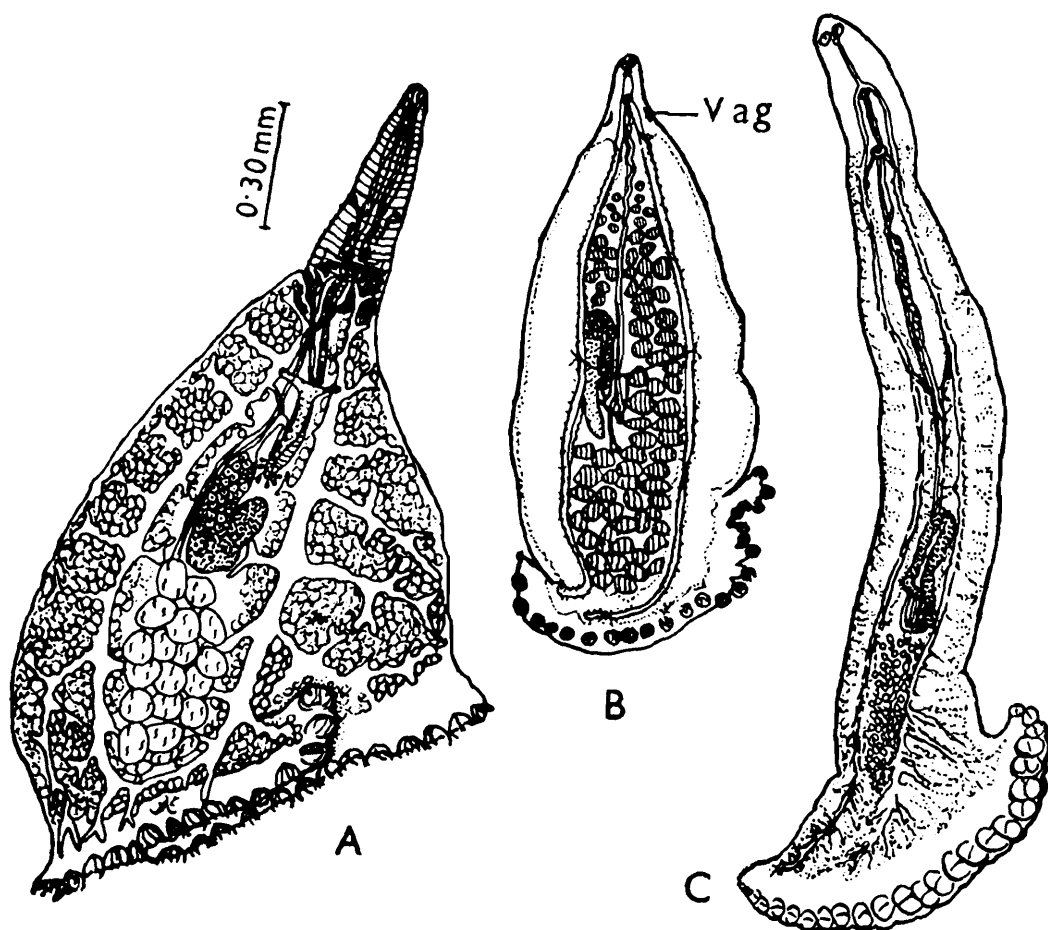
H. karavoli Unnithan, 1957 on *Formio niger* (Bloch) from Trivandrum, S. W. India: again only 6 small clamps in short row; but widely spaced, so that both by length and number the short row is ca 12% of longer; atrium and penis highly muscular with small comb-like spines and 3 large imbedded, rhabdite-like, spicules; unarmed vagina a single duct, leading direct to ootype.

H. mcintoshi (Price, 1962) Yamaguti, 1963 syn. *Allencotyla mcintoshi* Price, 1962 on *Seriola lalandii* from Florida, U.S.A.; vagina median dorsal.

Heteraxinoides Yamaguti, 1963, *emend.* — *Heteraxininae* resembling *Heteraxine* except that the vagina is absent or unknown (?). Genotype: *H. triangularis* (Goto, 1894) Yamaguti, 1963 syn. *Axine triangularis*, *Heteraxine triangularis* Yamaguti, 1938 on the serranid *Anthias schlegelli* Günther, from Japan: only 6 clamps on short side (both by numbers and length about 17%); cup-like atrium lined with conical spines; vagina?; testes about 12; egg?

Other species are:

H. chinensis (Yamaguti, 1937) Yamaguti 1938 on the pomadasyd *Haplogenyx nitens* Rich. from Japan: also 6 similar clamps on short side (ca 17%); atrium with large spines laterally and 2 arcs of smaller spines; vagina absent; eggs?; testes 12.



TEXT-FIG. 2. A. *Chlamydaxine truncata* (Hargis, 1956) Unnithan, 1957—whole animal, ventral view (from Hargis, 1956); B. *Allo pseudaxine katsuworis* (Ishii, 1936) Yamaguti, 1943—whole animal, dorsal view (from Ishii, 1936); C. *Heteraxine seriolae* (Ishii, 1936) Yamaguti, 1938—whole animal, ventral view (from Ishii, 1936).

H. oligoplitis (Meserve, 1938) Hargis, 1956 (Syn. *Axinoides oligoplitis* of Sproston, 1946; *H. oligoplitis* of Hargis (1956, xi: 160), and *H. oligoplites* of Bychowsky (1957: 253), on *Oligoplites saurus* (Bl. & Sch.) from Ecuador; clamp-rows 52% in length ratio and numerically 40-43% (16-18 in short row); atrium with double lateral rows of spines; vagina?; testes 28-39; eggs?

H. xanthophilus Hargis, 1956, (*incertae sedis*?), on the sciaenid *Leiostomus xanthurus* Lacep. (Syn. *H. xanthophilis* Hargis (1956, xi,

160, in description but the former spelling on p. 157): clamps in short row 18-21 (62%), and the relative length of row 63.5%; atrium with two lateral spine-bearing pads and 2 kinds of spines; egg with a single filament; vagina unknown.

H. xanthophiloides Price, 1962, on *Leiostomus xanthurus* from U.S.A. (Massachusetts). 4.4×9.55 mm; 36 clamps on longer row, 20 on shorter row.

Kannaphallus Unnithan, 1957. Genotype: *K. virilis* Unnithan, 1957, on *Caranx atropus* (Günth.) from Trivandrum, S. W. India: haptor similar to *Heteraxine* spp., with 12-15 clamps in short row of similar size and about 30% of long row, which embraces only about the last fifth of the testicular field and is tilted only about 45° ; the clamps are nearly square, and there is an appendix on the spring; numerous scattered head-organs, but the intestinal lateral branches are unique: very regularly increasing in length, without tertiary branches, and the long posterior branches are nearly parallel pointing towards the long clamp-row, the crus of the long side extending as far as the 4th primary clamp where the vitelline fields are confluent (as in *Axinoa* and *Heteraxine* spp.). In other *Discocotylinea* the crural branches are not flexed backwards regularly but are given off more or less perpendicularly and then ramify irregularly. Testes more than 100, and there is a unique *penis-gun* consisting of a long cuticularized tube, a basal ejaculatory bulb, and a large muscular compressor distally derived from the atrium. There are two *dorsal vaginal pores* with muscular bulbs the two ducts eventually opening into the vitelline ducts. The ovary is double-arched as in *Heteraxine*, but the eggs have a filament at each pole.

Zeuxapta Unnithan, 1957: created for two potential homonym spp. of *Heteraxine seriola* Ishii, having a unique vaginal apparatus: two dorsal vaginae at opposite ends of a transverse vulva which opens in a median unarmed pore; the gonads are crowded into the posterior quarter of the body proper and are embraced on one margin by an extensive clamp-frill, on the other side of the only slightly tilted hind end is a clamp row of only half the length, barely reaching the gonad-zone, the nearly equal sized clamps are *twice as crowded* in the latter row. Genotype: *Z. zyxivaginata* Unnithan, (1957:43) Syn. *Microcotyle seriola* Yamaguti, 1940, nec. *Axine seriola* Ishii, 1936 (= *Heteraxine* s.), nec *Axine seriola* Meserve, 1938 (= *Heteraxine meservei* Sproston, 1946 — renaming of homonym), on *Seriola aureovittata* from Japan: clamps of short crowded row 87-90% of longer but only half as long, clamps of *graded* sizes, the largest being thrice the smallest; genital atrium wide, with extrinsic muscle-fibres, but unarmed; eggs 105-132 μ long with a single very fine, long, filament.

Z. meservei (Sproston, 1946) comb. n., (Syn. *Axine seriola* Meserve, 1938, non *Axine seriola* Ishii, 1936; *Heteraxine meservei* Sproston, 1946, a renaming of the homonym) — the wording of the re-assignment of genus for these species in Unnithan (1957, p. 43), is ambiguous, so that greater clarity has been attempted in this place. I do not consider that Meserve's species is certainly identical with Yamaguti's, which is selected as the genotype because there is a clearer figure of it. In

both, the transverse vaginal commissure, or 'vulva', with its median pore is between the upper end of the vitelline fields and a marked bilateral constriction in the fore-body, and is as far behind the genital atrium as the latter is behind the intestinal bifurcation. The atrium is unarmed but in *Z. meservei* the whole of the intercrural field from the brain to the ovary, on the ventral side, is covered with minute spines ("sharply recurved hooks", "several hundreds closely set")—a feature scarcely likely to have been overlooked by Yamaguti. The length of the clamp-rows is again in the ratio of 50%, but there is no graduation in size, according to Meserve they have a size-range of not more than 10%, but on one side they are more crowded, as before, the numerical ratio being 71-72.5% ; similar eggs, 96-136 μ long, with a fine filament one and a half times as long, at one pole. Host : *Seriola dorsalis* (Gill) from the Galapagos Islands.

Gonoplasius Sandars, 1944 — removed from Microcotylidae owing to its markedly asymmetrical haptor which, however is sharply demarcated from the body (one-sixth its length): like *Zeuxapta*, this is a transitory genus of doubtful affinity, but the double (paired) 'vulvae' suggest possible affinity with the latter ; the spine complex of the genital atrium and spined penis bear some resemblance to the condition in some *Heteraxine* spp. rather than to microcotylids (other than the *M. heteracantha*—group which have a far more highly differentiated complex of muscular loculi and 3 or 4 kinds of spines). *G. carangis* Sandars, 1944, the type species, from *Caranx georgianus* from W. Australia : a slender worm, less than one-tenth as wide as long, with only 17 clamps on one side and 34 on the other, the anterior being smaller than the middle clamps ; which taken with the relative secondary inhibition of the one row, provides its link with *Heteraxine*. The original diagnostic character is the conspicuous head-glands: paired semi-lunar groups and a median preoral group, but such occur frequently in *Microcotyle*, *sensu lato*, and are of generic importance only in combination with other criteria. The genital atrium has lateral muscle-pads bearing 5 small and 5 much longer spines, and the penis has 5 small spines on its muscular tip. Two spiny suckers, probably associated with dorsal 'vulvae' and a voluminous median vaginal duct appear to be characteristic.

Other species: *G. longirostri* (Robinson, 1961) Price, 1962, syn. *Microcotyle longirostri* Robinson, on *Longirostrum platessa* ; from New Zealand.

Axinoa gen. n. : erected for *Axine aberrans* Goto, 1894 (Genotype) apparently representing all-but-complete inhibition of one of the clamp-rows ; the single clamp interpreted as the remnant of the inhibited row ; analogous to the two derelict clamps in the gastrocotylid *Engrauliscobina thrissocles* (Tripathi, 1959) gen. n. (The Greek suffix 'oa', the fringe of a garment, added to the stem of 'Axine' forms the name of this transitional genus): the main clamp-row has become posterior and in front of it are the intestinal branches of the uninhibited side and the vitellaria corresponding are confluent with the opposite side as in *Heteraxine* ; vagina single mid-dorsal, spiny within ; genital atrium armed with conical spines, and penis with a corona of spines. The

spiny atrium excludes *Axinoa* spp. from *Axinoides* as emended by Hargis, and Unnithan.

Axinoa aberrans (Goto, 1894) comb. n. (Syn. *Axine a.*, Goto; *Axinoides a.* of Price, 1945, and others), on *Tylosurus schismatorhynchus* (Blkr.) from Japan 25-40+one clamps; 16-25 testes; eggs unknown.

Axinoa meservei (Price, 1945) comb. n. — (Syn. *Axine aberrans* of Meserve, 1938: renamed by Price without publication of reasons due to insufficient information) on *Tylosurus fodiator* Jord. & Gilb., from American Pacific off Columbia. In Meserve's fig. 59, there are 1+41 clamps, and about 96 testes; a single duct leads from the ampoule-like vagina to meet the transverse vitelline duct of the left side: no other details shown for the contracted specimen drawn. The validity of the species must remain *sub judice*, though the testes are 4 times more numerous than in the genotype.

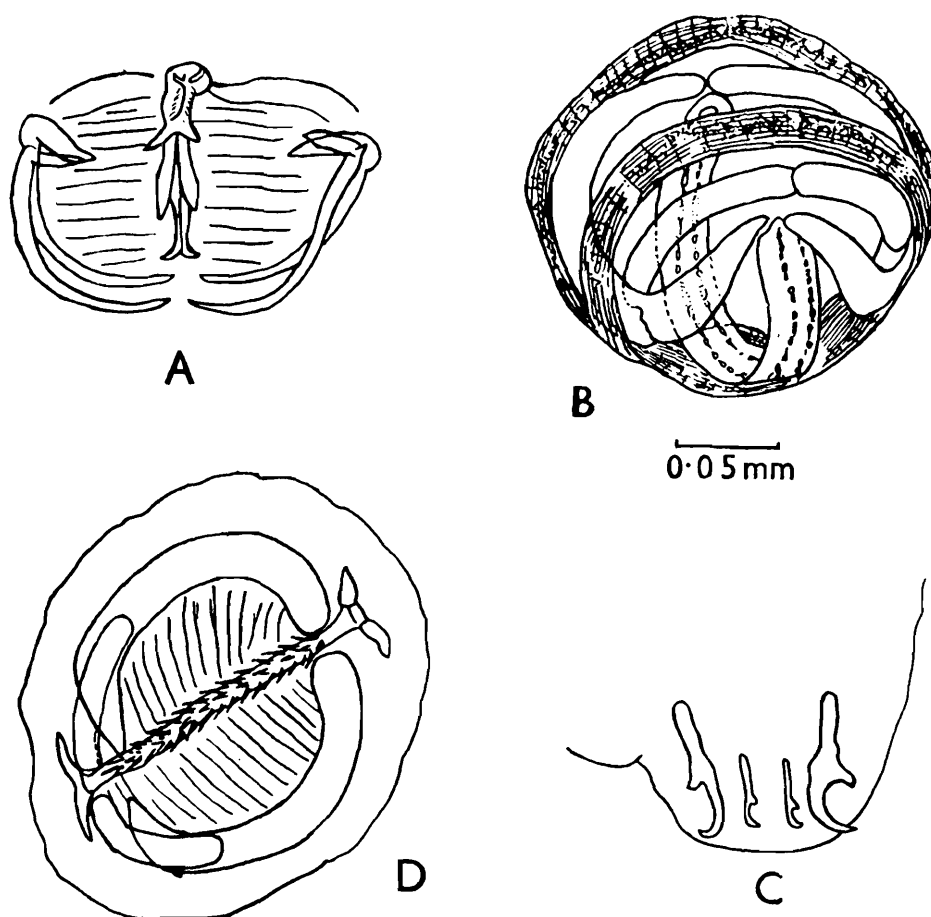
MONAXININAE Unnithan, 1957 *emend*—Axinidae in which there is complete inhibition of one side of the haptor (but not of the haptor/body axis of that side in all genera), the clamps when less than 50 in the single row show a graded diminution in size proximally, and in the genera on Thunnidae they have greatly thickened and simplified sclerites acting as supports for a cupuliform sucker of a characteristic type (Text-fig. 3B). The distal part of the ovary descends in all genera, but the vagina is mid-dorsal in those parasitic on Belonidae and *Formio*, and paired lateral in those on Thunnidae; male terminalia armed or not; eggs with two polar filaments. Protophaptor retained in adults by those on Thunnidae. Hydraulic system in haptor of all.

MONAXINE Unnithan 1957, *emend*. Genotype: *Monaxine formionis* Unnithan, 1957, on *Formio niger* (Bloch), from Trivandrum, S. W. India. The complete inhibition of the one side of the haptor has included inhibition of growth of the body/haptor axis, so that unlike *Heteraxine* spp., there is no "toe-of-boot" — like projection of the haptor on that side, but on the other side the body/haptor axis has a correspondingly greater development than in *Heteraxine*; a triangular wing of the body carrying additional branches of the intestinal crus of that side supports the proximally projecting clamp-row of more than 70 similar simple clamps. Median dorsal vagina is unarmed, has a sphincter and a wide surround of chromophilic secretory cells. Muscular rim of atrium masculinum with 2 kinds of spines, coarse papilla-like spines on penis-head. Eggs unknown.

Monaxine bivaginalis Ramalingam, 1961 on *Formio niger* (Bloch). from Mandapam, S. E. India.

NEOAXINE Price, 1945, *emend*. Monotypic with *Neoaxine constricta* (Yamaguti, 1938) Price, 1945 (Syn. *Axine constricta* Yamaguti, 1938; *Amonaxine constricta* Unnithan, 1957 — genus created in ignorance of Price (1945). Recorded only once, on *Tylosurus schismatorhynchus* from Japan. The single clamp-row has 55-58 similar clamps, and its organization appears similar to *Monaxine*, but its main character is a marginal funnel with an incomplete circlet of "pedicellaria-like" spines, but no peg: another character excluding it from Axininae (apart from

the inhibition of half the haptor and loss of anchors) is the unarmed atrium containing a penis armed with a well developed head of 50-80 spines. There is a strong constriction at the level of the vagina ; one polar filament of the egg is much shorter than the other.



TEXT-FIG. 3. A. *Heteraxine seriolae*, clamp (from Ishii 1936); B. *Uraxine macrova* Unnithan, 1957—clamp modified as sucker, showing lips of fibrous capsule with gland-cells (from Unnithan, 1957); C. *Allopseudaxine katsuwonis*, protohaptor with two pairs of anchors and D. Clamp modified as sucker in thick capsule (both from Ishii 1936).

CROTALAXINE Unnithan, 1957, *emend.* Monotypic with *Crotalaxine serpentina* Unnithan, 1957, on *Athlennes hians* (Val.), from Mandapam, South India. Haptor a unilateral frill of rather large clamps in fibrous capsules, but not modified other than the dorsal jaw-rami being longer than the ventral, and having a joint just proximally to their curvature, clamp-muscles and hydraulic ducts both conspicuous. The body/haptor axis does not share the inhibition of the clamp-row on that side, but is extended for more than half the length of the clamp-row posteriorly, forming a mobile wing which brings the tilting level of the body obliquely, behind the testicular zone. The 36 clamps in *C. serpentina* show the persistence of slight inhibitory influence in their gradual diminution to half-size proximally. The extreme narrowness of the body permits only a single row of elongated testes. The muscular penis within a fibrous sheath, but no pars prostatica or hydraulic gland-cells developed, and the muscular rim of the atrium is also unarmed. The vagina resembles that in *Axinoides* in being median dorsal and in having a peg,

and a radial muscular vulva surrounded by what may be hydraulic cells over a wide area ; the vaginal duct as in *Monaxine* runs directly back to the ootype ; eggs unknown.

URAXINE Unnithan, 1957 *emend.*—Monaxininae, the unilateral haptor held tilted posteriorly between 45° and 90° to the body-axis, the level of tilting behind the testicular zone ; relatively few large clamps tending to become smaller proximally ; distally there is no extension of the body/haptor axis, the crura extending to the base of the laterally projecting protohaptoral lobe bearing its two pairs of larval anchors. Cupuliform sucker-clamps with thick muscular capsules have sticky-glands within their rims (Text-fig. 3B) ; sclerites grossly thickened and simplified, but both rami of both jaws articulated and participating in the sucker framework, moreover the sucker is not of the "open" type (as in Heteromicrocotylinae, Mazocraeidae, Thoracocotylinae, and Choricotylinae) the jaws being still opposable by the action of the wide 3-ribbed spring, decorated by two lines of muscle-emplacements — a "C"-shaped meridian of the cup, but without appendages on its ends. Paired head-organs and the round oral suckers are scarcely half as big as the pharynx : paired vaginal pores as unarmed slits in the dorsal lateral fields in the zone of the crural bifurcation, the vaginal canals form a "Y"-shaped system opening directly into the ootype ; genital atrium with a wide muscular rim set with 17-19 elongated lozenge-shaped spines admitting an unarmed bifid penis ; testes less than 25, mostly par-ovarial and post-ovarial, a few may be pre-ovarial. Large operculate eggs with 2 polar filaments. Parasitic on Thunnidae. Genotype : *Uraxine chura* Unnithan, 1957. Though the shape of these worms is very like that of *Pseudaxine*, the clamps and vaginae are entirely different.

Uraxine chura Unnithan, 1957, on *Euthynnus alleteratus affinis* (Cantor), from Trivandrum, S. W. India. Specific characters include a double row of par-ovarial testes and only 3 or 4 post-and pre-ovarial ; atrial corona of 19 spines ; largest of the 15 clamp-suckers $180 \times 100 \mu$ eggs $168 \times 62 \mu$

Uraxine macrova Unnithan, 1957 (Syn. *U. chura macrova* Unnithan, 1957—sub-species now given full species rank), on the same host fish with genotype. Distinguished by most of the testes being post-ovarial and a single par-ovarial row ; atrial corona of 17 spines ; largest of the 15 clamps $210 \times 168 \mu$; eggs $260 \times 92 \mu$. Both clamp muscles and hydraulic vessels are more strongly developed in the haptor of this species.

ALLOPSEUDAXINE Yamaguti, 1943. Monotypic *A. katsuwonis* Ishii, 1936 (Syn. *Pseudaxine katsuwonis* Ishii, 1936), on *Katsuwonus vagens* (Lesson) from Japan. Genus very close to *Uraxine*, but a much larger type (8.0 mm. compared with about 6 mm.), and over 80 testes which are nearly as numerous pre-ovarially as post and par-ovarially packing the inter-crural field ; genital corona of 12 spines ; the clamp has become an open sucker framed by the opened ventral jaw-rami but supported at one end by the short thick dorsal jaw-rami. The meridional spring is shown straight (optical effect ?), and at each end it carries a bifid appendix. There are indications of transverse muscle-fibres from the spring across the walls of the cup-like capsule, which has an

exceedingly thick rim. 24 clamps are shown, the proximal on short stalks ; eggs $216 \times 66 \mu$; the anchors are 48 and 28μ long respectively, with relatively longer roots than in *Uraxine* spp., though their total length is similar. There appears to be only the original record for *Allopseudaxine katsuwonis* (Ishii, 1936 : 786-7, figs. 7, 8) Text-figs. 2B, 3C & 4D herein.

HETEROMICROCOTYLIDAE* (Yamaguti, 1963) *S. Str. emend.*

Microcotyloidea *s. str.* in which asymmetry within the haptor suggests a differential stimulation of secondary growth, rather than the differential inhabitation, which is characteristics of the family *AXINIDAE*. The growth differences along the axes of the haptor in Heteromicrocotylidae are not only quantitative but, uniquely, qualitative also. Hence, a usually asymmetrical haptor bears clamps of mixed types, but these are mere remodellings on the simple microcotylid pattern, and no additional sclerites appear in the essential structure. The protohaptor (anchor-bearing lobe of the larval haptor) may be lost in the adults, or retained as a distal vestige on the end of the euhaptor (definitive haptor of the adult) incorporating the larval clamps distally. A *meta-haptor* may be developed proximally on one or both sides as a continuation of the clamp-rows of the euhaptor, but showing a discontinuity by its own structure (it may be wing or shelf-like, and may be wholly or partially free of the body as a morphologically anterior lobe in relation to the euhaptor), the discontinuity may appear in the form and in the size of its clamps. A similar discontinuity often marks the passage from the primary (larval) clamps to the secondary clamps in the euhaptor, particularly when the latter are atypical. The distal part of the ovary descends ; the vagina opens dorsally in an unarmed pore, but the nature and armature of the male terminalia is highly variable. Parasitic on Carangidae, Stromateidae and Chirocentrus.

The three subfamilies are characterized by the level of incidence of the secondary differential growth stimuli along the haptoral axis :—

HETEROMICROCOTYLINAE subfam. nov.—5 genera : *Heteromicrocotyla* Yamaguti, 1953 ; *Heterapta* Unnithan, 1961 (incl. "*Diplasiocotyle*" *chorinemi* Tripathi) ; *Dicotyle* Tripathi, 1959 ; *Dictydenteron* gen. nov. ; and *Carangiamata* gen. nov.

CEMOCOTYLINAE subfam. nov.—4 genera : *Cemocotyle* Sproston, 1946 ; *Xureliphilus* gen. n. ; *Tripathiana* gen. n. ; and *Megamicrocotyle* Tripathi, 1956.

PYRAGRAPHORINAE subfam. nov.—2 genera : *Pyragraphorus* Sproston, 1946 ; and *Hargisiella* gen. n.

HETEROMICROCOTYLINAE subfam. nov.—Heteromicrocotylidae, with atypical clamps on one or both of the usually unequal sides of the haptor: these are usually on a euhaptor more or less adherent to the body, or on an adherent bilateral metahaptor (in *Heterapta* only).

* This family now preoccupied by Yamaguti, 1963 was originally erected in the first draft of this paper and reference to this was made in Unnithan, 1961. Yamaguti, 1963 however, limits the family assemblage with the type genus and the definition also is different from those used in the present rationale.

Protohaptor retained by adults only in *Carangiamata*. The microcotylid clamps are modified in at least three different ways, but the sucker-types are on the "opened box" plan, in which the rami of both jaws contribute to the frame. The secondary growth stimuli are expressed in the increasing modification of the clamps proximally, accompanied by an increase in their size, but these stimuli are imposed differentially on the two clamp-rows; the body/haptor axial tissue is not involved in the secondary growth, even when there is a metahaptor (the clamp-frills being usually adherent to the body proper, in contrast to Pyragraphorinae). Type genus *Heteromicrocotyla* Yamaguti, 1953.

Heteromicrocotyla Yamaguti, 1953 — Microcotylid clamps on unequal body-frills of entirely different units: the shorter row has the pyragraphorus-type of modification with 12-25 pedunculated clamps, and the longer sessile row 19-35 open suckerclamps which, though the rami of both jaws contribute to the frame, have opened more like a fan than a box, the ventral jaws (forming the 'lid' of the box) are more laterally spread and their shoulder pieces form two articulating arches anteriorly, while posteriorly their tips overlap the much smaller dorsal jaw-rami; the ventral arm of the median spring is greatly expanded distally forming two arched anterior supports for the sucker, the dorsal, now posterior end of the spring is more narrowly bifurcated, but the form of the spring varies in different species and may appear 'X'-shaped, rather than almost 'T'-shaped in the genotype (see Text-fig. 6D). There is a spiny eversible cirrus in a muscular sac and the atrium is armed with up to 3 groups of more slender spines. A large pre-ovarial vesicula seminalis is characteristic and is sub-lateral, probably always on the side of the long (sessile-) clamp-row, both of which may occur on right or left of the worm (Unnithan, 1961). The testes are numerous, usually more than 20 and up to 155. The single dorsal vagina may have an armed vulva, or gland-cells and radial muscles alone: the duct leads to the vitelline reservoir or to one of its lateral ducts. Genotype: *H. carangis* Yamaguti, 1953 from *Caranx* sp. from Macassar, Celebes. Two new spp. *H. vaginispina* and *H. polyorchis* on *Caranx malabaricus* (Bl. & Schn.) are described by Unnithan (1961) from Kerala, India.

Heterapta Unnithan, 1961 — Described fully elsewhere, is erected for what are probably two distinct species of Heteromicrocotylinae from Indian *Chorinemus* spp. The second species is "*Diplasiocotyle*" *chorinemi* Tripathi, 1956, which is certainly not congeneric with *D. johnstoni* Sandars, 1944 — an atypical microcotylid from an Australian mugilid fish. *Heterapta chorinemi* (Tripathi 1956) comb. nov. on *Chorinemus tala*, Cuv., from the Mahanadi Estuary, NW. Bay of Bengal (Tripathi '56: 235, fig. 2 a-c) and the genotype, both show a unique development of a metahaptor: a secondary growth stimulus has affected both clamp-replication axes equally, but has not involved the haptor/body axis: while the body itself is extremely elongated, the secondarily modified sucker-clamps of the metahaptor are in almost sessile rows along its ventro-lateral fields for half to nearly two-thirds its length. Doubtless the adhesion to the gill-surface of this long haptoral region, and the resulting traction, has been responsible for the shifting of the gonads into the relatively short field immediately in front of the proximal sucker-clamps. The euhaptor on the tapered tip of the body has not

retained the protohaptor, and has its clamp-rows closely crowded together: 5 to 7 pairs of only slightly modified 'closed' microcotylid clamps, rather more stout and square than the typical. Clearly there has been some secondary replication here from the primary 4 pairs, but this has been interrupted and the formative zone has shifted forwards leaving (in the genotype) an isthmus devoid of traces of clamps. The meta-haptoral stimuli have resulted in producing an entirely different, open-sucker type of clamp, which has "opened like a box" with sub-equal quadrants bordered by the jaw-rami and supported along the hinge-line by the shoulder-pieces of the ventral jaw and the thickened anterior edge of the microcotylid clamp: the spring has become articulated and thickened as the meridional support for the sucker (see Text-fig. 6C). The most distal of these clamps may show a transitional form from the closed to the open type. The metahaptoral sucker-clamps increase in size gradually to the proximal third of their rows, then show a slight diminution, sub-equal in number 37-41 on either side, they may retain some power of reclosing their jaws, since they are well supplied with muscles (Tripathi, fig. 2c). There is an eversible cirrus, when retracted its graded curved spines lie in 2 lateral ranks decreasing in size anteriorly, and deep in the sides of the cirrus-pouch are two very long rod-like spines (doubtless protrusible through the otherwise unarmed atrium as vaginal dilators). The vagina opens in a median dorsal pore, unarmed, about 5 times the length of the cirrus-pouch behind the bifurcation of the gut: at this level, the crural branches and vitellaria begin, and continue posteriorly to the last quarter of the metahaptoral region, whence the crura continue unbranched to their confluence at the end of this region (see Unnithan (1961) for genotype *Heterapta heterapta*, since Tripathi's figure lacks these details).

Dicotyle Tripathi, 1959 (Syn. *Bicotyle* Tripathi 1956—orthography emend 1959: 128) — Genotype *D. stromatea* (Tripathi, 1956) comb. nov. (Syn. *Bicotyle stromatea* Tripathi, also as *B. stromatei* Tripathi, 1956: 238) on *Stromates cinereus* of Day (= *Pampus argenteus* (Euphr.)) from Puri, Orissa, Bay of Bengal: a second species (*D. vellavoli*) is described from another Stromateidae *Chondroplites (stromateus) chinensis* (Euphr.), from Kerala, by Unnithan, 1961. The ovoid flattened body may have an elongated neck, constricted at the vaginal zone below the genital atrium, at the end of the oesophagus, which may be diverticulate. The asymmetrical clamp-rows are unequal body-frills in the posterior third: along the markedly convex side, the longer row of stout squarish microcotylid 'closed' clamps have cuticular ridges across their ventral walls (34-40, usually on the right side); the slightly shorter row- on the less convex side, consist of 10-17 larger and partly opened sucker-clamps: opening 'like a box', but not completely, the rami are thickened and simplified into 'C'-shaped arcs, and the spring is expanded at the ends and has perforations for the muscles. These clamps increase in size proximally, the first-formed (distal) clamp is very small and may be less than the microcotylid clamp opposite to it, the tip of the body is quite bare, the protohaptor, at least, being shed in earlier life. The outstanding feature of *Dicotyle* spp. is the reticulate intestine (though not mentioned for the genotype, its occurrence is inferred by Tripathi making *Microcotyle reticulata* Goto, a congener). The testicular field

is partly embraced by the haptoral frills, causing a slight somatic asymmetry, due to torques set up by the pivoting in the feeding postures ; testicular follicles in several rows, so that they have some freedom of relative movement during body-twisting—a distinct advantage of numerous small follicles over a few large follicles. There is a genital corona of strong spines (certainly not a cirrus) which may or may not be part of protrusible penis. The vagina is at the constriction of the fore-body, dorsal and cuticularized distally, either in irregular fimbriae and folds or with a circlet of teeth: it is single throughout and passes direct to the ootype.

Dictydenteron reticulatum (Goto 1894) comb. nov. (Syn. *Microcotyle reticulata* Goto, 1894 ; *Bicotyle reticulata* (Goto) Tripathi 1956), is the genotype of this newly erected genus. Its systematic position is problematic, since no difference was mentioned by Goto between the clamps of the unequal rows, other than those of the shorter row being about three times the size of the doubly numerous clamps in the longer row: on this evidence alone, it might be placed in Heteraxininae, on analogy with *Zeuxapta* and *Gonoplasius* ; but in *Dictydenteron* the shorter side cannot be regarded as inhibited, since its clamps are larger. In view of its close similarity to *Dicotyle* particularly in the otherwise unique reticulate intestine, it must represent a transitional genus in Heteromicrocotylinae. An additional circumstantial reason is that it occurs on *Stromateus argenteus* Euphr. in Japanese seas. Apart from the clamp-type difference from *Dicotyle*, *Dictydenteron* has a cup-like genital atrium with a double corona of spines, probably the inner belonging to the penis ; there is an unarmed vaginal pore leading to two ducts which enter the vitelline ducts rather than a single vaginal duct passing direct to the ootype: differences which are probably of more than specific rank.

Carangiamata gen. n.—erected for *Cemocotyle sagae* Manter & Prince, 1953 from *Caranx* sp. from Suva, Fiji: because both the structure of the clamps and the lack of a metahaptor exclude it from Cemocotylinae. It does, however, retain its protohaptor, with the usual 3 dissimilar pairs of larval hooks: but the euhaptor shows immediate differential growth-stimulation, both in intensity and in kind on each side: the haptor is an asymmetrical extension of the body-axis, but there is no lateral growth on one side comparable to the wing on the other which forms the postero-lateral end of the body, fringed with grapnel-like clamps (appearing like glochidia in profile view). On the straight side is a shorter row of 6 similar clamps of about twice the size of those in the opposite row: slightly different, however, since the ventral jaws are here much longer than the dorsal, and their rami swung apart as grapnel-hooks (M. & P.'s fig. 8), but both jaw-rami, dorsal and ventral are sharply pointed and can act as hooks as well as clamp-jaws. Neither of these clamp-types is quite like those of *Cemocotyle* nor the more asymmetrical clamps of *Xureliphilus elongata*, though the appendix on the dorsal arm of the median spring is a double in-curved filament rather like that in *Megamicrocotyle*, and there are also fine ridges on the capsule walls, at least in the larger clamps. The spherical oral pouches are very wide apart and a similar-sized pharynx is behind them. The penis is unique in being a thickened rigid tube (apparently without muscular bulbs as in *Kannaphallus* Unnithan, 1957) with conical

apex protrusible through a round muscular genital atrium. The vagina was not seen. Monotypic genus with *Carangiamata sagae* (Manter & Prince 1953) comb. nov.

CEMOCOTYLINAE subfam. nov.—Heteromicrocotylidae with atypical microcotylid clamps usually only on the unilateral metahaptor: the larval haptor and euhaptor having apparently nearly normal unmodified microcotylid clamps. Except in *Megamicrocotyle*, the euhaptor is deflected laterally as a postural effect of the development of the more powerful clamps of the unilateral metahaptor. This is a common form of asymmetry in Axinidae also: the tendency of the body to be bent parallel to the longest line of attachment along the gill-lamella—as was so nicely demonstrated for various forms by Llewellyn (1956 *a*, pl. 2). Of the 4 genera, three occur on Carangidae and one on *Chirocentrus dorab* (Clupeiformes).

Cemocotyle Sproston, 1946 — The symmetrical euhaptor is a laterally deflected triangle, with rows of about 11 square microcotylid clamps, practically equal in size, immediately in front of the short protohaptor with 3 typical dissimilar pairs of larval anchors, and succeeded on one side only by the thick flange of the metahaptor. This is a perfectly straight shelf-like projection adherent to the side of the body proper to half way up the testicular zone, bearing in a close row some 26 larger clamps of the “muzzle”, or rather “grapnel”-like, type. These diminish in size proximally: they are all twisted on their short pedicels to the profile view (as also in *Carangiamata* and the next two genera). Both jaws are slender and convex, the one considerably overlapping the other, both with sharply pointed rami acting like slender claws—these are much longer and more prong-like than those of *C. sagae* Manter & Prince. They have reported on their re-examination of the type and paratype of *Cemocotyle carangis* (MacCallum, 1913) Sproston 1946, from *Caranx crysos* (Mitchill) from the American North Atlantic, and largely confirm the original description, but adding a third small pair of protohaptor hooks; they contend that the spiny sucker surrounding the vagina is ventral (?). MacCallum stated that this ring-sucker was ventral, but that the (figured) vagina has a dorsal unarmed pore slightly behind this. The round oral suckers occupy the corners of the wide flat forehead, and there is a triangular cuticularized genital atrium with lateral and median spine-groups, though the penis is unarmed. Hargis (1956 (xi): 154, 159) would include this species in Heteraxininae, but this is inadmissible since the clamps are not uniformly microcotylid, and a metahaptor is never present in Axinidae. He found it on the type host in Alligator Harbour, Florida.

In my opinion, the evidence fully establishes the genus, which remains monotypic with *Cemocotyle carangis* (MacCallum, 1913) Sproston, 1946.

Xureliphilus gen. nov., erected for *Axine elongata* Meserve (1938, 61, figs. 53-58) found off Secas Island, Panama, E. Pacific, on *Xurel melampygus* Cuv. This is removed from Heteraxine for the same reason as is the next species: the possession of a unilateral metahaptoral flange with abruptly modified clamps.

In *Xureliphilus elongatus* (Meserve) comb. nov., though the protohaptor is lost, probably the 3 pairs of small distal microcotylid clamps are the primary clamps of the larval haptor, and the euhaptor is represented by the succeeding 3 pairs of larger microcotylid clamps on either side. Then on one side there is an abruptly projecting wide flange, the metahaptor, adherent to the body except at its extreme anterior end, and bearing a close row of (18) *Cemocotyle*-type clamps, again twisted into profile position in ventral view. These metahaptor clamps have a double internal asymmetry; the ventral jaws are longer than the dorsal, and the rami of both are much longer on one side than on the other (the shorter being more convex, so that their side of the clamp is the wider). In *Cemocotyle* the prong-like ventral jaws are sigmoidally arched and sharply clawed, but in *Xureliphilus* the inwardly bent ends of the ventral jaw are expanded as notched knobs. The vast development of the uterus (at least half of the body-length and width), packed with bi-filamented eggs, perhaps obscured the male terminalia, since only a muscular oval was seen (referred to as the genital atrium, but without mention of its contents), which may have been the uterine pore. A vagina was not seen. The aseptate oral suckers are extremely far apart, and the wide forehead has a median conical papilla.

There is a wide calibre loop internally to the euhaptor, with a branch along the base of the metahaptor (and here a transverse commissure between the two lateral trunks) giving off thinner radial branches to each clamp-base. This is referred to as part of the nervous system, but it is strongly reminiscent of the "semi-circulus haptoris", so conspicuous also in some *Opisthogyninae* (see Unnithan, 1962), and in *Axinidae* Unnithan (1957), which is suspected of being a water-vascular system ancillary to the clamp mechanism (see also remarks under *Pricea* infra).

Tripathiana gen. nov., erected for *Heteraxine minuta* Tripathi, 1959, found on *Megalaspis cordyla*, from Puri and Chilka Lake, Orissa, Bay of Bengal. *Tripathiana minuta* is characterized by the development of a powerful unilateral metahaptor, which is practically all free from the body and bears atypical clamps. The obliquely truncated posterior end lacks the protohaptor, and it is deflected laterally from the body-axis as in *Cemocotyle* and *Xureliphilus*. The euhaptor is asymmetrical though the sides bear a similar number of clamps (10/13), which are squareish, typically microcotylid; but on the shorter side they increase in size slightly, while on the long side the 2nd. to 5th. are larger than the others but smaller than those opposite to them on the short side.

The metahaptor has a wide fleshy margin bearing closely set modified longer clamps at right angles to the others (profile view only, in face-view of haptor). These clamps are twice as long as the euhaptor clamps but only about as wide; and their jaws, though hooked, are sub-equal. Of these eleven clamps, the anterior 4 or 5 are uniformly smaller than the others. The blunt rounded head is about the same width as the rest of the cylindroid body. The unarmed dorsal vagina was obscured by dense vitellaria; the genital atrium is unarmed, but the penis has a corona of 6 hooks with broad tapering handles. It was

found on 3 occasions when an average of nearly 70% of the hosts were infected.

Megamicrocotyle Tripathi, 1956 — Originally monotypic, with *M. chirocentrus* Tripathi (1956, 236, fig. 1 g-k) on *Chirocentrus dorab* (Forsk.), from Puri, Orissa, Bay of Bengal: a closely allied species discovered on the same host in 1955 and described by Unnithan (1961), in Kerala (Arabian Sea), and *Lintaxine microcotyla* Manter & Prince from 'a ribbon-fish' in Fiji, now form a highly compact genus; it is even probable that re-examination of the types may suggest the Indian examples being subspecies. Outstanding is the extreme difference in the clamps in the two rows, both in size and in modification of the microcotylid type; also, there is no difference in the clamp shape as the euhaptoral row passes into the unilateral metahaptoral wing, such as is seen in *Tripathiana*. The haptor is an extension of the body-axis though set off from it by a tapered rather short pedicel which contains no crural branches nor vitellaria, but the unbranched intestinal crura extend for at least two thirds the length of the haptor to slightly different levels. The larger stalked clamps have a unique modification of the ventral jaw-rami: distally each has an ankylosed horizontal bar on its tip, recalling an anther of a flower stamen. I feel that the temptation must be resisted to homologize these bars or reflexed flanges with the braces of the gastrocotylid clamp and for three reasons; (1) they are not connected in any way with the dorsal jaw-rami, nor with the appendages of the median spring — relationships invariably found in the true gastrocotylid structure; (2) they are not represented by any vestige in the sessile clamps; (3) the sessile clamps, while sometimes being completely opened sucker-clamps, are not of the gastrocotylid sucker-type, for example in *Lintaxine*, but are perfectly conformable to the opened-box type found in *Heterapta* (compare Text-figs. 6B & F). In the former the gastrocotylid sucker-clamps are seen to open always like a book, and the dorsal jaw-rami take no part in the sucker-frame. The development of the appendages on the dorsal arm of the spring is microcotyloid rather than gastrocotyloid — there are no dorsal lamellae developed, but only a narrow bifurcation, the arms of which come together in a pointed loop far anterior to the tips of the dorsal jaw-rami, which are long and gaping like grapnel-hooks. The ventral wall of the capsule is finely striated, but there are no true ribs as in gastrocotylids or some Pyrographorinae (cf. Text-figs. 4, 5C & 7F). In Tripathi's figure (1956, *lh*) the bars from the ventral jaw-rami are shown fused together as a single bar, but in the other species they are quite separate and unconnected with the end of the spring — a re-examination of the Bay of Bengal material is indicated. The sessile clamps are usually only 8-9 μ in diameter (Tripathi states 15-19 μ), whereas the larger are 40-60 μ , and in the proximal four-fifths of their row they are placed well within the margin of the ventral side of the euhaptor. Their structure is simplified microcotylid with strong 'C'-shaped jaw-rami, partly opened as in *Dicotyle*, or with the ventral jaw opened back like the lid of a box as in *Heterapta*, the spring having wide-splayed ends and the hinge-line cuticularized which together form the cross-wise supports in the base of the sucker-clamp: they are well supplied with muscles into the body of the haptor, which are seen as ranks of striae in the ventro-lateral field of this nearly straight row. The distal clamps are sub-

sessile on both sides, at the tip there is a minute lobe perhaps representing the vestige of the protohaptor, but the four pairs of primary (larval) clamps are no longer distinguishable from their successors (nor were they in *Heterapta* or *Cemocotyle*) but the distal 10 or 14 small and the distal 5 large clamps are, respectively, slightly larger and smaller than the others, and on short stalks (the smaller being nearly closed). After these distal subsessile small clamps *Megamicrocotyle* Tripathi shows a relatively long bare gap in the row, which continues with the submarginal row: in both the other species, also, there is a change in disposition of the small clamps at this level: the distal dozen or so are strictly marginal like the larger clamps. The latter then have longer stalks, with a marked increase in stalk length and size of clamp when the row departs as the metahaptoral free wing, bearing about 14-18 (or about a third of the total number of) large clamps.

The anterior end is slightly expanded and the oral pouches almost transverse in its angles, the pharynx is about half their size and the mouth appears to be protrusible, much as in *Cemocotyle* and *Xureliphilus*, without very conspicuous gland-organs. The male terminalia are unique: in the Indian species there are two more or less elongated triangular plates on either side of a highly cuticularized flask-shaped penis (the 'hooks' figured by Tripathi appear to be equivalent in position to the thickened walls of the penis seen in profile in the new species); proximally there is a strong muscular bulb thought to act as a compressor in ejaculation. In the Fijian *Megamicrocotyle microcotyla* (Manter & Prince, 1953) comb. n., the male apparatus seems to show clear specific differences: there are the lateral (spinose) plates and a forward-pointing transverse plate bearing a row of small sharp spines (atrial structures), the muscular bulbous penis has laterally graded thorns on its head. The vagina is similar in all, and unusual in being in the ovarian zone and short, leading directly to the receptaculum seminis: the vulva is provided with a hood and cuirass-like transverse plates, their diameter, of course, being the same as the flattened anterior ridge of the atrium masculinum, which would be anchored by the vaginal plates, but the vaginal pore is minute at the posterior end of the 'vulval ovoid' (see Unnithan, 1961); in *M. microcotyla*, the pore is larger and the hood more extensive.

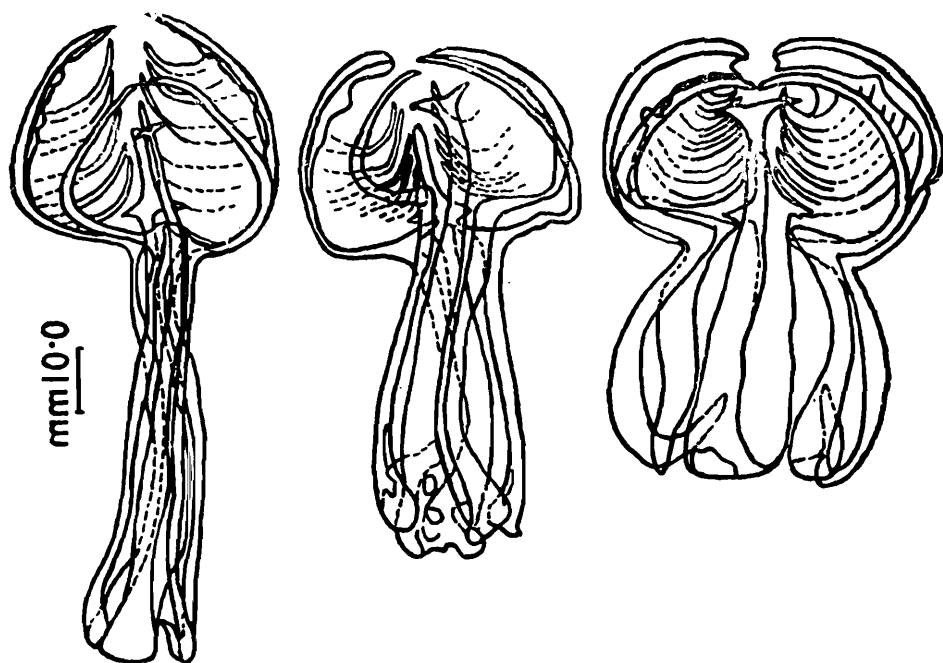
In spite of the extreme smallness of the one row of clamps this cannot be interpreted as due to inhibitory influences, but rather to extreme stimulation in replication (56 to 90 of them), and the stimuli are manifest on the other side by the increase in size, stalk-length and finally the metahaptoral wing. The host of the Fijian material was not named, but it is perhaps unlikely that the Dorab would be described as a 'ribbon-fish' in spite of its elongated body, it is altogether stouter than the Trichiurids, for instance. The original placing in *Lintaxine* is not understandable, particularly on the host basis, since *L. cokeri* is from a freshwater sciaenid, and no sciaenid fishes are known to occur in Fiji Islands.

PYRAGRAPHORINAE subfam. nov. *Heteromicrocotylidae* which have morphologically bilateral symmetry, but the bilateral metahaptor being entirely free from the body proximally (ventrally) is, as a postural effect,

twisted through a right-angle, and still in line with the distal euhaptor, forms a "T"-shaped tail. Such a "fish-tail" effect is also common in several Microcotylidae (other than Microcotylinae) also in *Pricea*, and to some extent in *Thoracocotyle crocea* (Gastrocotylidae). But unlike these genera the clamps of Pyragraphorinae are specially modified, in some ways similar in all three known species. Other characters in common are the biloculate spiny oral suckers (round and simple in the other subfamilies), and the dorsal vagina, which like the penis or cirrus may be cuticularized or not. Parasites of Carangidae.

Hargis (1956 (x): 448-452) reports on a re-examination of the type material of the two older species and describes a new species, all of which he considers congeneric. In view of some differences of generic rank, I prefer to consider *Pyragraphorus* monotypic, and to unite the second and third species in a new genus dedicated to our prolific colleague: *Hargisiella* gen. nov.

Pyragraphorus Sproston, 1946 — Pyragraphorinae in which there is a more or less abrupt change in clamp-type from the euhaptor to the metahaptor: the clamps on the latter are of the pyragraphorus (fire-rongs) type, having the anterior parts of the rami of both jaws drawn out into a handle: this modification *in transit* is clearly figured by Bychowsky & Nagibina (1959 fig. 21) (Text-fig. 4 herein) and they also show for the first time, the development of rib-like thickenings from the capsule wall becoming free medially as inward-pointing curved claws. The clamp figured on the right shows a deep ridge-like lip of the ventral jaw-rami: this is significant, since it helps to explain an anomaly in both 'Macallums and Hargis' figures of the distal (=Euhaptor) clamps. These less modified clamps have the jaw-sclerite lip bent



TEXT-FIG. 4. *Pyragraphorus* sp. progressive modification of clamps (from Bychowsky & Nagibina, 1959).

at a right angle posteriorly, and evidently in optical section it appeared as a double sclerite. At first glance the American figures recall a

gastrocotylid clamp with the two extra posterior sclerites, but whereas the oblique "braces" of the gastrocotylid clamp occur internally and articulating with the dorsal jaws, these figured for *Pyragraphorus* are posterior and external to the rami of both jaws. I conclude, therefore, that the two extra sclerites in the American figures are optical illusions resulting from the deep bent jaw-lip, and the clamps are all essentially microcotylid, albeit highly modified.

Hargis claims that there are two kinds of modified clamp in the euhaptor (his "dorsal lobe" — an inconvenient term since it has only postural and not strictly morphological import): in the more distal clamps (Hargis 1956: fig. 23) there is a strong internal asymmetry, the abaxial jaw-rami are grossly thickened and more convex, and in others in the euhaptor (more proximal clamps?) he claims to have found developments like those in *Hargisiella* spp. particularly in respect of the hole through the elongated dorsal end of the median spring — to admit the tendon of the adductor muscles. This hole has shifted to the middle of the spring in the more proximal of the pyragraphorus clamps as in Bychowsky & Nagibina's figure (Fig. 11): compare Fig. 1 in Sproston (1946) for various types, and Llewellyn (1956 *b*, fig. 1) for *Plectancotyle*.

In *Pyragraphorus*, besides the dissimilarity between the clamps of the euhaptor and metahaptor, there are three generic characters which are absent in *Hargisiella*: lateral diverticula in the oesophagus, and a spiny eversible cirrus in a long muscular sac along with an internal vesicula seminalis (see Hargis 1956, fig. 22); furthermore, the receptaculum seminis immediately behind the cuticularized vagina opens into the right lateral vitelline duct. This genus remains monotypic with *Pyragraphorus pyragraphorus* (MacCallum & MacCallum 1913) Sproston 1946: on *Trachinotus carolinus* (Linn.), probably from the North American Atlantic.

Hargisiella gen. n., erected for *Pyragraphorus hippos* Hargis, 1956 (designated genotype, since it is the better described and figured) Text-fig. 5F, and *Pyragraphorus* (*Microcotyle*) *incomparabilis* (MacCallum 1917) Hargis 1956: the former on *Caranx hippos* (L.) from Florida and Texas, and the latter on *Caranx ruber* (Bloch) from Florida. The symmetrical euhaptor is again the continuation of the body-axis, but growth potentials in the long-axis of the haptor are evidently much higher than in the hind-body, for subsequent growth continues independently, nevertheless receiving branches from the intestinal crura as the new lobe leaves the body. The crural branches join in a median, secondarily branched, crus in the metahaptor (proximal and ventral lobe of the haptor), just as they do in the euhaptor: neither testes nor vitellaria enter either euhaptor or metahaptor. Growth potentials are so strong, at least in the genotype, that the metahaptor can be double the length of the euhaptor — in *Pyragraphorus* the two parts are practically equal. *Hargisiella* however, does not show a change in clamp-type between euhaptor and haptor — the pedunculated elongated clamps are all alike, and they are comparably modified in both species. In *H. hippos* there is a marked internal asymmetry (according to Hargis, 1956, fig. 20) the more elongated dorsal jaw-rami do not meet in the

middle line, one side is more bent and lipped than the other distally but proximally the other side is the more bent before the articulation under the shoulder of the ventral jaw. The dorsal arm of the median spring is elongated to the jaw-lip where it expands and has a transversely oval hole (Text-fig. 5E).

In *H. incomparabilis* the whole clamp is much stouter and longer in proportion to its width (Text-fig. 5D), and the dorsal jaws are a little longer than the ventral again having asymmetrical rami. The outstanding feature of this clamp is the pocket-like expansions of the dorsal arms of the ventral jaw-rami which form the shoulder articulation, and one side is larger than the other here. The dorsal arm of the median spring is elongated and evenly wide, having a round hole at its end.

The abaxial-adaxial asymmetry of the clamps of *Hargisiella*, and to a less extent those of the euhaptor of *Pyragraphorus*, suggest an advanced level of adaptive evolution comparable to that in Opisthogyninae and Gotocotylinae (Gastrocotyloidea), but in the latter internal asymmetry of the clamp has reached its zenith.

In *Hargisiella* there is an eversible cirrus but no internal vesicula seminalis, and there is no armature whatever near the male terminalia. The mid-dorsal vagina has a cuticular folded lining in *H. incomparabilis*, but it is not cuticularized in *H. hippos*, where the short duct leads direct to an anterior bridge between the lateral vitelline ducts at the anterior fourth of the body, and they do not form their short median duct until the mid-ovarian zone at the middle of the body. Some vitellaria enter the euhaptor only in *H. incomparabilis*.

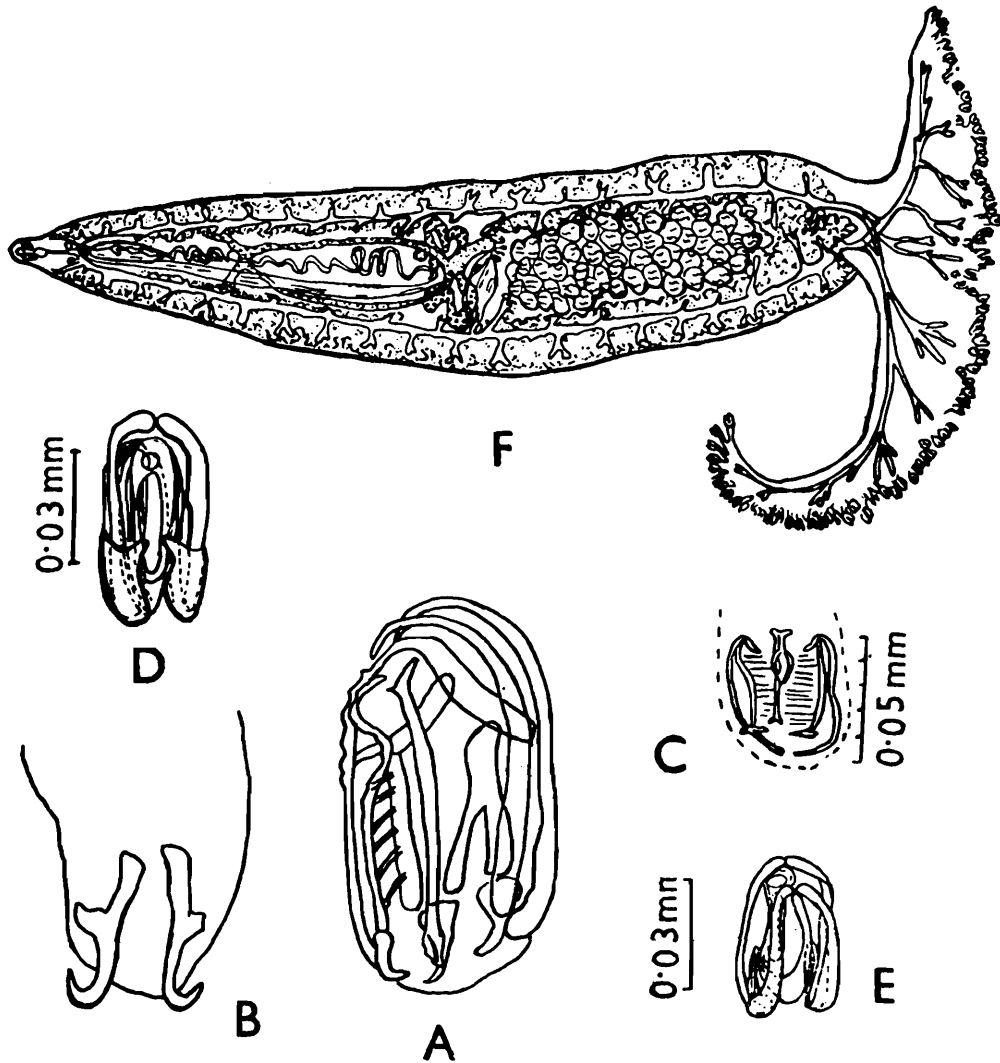
GASTROCOTYLOIDEA Price 1959

(Syn. Gastrocotylidae Price 1943 + Discoctylidae *s. lat. partim*)

This superfamily was originally erected in the first draft of this paper, to consolidate some of the variety of new forms which have been discovered during the past few years. Price (1959) has published this name for a similar assemblage, but which he subdivides more according to the older views than I do. In common, they all have microcotylid (discoctylid) type of clamps with the addition of a pair of oblique frontal braces.

These, seem to have been derived from the appendages on the end of the ventral arm of the median spring, often present as a bifid appendix but of no structural importance in various species of Microcotyloidea (Text-figs. 1B, 3A). In Anthocotylidae Bychowsky, 1957, they are being transitionally incorporated as definitive sclerites in the clamp mechanism. In some subfamilies of Gastrocotyloidea further additional sclerites are incorporated, apparently derived (a) from the anterior end of the dorsal arm of the median spring (in Priceinae and Gotocotylinae *s. str. nov.*), and (b) from the rib-like thickenings in the (mainly ventral) wall of the capsule, which occur rather spasmodically in many species of the Order Mazocraeidea Bychowsky, 1957, but in some subfamilies of Gastrocotyloidea they are more highly developed and contribute in various ways to the essential clamp-mechanism (Thoracocotylinae & Gotocotylinae).

Gastrocotyloidea echo, in several keys, the main evolutionary calls of all the rest of the Suborder Discocotylinea Bychowsky 1957; so that to satisfy logical consistency, a parallel suborder would be necessary for them. I hesitate to take this step, however, until it can be supported by more evidence from ontogenies. Llewellyn (1967 a)



TEXT-FIG. 5. A. *Gotocotyla sawara* Ishii, 1936, a single clamp, and B. protohaptor with one pair of anchors (both from Ishii, 1936); C. *Megamicrocotyle* (Manter & Prince, 1953) 'comb'. nov., ventral view of a large clamp (from Manter & Prince, 1953); D. *Hargisiella incomparabilis* (MacCallum, 1917) gen. nov., dorsal view of clamp; E. *Hargisiella hippos* (Hargis, 1956) gen. n., clamp ventral view, and F. the whole worm, ventral view (figs. B-F from Hargis, 1956).

described briefly the larvae of *Gastrocotyle* and *Pseudaxine*, and found the shape of the terminal anchors to be quite different from other Discocotylinea, including *Microcotyle* spp.; he concluded, with every justification, that Sproston (1946) was in error (*inter alia*!) in uniting Gastrocotylinea with Microcotylinea in Microcotylidae.

In attempting to classify the Gastrocotyloidea group, I have used the same principles as before in this paper, at least in separating the higher taxa: but at present each higher category here is one rank lower than in the rest of Discocotylinea. The family Gastrocotylidae s. str. nov. corresponds to the superfamily Microcotyloidea (Unnithan, 1957) s. str. emend., in that it represents subfamilies in which the

growth of the haptor is potentially unlimited. Among the subfamilies, difficulties arise in the maintenance of a strictly logical parallelism: there are 4 distinct clamp-types within the "gastrocotylid-type" variants, but none of them corresponds with the grossly remodelled clamps in Heteromicrocotylidae. The clamp variants are morphologically more fundamental, but not so striking in appearance. The haptor which bears them shows sometimes inhibitory influences as in Axinidae Unnithan, 1957, (*Gastrocotyle* and *Pseudaxine* are both "Monaxinid" genera), and sometimes secondary growth-stimulation, resulting in a unilateral or bilateral metahaptor, which tends to grow anteriorly (and ventrally if bilaterally symmetrical as in *Pyragraphorus*, *Pricea* and *Thoracocotyle*). Since these growth inhibitions and secondary stimulations occur with 4 different types of clamps, they have been subordinated as taxonomic criteria, to those of clamp-type notwithstanding their striking effects, and probably deep-seated origin (differential inhibitions in growth of haptor are family criteria in Microcotyloidea — Unnithan 1957).

It is interesting to note, without going into a detailed analysis at this stage, that among these more highly evolved Discocotylinae, the Heteromicrocotylidae and Gastrocotylidae, there is a parallelism in their parasitizing the more highly evolved group of fishes: the former predominantly on Carangidae, and the latter on Scomberomoridae (=Cybiidae *auct.*)

GASTROCOTYLIDAE Price 1943 *emend.*

(Syn. *Gastrocotylinae* Sproston, 1946)

Gastrocotylidae shares with other Gastrocotyloidea the character of the extra pair of the sclerites (oblique braces) in the distal (posterior) region of the clamp capsule, and is distinguished by the potentially unlimited growth of the haptor.

The five subfamilies, distinguished by structural modifications and/or the presence of accessory sclerites in the clamp structure are: Gastrocotylinae Sproston (1946), *partim, emend.*; Thoracocotylinae subfam. nov.; Priceinae Chauhan (1953) *partim, emend.*; Gotocotylinae subfam. nov. and Engraulicolinae subfam. nov.

GASTROCOTYLINAE Sproston 1946, *partim, emend.*

Gastrocotylidae in which the basic gastrocotylid clamp structure is unmodified. Other characteristics, except for the ovary with its distal limb descending, are all highly variable. 5 genera:—*Gastrocotyle* v. Ben. & Hesse, 1863; *Chauhanea* Ramalingam, 1953; *Yamaguticotyla* Price, 1959; *Churavera* Unnithan, 1968 and *Eyelavera* Unnithan, 1968.

Gastrocotyle v. Ben. & Hesse 1863: Gastrocotylinae in which the haptor has sustained a complete unilateral inhibition (as in Monaxininae, Axinidae), an inhibition which has affected the haptor-body axis immediately after the protohaptor. The result is a single euhaptoral flange adherent to the body, on one side only: the body axis has not lengthened

infront of the protohaptor, which is retained as a short lappet with, typically, 3 dissimilar pairs of larval anchors (see Llewellyn 1957: figs. 12, 22). The clamps are internally symmetrical, but the ends of the median spring are atypical in *G. trachuri* v. B. & Hesse, the end of the ventral arm may be bifurcate and articulate with the dorsal jaw-rami (*vide* Sproston 1946, fig. 108 *d, e*). In *G. indica* Subhadracharya (1951) however, there is shown what is called an "extra sclerite" on the dorsal end of the spring, like two convergent horns arising from a fine cross-bar: but comparing this with my own observations and those of Yamaguti (1938, fig. 37), both for *G. trachuri*, Subhadracharya's 'horns' would appear to be the slightly thickened edges of the hole in the dorsal wall of the capsule which admits the adductor tendon and lateral muscles on the spring; and the cross-bar, in her fig. 8 *a*, might be a transverse fold in the wall, since it has no counterpart in Priceinae, in which veritable sclerites do arise as paired lamellae on either side of the tendon-hole. Until this question is re-examined in all three species, I tentatively assume that no extra dorsal sclerites are actually formed in the essentially simple clamp of *Gastrocotyle*.

The male terminalia consist of a simple muscular bulb with a crown of erect stout spines abruptly diamond-shaped or bifurcate at their bases, exactly as in *Psuedoxine*; the nearby dorsal vaginal pore is unarmed. Genotype: *G. trachuri* v. Ben. & Hesse 1863, on *Trachurus trachurus* L. from English Channel. North Sea, and from Tarumi and Majsaka in Japan; other spp.:— *G. japonica* Ishii & Sawada, 1938 on *Pneumatophorus (Scomber) japonicus* (Houttuyn), from Japan; *G. indica* Subhadracharya, 1951 on *Caranx kalla* Cuv., from Madras, Bay of Bengal; *G. kalla* Unnithan, 1968, on *Caranx kalla* Cuv., and *G. kurra* Unnithan, 1968 on *Caranx kurra* Cuv. from Trivandrum, Arabian Sea.

Chauhanea Ramalingam 1953: monotypic with *C. madrasensis* Ramalingam, 1953 on *Sphyræna acutipinnis* Day, from Madras (Bay of Bengal), and by Euzet & Razarihelisoa (1959), on *S. commersonii* Cuv. from Madagascar: the symmetrical haptor is an extension of the body-axis, with a few more clamps on one side than the other (30-49/36-55); they are slightly longer than wide but the jaw-rami on one side are slightly thicker and more convex than on the other, an incipient internal asymmetry found also in Opisthogyninae. Growth stimuli in the long-axis of the haptor have been in excess of those of the haptor-hindbody but apparently confined to the clamp frill, and not producing anterior extensions (metahaptor). Here is the first example of a highly localized growth-stimulus: a double row of clamps on either side, beginning soon after the protohaptor—the hooks of which are lost in the adults of *Chauhanea*. Oral suckers aseptate; cirrus unarmed, opening immediately under the median vagina which has a finely dentate pore. *Chauhanea* is exceptional in the entire family in having testes parovarial, and an almost equal number post- and pre-ovarial.

Yamaguticotyla truncata (Goto 1894—as *Microcotyle*) has been considered by Price (1959) to be a gastrocotylid, and type of his new genus. Originally found on *Pristipoma japonicum* and later by Ishii & Sawada (1938) on *Parapristipoma trilineatum* on both occasions

from Japan (hosts considered by some to be identical), has only 10 or 11 clamps on each side of the short frill-like haptor; genital atrium (? penis) said to be armed with 20 or more slender spines of variable length; vagina unarmed, and polar filaments of egg long.

Churavera Unnithan, 1968: monotypic with *C. macrova* Unnithan, 1968, on the gills of *Euthynnus affinis* (Cantor) from Trivandrum (Arabian Sea): the haptor and clamps almost gastrocotylid with only the oblique sclerites and no accessory sclerites nor an appendix for the median spring. Riblike thickenings also absent in the clamp capsule. Haptor includes only the posterior half of the testes zone. Male terminalia is armed with a corona of hooks and a large ejaculatory bulb is present. Ovary is inverted 'U' shaped and testes numerous. Egg is large and vagina is absent. Parasitic on the gills of marine fishes.

Eyelavera Unnithan, 1968: Another monotypic genus recorded by Unnithan (1968) on the gills of the Indian mackerel *Rastrelliger kanagurta* (Cuv.) at Trivandrum (Arabian Sea). The haptor forms a unilateral oblique frill of gastrocotylid clamps at the posterior third of the body, overlapping a part of the testicular zone. Clamps are heavily cuticularised with fleshy lips but no extra sclerites except the short oblique ones; median spring has a broad ventral and vestigial dorsal arm. There are two well defined lateral vaginal pores. Ovary inverted 'U' shaped, testes though mainly postovarian there are few par-ovarian ones also. Male terminalia armed with hooks. The intestinal crura has long ramifying outer branches. Parasitic on the gills of marine fishes. Type species: *Eyelavera typica* Unnithan, 1968.

THORACOCOTYLINAE Sub-fam. nov.

(Syn. Priceinae Chauhan (1953) *partim*). Erected for *Thoracocotyle* MacCallum, 1913 (which was previously grouped with *Pricea* Chauhan and *Lithidiocotyle* Sproston, solely on account of the rib-like thickenings of the capsule-wall—a character common to numerous genera in other subfamilies), and for three newly recruited genera having essentially the same type of "open-sucker" clamp modification: *Dawesia* Unnithan, *Lintaxine* Sproston, and *Amphipolycotyle* Hargis.

The gastrocotylid "open-sucker" clamp is quite differently formed from that in Heteromicrocotylidae (Heteromicrocotylinae), which was a simple posterior-anterior opening, like the hinged lid of a box (discussed under *Megamicrocotyle*), where all four quadrants of the jaw-rami contributed equally to the effective frame of the sucker. In Thoracocotylinae only the rami of the ventral jaws contribute to the effective frame of the sucker. Incidentally, in Diclidophoridae (Choricotylinae it is only the abaxial ramus of the ventral jaw and the ventral arm of the median spring which frame the sucker. This clearly contrasting enlistment of sclerites for the sucker frame may be a highly significant systematic pointer (Text-figs. 6 D-G).

The gastrocotylid "open-sucker" clamp characterizing Thoracocotylinae is like an opened book: a lateral opening-out, in which the right and left moieties have been flung back, more or less flat against

the supporting tissues. In the process, the median spring, freed from the restraint of the jaw-adductors, has opened out nearly straight and slid outwards and dorsally under the now shallow bowl-like clamp capsule, for which it provides the meridional brace. At the same time the pair of oblique braces of the original gastrocotylid clamp have also been thrust outwards and lie near the end of the spring on the posterior rim of the capsule. The dorsal jaws are also jettisoned from the sucker-frame, at first remaining at the sides of the frame (*Lintaxine*), and perhaps in a later phase of evolution, pulled medially to lie parallel with the oblique braces outside the dorsal anterior edge of the frame (*Amphipolycotyle*, *Thoracocotyle*). In the last, there is slight asymmetry and the concavity is strengthened by thickened ribs from the capsule wall. In all of these, the ventral jaw rami have their shoulder-piece bent back and towards the centre of the former hinge so that they form the two "C"-shaped halves of the frame.

Again, in this subfamily, there are very different displays of growth-potentials in the haptor: specialised stimulation in *Amphipolycotyle* (unilateral metahaptor with atypical clamps), unspecialized in *Thoracocotyle* (bilateral metahaptor, all clamps similar, but suppression of haptor-body axis), and a unique suppression of only the lateral axes of the haptor in *Lintaxine* (quantitative differential stimulation in the growth of the longitudinal axes of the haptor — clamp rows). In *T. ovalis* Tripathi, the unusually wide body and posterior shift of the pivoting point combine to produce a somatic asymmetry reminiscent of that in *Vallisiopsis*. The protohaptor is apparently lost in the adults of *Lintaxine*.

Thoracocotyle MacCallum, 1913 is characterized by open ribbed sucker-clamps which usually show an incipient internal asymmetry (see Meserve's fig. 43): the 'C'-shaped rami of the ventral jaws forming the right and left halves of the frame joined by the widely forked ends of the opened median spring, while the vestigial rami of the dorsal jaw, along with the oblique braces have been thrust out of the frame to lie against the anterior rim. The protohaptor is retained on the posterior end of the body: a stout lobe bearing the two posterior pairs of larval anchors, separated from the primary clamps by a short interval.

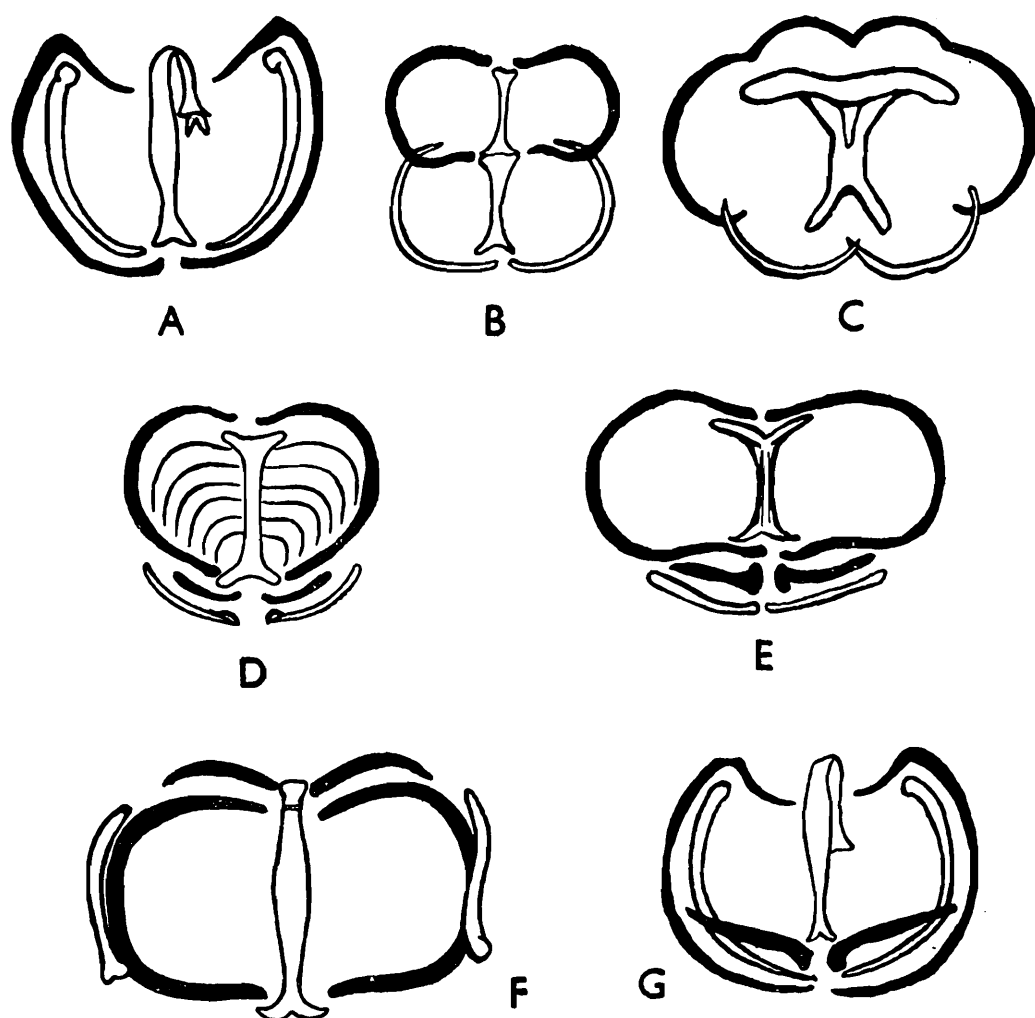
The testes are relatively large, 7-9 in single file in *T. crocea*, but in *T. ovalis*, there are hundreds of small spheroidal follicles packed in the intercrural field in the posterior half of the body proper. The penis and atrium are unarmed, the vaginal pore is just anterior to the ovarian zone, and (at least in MacCallum's material of the genotype, it opens ventrally) surrounded by muscles. It leads to a sac-like receptaculum seminis, which is large, pyriform in *T. ovalis*, and has a reflexed duct from the apex back to the ootype, in both cases apparently independent of the vitelline ducts. Genotype: *Thoracocotyle crocea* MacCallum, 1913 from New York Aquarium on *Scomberomorus maculatus* (Mitchill), and from Florida by Hargis (1956: xii): (Syn. *T. paradoxa* Meserve, 1938 on the same host in Mexican Pacific, at Tangola-Tangola); second species *T. ovalis* Tripathi, 1959 (Syn. *T. ovale* Tripathi, 1956) on *Scomberomorus guttatus* (Bloch & Schneider), from Puri, northern sector of Bay of Bengal, India.

Dawesia Unnithan, 1964: monotypic with *D. indica* Unnithan, 1964 on *Scomberomorus guttatus* (Bl. & Schn.) at Trivandrum, Arabian Sea. The genotype described and discussed in detail elsewhere (cf. Unnithan 1964) resembles *Thoracocotyle crocea* MacCallum, 1913 very closely especially in the nature of the haptor and clamp pattern. *Dawesia* however, has an elaborately developed armed penis, two lateral vaginae and its body organs do not extend into the haptoral zone.

Lintaxine Sproston 1946: monotypic, with *L. cokeri* (Linton, 1940 as *Heteraxine* sensu Linton, non *Heteraxine* Yamaguti, 1938), on the freshwater Sciaenid *Aplodinotus grunniens*, Raf., from Fairport, Iowa, USA. Thanks to the re-examination of the type material by Manter & Prince (1953: 110, 112, figs. 18, 19), doubts about this genus, shared by Tripathi (1959: 129), are now dispelled. The unique feature of *Lintaxine* is the complete inhibition of lateral growth in the haptor (euhaptor), resulting in a morphologically posterior-anterior thick ridge directed obliquely laterally in with respect to the body-axis, or rather *vice versa* in the normal attitude of these Monogenea on the gill-filaments. This tapered fleshy end of the body bears two close sessile rows of "open-sucker" type of clamps. The growth on the right and left sides is controlled by quantitatively different impulses: while the rows are equally long, on the one side large wide sucker-clamps (10 of them, increasing gradually in size anteriorly, and on the other there are three times as many but only one-third the size and sub-equal, yet apparently of the same type.

The lintaxinid clamp-type (Text-fig. 6F) may represent an earlier stage in the evolution of the thoracocotylid clamp-type than even *Amphipolycotyle* (Text-fig. 6E), for though it is a stouter version, the jettisoned dorsal jaw rami remain on the edges of the sides of the frame formed entirely by the ventral jaw rami, while the oblique braces lie outside the frame on the posterior edge, though still attached to the ventral end of the median spring (which, as in related genera, forms the sole meridional support of the sucker). There are no rib-like thickenings bracing the cavity of the sucker in *Lintaxine* or *Amphipolycotyle*, yet these adhesive units are plainly closely related: a strong argument for reducing this character from its erstwhile subfamily rank to generic rank. Manter & Prince (1953: 110) found at the extreme posterior end of the body, a single clamp-sucker, half the size of the large kind and twice the size of the smaller. This may be the first-formed larval clamp, but no remnant of the protohaptor has been seen, yet larval anchors are reported for all other members of the subfamily.

The genital atrium is unarmed, though it is strongly muscular and the penis is protruded through it in an anterior-posterior direction, a very unusual orientation. Manter & Prince correct Linton's interpretation of the spiny penis: they consider it in relation to the laterally thorned penis of *Megamicrocotyle*, but it appears to me only remotely similar. In *Lintaxine cokeri* the ventro-lateral arc of penis-thorns are bent outwards, and dorsally there are graded needle-like knobbed spines, the shorter laterals of this set are provided externally with minute comb-like teeth. The median dorsal vaginal pore is unarmed, and lies mid-way between the atrium and the top of the ovary.



TEXT-FIG. 6. A-G Diagram indicating the different lines of evolution of the "open sucker-clamp" in Microcotyloidea and Gastrocotyloidea :

A. Typical, unmodified microcotylid clamp; B. Clamp-jaws have opened 'like a box', as in *Megamicrocotyle chirocentrus*, Tripathi 1956, smaller clamps, and in the larger clamps of Tripathi's "*Diplasiocotyle*" *chorinemi* and *Dicotyle stromatiei*; C. 'Fan-wise' opening of the clamps of the sessile row from *Heteromicrocotyla carangis*, Yamaguti 1953; D. Clamp-jaws have opened 'like a book', the dorsal jaw-rami and oblique braces having been jettisoned from the sucker-frame, as in *Thoracocotyle* spp. and in which the capsule-wall is strengthened by curved ribs; E. Similar 'book-like' opening of the clamp-jaws, the ventral jaw rami alone forming the sucker-frame, but there is no rib-like thickening of the capsule wall—the larger clamp-type from *Amphipolycotyle chloroscombrus*, Hargis 1957; F. The clamp has 'opened like a book', but the dorsal jaw rami lie laterally while the oblique braces lie distally, neither contributing to the frame of the sucker—from one of the larger clamps of *Lintaxine cokeri* (Linton 1940) Sproston 1946 (from Manter & Prince 1953). In all, the ventral jaws and oblique braces are shaded black; G. Typical, unmodified gastrocotylid clamp.

It is remarkable that so far this is the only Gastrocotyloidea species found on a Sciaenid fish (the euryhaline Sciaenid, *Pama pama*, yielded *Microcotyle pamae* Tripathi, 1956, in the Calcutta river).

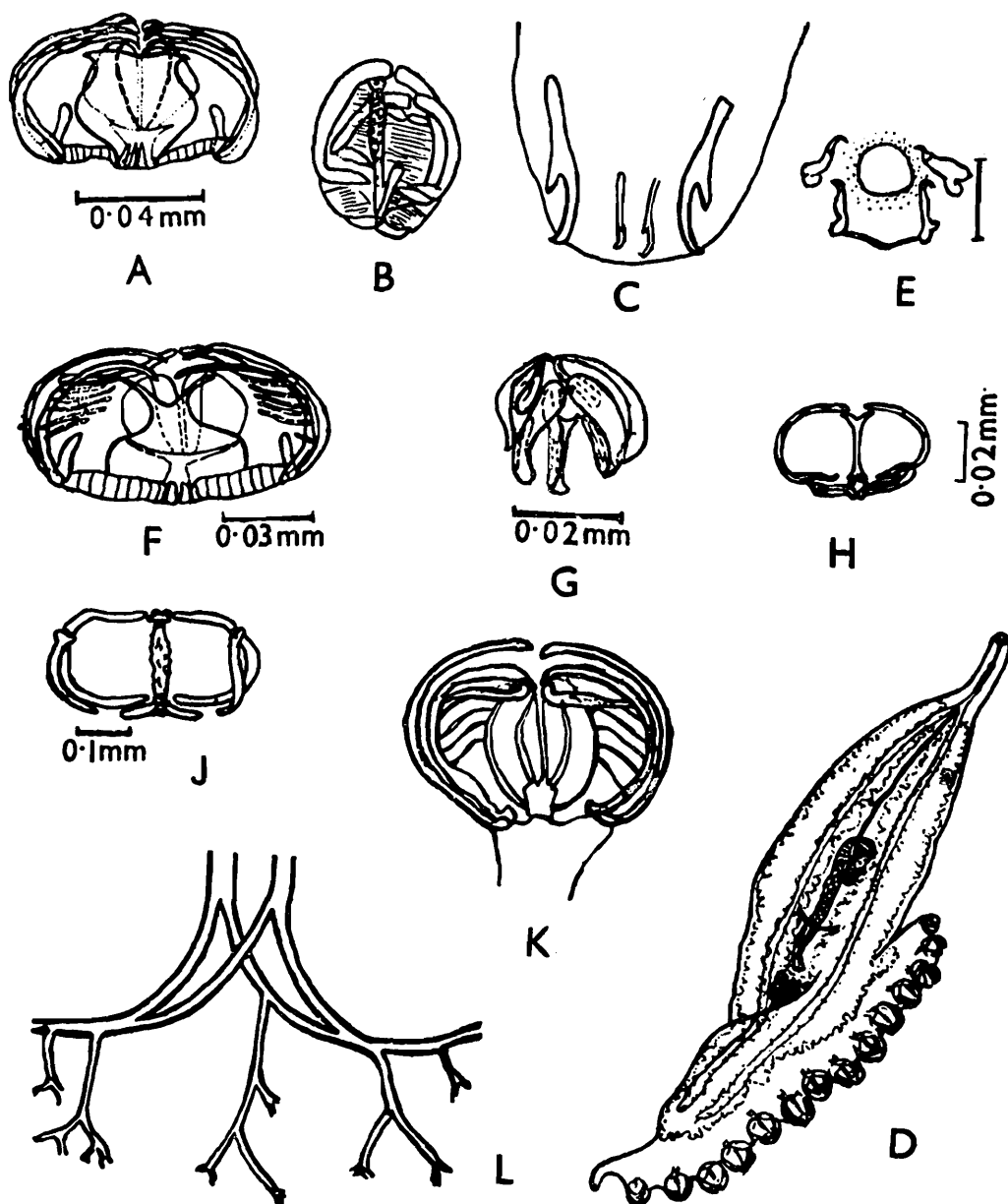
Amphipolycotyle Hargis, 1957) : monotypic, with *A. chloroscombrus* Hargis (1957 : xiii : 2-3, figs. 1-6), on *Chloroscombrus chrysurus* (L.), a carangid from Florida waters.

The haptor is asymmetrical due to both qualitative and highly complex quantitative difference in growth stimuli in the two lateral longitudinal axes. Its resemblance to *Heteraxininae* is at once denied, not only by the unilateral modification of the clamps to the open-sucker type, but by the asymmetry being due to intervention of (unilateral) stimuli, and not the result of inhibitory influences which characterize Axinidae. At this moment it is pertinent to remember that in *Heteraxininae* any proximal diminution in size of the clamps is gradual, as in *Heteraxine heterocerca* (Goto), *H. chinensis* (Yamaguti), *H. karavoli* Unnithan, 1957 and *Crotalaxine serpentina* Unnithan, 1957, the result of a gradually increasing inhibition in the advancing growth-axis. But in *Amphicotyle* and *Tripathiana* (and perhaps in *Cemocotyle*) all forms with a unilateral flange-extension with atypical clamps, and suspected of being a metahaptor, there is an abrupt decrease in size for the 4 equal clamps at the anterior end of the row. In the bilateral metahaptor of *Thoracocotyle* spp. the change in size of clamps is also abrupt. In *Amphipolycotyle* the flange with sucker-clamps, adherent to the body proper up to mid-ovarian zone, may be part euhaptor and part metahaptor, while the short stalked more normal clamps on the other side probably represent only the euhaptor of that side.

The protohaptor is on a stout stalk and bears the 3 dissimilar pairs of larval hooks (the two pairs of anchors and the posterior pair of hooklets — see Llewellyn's generalized diagrams, 1957 a, fig. 5 a, b). The posterior 2 pairs of clamps are small, equal, open-sucker type whence, on the short side, no other sucker-clamps occur. On the long side they are all sucker-type, and the anterior 4 are abruptly smaller than the 8 which follow them. It may be then, that these are the missing 4 (2+2) from the anterior part of the larval haptor, have been pushed forwards to the end of the metahaptor by intercallary growth from a more posterior formative zone (as in *Thoracocotyle*) near the end of the body proper. In *Amphipolycotyle* this dual zone may be near the small clamp-sucker, No. 4 from the posterior end. This would indicate a very high growth-rate for the metahaptor, and a greatly depressed one for the euhaptor of that side. Moreover, the assumption is that the split in the formative zone in the larval haptor took place between the middle clamps, and the torque of the body axis, even in the larva, pulled the 2 anterior pairs of clamps from short side over to the metahaptor side and the 4 were carried forward in the metahaptor.

On the short side the clamps, after the first 2 sucker-type (*vide* Hargis: 1957, fig. 1) are all similar in shape and size, as in a regular euhaptor: it is a simple marginal nearly straight row, but only up to the hind end of the ovarian zone. These only slightly modified gastrocotylid clamps are, however, unique (Text-fig. 7, G): the jaws are markedly unequal, but the shorter ventral jaw rami twice as thick as the dorsal with broadly rounded ends, though their bent shoulder parts are normal. There is no appreciable internal asymmetry. As is so frequently found in gastrocotylid clamps (in contrast to microcotylid) the dorsal arm of the median spring is longer and wider than the ventral arm, and it is deeply cleft at the end, but lacks accessory sclerites in

this or any other region. The open-sucker clamps, at least double the size, are like those in *Lintaxine* in lacking wall-ribs and having a simple oval frame made from the, now "C"-shaped, ventral jaw rami: the jettisoned dorsal jaw rami have slipped round under the posterior rim, just outside the oblique braces, here no longer articulating with the end of the spring (Text-fig. 7, H). The latter sclerites are in the same



TEXT-FIG. 7. A. *Pseudaxine mexicana*, Meserve, clamp ventral view (from Hargis, 1956); 26-28. *Pseudaxine vagans* Ishii. B. Clamp, C. Protohaptor with 2 pairs of anchors; D. Whole worm, dorsal view (all from Ishii, 1936); E. *Scombercotyle scomberomori* (Koratha 1956), dactylogyrid-like hooks round vaginal pore, and F. Ventral view of clamp (both from Hargis, 1956); G. *Amphipolycoryle chloroscombrus*, ventral view of small clamp, and H. Large-type clamp of open sucker row (both from Hargis 1957); J. *Lintaxine cokeri* (Linton), the larger open-sucker type of clamp (from Manter & Prince 1953); K. *Pricea minima*, Chauhan 1945, pedunculated clamp, typical of the genus (from Chauhan); L. *Hargisiella hippos* (Hargis)—diagram to show the diamond-shaped circulus formed by branches of the intestine at the junction of the trunk with the euhaptor (to the left, posteriorly) and the matahaptor (to the right, anteriorly)—adapted from Hargis 1956 (x) fig. 19).

relative positions as they are in *Thoracocotyle*, the *Amphipolycotyle* sucker-clamps forming an evolutionary link with these and *Lintaxine* sucker-clamps.

Amphipolycotyle chloroscombrus is unique in the family in having consolidated testes : in two unequal elongated parts, the anterior (exceptionally) parovarial. This condition of the testes and the unusually posterior position of the ovary could be correlated with the torque towards the stronger sucker-clamp (metahaptor) row from the early life. In *Vallisiopsis*, a similar torque, though more violent but from similar origins, has pulled the ovary and testes far back into the hind body and compressed them into the same zone. This effect is not seen elsewhere, either because the torque occurs in a flexible region (haptor-stem in Pyragraphorinae and *Pricea*, neck-region in *Thoracocotyle crocea*), or when it occurs in the body region, the clamps on either side are not of markedly contrasting power and usually not attached to the body proper as they are here.

There is a muscular penis and the corona of typical erect spines is attached to the walls of the muscular atrium. The base of these hook-like spines is unusual in bearing a few outwardly pointing very short spines. A vagina was not seen.

Though the growth-rhythms are so very different in *Thoracocotyle*, *Dawesia*, *Lintaxine* and *Amphipolycotyle*, they are unquestionably related in respect of their clamp-type (cf. Text-figs. 6D-G).

PRICEINAE Chauhan, 1953, *s. str.*, *emend.*

The subfamily as originally defined, on the basis of rib-like thickenings in the capsule wall, was heterogeneous regarding more fundamental clamp structure, and it embraced both the subfamilies, Thoracocotylinae and Gotocotylinae but the name and type genus may be retained for the new grouping based on different criteria. The clamps are basically gastrocotylid and are mostly symmetrical internally (Text-figs. 7A, B, F & K). Short ribs may be developed in the capsule wall, or not (a species character in *Pseudaxine*); but lamellae arising from the dorsal arm of the median spring, and the sides of the tendon-hole in the dorsal wall of the capsule, are developed as vertiable sclerites. In *Pricea* they support the inner ends of the lateral row of ribs forming the wide arched roof of the capsule, in *Pseudaxine* they do not reach the ribs but are still wide, and in *Neothoracocotyle* they are much narrower or incipient (lightly cuticularized and probably overlooked (?) in *N. coryphaenae* Yamaguti). The bulbous penis is remarkably uniform in all species, with a similar number of spines in the corona. This, however, may well be the muscular wall of the *atrium masculinum*, partly protrusible as a grapple, with an unarmed simple, more or less muscular, penis emergent within it, as shown in *Amphipolycotyle* (Hargis, 1957: xiii, fig. 2). In *Scomberocotyle* the bulbous penis is exceptional in having a crown of long spines like needles emerging through a long-spined atrium. The single dorsal vagina, where known, is unarmed and without accessory suckers or armature, except for the unique dactylogyrid anchor complex round the dorsal vagina of *Scomberocotyle* (Text-fig. 7, E).

The growth-rhythms in the haptor of Priceinae show even more variety than in the last two subfamilies: complete inhibition of growth in the one lateral longitudinal axis (*Pseudaxine*), combined with secondary stimulation on the other, leading to the formation of a unilateral metahaptor in *Pseudaxine*, a simpler unilateral metahaptor in *Scomberocotyle*; and a bilateral metahaptor, of protohaptoral origin, in *Pricea*; while in *Neothoracacotyle*, where the haptor/body-axis has been suppressed (as in *Pseudaxine*), there is a high growth potential in both lateral longitudinal axes of the haptor, resulting in a simple euhaptoral frill on each side of the body for more than half the total length. The four genera included in *Priceinae* emend. nov. are: *Pricea* Chauhan, *Neothoracocotyle* Hargis (2 spp.), *Scomberocotyle* Hargis (1 sp.), and *Pseudaxine* Par. & Per. (4 spp.)

Pricea Chauhan, 1945: has the most highly developed haptor of the sub-family, showing every sign of high growth potentials operating without inhibitory influences, and there is both internal and external symmetry: the body as a whole develops a transient asymmetry due to postural causes. There is a more or less long metahaptor, its pedunculated clamps continuous with those of the lateral rows on the euhaptor. Recognisable primary, larval clamps have not been recorded, but a single pair of unique larval anchors occur on the posterior rather wide lappet: these have split ends producing two subequal points, *analogous* to certain Dactylogyrid anchors (*Falciunguis* Achmerov 1952, shows the beginning of this tendency): Bychowsky (1957 fig. 312), compares the *Pricea* anchors with those of *Dactylogyrus pterocleidus* Gussev, and *Urocleidus acer* Mueller. There is a second pair of larval anchors, termed "body hooks" by Chauhan and Ramalingam who have both contributed species to *Pricea*: these are usually squat stout hooks with short wide bifid roots and a sharply reflexed point, and they are said to be situated in varying positions on the haptor axis, but usually near the origin of the metahaptor; that is, where the clamp frills leave euhaptor-body axis to form an independent (morphologically ventral) lobe growing anteriorly.

This fact is an additional proof of the dichotomy of the haptor axis early in life, but in *Pricea*, the dichotomy evidently took place in the protohaptor, infact between the two principal pairs of hooks (anchors), producing a double formative zone: one replicating clamp on the anterior side and the other on the posterior side. The result would be to force the anchor-pairs increasingly farther apart; but the proximal anchors, being associated with muscles attached to the wall of the body-proper, would be torn away from the anterior tip of the new metahaptor, as it budded off from the body-euhaptor axis to form an independent outgrowth. The metahaptor may then be assumed to retain its formative region immediately anterior to (the morphologically proximal end of) the euhaptor. The anterior side growth is not accelerated to such an extent as the posterior, for the metahaptor is seldom as long as the euhaptor, particularly in the smaller "species" named, though in the largest (*P. multae* Chauhan and *P. robusta* Ramalingam) the metahaptor is nearly as long as the euhaptor.

In its natural position on the gill-filaments, the body is bent, as usual, at rightangles and then obliquely laterally to the haptor axis,

so that in the detached worm the appearance is of an inverted "T". In the instances where the "body-hooks" are depicted some way down the metahaptor they are probably seen through its thickness, and are actually *in situ* on the posterior end of the body proper, as in Chauhan's figures in his first (1945) paper. In view of these considerations it is most probable that Ramalingam's species will prove identical with one or more of Chauhan's. The loss of one or more of the "body-hooks" or their displacement as a result of operative trauma may be expected.

Another manifestation of high growth potentials in the longitudinal axes of both the euhaptor and metahaptor, is the doubling of the marginal rows of clamps figured in most of the "species". This means that in the formative zone, in addition to the primary and persistent dichotomy of the axes (anterior and posterior juxtaposed zones of replication), there is a secondary lateral dichotomy of each of the 4 axes. But this may be spasmodic: sometimes both sides of either euhaptor or metahaptor may have double rows for a short distance, then resume the double row, or one side only may be double for a varied distance. This doubling of the rows of clamps has already been noted for *Chauhanea*. The same lateral replication at the same time as the serial replication of clamps, is known to occur in *Gotocotyla* spp. from *Scomberomorus* spp. in India, and it has been indicated in the proximal region of *Gotocotyla elagatis* Meserve (1938, fig. 37), similarly in *Lithidiocotyle secunda* Tripathi (1956, fig. 2f). It may not be uncommon in *Microcotylinae*, but until recently we have interpreted figures of 'over-crowded clamps' as being due to contraction and mere overlapping: this is certainly not so in the above examples, and *Microcotyle priacanthi* Meserve (1938, fig. 30) with mostly about 7 clamps abreast in the proximal half of the haptor, should be looked upon with a new interest.

The clamps of *Pricea* spp. are remarkably uniform and symmetrical according to the figures (Text-fig. 7K): the ventral jaw rami just fit over the dorsal jaw rami like the lid of an oval box, except anteriorly where the oblique braces are fitted between them when the capsule is closed. The ventral arm of the spring is narrow and not forked at the end, but the dorsal arm, though short, has two broad tapering lamellae supporting the 5-7 ray-like ribs under the roof of the capsule, which appear to articulate laterally with the dorsal jaw rami. The clamp pedicels are highly mobile and contractile: they may owe their varying diameter to turgor provided by a water-vascular system homologous with that referred to in Opisthogyninae, and already described for some Axinidae (Unnithan, 1957). This is suggested by the slender flaccid peduncles of some and the thick or bulbous peduncles of others in Chauhan's (1945, fig. 37) carefully drawn figure and also by the exceptionally wide extension of the lateral excretory ducts in the hind body. The peduncles in *Pricea* are only sparsely muscular.

The vagina is just over the intestinal bifurcation and its opening sac is claimed by Chauhan (1945) to have a "U"-shaped spring within it and a sucker-like 'vulva', usually triangular; but some of the figures suggest that the spring or U-hook in the vaginal sac may be an optical

effect of a thick cuticular lining ; but cuticular structures were lacking in three of Ramalingam's species.

Genotype: *Pricea multae* Chauhan, 1945, on *Cybium* (?) *lineolatum* Cuv., from Bombay (Arabian Sea); *P. minimae* Chauhan, 1945 on *Katswonus pelamys* (L.), from Bombay; *P. microcotylae* Chauhan, 1945 on *Rastrelliger kanagurta* (Russel), from Bombay; *P. tetracantha* Ramalingam, 1952 on *Cybium guttatum* Cuv., from Madras (Southern sector Bay of Bengal); *P. armata* Ramalingam 1952, on *C. guttatum* Cuv., from Madras, and the same host and locality for the following species; *P. tricantha* Ramalingam, 1952; *P. melane* Ramalingam 1952; *P. minuta* Ramalingam 1952; and *P. robusta* Ramalingam 1952.

Neothoracacotyle Hargis 1956: erected for two closely related species formerly in other genera, on the basis of similarity of their modified gastrocotylid clamps, which are not open suckers as in *Thoracocotyle* MacCallum. Genotype: *N. coryphaenae* (Yamaguti, 1938 -as *Thoracocotyle*) on *Coryphaena hippurus* L. from the Japanese Pacific; and the second species *N. acanthocybii* (Meserve 1938 — as *Gotocotyla*) Hargis 1956 on *Acanthocybium solandri* Cuv., from the Galapagos Islands.

In *Neothoracocotyle* the haptor/body relationships are similar to those in *Thoracocotyle*, except that there is no metahaptor, for after the protohaptor there is no growth in the haptor-body axis, though the longitudinal axes of the haptor have a high growth potential, so that they grow forwards as lateral flanges adherent to the sides of the body past the ovarian zone. This far anterior extent of the haptoral flanges is otherwise rarely found, but another instance is in *Prasomicrocotyla gotoi* (Yamaguti 1934) Yamaguti, 1958 (*Microcotylidae*)—a character on which Yamaguti (1958, liii: 83) erected this genus, with *Microcotyle chiri* Goto 1894, as the second species, both on *Hexagrammos otakii* Jord. & Starks.

The clamps are all alike in size and shape and are internally symmetrical, but they differ from those of *Gastrocotyle* in that the short dorsal arm of the median spring bears a pair of lamellar sclerites, homologous with those in *Pricea* and the next two genera, but here much narrower and not reaching the roof-ribs. They clearly act in strengthening the sides of the tendon-hole (incipient cuticularization' shown' by Subhadrappa in *Gastrocotyle indica*), as well as supporting the capsule roof. Unfortunately Yamaguti omitted the dorsal arm of the spring entirely from his figure of *N. coryphaenae*, but Hargis' reinvestigation of the type material of *N. acanthocybii* (Meserve) Hargis (1956, xii: fig. 25) has established this generic character. There are 4 pairs of straight, not very long, parallel ribs developed in the dorsal capsule wall in both species. The protohaptor is represented in the adults by one pair of rather long-handled sickle-hooks.

Both species grow to the great length of 11-12 mm. and the haptor extends for a little more than half that length, but in *N. coryphaenae* the whole gonad zone is in the posterior fourth of the worm; the ovary is shorter, and the numerous testes are in two very regular parallel ranks. The wide oval genital atrium is armed with several

hundreds of long-rooted slender spines; there is probably an unarmed penis (not an armed cirrus as Hargis's figure-caption suggests, since both original authors describe only the atrium as armed and the vas deferens opening into it). The vagina opens at the posterior fourth of the anterior vitellaria-free zone which is about one-seventh of the total length in the genotype but one-fifth in *N. acanthocybii*. The vaginal pore is in a wide transverse oval of muscular tissue mid-dorsally. The vitellaria begin with the crural branches and extend nearly to the end of the body, a little in front of them here, the crura become confluent. The oval oral suckers are aseptate. Several 2-filamented eggs may occur in single file in the uterus.

Scomberocotyle Hargis 1956 — erected for *Heteraxine scomberomori* Koratha (1955) found by both authors on *Scomberomorus maculatus* (Mitchill) and *S. cavalla* (Cuv.), from Florida and Texas coasts. No other species. Elongate slender priceine worms with an asymmetrically developed haptor and probably a unilateral metahaptor. Hargis (1956: xii, fig. 2) shows that the longer clamp row with its anterior flange has caused the posterior end to be deflected to the opposite side, as in *Heretaxine*. The protohaptor is represented by a stout terminal lobe bearing a single pair of anchors with roots barely as long as the long sickle-shaped hooks; moreover on the proximal end of each there is a conspicuous ampoule-like structure (gland reservoir?) frequently seen in Dactylogyridae, but exceptional for Discocotylinea.

The clamps are all alike, but in the two rows distal to the lobe they are in not quite equal numbers: those on the straight side being more crowded, and both rows (here considered as the euhaptor) are equally long. There is an increase in clamp-size towards the middle, and a marked diminution at the proximal end of the straight row. The curved and slightly irregular edge of the other side shows that the increased clamp-size to the middle is maintained to the end, where there is an abruptly projecting wide lobe-like flange and a gap in the clamp-row, which is then continued round the slight curve of the flange, (which is considered to be a metahaptor). About one-third from the anterior end of the metahaptor there is a marked diminution in size of a few of the clamps, and opposite to this is an unusually long branch from the intestinal crus, accompanied by a few vitelline follicles outside their otherwise limited field. It suggests that this may be the formative zone of the metahaptor, and by analogy with *Pricea*, a second pair of larval anchors might be found here. This is an hypothesis which the American colleagues will be able to test and modify. The asymmetry is therefore due to growth-stimulation, rather than to inhibition as in *Heteraxine*.

Another peculiarity in *Scomberocotyle* is the presence of accessory buccal suckers, close against the large septate suckers with the opening tilted opposite to the septum, but quite independent from the normal sucker. The only similar condition is in *Diplozoon nipponicum* Goto, 1891.

The genital atrium has a dense double rosette of straight spines with bent tips and the muscular penis, as usual globose with a spiny

corona, but here the penis-spines are needle-like. The vaginal pore is similarly situated to that in *Neothoracocotyle*, but it is unique in having on its flanks two pairs of hooks strongly reminiscent of dactylogyrid anchors. The anterior pair have broad bifid roots and separated sharp points, and the posterior, similar but more slender, are connected by two narrow bars (!). The proximal parts of the vagina are not indicated.

Pseudaxine Parona & Perugia 1890, contains at least 4 species which vary mainly in the extent of the unilateral haptoral flange along the one side of the body, from which it may be free distally. The genus shares with *Gastrocotyle* the unusual character of the complete inhibition of the haptor on one side, but *Pseudaxine* differs mainly in the euhaptor being oblique and not parallel to the body-axis, and not extending to the ovarian zone; in particular, in those species which have been more recently re-examined, additional sclerites have been found associated with the dorsal arm of the spring. The genus still needs re-investigation, especially in respect of the armature of the genital atrium figured only for the genotype from the Mediterranean, and also of formative region for the clamps near the middle of the row, and the structure of the dorsal region of the clamps themselves.

In *P. trachuri* Par. & Per., there is a brief gap in the clamp-row opposite to the intrusion of a branch from the intestine into the flange (Sproston 1946, fig. 109 a); and in *P. mexicana* Meserve (1938, fig. 60), there is an abrupt diminution in size of 2 clamps, just proximally to the middle of the row and opposite to the level at which the flange becomes free from the body. Both these instances of interruption in the clamp succession suggest the occurrence of a formative region: in other words, that the proximal, partly projecting sector of the row, is in fact a *metahaptor*. The single smaller clamp found in both these species on the proximal tip of the haptor would then be the first-formed clamp of the metahaptor, and not a recently formed clamp as originally suggested by Sproston (1946: 465). So that both in *Scomberocotyle* and in *Pseudaxine* there is the possibility of a unilateral metahaptor, but nothing of the kind occurs in the apparently similar *Gastrocotyle* spp. There is also a slight diminution in size of two adjacent clamps in the middle of the haptor in *P. vagans* Ishii (1936, fig. 9), and certainly a smaller clamp at the tip; the last 3 clamps being on the free part of the flange which here extends exceptionally far along the body to the distal end of the ovarian zone, where a fold on the opposite side of this widest region causes a somatic asymmetry faintly resembling that in *Thoracocotyle ovalis* Tripathi.

The clamps in *P. trachuri* and *P. vagans* are about as long as wide, in *P. indicana* slightly wider, and in *P. mexicana* about twice as wide as long. The latter, recently restudied by Hargis from new material from Florida (1956, xii, fig. 1) shows an immensely expanded ventral arm of the spring (escutcheon-shaped) and widely bifurcate anteriorly, while the short dorsal arm bears two triangular plates, very similar to those in *Scomberocotyle scomberomori*. In the Pacific material of *P. mexicana* the accessory dorsal plates are shown much narrower

(Meserve 1938, fig. 61), and there are 6 or 7 oblique ribs, absent from the Florida specimens (Text-fig. 7A). In *P. trachuri* ribs are also absent and the dorsal accessory sclerites are short, as they are in *P. indicana* Chauhan (1945, fig. 20), and the jaws are as stout as they are in *P. vagans* Ishii (1936, fig. 10, Text-fig. 7B). In both the last two species the spring is stout and is associated with two cuticularized horns apparently supporting the anterior edge (hinge) of the capsule: Ishii does not indicate any dorsal accessory sclerites. All authors agree that there are two dissimilar pairs of anchors on a projecting lappet (protohaptor) and that the penis has a corona of nearly straight spines (10-22), but none could see a dorsal vagina: the lateral paraoesophageal vaginae referred to by Ishii may after all not be excretory vesicles or pores.

Genotype: *Pseudaxine trachuri* Par. & Per., 1890, on *Trachurus trachurus* (L.) from the Mediterranean, English Channel, and two localities in Japan (in the last three localities found in association with *Gastrocotyle trachuri*); other species:—*P. vagans* Ishii, 1936 (Text-fig. 7D) on *Katsuwonus vagans* (Lesson), from Japan; *P. mexicana* Meserve, 1938 on *Scomberomorus maculatus* (Mitchill) and *S. cavalla* (Cuv.) from the Mexican Pacific, and from Florida; (Hargis 1956 considers that *P. texana* Koratha 1955 from the same hosts off Texas is synonymous with *P. mexicana*); *P. indicana* Chauhan, 1945 on *Sparus berda* Forsk., from Bombay (Arabian Sea); and *P. kurra* Unnithan, 1968 on *Caranx kurra* Cuv. & Val. in association with *Gastrocotyle kura* Unnithan, 1968 from Trivandrum, Arabian Sea.

ENGRAULICOLINAE Subfam. nov.

The new subfamily has been created to accommodate *Engraulicola* George, 1960 and allied genera of atypical gastrocotylid worms in which the tendency to unilateral inhibition of the clamp rows is incomplete, resulting in a long and an opposite short row of gastrocotylid clamps. The short row is represented by a minimum of one primary clamp (as in *Engraulicola* George, 1960) and may extend to half or nearly half the number and/or length of the long clamp row in some genera (as in *Pellonicola* Unnithan, 1967). The structure of the clamp in the short and long row is similar and essentially gastrocotylid. It is interesting to note that the short clamp row which has been retained as a result of incomplete inhibition occupies the euhaptoral area just in front of the protohaptor. Beyond the distal level of the euhaptoral frill of the short clamp row the haptor continues forward on the long clamp row side as a unilateral metahaptoral frill which is indicated by the posterior level of haptoral extensions of body organs. The subfamily may reflect an indirect parallel condition in Heteraxininae of Axinidae Unnithan, 1957. However, in Engraulicolinae the condition of the haptor is the result of a tendency to incomplete unilateral inhibition of the clamp rows. Type genus: *Engraulicola* George, 1960.

Other genera included in the subfamily are *Engraulixenus* Unnithan, 1957 (1 sp); *Engrauliphila* Unnithan, 1967 (1 sp); *Engrauliscobina* gen. nov. (2 spp) and *Pellonicola* Unnithan, 1967

(1 sp). (cf. Unnithan, 1967 for detailed description of the species included under these genera).

Engraulicola George, 1960. A detailed description of the genotype *E. forcepopenis* recorded on the gills of the Indian clupeoid fish *Anchoviella bataviensis* (Hordenberg) at Trivandrum (Arabian Sea) has been given by George (1960).

Engraulicola micropharyngella Unnithan, 1967 — the second species of the genus was collected from the gills of *Anchoviella commersonii* (Lacepe) also at Trivandrum (Arabian Sea). Relationship of *E. micropharyngella* has been fully discussed elsewhere (cf. Unnithan, 1967).

Engraulixenus Unnithan, 1967: Monotypic with *Engraulixenus malabaricus* from the gills of *Thrissocles malabaricus* (Bloch) at Trivandrum (Arabian Sea). Has an elongate tapering body, slender anteriorly, with long foot-shaped hindbody tapering backwards and which has an unusually prominent heal with a spurlike extension forming the metahaptor. The inhibited clamp row retains two clamps of similar structure though smaller in size than those on the long clamp frill, the dorsal appendix of the median spring is a stalked 'U'-piece with parallel arms not divergent as in most of its relatives. The ventral arm of the spring is not truly bifurcated and is slender throughout. The anterior anchors have a characteristic shape — with handle markedly longer than the hook which is barely one quarter of a circle and with a stepped conical spur at right angles to the handle. Paired vaginae and exceptional intercrural bridges are present and the crural ends are subequal and markedly inflated. Parasitic on marine fishes.

Engrauliphila Unnithan, 1967: Another monotypic genus. The genotype *E. grex* was collected from the gills of *Thrissocles dussumieri* (Val.) at Trivandrum and Ayirumthengu (Arabian Sea). Those from Trivandrum had a closely related species *Engrauliscobina triaptella* Unnithan, 1967 also on the same host specimen. *Engrauliphila* has haptor-body relation similar to that in *Engraulixenus*. The inhibited clamp row retains two primary clamps only. The two pairs of persistent anchors are characteristic, both less curved than in *Engraulixenus* and entirely unlike those of *Engraulicola*. The penis head is devoid of forceps and a collar is lacking round the atrium. Paired lateral vaginae join transverse vitelline ducts, the vulvae are not supra-marginal and they are situated much nearer to ovary. Pharynx is elongated ovoid. Parasitic on marine fishes at a very high infection rate.

Engrauliscobina gen. n. has been erected for *Gastrocotyle thrissocles* Tripathi (1959: 124-5, fig. 56) found on *Thrissocles mystax* at Puri, in the northern sector of the Bay of Bengal. This species is excluded from *Gastrocotyle* v. Ben. & Hesse, by its triangular body and the incomplete suppression of the clamp row on the longer side of the body. In *Gastrocotyle* there is a complete suppression of haptoral growth on the one side, and the clamps on the other, always parallel, side of the body extend as a rule well above the gonad zone.

Its peculiar shape suggested its new name (*Engraulis*—the name of the type genus of the hostfamily, and *scobina*—Latin for a rasp, or scraping tool): a shape resembling that of *Pseudaxine vagans* Ishii, in which the oblique haptor also extends about half way up an exceptionally wide body; but again, there is a complete inhibition of the other side of the haptor. The finger-like protohaptor is very like that in *Pseudaxine indicana* Chauhan, in that the proximal pair of larval anchors are far separated from the posterior pair. Here they are set transversely on the blunt end, with a minute pair of larval hooklets between them. The posterior anchors have very short bifid roots, while the penultimate pair are thrice the length and the straight root is longer than the elongated sickle.

In the retention of two small token clamps on the inhibited side, *Engrauliscobina* gen. n. is analogous to *Axinoa aberrans* (Goto, which has only a single token clamp. There is no information published either on the detailed structure of the vestigial clamps (Tripathi's 1959, Fig. 56 c) or on that of the larger clamps crowded in profile view along the main row, but their oblong shape suggests a possible modification of their basic gastrocotylid sclerites (cf. George, 1960). The brevity of Tripathi's description is partly compensated by his figure, which shows that while there is no exact counterpart of the minute rounded token clamps on the opposite side of the protohaptor, the first two (primary) clamps are already elongated, but much smaller than the others except for two similar (primary) clamps at the far anterior end of the row, on a short lobe projecting from the body margin. Moreover, in the middle of the clamp-row there are two small clamps flanked by two of medium size, all slightly indented towards the boundary of the body proper. This region suggests the site of the formative zone: backwards for the euhaptor, and forwards for the metahaptor, which has carried the last two primary clamps of that side away on its advancing tip. The dichotomy of the growth-zone in the larval haptor would thus have taken place between the middle pairs of primary clamps, producing secondary replications on either side of the zone on the one flank, while there was a complete suppression of the growth zone and the clamps of the larval haptor anterior to this level on the other flank. In *Pseudaxine* there was evidently a complete inhibition of primary clamps on the larval haptor on this flank, and the dichotomy of the formative zone for secondary clamps took place between the two anterior of the four primary clamps on the uninhibited flank: since in *Pseudaxine* spp. there is but a single diminutive clamp on the anterior tip of the metahaptor.

In *Engrauliscobina thrissocles* and its allies, the whole of the body just behind the genital pore is packed with rather large vitelline follicles which obscure most of the internal organs, so a vagina has not been detected in any of them: in addition, since they are blood-feeders from the gill-tissue, melanotic granules deposited on the walls of the richly branched intestine add to the obfuscation. The anterior quarter of the long side (hypotenuse of the rightangled triangle) of the worm forms a narrow cylindrical 'handle of the scraper', and the genital pore is at about one-third its length from the anterior end. The bulbous atrium masculinum carries a corona of 12 erect hooks

just as in *Pseudaxine mexicana* (about double this number in *P. vagans* and *P. indicana*).

The undoubted affinity of *Engrauliscobina* with *Pseudaxine* and *Gastrocotyle* raises a phylongenetic problem, since the last two are so characteristic of Carangid and Scombroid fishes, but the new genus is parasitic on the relatively primitive *Engraulidae*. It is a precisely parallel problem to that posed by the distribution of the Mazocraeid genera *Kuhnina* (on *Scombridae*) and *Mazocraes* (on *Clupeidae*): a question discussed by Bychowsky (1957:307, and schemata in figs. 263, 264, 265).

Engrauliscobina triaptella Unnithan, 1967: This species was obtained from the gills of *Thrissocles dussumieri* (Val.) at Vizhingam, Trivandrum (Arabian Sea). The host specimen examined at Trivandrum had multiple infection by *Engrauliphyla grex* Unnithan also. In *E. triaptella* the clamp flange is 36% to 48% of the total length while it is 50% in the genotype and there are 3 remnant clamps on the inhibited side of the haptor of this species. The number and extent of the clamps and its frill in the two species differ considerably. In the structure of the clamps and anchors also there are specific differences. Internal organs also show specific variation in the two species of *Engrauliscobina* as detailed in Unnithan (1967).

Pellonicola Unnithan, 1967: Monotypic with *P. elongata* Unnithan, 1967 obtained from the gills of *Pellona (Ilisha) brachysoma* (Blkr.) at Trivandrum (Arabian Sea). Body elongate ribbon like with distinct but short caudal haptor. The unilateral inhibition is far less than in any other genus of the subfamily and in this respect is comparable with *Scomberocotyle* Hargis, 1956 but in that genus a metahaptoral wing or secondary stimulation of secondary clamp replication accounts for the large number of clamps on one side. The anterior moiety of the long clamp row may on further observation prove to be a metahaptor and its posterior moiety being the euhaptor parallel with its counter part on the opposite side of short clamp row, the short row has nearly half the number of clamps in the long row. The two pairs of anchors are on a telescopic lappet. There are few parovarian testes though they are mainly postovarian. Penis corona has no additional sclerites and the paired vaginae are supra-marginal as in *Engraulixenus* but very far forwards. There is a median vitelline duct. Oral pouches are particularly large and better developed than in other genera. Parasitic on marine fishes.

GOTOCOTYLINAE Subfam. nov.

This subfamily of Gastrocotylidae is erected for what at present appears to be a single genus, *Gotocotyla* Ishii, 1936. Yet it stands in contrast to all other genera of the family in the extreme internal asymmetry of the clamps (Text-fig. 5A): on the one side the ribs from the capsule roof have been incorporated into the supporting skeleton of the side-wall and are often ankylosed to the ventral and dorsal jaw-rami of that side to form a ladder-like compound sclerite, while the ends of the rami are variously bent and hooked. On the wider side

of the clamp the sclerites derived from the dorsal arm of the spring (simple lamellae in *Priceinae*) are variously shaped or even divided, and the shoulder-piece of the ventral jaw on this side is expanded and may be free. The median spring, elongated and slender, is variously bent away from the meridian and ends in a hook-like point anteriorly, but its dorsal arm is reduced. The oblique braces are unequally developed: that on the wide side always wider and longer.

There is a symmetrical haptor as a continuation of the body-axis (its possible partition is discussed below), and the terminal hooks of the protohaptor are retained in the adult.

These species are also exceptional in this family in having a long eversible true cirrus, bearing hundreds of sharp spines, or according to Hargis (1956, fig. 15) long-handled hooks with short points. There is a conspicuous dorsal vagina, usually surrounded by a wide rim of circular muscles and sometimes gland cells.

It is noteworthy that all but two (one doubtful) records are from hosts belonging to either Scomberomoridae (=Cybiidae auct.) or Scombridae.

Gotocotyla Ishii (1936 : 788) is apparently the only valid genus. Syn.: *Lithidiocotyle* Sproston, 1946, was created without a full understanding of Ishii's genotype, and as Tripathi has proposed (1959 : 129), the genera must be merged (unfortunately he suppresses *Gotocotyla* in favour of *Lithidiocotyle* in his Key on the next page). I also concur in his making *Pseudomicrocotyle* Sandars (1947) a second synonym. *Microcotyle* (*sensu lato* auct.) is also a synonym in part. The following notes do not purport to be specific diagnoses, but they draw attention to some possible specific criteria for this compact group, yet evoking so many problems.

Genotype: *G. sawara* Ishii, 1936, on *Cybium nipponium* Cuv., from Japan: numerous testes occupying at least half the length of the body, preceded by a large receptaculum seminis behind the proximal lobe of the inverted "U"-shaped ovary, and extending into the haptor; but the unbranched ends of the intestinal crura extend farther, nearly to mid-haptor level. There is a scleriform sclerite on the adaxial side of the clamp, and the shoulderpieces of the ventral jaw rami are articulated hooks (Text-fig. 5A).

G. acanthura (Parona & Perugia 1896 — as *Microcotyle*) Meserve 1938 (Syn. *Lithidiocotyle acanthura* (Par. & Per.) Bychowsky (1957 : 439) on *Brama rayii* (L.), from Genoa (Mediterranean), and North Sea.

G. lintoni nom. nov. pro *Microcotyle* sp. of Linton (1906 : 370, figs. 147-150) on *Pomatomus saltatrix* (L.), from the American Atlantic: non *Microcotyle pomatomi* Goto, 1899, from the same host off Rhode Island USA, which Linton (1940) identified with his *Microcotyle* sp. of 1901, also from *Pomatomus saltatrix* — *M. pomatomi* has been re-studied and its ontogeny described by Bychowsky (1957 : 207-8, figs. 241-3) from the same host from the Black Sea. *G. lintoni* was said to have clamps twice as wide as long, and though the figure is admitted to be a crude sketch, the asymmetry is con-

sistent in that the shoulder-piece is much longer on the wider side, and the oblique braces are conspicuous; the highly characteristic spiny cirrus is nicely figured, and here the sharp spines have bifid bases; the vitellaria occupy two-thirds of the body but do not enter the haptor, and the vaginal pore may be slightly lateral. These worms are unusually small: 2.3 to less than 4 mm. long, whereas both the foregoing species are at least 10 mm. long.

G. acanthophallus (MacCallum & MacCallum 1913 — as *Microcotyle*) comb. nov. (Syn. *Lithidiocotyle acanthophallus* of Sproston 1946 — genotype: and of subsequent authors), on *Roccus saxatilis* (Walb.) from Atlantic coast of USA. The type material has been re-examined by Hargis (1956, xii: 37, figs. 10, 11), and the terminal anchors figured for the first time; the 5 or 6 short ribs do not contribute to form a scalariform sclerite, and the shoulder piece of the ventral jaw on that (adaxial) side does form an articulated hook, there is a third (saddle-shaped) free dorsal sclerite proximally near the short end of the spring. The testes and vitellaria do not enter the rather long stem of the haptor, though unbranched crura do. The vaginal sucker is very wide: a transverse oval in the mid-dorsal line in the zone of the intestinal bifurcation. The MacCallums' worms were 7 mm. long.

Hargis considers the worms from *Scomberomorus cavalla* and *S. maculatus*, which he found in Florida waters to be conspecific with MacCallums' which he thinks may have been accidental passengers on *Roccus* from the fish-market. His worms from *S. cavalla* were larger and more numerous than those on *S. maculatus*, yet the clamps from the former are still smaller than those from *Roccus* according to Hargis' 1956: figs. 10 & 19), and so are the proximal (Penultimate) larval anchors, though similar shape, the handle forms a broad triangular sleeve for the 'C'-shaped hook. In the terminal anchors the 'C'-hook is relatively longer in the worms from *S. cavalla* than from *S. maculatus*; in the clamps of both the latter, the third free dorsal sclerite is not developed.

There may be a case here for the establishment of three subspecies, but the array of qualitative variation data for each needs amplification, particularly in view of Ramalingam's discovery of clamp polymorphism within the individual (see below).

Hargis attempts to retain this species in *Lithidiocotyle*, and re-defines the two genera, but he admits the differences are very slight: the lateral extent of the testes over the crural fields and the relative length of the haptor-stem. I think he may agree after examining data from Indian material (Ramalingam 1961) that these differences are only of specific rank, and that *Lithidiocotyle* Sproston, is a clear synonym of *Gotocotyla* Ishii, 1936.

Hargis thinks it highly probable that *Microcotyle scomberomori* Koratha, 1955, from the Texas Coast on the same *Scomberomorus* spp., is a synonym of *G. acanthophallus*.

G. elagatis Meserve, 1938 (Syn. *G. elegatis* Mes. of Hargis, 1956, 28, 38, 39, 42), on *Elagatis bipinnularis* (Quoy & Gaimard), from

Bahia Honda, Panama (*Sic*): — this citation is ambiguous, since Bahia Honda is in western Cuba, far from Panama; and though it is possible that the Galapagos-bound ship called at this coaling station, it is more likely to be one of the two ports named Bahia in Equador. "Bahia" opposite Quito and just south of Cape San Francisco would be among the nearest continental landfalls from Galapagos, and is suggested as a more probable locality. If it can be established that the origin of Meserve's material is in Pacific waters, it is a further point in favour of Sandars's *Pseudomicrocotyle elagatis* from the same host species in southern Australian waters, being identical with Meserve's: resulting in the homonym *Gotocotyla elagatis* (Sandars 1947) comb. nov., but if the identity is valid, there is no need to substitute a new specific name for Sandars material.

Hargis has re-examined the type material (1956, xii, 39, figs. 20-23), and his more detailed figure of the elongated clamps (twice as long as wide) shows a scalariform compound sclerite on the adaxial side articulating with an expanded shoulder-piece. There is probably only one free dorsal sclerite developed, the proximal lamella being the dorsal arm of the ventral jaw ramus of the abaxial side. The hundreds of testes overlap the crural fields, and are flanked by vitellaria for only half their zone; feebly diverticulate ends of the crura extend half way down the haptor. The cirrus has long needle-like spines with a short rightangled bent at the bases. The terminal anchor hook is less than a semicircle. Hargis finds two lateral rows of clamps on one side, but Meserve figures three, in the proximal half of the haptor. The vagina is evidently inconspicuous since it is not mentioned by either author.

Gotocotyla meservei Yamaguti 1953 also occurs on *Elagatis* sp. but from the extreme western Pacific, off Celebes. It differs from *G. elagatis* Mes. in the significantly fewer testes, the shorter crura which reach only half way down the testicular zone, where the vitellaria also cease, and the male terminalia are said to be different. In the oval clamps there is an adaxial scalariform sclerite and one dorsal plate is very wide.

G. secunda (Tripathi, 1956 — as *Lithidiocotyle secundus*) comb. nov., occurs on *Scomberomorus guttatus* (Bl. & Schn.), from Puri, in the northern sector of the Bay of Bengal. It is claimed to differ on account of the presence of anchors, but these have now been found (2 pairs, one terminally and the other, smaller, in the anterior dorsal region of the haptor) on the former genotype by Hargis 1956. In *G. secunda*, however, the testes are in only 2 rows and the crura are said to enter the haptor; the oral suckers are relatively as well as absolutely much smaller and the muscular vaginal opening is longitudinally oval instead of transverse, it may also, be slightly lateral.

G. bivaginalis (Ramalingam, 1961 as *Lithidiocotyle bivaginalis*) comb. nov. on *Scomberomorus guttatus* (Bl. & Schn.) at Mandapam, S. E. India. It differs from the known species of the genus in the presence of two vaginae opening by separate pores surrounded by well developed suckers (cf. Ramalingam, 1961 b. Fig. 1-7).

Apart from the highly developed abaxial/adaxial asymmetry found

in *Gotocotyla* clamps, comparable in degree only with that of *Anchorophorus* Bychowsky & Nagibina (1958) there are three other points of general biological interest which may be mentioned briefly. There is an unusual degree of polymorphism shown in the clamps of individual worms, at least in some species: this has been analysed in detail by Ramalingam (1961). A detailed exposition of the limits of variation will have to be studied before a critical assessment of this kind of species character can be made.

Hargis' (1956: 37) discovery of the characteristic single pair of anchors on the terminal lappet in *G. acanthophallus* from three different hosts (perhaps subspecies) completes the characters for the generic identity of *Lithidiocotyle* Sproston, 1946, and *Gotocotyla* Ishii, 1936. But at the same time he made the far-reaching discovery of additional larval anchors and hooklets in the anterior region of the haptor, between the clamp-rows and on the dorsal side. Unfortunately he supplies no diagram to indicate the approximate location or the number of these larval anchors, but the bare fact of their occurrence in *Gotocotyla* is highly significant. They at once recall the "body hooks" of *Pricea*, and therefore an indication of a primary dichotomy of the longitudinal growth-axes in the protohaptor—in fact, between the ultimate and penultimate pairs of hooks (posterior and posterior-laterals in the nomenclature of Llewellyn (1957a), as in *Pricea*. Whereas in *Pricea* the 'metahaptor' arising from the anterior side of the formative zone produces a complete haptoral lobe independently of the body/haptor axis, none such is formed in *Gotocotyla* spp. Yet if the anchor-pairs are separated, the replication of clamps between them can be accounted for only by an early fore and aft dichotomy in the formative zone, producing new clamps which successively push the anchor-pairs farther as under. In *Gotocotyla* therefore, the formative zone must be sought perhaps in the proximal half of the haptor. The absence of an independent anteriorly growing lobe could be explained by the body/haptor axis to some extent "keeping pace", in its growth with the growth of the lateral replication axes. The occurrence of double or triple lateral rows of clamps reported for most species in the anterior region of the haptor, would indicate that the growth in the metahaptor clamp-rows had overtaken that of the median axis and a further (lateral) dichotomy took place, accommodating additional clamps medially at every second (and third) division of the 'clamp-primordium'. The inability to form a ventro-anterior external metahaptor-bud would be accounted for by the original dichotomy not being sufficiently deep to involve tissues of the median axis of the haptor—as in the delicate frilly haptor of *Microcotyle priacanthi* Meserve.

The unique features of the growth gradients in Monogenoidea would appear to separate them clearly from all other Platyhelminthes, and to indicate a very long phylongenetic history, with an exceptionally high level of organization in present-day forms on the more highly evolved fish groups: co-existing with admittedly more primitive forms on some primitive fish-groups, and in Amphibia and Reptilia.

V—SUMMARY OF THE SYSTEMATIC REVISION OF THE VALID SPECIES OF
THE AXINIDAE, HETEROMICROCOTYLIDAE AND GASTROCOTYLIDAE,
WITH THEIR HOSTS AND LOCALITIES

MICROCOTYLOIDEA (Unnithan, 1957) *s. str. emend.*

AXINIDAE Unnithan, 1957 (3 subfamilies)

AXININAE Monticelli, 1903 *s. str.* Unnithan, 1957. (7 genera)

Axine belones Abildgaard, 1794 : on *Belone belone* (L.) Europe.

Axine cypseluri (Meserve, 1938) Price, 1945: on *Cypselurus agoo*,
Japan and *C. callopterus*, Galapagos.

Axine yamaguti (Meserve, 1938) Price, 1945, on *Exocoetid* sp.
Mexican Pacific.

Axine parawa Unnithan, 1957, on *Cypselurus bahiensis*, S. W. India.

Axine hemirhamphae Unnithan, 1957 : On *Hemirhamphus xanthopterus*,
Val. Trivandrum, SW. India.

Axine tripathii (Tripathi, 1959) Yamaguti 1963 n.n.pro *A. hemirhamphae*
Tripathi 1959 (*non* Unnithan, 1957), on *Hemirhamphus georgii* Val. Hooghly R. & Orissa, NW.
Bay of Bengal.

Axine inada Ishii & Sawada, 1938, on *Seriola aureovittata* T. & S.,
Japan.

Axinoides tylosuri Yamaguti, 1938, on *Tylosurus schismatorhynchus*,
Japan.

Axinoides gracilis (Linton, 1940) Sproston, 1946, on *Tylosurus mari-*
nus (Walb.), USA, Atlantic Coasts.

Axinoides raphidoma Hargis, 1956, on *Tylosurus raphidoma*, USA,
Atlantic.

Axinoides kola Unnithan, 1957, on *Athlennes hians* (Val.), SW. India.

Axinoides sebastisci Yamaguti, 1958, on *Sebastiscus marmoratus*, Japan.

Axinoides resplendens Caballero, Bravo & Grocott, 1954, on *Tylo-*
surus fodiater, Columbia, E. Pacific.

Chlamydaxine truncata (Hargis, 1956) Unnithan, 1957, on *Tylosurus*
raphidoma, USA Atl.

Loxura ananaphallus Unnithan, 1957, on *Tylosurus leiurus* (Blkr.), SW.
India.

Loxuroides sasikala (Unnithan, 1957) Price 1962, on *Cypselurus oli-*
golepis (Blkr.), S. India.

Oligapta oligapta Unnithan, 1957, on *Hemirhamphus georgii*, S. India.

Indocotyle hemirhamphae Tripathi, 1959, on *Hemirhamphus georgii*,
Hooghly R., & Orissa, Bay of Bengal.

HETERAXININAE Unnithan, 1957 *emend.* (6 genera)

Heteraxine heterocerca (Goto, 1894) Yamaguti, 1938, on *Seriola aureovit-*
tata T. & S., Jap.

Heteraxine seriolae (Ishii, 1936) Yamaguti, 1938, on *Seriola aureovittata*,
Japan.

Uraxine chura Unnithan, 1957, on *Euthynnus alleteratus affinis* (Cantor), from Kerala, India.

Uraxine macrova (Unnithan, 1957) *status nov.*, on *E. alleteratus affinis*, from Kerala, India.

Allopseudaxine katsuwonis (Ishii, 1936) Yamaguti, 1943, on *Katsuwonus vagans* (Lesson), Japan.

HETEROMICROCOTYLIDAE (Yamaguti, 1963) *s. str.* emend. (3 subfamilies)

HETEROMICROCOTYLINAE subfam. nov. (5 genera)

Heteromicrocotyla carangis Yamaguti, 1953, on *Caranx* sp. from Macassar, Celebes.

Heteromicrocotyla vaginispina Unnithan, 1961, on *Carangoides malabaricus* (Bloch & Schneider) at Trivandrum and Neendakara (South Arabian Sea).

Heteromicrocotyla polyorchis Unnithan, 1961, on *Carangoides malabaricus* at Trivandrum (South Arabian Sea).

Heterapta chorinemi Tripathi, 1956, — as "*Diplasiocotyle*" comb. nov., on *Chorinemus tala* Cuv., from Mahanadi Estuary, Bay of Bengal.

Heterapta heterapta Unnithan, 1961 (genotype), on *Chorinemus sanctipetri* Cuv., at Trivandrum (South Arabian Sea).

Dicotyle stromatea (Tripathi, 1956) comb. nov., on *Pampus argenteus* (Euphr.), from Puri, Bay of Bengal.

Dicotyle vellavoli Unnithan, 1961, on *Chandroloites* (*Stromateus*) *chinensis* (Euphr.) at Trivandrum and Vizhingom (South Arabian Sea).

Dictydenteron reticulatum (Goto, 1894) gen. n., *Pampus argenteus* (Euphr.), from Japanese Seas.

Carangiamata sagae (Manter & Prince, 1953) gen. nov., on *Caranx* sp., from Suva, Fiji.

CEMOCOTYLINAE Subfam. nov. (4 genera)

Cemocotyle carangis (MacCallum, 1913) Sproston, 1946, on *Caranx crysos* (Mitch.), USA, Atlantic.

Xureliphilus elongatus (Meserve, 1938) gen. nov., on *Xurel malampygus* Cuv., from Secas Isl., Galapagos.

Tripathiana minuta (Tripathi, 1959) gen. nov., on *Megalaspis cordyla* from Puri, Orissa, Bay of Bengal.

Megamicrocotyle chirocentrus Tripathi, 1956, and Unnithan, 1961 on *Chirocentrus dorab* (Forsk.), From Puri, Bay of Bengal and Trivandrum, Arabian Sea.

Megamicrocotyle microcotyla (Manter & Prince, 1953) Unnithan, 1961, on a 'ribbon-fish' from Fiji.

PYRAGRAPHORINAE Subfam. nov. (2 genera)

Pyragraphorus pyragraphorus (MacCallum & MacCallum, 1913) Sproston, 1946, on *Trachinotus carolinus* from USA. Atlantic.

- Heteraxine carangis* (MacCallum, 1918) Yamaguti, 1938, on *Caranx hippos*, from USA Atlantic Coast.
- Heteraxine scomberomori* Koratha, 1955 (?), on *Scomberomorus* sp., from USA Atlantic.
- Heteraxine karavoli* Unnithan, 1957, on *Formio niger* (Bloch), from SW. India.
- Heteraxine meintoshi* (Price, 1962) Yamaguti, 1963 syn. *Allencocotyla mcintoshii* Price (1962), on *Seriola lalandii* from Florida, USA.
- Heteraxinoides triangularis* (Goto, 1894) Yamaguti, 1938, on *Anthias schlegelii* Gunth., from Japan.
- Heteraxinoides chinensis* (Yamaguti, 1937) Yamaguti, 1938, on *Haplogenyus nitens* Rich. Japan.
- Heteraxininoides oligoplitis* (Meserve, 1938) Hargis, 1956, on *Oligoplites saurus* (Bl. & Sch.) from E. Pacific.
- Heteraxinoides xanthophilus* Hargis, 1956, on *Leiostomus xanthurus* Lacep., from USA Atlantic Coast.
- Heteraxinoides xanthophiloides* Price, 1962 on *Leiostomus xanthurus* Lecep., from USA.
- Kannaphallus virilis* Unnithan, 1957, on *Caranx atropus*, — SW. India.
- Zeuxapta zyxivaginata* Unnithan, 1957 (pro *Microcotyle seriolae* Yamaguti, non *H. seriolae* Ishii) on *Seriola aureovittata*, from Japan.
- Zeuxapta meservei* (Sproston, 1946) comb. nov. (pro *H. seriolae* Meserve, 1938, non of Ishii 1936), on *Seriola dorsalis* (Gill), from Galapagos Islands.
- Gonoplasius carangis* Sandars, 1947, on *Caranx georgianus*, from W. Australia.
- Gonoplasius longirostri* (Robson, 1961) Price, 1962, Syn. *Microcotyle longirostri* on *Longirostrum platessa* from New Zealand.
- Axinoa aberrans* (Goto, 1894) gen. n. (Genotype), on *Tylosurus schismatorhynchus* (Blkr.), from Japan.
- Axinoa meservei* (Price, 1945 — pro *Axine aberrans* of Meserve, non of Goto, 1894) comb. n., on *Tylosurus fodiator* from Columbia, E. Pacific.

MONAXININAE Unnithan, 1957 (5 genera).

- Monaxine formionis* Unnithan, 1957, on *Formio niger* (Bloch), — S. India.
- Monaxine bivaginalis* Ramalingam, 1961, on *Formio niger* (Bloch), — S. E. India.
- Neoaxine constricta* (Yamaguti, 1938) Price, 1945 : (Syn. *Amonaxine constricta* of Unnithan, 1957), on *Tylosurus schismatorhynchus*, from Japan.
- Crotalaxine serpentina* Unnithan, 1957, on *Athlennes hians* (Val.) from S. India.

Hargisiella hippos (Hargis, 1956) gen. n. (type species), on *Caranx hippos*, Florida, USA, Atlantic.

Hargisiella incomparabills (MacCallum, 1917) comb. nov., on *Caranx ruber* (Bloch), from USA Atlantic.

GASTROCOTYLOIDEA Price, 1959 (3 families)

GASTROCOTYLIDAE Price, 1943 (5 subfamilies)

GASTROCOTYLINAE Sproston, 1946 (5 genera).

Gastrocotyle trachuri v. Ben & Hesse, 1863, on *Trachurus trachurus*, from European and Japanese waters.

Gastrocotyle japonica Ishii & Sawada, 1938 on *Pneumatophorus japonicus* (Houttyn), from Japan.

Gastrocotyle indica Subhadrappa, 1951, on *Caranx kalla* Cuv., from Madras, Bay of Bengal.

Gastrocotyle kurra Unnithan, 1968, on *Caranx kurra* Cuv., from Trivandrum, Arabian Sea.

Gastrocotyle kalla Unnithan, 1968, from *Caranx kalla* Cuv., from Trivandrum, Arabian Sea.

Chauhanea madrasensis Ramalingam, 1953, on *Sphyaena acutipinnis* and *S. commersonii* Cuv., resp. from Madras and Madagascar.

Yamaguticotyla truncata (Goto, 1894) Price 1959, on *Parapristipoma trilineatum* from Japan.

Churavera macrova Unnithan, 1968, on *Euthynnus affinis* (Cantor) from Trivandrum, Arabian Sea.

Eyelevera typica Unnithan, 1968, on *Rastrilliger karagurta* (Cuv.) at Trivandrum, Arabian Sea.

THORACOCOTYLINAE Subfam. nov. (4 genera).

Thoracocotyle crocea MacCallum, 1913: on *Scomberomorus maculatus* (Mitchill), USA, Atlantic, & Mexican Pacific.

Thoracocotyle ovalis Tripathi, 1956 (emend. orthogr. 1959): on *Scomberomorus guttatus* NW. Bay of Bengal.

Dawesia indica Unnithan, 1964, on *Scomberomorus guttatus* (Bl. & Schm.) at Trivandrum, Arabian Sea.

Lintaxine cokeri (Linton, 1940) Sproston 1946: on *Aplodinotus Grunniens* Raf., Iowa, USA.

Amphipolycotyle chloroscombris Hargis, 1957: on *Chloroscombrus chrysurus* (L.), S. USA, Atlantic.

PRICEINAE Chauhan, 1953, s. str. emend. (4 genera)

Pricea multae Chauhan, 1945, (genotype): on *Cybium lineolatum* Cuv., Bombay, E. Arab. Sea.

Pricea minimae Chauhan, 1945: on *Katsuwonus pelamis*, Bombay.

Pricea microcotylae Chauhan, 1945: on *Rastrelliger kanagurta*, Bombay.

- Pricea tetracantha* Ramalingam, 1952, on *Scomberomorus guttatus* (Bl. & Sch.), Madras, W. Bay of Bengal.
- Pricea armata* Ramalingam, 1952, on *Scomberomorus guttatus* (Bl. & Sch.), Madras, W. Bay of Bengal.
- Pricea tricantha* Ramalingam, 1952, on *Scomberomorus guttatus* (Bl. & Sch.), Madras, W. Bay of Bengal.
- Pricea melane* Ramalingam, 1952, on *Scomberomorus guttatus* (Bl. & Sch.), Madras, W. Bay of Bengal.
- Pricea minuta* Ramalingam, 1952, on *Scomberomorus guttatus* (Bl. & Sch.), Madras, W. Bay of Bengal.
- Pricea robusta* Ramalingam, 1952, on *Scomberomorus guttatus* (Bl. & Sch.), Madras, W. Bay of Bengal.
- Neothoracocotyle coryphaenae* (Yamaguti, 1938) Hargis, 1956 (Genotype), on *Coryphanena hippurus* L., Japan.
- Neothoracacotyle acanthocybii* (Meserve, 1938) Hargis, 1956, on *Acanthocybium solandri* (C.) Galapagos.
- Scomberocotyle scomberomori* (Koratha, 1955) Hargis, 1956, on *Scomberomorus maculatus*, & *S. cavalla*, S. USA, Atlantic.
- Pseudaxine trachuri* Par. & Per., 1890 (genotype), on *Trachurus trachurus* (L.), Europe and Japan.
- Pseudaxine vagans* Ishii, 1935, on *Katsuwonus vagans* (Less.), Japan.
- Pseudaxine mexicana* Meserve, 1938, on *Scomberomorus maculatus* (Mitchill), *S. cavalla* (Cuv.), Mexican Pacific and S. USA, Atlantic.
- Pseudaxine indicana* Chauhan, 1945, on *Sparus berda* Forsk., Bombay.
- Pseudaxine kurra* Unnithan, 1968, on *Caranx kurra* Cuv. & Val. at Trivandrum, Arabian Sea.

ENGRAULICOLINAE Subfam. nov.

- Engraulicola forcepopenis* George, 1960, from *Anchoviella betaviensis* (Hardenberg) at Trivandrum, Arabian Sea.
- Engraulicola micropharyngella* Unnithan, 1967, from *Anchoviella commersoni* (Lacepi) at Trivandrum, Arabian Sea.
- Engraulixenus malabaricus* Unnithan, 1967, on *Thrissocles malabaricus* (Bloch) at Trivandrum, Arabian Sea.
- Engrauliphila grex* Unnithan, 1967, on *Thrissocles dussumieri* (Val.) at Trivandrum, and Ayrumthengu, Arabian Sea.
- Engrauliscobina thrissocles* (Tripathi, 1959) gen. nov., on *Thrissocles mystax* at Puri, N.W. Bay of Bengal.
- Engrauliscobina triantella* Unnithan, 1967, on *Thrissocles dussumieri* (Val.) at Vizhingom, Trivandrum, Arabian Sea.
- Pellonicola elongata* Unnithan, 1967, on *Pellona* (Illisha) *brachysoma* (Blkr.) at Trivandrum, Arabian Sea.

GOTOCOTYLINAE Subfamily nov. (one genus)

- Gotocotyla sawara* Ishii, 1936 (genotype): on *Cybium nipponium* Cuv., Japan.

- Gotocotyla* Ishii, 1936 (Syn. *Lithidiocotyle* Sproston, 1946 ; *Microcotyle* auct. ; *Pseudomicrocotyle* Sandars 1947).
- Gotocotyla acanthura* (Par. & Per., 1896) Meserve, 1938, on *Brama rayii* (L.), European Seas.
- Gotocotyla lintoni* nom. nov. pro *Microcotyle* sp. of Linton, 1906, on *Pomatomus saltatrix*, USA, Atlantic.
- Gotocotyla acanthophallus* (MacCallum & MacCallum, 1913) comb. n., on *Roccus saxatilis* USA, Atlantic.
- also (?) sub spp. on *Scomberomorus maculatus* & *S. cavalla*, USA, Atlantic.
- Gotocotyla elagatis* Meserve, 1938, (Syn. *Pseudomicrocotyle elagatis* Sandars, 1947 (?), on *Elagatis bipinnularis* (Quoy & Gaim), off Ecuador, E. Pacific, & S. Australia.
- Gotocotyla meservei* Yamaguti, 1953, on *Elagatis* sp., Celebes.
- Gotocotyla secunda* (Tripathi, 1956) comb. n., on *Scomberomorus guttatus* (Bl. & Schn.), NW, Bay of Bengal.
- Gotocotyla bivaginalis* (Ramalingam, 1961) comb. n., on *Scomberomorus guttatus* (Bl. & Schn.), SE India.
- (Total reviewed : 107 spp.).

VI — ACKNOWLEDGEMENTS

The author would like to express his deep appreciation to Miss Nora G. Sproston for the discussions in the Laboratory of the Central Marine Fisheries Research Institute at Mandapam Camp in Southern India during 1956-57, and for the continued exchange of factual data and opinions since she left India, which all helped a long way in the preparation of this paper.

VII — SUMMARY

An analysis of the dynamics of axial growth potentials in the haptoral region of the higher Monogeneoidea reveals, 1) the presence of a characteristic growth gradient arising in the protohaptor (the anchor-bearing ventral lobe of the larval haptor), and controlling the successively anterior replacements of the lateral hooklets of the larva by the 4 pairs of primary clamps. 2) Secondary growth stimuli may induce a potentially unlimited forward replication of the primary clamps (in Microcotyloidea and Gastrocotylidae). 3) inhibitory influences may be secondarily imposed, usually differentially, on the two lateral replication-axes. 4) Various degrees and kinds of asymmetry may be the result of interactions of differential inhibitions and postural stresses. 5) The effects of secondarily imposed growth-stimuli, particularly characteristic of Heteromicrocotylidae Yamaguti, 1963, *s. str. emend.* as inhibitory influences are of Axinidae Unnithan, 1957, in the clamps themselves are usually abrupt ; remodelling and increase in size often affects only the last-formed primary clamps, and may be unilateral or bilateral (e.g. *Paramazocraes* Tripathi, 1959, *Pseudoanthocotyle* Bychowsky & Nagibina, 1954, *Anthocotyle* v. Ben. & Hesse, and *Xureliphilus elongatus* (Meserve) comb. n., and in forms with secondary growth stimulation it is persistent at the same intensity. 6) Replication

stimuli, on the other hand, may appear later in life, and in the secondary part of the euhaptor, when a lateral dichotomy occurs in the replication axes resulting in more than a single file of clamps on each side. 7) more frequently, replication stimuli are imposed at various levels in the larval haptor, when there is a transverse scission in the formative zone on one or both sides, producing an anterior-posterior dichotomy of the replication axis of one or both sides, forming respectively a unilateral or bilateral metahaptor.

A systematic revision in the light of these findings, and of a reconsideration of the comparative morphology of the clamps, has led to give preference to the latter criteria for the higher taxa, since secondary growth of various degrees in the haptor may have been developed in more than one evolutionary line its characters not being exclusive to those of clamp-type. The outcome is the re-introduction of superfamilies and the elevation of 6 of Bychowsky's 7 families of the sub-order Discocotylinea to superfamily rank. Microcotyloidea (Unnithan 1957) *s. str. emend.* has 3 families: Microcotylidae *s. str.*, Axinidae Unnithan, 1957, and Heteromicrocotylidae Yam. 1963 *s. str. emend.*; Gastrocotyloidea Price 1959, has 4 families: Anthocotylidae Bych. 1957, Opisthogynidae Unnithan 1962, Gastrocotylidae Price 1943 and Gephyrocotylidae Unnithan, 1966. Present detailed revision covers only the families Axinidae, Heteromicrocotylidae, and Gastrocotylidae: some emendations have been made in the definitions of the first, and some new allocations, including the new genus *Axinoa*. Four new subfamilies have been created for the second, and 4 genera are new; the last contains the subfamilies Gastrocotylinae Sproston, 1946, Thoracocotylinae nov., Priceinae *s. str. emend.*, Engraulicolinae nov., and Gotocotylinae nov. considerable rearrangement is suggested and 2 new genera: the total *novae*, 6 subfamilies, 9 genera, 3 spp. n., some 18 new combinations and several orthographical emendations for species and hosts are tabulated among the list of over 107 species reviewed, with their hosts and localities.

Comparative morphology of the clamps suggests that there has been a re-evolution of the sucker type of adhesive unit, but this return to the mode of the Polyopisthocotylinea is structurally a far more complex one in the higher Discocotylinea (even more complex in Hexostomatidae, but two simpler types in Mazocraeidae). Essentially it is an opened clamp in which asymmetrical stresses have distorted the sclerites and brought about a redevelopment of the adductor muscles to form a *framed* acetabulum. The different types of "open-clamp-sucker" are characterized by their mode of distortion and the decreasing number of sclerites contribute to their framework. This has probably evolved independently 6 times in Discocotylinea: a deep muscular cup supported by thick cylindrical simplified jaws and the meridional spring in *Uraxine*; the jaws opening like the hinged lid of a box, the C-shaped rami of both jaws forming the quadrants of the open sucker in species belonging to the Heteromicrocotylinae; but in *Heteromicrocotyle* itself, the sessile clamps have opened rather like a fan, and the spring has a roof-support developed from its expanded end, the ventral jaws forming more than half the frame; while in the series *Lintaxine*, *Amphipolycotyle*, *Thoracocotyle*, *Dawesia* the clamp has opened like a book,

the ventral jaw-rami alone contributing to the frame, the dorsal jaw-rami being jettisoned outside the rim along with the oblique sclerites ; the rib-like thickenings in the capsule wall are only developed in *Thoracocotyle* in this series, but they are incidental to the clamp mechanism in practically all the many genera in which they occur, hence their elimination as a diagnostic criterion of the subfamily Priceinae as originally conceived. The "open-clamp-sucker" in *Diclidophoropsis* appears to be a simple box-lid opening with asymmetrical quadrants framed by the rami of both jaws, but in *Choricotyle* spp. and some *Diclidophora* sensu lato, the highly asymmetrical diclidophorid clamp has become secondarily distorted (see Bychowsky 1957, figs. 303-306) and the abaxial-anterior sucker is framed by the median spring and the abaxial ramus of the ventral jaw.

Secondary growth phenomena in the haptor, combined with the various other peculiarities are considered valid criteria for separating Monogeneoidea from all the rest of Platyhelminthes, and indicative of their very remote ancestry.

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TAXONOMIC STUDIES ON SOME INDIAN SPECIES OF THE GENUS *AGROTIS* OCHSENHEIMER AND ALLIED GENERA (NOCTUIDAE, LEPIDOPTERA)

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(With 24 Text-figures and 2 Plates)

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I—INTRODUCTION

Species of the genus *Agrotis* Ochsenheimer (1816) and allied genera, commonly called the 'Greasy cutworms' or 'Surface cutworms' on account of their caterpillars having greasy appearance and the habit of cutting seedlings near the surface of the soil, are of interest from several points of view. The caterpillars remain hidden just below the surface of soil and cause damage to young agricultural crops and seedlings of different kinds of plantations during the night when they come out of their diurnal hidings. The moths of certain species are migratory in habit and have thus attracted the attention of research workers in a number of countries, such as Egypt (Williams, 1924, 1930), India (Fletcher, 1925; Venkataraman 1954; Kapur, 1955), and Australia (Common, 1958), etc. The species are also of interest as some of them are widely distributed and show remarkable colour variations.

Hampson (1903) gave a detailed account of the species from various parts of the world in his *Catalogue of the Lepidoptera Phalaenae in the collection of the British Museum*. Warren (1909) published a taxonomic revision of the species occurring in the palaearctic region, and the species of the same region were later studied by Corti (1933) and Corti & Draudt (1933). Although Hampson (1903) utilised genitalic characters for the separation of genera grouped under the subfamily Agrotinae (=Noctuinae), he placed greater reliance upon the characters of the spurs and spines of the legs and on the shape of the frons. He clearly stated that in the genus *Euxoa* Hübner (1822), the claspers in the male genitalia were bifurcate, but he disregarded this character in the case of Australian species (*vide*, Common, 1958), and certain palaearctic and Indian species. Corti (1933) was consistent in his use of the genitalic characters and transferred a number of species from *Euxoa* to *Agrotis*. Other important revisionary works on the taxonomy of *Agrotis* and the allied genera, following Corti's monograph, are by Boursin (1954a, 1955 respectively) on the species from China and Nepal and by Common (1958) on the Australian species. The two papers by Boursin include a number of species which also occur in India but the paper by Common includes only one species which occurs both in India and Australia. As far as known to us, detailed studies on the Indian species have not been made in recent years, although the need for the same has been expressed by several workers in the past. Beeson (1941) in his book, "*The Ecology and Control of Forest Insects of India and the Neighbouring Countries*" states (p. 644), "There are several species of cutworms in India but the group has not been critically studied there as it has in other countries and little is known of the identity, distribution and food habits of the various larvae. The name *Agrotis ypsilon* has been generally used to denote a cutworm in the plains of India and the term undoubtedly covers several species." In most other books on agricultural entomology in India, various species of cutworms have been referred to under the generic names *Agrotis* Ochsenheimer, *Euxoa* Hübner, *Amathes* Hübner and *Rhyccia* Hübner as will be seen from the taxonomic account of different species.

II—HISTORICAL ACCOUNT

Cotes & Swinhoe (1887-1889) were the first to prepare a Catalogue of Moths of India wherein they listed 24 species of *Agrotis* Ochsenheimer

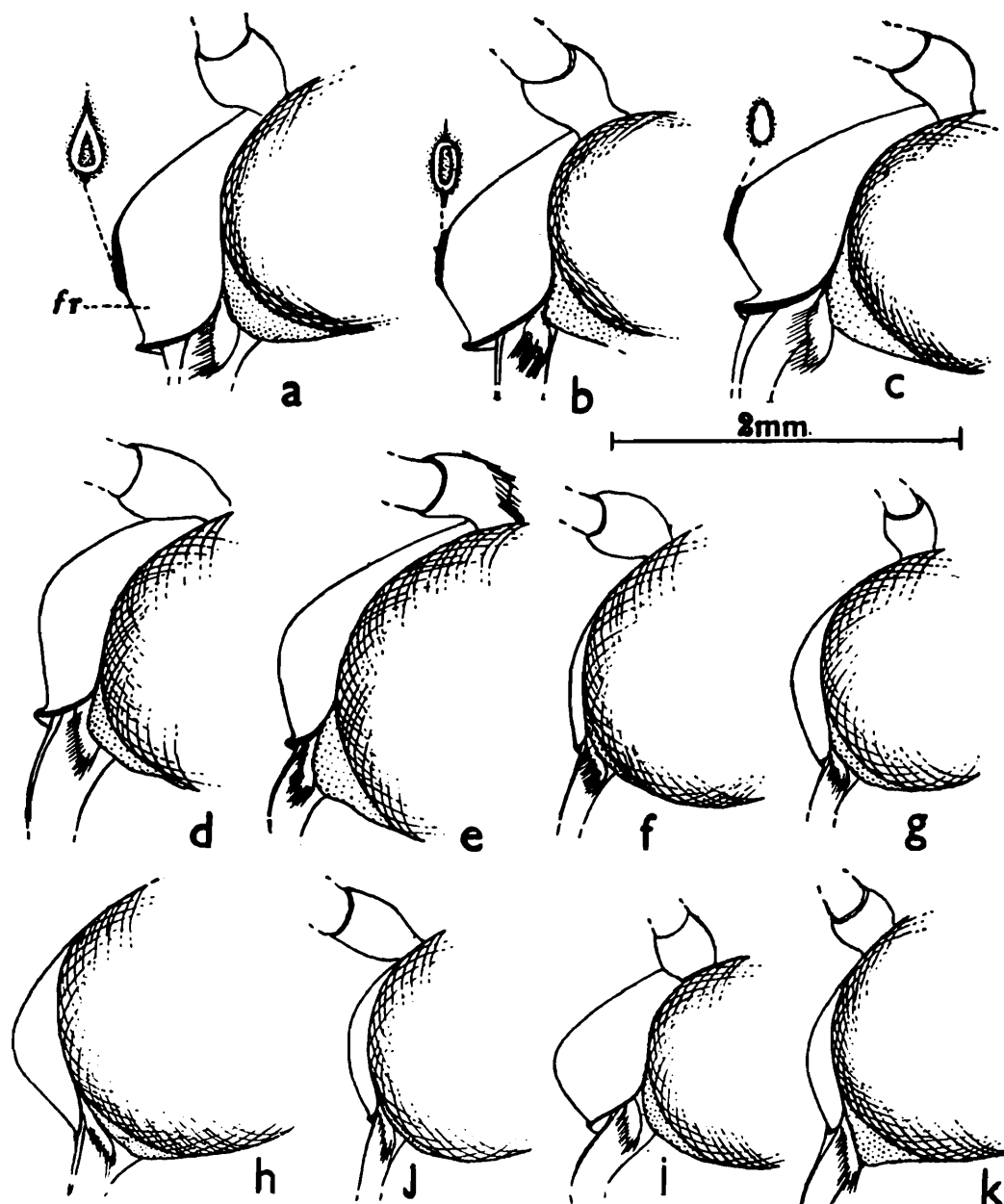
from various parts of India. Hampson (1894) synonymised eight species listed in the above-mentioned catalogue and excluded as many as ten species, thus leaving only six out of the former total of 24 species in the genus *Agrotis*. Hampson (1894), however, included 18 species under the genus *Agrotis* which were referred to by Cotes & Swinhoe under four different genera, viz. *Spaelotis* Boisduval, *Graphiphora* Ochsenheimer, *Ochropleura* Hübner, and *Oxira* Walker. Hampson (1894) also included a number of other Indian species, including four new species, under the genus *Agrotis*, not referred to earlier by Cotes & Swinhoe. He thus raised the total number of recorded Indian species to 35. However, in 1903, Hampson synonymised or transferred 17 species from *Agrotis* to other genera and retransferred to the genus *Agrotis*, ten species which were earlier considered by him (Hampson, 1894) as synonyms, with the result that the genus included at the time only 28 species. Most of the species, transferred from *Agrotis*, were placed in the genus *Euxoa* Hübner, including three well-known species, *A. segetum* (Schiff.), *A. corticea* (Schiff.) and *A. spinifera* (Hübner). This was done in spite of the fact that the male claspers in these species are not bifurcate — a character which Hampson had himself proposed for the genus. Warren (1909) disregarded the name *Agrotis* from his work and proposed the subfamily Euxoinae to include almost all the species previously referred to under the genus *Agrotis*. He placed some of the species under the genus *Euxoa* Hübner, while others were transferred to *Rhyacia* Hübner. Corti (1933), for the most part, accepted the classification given by Hampson (1903) and transferred five species back to *Agrotis*.

Boursin (1954a) studied the species of *Agrotis* and allied genera from China. He dealt with about 70 species, many of which had been referred to earlier under the genus *Agrotis* (*sens. lat.*), while several others, including a few new species, were transferred to eleven known or new genera proposed by him. The paper includes eight Indian species. While Boursin's (1954b) account of the species from Kashmir deals with seven species, including *Agrotis segetum*, that from Nepal (Boursin, 1955) deals with only two species, namely *Amathes c-nigrum deraiota* (Hampson) and *Amathes consanguinea* (Moore).

III — MATERIAL AND METHOD OF STUDY

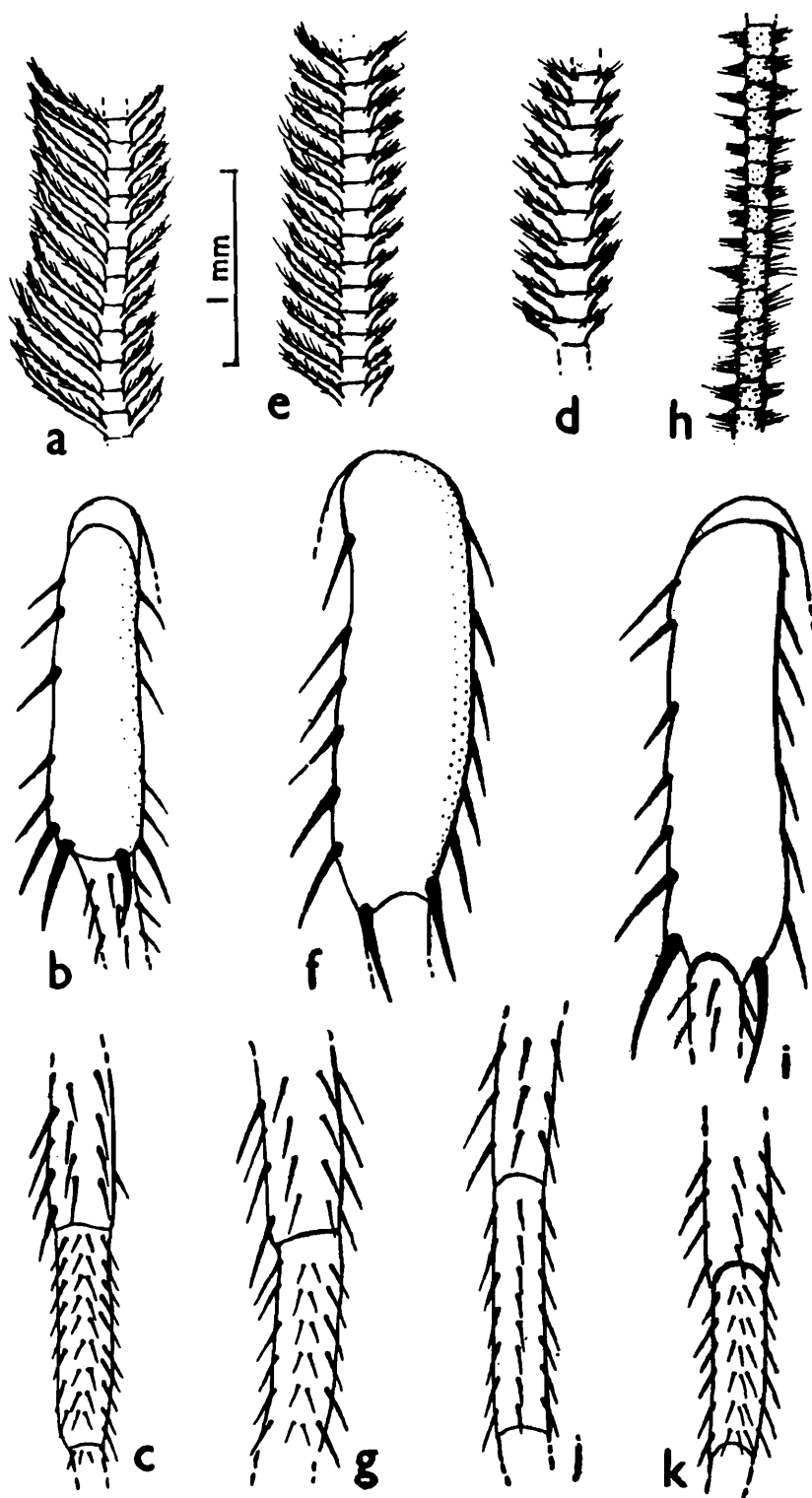
The material before us consists of some 250 specimens belonging to 22 species and four genera, namely, *Agrotis* Ochsenheimer, *Amathes* Hübner, *Diarsia* Hübner and *Chersotis* Boisduval. The material studied is deposited in the National Zoological Collections at the Zoological Survey of India, Calcutta. In addition, material of certain species, available in the entomological collections of the Division of Entomology, Indian Agricultural Research Institute, New Delhi, has been examined. Information on certain species was also obtained from the Entomological Branch, Forest Research Institute, Dehra Dun. We are grateful to Dr. S. Pradhan and Dr. P. N. Chatterjee, of the two institutions mentioned above, respectively, for their cooperation in this study.

Both the external and the genitalic characters have been studied with a view to present, as far as possible, a detailed account of the taxonomy of the species. The characters, which are considered important in this connection are as follows:



TEXT-FIG. 1. Shape of the frons of *Agrotis* and allied genera: (a) *Agrotis segetum* (Schiff.); (b) *A. corticea* (Schiff.); (c) *A. spinifera* (Hübner); (d) *A. ypsilon* (Rott.); (e) *A. flammata* (Schiff.); (f) *A. plecta* (Linn.); (g) *Amathes c-nigrum* (Linn.); (h) *Am. deraiota* (Hampson); (i) *Diarsia sicca* (Guén.); (j) *D. postfusca* (Hampson); (k) *Chersotis triangularis* (Moore).

Frons: The shape of frons varies considerably within a genus; it may be flat, smoothly curved, or produced medially into a light prominence, with or without a raised central structure of variable shape in the different species (Text-fig. 1 a-k). Soaking of frons with toluene or, if necessary, scraping off some of the scales was resorted to for the study of frons.



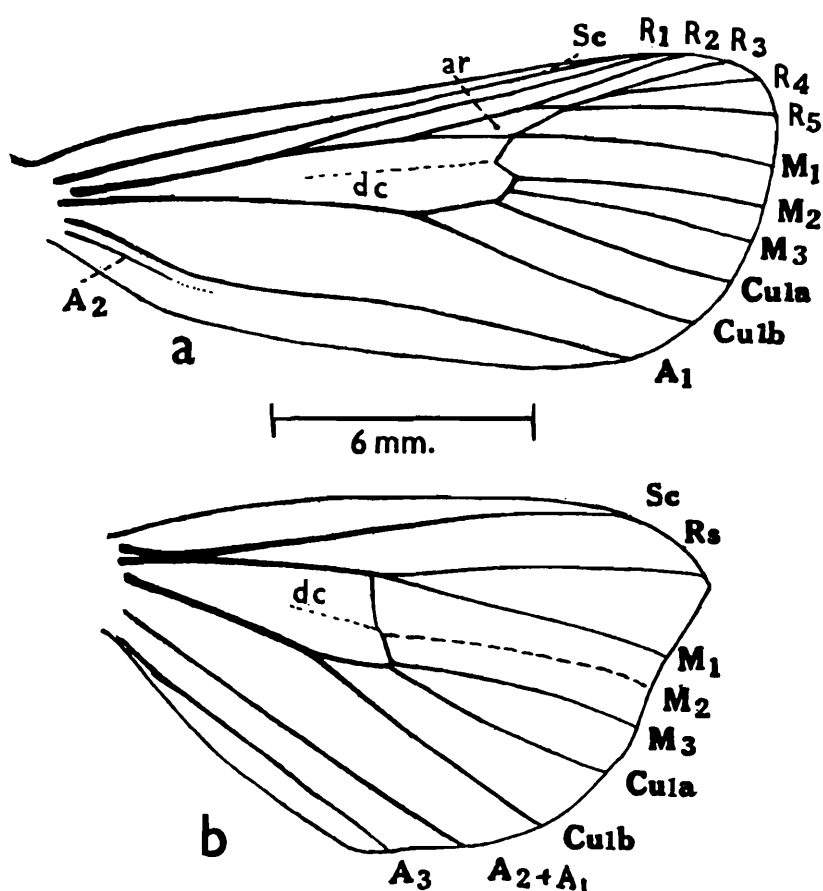
TEXT-FIG. 2. Portion of antennae and legs of the genus *Agrotis*: (a) antenna, (b) fore tibia and (c) hind-tarsal segments of *A. segetum* (Schiff.); (d) antenna of *A. spinifera* (Hübner); (e) antenna, (f) fore tibia and (g) hind-tarsal segments of *A. ypsilon* (Rott.); (h) antenna, (i) fore tibia and (j) hind-tarsal segments of *A. flammatrix* (Schiff.); (k) hind-tarsal segments of *A. plecta* (Linn.).

Antennae: In the male the antennae may be either bipectinate as in *Agrotis segetum* (Schiff.) (Text-fig. 2 a), *A. spinifera* (Hübner) (Text-fig. 2 d), *A. ypsilon* (Rott.) (Text-fig. 2 e), *Diarsia ochracea* (Walker) (Text-fig. 17 a), *D. ruptistriga* (Walker) (Text-fig. 17 f), and

D. postfusca (Hampson) (Text-fig. 17 e), or ciliate or fasciculate as in *Agrotis flammatra* (Schiff.) (Text-fig. 2 h) and *Amathes deraiota* (Hampson) (Text-fig. 13 a). The antennae are wholly simple in the female.

Wing venation: The venation is fairly constant. Typical venation has been described in the case of *Agrotis segetum* (Schiff.) (Text-figs. 3 a-b). It was studied by applying toluene with the help of a fine sable-hair brush. This did not cause any damage to the scales.

Tibial spurs and spines: The tibial spurs and spines, both in respect of their length and number, are useful for generic as well as specific identification. The number of rows of spines on the tarsal segments is also of value in this connection. Toluene was employed for their study, where necessary.



TEXT-FIG. 3. *Agrotis segetum* (Schiff.): (a) fore wing and (b) hind wing venation.

Genitalia: For making genitalic preparations the following method was employed. After a brief study of the external morphology of the abdomen, the whole or, in some cases, the apical half of the abdomen was kept overnight in 10% KOH. If found necessary the period for KOH treatment was prolonged but the material was not treated with hot KOH solution.

After washing thoroughly with distilled water the material was dissected for study and the sketches made. The material was later passed through various grades of alcohol and preserved in 90% alcohol. We have followed Sibatani, *et al.* (1954) and Klots (1956)

in respect of the nomenclature of the genitalia. Important genitalic characters are as follows. In the male genitalia the presence or absence of the harpe, ampulla and clavus may be noted. The shape of the juxta and claspers and the structure of the aedeagus are helpful in distinguishing the genera as well as species. The structure of the female genitalia shows great variety even within the same genus. The signum on the corpus bursae may be present or absent; similarly, in certain species, the sclerotised ribbons inside the corpus bursae may be present. The shape of ostium bursae is also of great help in distinguishing the species in certain cases.

IV — TAXONOMIC ACCOUNT

The subfamily *Agrotinae*, to which *Agrotis* and the allied genera belong, is readily recognised by the obsolescent nature of vein M_2 and the rapid divergence, from the base, of the vein $Sc+R_1$ in the hind-wing; the eyes are usually smooth, but sometimes hairy. The tibial spines vary in size in different genera; these may be present in all the tibiae or absent in one or two tibiae but rarely absent in all the tibiae. For example, the genus *Agrotis* is characterised by the presence of stout and long terminal spines at the distal end of the fore tibiae; in *Amathes* and *Chersotis* the terminal spines of the fore tibia are longer but not stouter than the rest; in *Diarsia* all the spines on the fore tibia are almost equally long and slender. The characters of tibia, together with the number of rows of spines in the middle and hind tibiae are helpful in identifying the genera.

The frons and antennae vary even in the same genus, so that their characters are of little value for the separation of genera. For instance, while certain species of *Agrotis* have pectinate antennae in the males, others have ciliate antennae. In *Diarsia* also both the ciliate and pectinate antennae are found in the males. The same is true of the shape of frons. However, the characters of both the antennae and frons are useful in the identification of species.

The male genitalia is of great importance in recognising the genera as well as the species. Both *Agrotis* and *Diarsia* are characterised by the presence of corona on the claspers, while the corona is absent in *Amathes* and *Chersotis*. The presence of coronal setae along the distal margin of claspers in *Diarsia* is further helpful in differentiating it from *Agrotis*. The clavus and the ampulla are, likewise, useful in separating *Amathes* and *Chersotis*; the ampulla is present and the clavus absent in *Amathes* while the reverse is the case in *Chersotis*. Various characters of the aedeagus and juxta are also useful in the identification of genera.

The female genitalia vary to a greater degree within each genus than is the case with the male genitalia, but these are quite helpful in the identification of the species.

Diagnosis of each genus is given in the respective place where the genus is dealt with. A key to *Agrotis* and the allied genera is given below:

Key to Agrotis and the allied genera

- | | | | |
|--|-----|-----|---------------------|
| 1. Male genitalia with the claspers bifid | ... | ... | <i>Euxoa</i> Hübner |
| Male genitalia with the claspers not bifid | ... | ... | 2 |

2. Fore tibia strongly spined laterally, terminal spines stouter than the rest ; middle and hind tibiae with three rows. Male genitalia with the claspers having corona *Agrotis* Ochsenheimer
- Fore tibia not strongly spined laterally, terminal spines not stouter than the rest ; middle and hind tibiae with two rows of spines. Claspers of the male genitalia with or without corona 3
3. Fore-tibial spines slender, terminal spines not longer than the rest. Claspers in the male genitalia with corona *Diarsia* Hübner
- Fore-tibial spines slender, terminal spines longer than the rest. Claspers in the male genitalia without corona 4
4. Male genitalia with the ampulla present but clavus absent *Amathes* Hübner
- Male genitalia with the clavus present but the ampulla absent *Chersotis* Boisduval

Description of Genera and Species

Genus *Agrotis* Ochsenheimer

1816. *Agrotis* Ochsenheimer, *Die Schmetterlinge von Europa*, 4, p. 66. (Type *Noctua segetum* Schiffermüller).
1816. *Graphiphora* Ochsenheimer, *Die Schmetterlinge von Europa*, 4, p. 68. (Type *Noctua ravidia* Schiffermüller). (For Synonymy see Hampson, 1894, 1903).
1816. *Caradrina* Ochsenheimer, *Die Schmetterlinge von Europa*, 4, p. 80. (Type *C. glareosa* (Esper) (Syn. vide Hampson, 1903).
1822. *Chera* Hübner, *Verz. bek. Schmett.*, p. 211. (Type *C. serratilinea* Ochs). (Syn. vide Hampson, 1894).
1822. *Megasema* Hübner, *Verz. bek. Schmett.*, p. 222. (Type *Megasema triangulum* Hübner) (Syn. vide Hampson, 1903).
1822. *Eugraphe* Hübner, *Verz. bek. Schmett.*, p. 224. (Type *Noctua sigma* Schiffermüller) (Syn. vide Hampson, 1903).
1822. *Ogygia* Hübner, *Verz. bek. Schmett.*, p. 224. (Type *Noctua flammata* Schiffermüller) (Syn. vide Hampson, 1903).
1825. *Axylia* Hübner, *Verz. bek. Schmett.*, p. 242. (Type *A. exsoleta* Linn.) (Syn. vide Hampson, 1894).
1825. *Noctua* Treitschke, *Die schmetterlinge von Europa*, 5, p. 206. (Type *Noctua ravidia* Schiffermüller) (Syn. vide Hampson, 1903).
1840. *Agrotis* Ochs. : Boisduval, *Genera et Index-Meth. Eur. Lep.*, pp. 108-111.
1840. *Spaelotis* Boisduval, *Genera et Index-Meth. Eur. Lep.*, p. 106. (Type *Spaelotis augur* (Fabr.) (Syn. vide Hampson, 1894, 1903).
1847. *Agrotis* Ochs. : Zeller, *Isis*, pp. 439-441.
1852. *Agrotis* Ochs. : Guénee, *Noctuelites-I*, 5, p. 267.
1856. *Agrotis* Ochs. : Walker, *List Lep. Brit. Mus.*, 10, pp. 303-355.
1857. *Dichagyris* Lederer, *Noctua Eur.*, p. 206. (Type *Dichagyris melanura* (Kollar) (Syn. vide Hampson, 1903).
1894. *Agrotis* Ochs. : Hampson, *Fauna Brit. India, Moths*, 2, pp. 180-190.
1903. *Agrotis* Ochs. : Hampson, *Cat. Lep. Phal.*, 4, pp. 363-462.
1909. *Euxoa* Hübner : Warren, *Euxoinae*, in Seitz *Macrolepidoptera of the World*, 3, p. 23. (Syn. "*Agrotis*").
1933. *Agrotis* Ochs. : Corti, *Agrotinae*, in Seitz *Macrolepidoptera of the World*, Suppl. 3, pp. 42-49.

1933. *Agrotis* Ochs. : Corti & Draudt, *Agrotinæ*, in Seitz *Macrolepidoptera of the World*, Suppl. 3, pp. 49-96.
 1954(a). *Agrotis* Ochs. : Boursin, *Bonn. zool. Beitr.*, 5, p. 213.
 1958. *Agrotis* Ochs. : Common, *Aust. J. Zool.*, 6(1), pp. 64-88.

Type of the genus : *Noctua segetum* Schiffermüller from Europe.

Distribution : Universal.

Diagnosis.—Frons without or with a prominence, the latter may be smooth, or truncate, with the edges raised slightly. Antennae bipectinate up to basal half or two-thirds the length, fasciculate or ciliate in the male; wholly simple in the female. Eyes smooth, large, rounded. A well developed ocellus present behind each antenna. Proboscis fully developed. Labial palpi oblique, upturned, the second segment longest, with scales in the front; the third segment porrect, generally without scales. Collar with radiating scales. Fore tibiae smaller than the femur, with a row of spines laterally, those at the extremity stout and long; middle and hind tibiae, which are equal to femur and exceed femur in the length, respectively, have three rows of spines each; the number of rows of spines on the tarsal segments vary from three to four on the first and three to five on other segments; all the segments unequal, gradually decreasing in length from the first to the fifth segment; claws with arolium. Abdomen dorsally rather flattened, clothed with hair and scales at the base and having lateral tufts near its extremity. Fore wings long and narrow, coloured differently in different species; frenulum consisting of a single spine in the male and of two or three spines in the female.

Venation.—The venation is almost constant nearly in all the species studied so far. The following description based on an examination of *A. segetum* (Schiff.) will also apply to the species dealt with here under this genus.

Fore wing (Text-fig. 3a) with areole; Sc free; R_1 from the cell; R_2 from the areole; R_3 arising from R_2 and anastomosed with R_4 to form the areole, both R_3 - R_4 arising from near the point of origin of Radial vein R_5 ; M_1 from upper angle of the cell; M_2 and M_3 arise from above the lower angle of the cell; Cubital vein, Cu_1 arises from the angle; Cu_{1b} from behind the angle; Cu_2 absent; 1A well developed, 2A not anastomosing with the latter. Hind wing (Text-fig. 3b) with the vein Sc free at the base but shortly anastomosing with the cell near its base and thereafter diverging towards apex; Rs and M_1 on a short stalk arising from the upper angle; M_2 obsolescent from the discocellulars; M_3 and Cu_{1a} connate, arising from the lower angle; Cu_{1b} arising from behind the angle; Cu_2 absent; 1A + 2A, 3A present and well developed.

Genitalia.—Claspers not bifid; corona well developed, the setae oblique, present along the distoventral margin. Aedeagus with spinous protuberances or process on the distal part of the vesica. Juxta of variable shape in different species. Female genitalia simple or sclerotised; corpus bursae assuming various shapes, with or without signum in different species.

Remarks.—The present study is based on eight species of the genus, viz., *A. segetum* (Schiffermüller), *A. corticea* (Schiffermüller), *A. spinifera* (Hübner), *A. subspinifera* (Hampson), *A. ypsilon* (Rotten-

The species of this genus have been recorded as serious pests of several crops and are commonly known as 'cutworms'. Majority of them have been reported as pests and are stated to be widely distributed.

Various workers have expressed their opinion with regard to the retention of name "*Agrotis* Ochsenheimer" instead of '*Agrotis* Hübner', with the type as *Noctua segetum* Schiffermüller. Common (1958, p. 70) states as follows in this connection, "Hübner (1806) first used the name *Agrotis* in the combination *Agrotis segetum* in the Tentamen which the International Commission on Zoological Nomenclature has added to the Official Index of Rejected and Invalid Works in Zoological Nomenclature (Opinion, 278). The combination *Agrotis grata* appeared as a *nomen nudum* in Hübner's (1808) 'Erste Zuträge zur Sammlung exotischer Schmetterlinge'. In the text of the 'Zuträge zur Sammlung exotischer Schmetterlinge', Hübner (1818) substituted the name *Elapharia grata*, associating it by number with a plate published earlier than the text. In Hemming's (1937) opinion the plate of Zuträge validated the name *Agrotis grata* listed in the Erste Zuträge, though it was apparently Hübner's intention in the text of Zuträge not to use the name *Agrotis* for this species. The name *Agrotis* was next used by Ochsenheimer (1816) for a group of species including *Noctua segetum*. As the name has been used consistently in this sense for more than a century, it would seem logical to add *Agrotis* Ochsenheimer, 1816, with type *Noctua segetum* to the Official List of Generic Names as suggested by Tams (1939)". The present authors agree with the views expressed by Common and by Tams and have employed the name *Agrotis* Ochsenheimer with *Noctua segetum* Schiffermüller as the type of the genus.

The following keys for recognition of the species dealt with here are based on the material present before us.

1. Antennae bipectinate or serrate,
with the apical portion ciliate
and simple in the males. Fore
wings without a pale costal
fascia 2

- Antennae simple and ciliate throughout in the males. Fore wings with a pale costal fascia ... 6
2. Frons sub-rounded, smooth. Legs with four rows of spines on tarsi. Fore wings with the orbicular elliptical ... *ypsilon* (Rottenburg)
- Frons sub-rounded but produced forward medially, not smooth, with central prominence in the front. Legs with three to four rows of spines on tarsi. Fore wings with the orbicular elliptical, elongate or round ... 3
3. Frons with conical or oblong prominence in the front. Fore wings with the orbicular round ... 4
- Frons with oval prominence in the front. Fore wings with the orbicular elliptical or elongate ... 5
4. Frons with conical prominence in the front ... *segetum* (Schifferrmüller)
- Frons with oblong prominence in the front ... *corticea* (Schifferrmüller)
5. Antennae bipectinate. Fore wings with the orbicular elliptical ... *spinifera* (Hübner)
- Antennae serrate. Fore wings with the orbicular elongate ... *subspinifera* (Hampson)
6. Frons distinctly produced in the front, sub-rounded. Fore wings with the orbicular semi-circular ... *flammatra* (Schifferrmüller)
- Frons not distinctly produced in the front, rather flattened. Fore wings with the orbicular elliptical or round ... 7
7. Orbicular elliptical ... *plecta* (Linn.)
- Orbicular round ... *beesoni* sp. n.

(b) *Based on the male genitalia*

1. Clasper strongly incurved beyond the middle, with its distal part—the cucullus, about half as wide as in the middle; aedeagus with a well developed, long and hard cornuti ... 2
- Clasper straight or excurved beyond the middle, with the distal part—the cucullus, either more than, or as wide as, in the middle; aedeagus with a slender and short cornuti or several short cornutus ... 3

2. Juxta triangular, broad, medially raised into a well developed sac ... *plecta* (Linn.)
 Juxta triangular, narrow, slightly raised medially ... *beesoni* sp. n.
3. Anellus lobes present ; clavus present, glabrous, aedeagus with several spines distally on the vesica ... *segetum* (Schifferrmüller)
 Anellus lobes absent ; clavus indistinct or hairy when present ; aedeagus with either several spines distally, or a single, hard and short cornuti ... 4
4. Clavus indistinct ; aedeagus small, with several spines only distally ... 5
 Clavus indistinct, or hairy when present ; aedeagus large, with single or several spines distally as well as internally on the vesica ... 6
5. Juxta almost spherical and rounded laterally, pointed below ... *corticea* (Schifferrmüller)
 Juxta pentagonal ... *spinifera* (Hübner)
6. Clavus present, hairy, aedeagus without short process distally ... *ypsilon* (Rottenburg)
 Clavus indistinct, glabrous ; aedeagus with a short process distally ... *flammatra* (Schifferrmüller)

(c) Based on the female genitalia

1. Corpus bursae with or without sclerotised ribbons; signum present or absent; receptaculum seminalis separate ... 2
 Corpus bursae with sclerotised ribbons inside it; signum present; receptaculum seminalis not separate ... *plecta* (Linn.)
2. Sclerotised ribbons present in corpus bursae and receptaculum seminalis; corpus bursae without signum ... *subspinifera* (Hampson)
 Sclerotised ribbons absent in both; corpus bursae with or without stripe or signum ... 3
3. Corpus bursae without sclerotised stripe or signum ... 4
 Corpus bursae with either stripe or signum present ... 5
4. Ductus bursae lightly sclerotised, without striations ; corpus bursae and the receptaculum seminalis striated, the latter smaller than corpus bursae ... *flammatra* (Schifferrmüller)
 Ductus bursae unsclerotised, with slight bands; only the corpus bursae slightly striated; receptaculum seminalis longer than corpus bursae ... *corticea* (Schifferrmüller)

5. Ductus bursae lightly sclerotised,
with bands; corpus bursae with
stripes, signum absent *segetum* (Schifferrmüller)
- Ductus bursae unsclerotised, without
bands; signum present, stripes
absent 6
6. Corpus bursae with the signum
complete and oval-shaped; ductus
bursae long *ypsilon* (Rottenburg)
- Corpus bursae with the signum
short and incomplete and elongate;
ductus bursae comparatively short ... *spinifera* (Hübner)

1. *Agrotis segetum* (Schifferrmüller)

(Plate I, Fig. 1 ; Text-figs. 4 a-e)

1776. *Noctua segetum* Schifferrmüller, *Wien. verz.*, pp. 81, 252. (Type loc.—Europe).
1806. *Agrotis segetis* Hübner, *Tentamen*, 2 pp. (*segetis* as type of *Agrotis* Hübner).
1816. *Agrotis segetum* (Schiff.) : Ochsenheimer, *Die schmetterlinge Von Europa*, 4, p. 212.
1826. *Noctua praecox* Hübner, (*nec* Linn.) *Eur. Schmett. Noct.*, p. 77, fig. 359. (Type loc.—Europe) (Syn. of *Euxoa segetis* (Schiff.), *vide* Hampson, 1903).
1826. *Noctua fervida* Hübner, *Eur. Schmett. Noct.*, p. 153, fig. 711. (Type loc.—Europe) (Syn. of *Euxoa segetis* (Schiff.), *vide* Hampson, 1903).
1840. *Agrotis sicala* Boisduval, *Genera et Index-Meth.*, p. 109. (Type loc.—Sicilia, Neopolis) (Syn. of *Euxoa segetis* (Schiff.), *vide* Hampson, 1903).
1847. *Agrotis dimidia* Zell., *Isis*, p. 439. (Type loc.—Sicily) (Syn. of *Euxoa segetis* (Schiff.), *vide* Hampson, 1903).
1852. *Agrotis segetum* (*nec* Schifferrmüller): Guén. *Noctuelites-I.*, 5, p. 275. (Syn. of *Euxoa segetis* (Schiff.), *vide* Hampson, 1903).
1852. *Agrotis sicania* Boisduval : Guén., *Noctuelites-I.*, 5, p. 275. (Type loc.—Sicile) (Syn. of *Euxoa segetis* (Schiff.), *vide* Hampson, 1903).
1856. *Caradrina trituratora* Walker, *List. Lep. Brit. Mus.*, 10, p. 295. (Type loc.—Sierra Leone) (Syn. of *A. segetis* (Schiff.), *vide* Hampson, 1894).
1856. *Agrotis marginalis* Walker, *List Lep. Brit. Mus.*, 10, p. 339. (Type loc.—South Africa). (Syn. of *A. segetis* (Schiff.) and *Euxoa segetis* (Schiff.), respectively, *vide* Hampson, 1894, 1903).
1856. *Agrotis obliuosa* Walker, *List Lep. Brit. Mus.*, 10, p. 340. (Type loc.—Cape, S. Africa) (Syn. of *A. segetis* (Schiff.) and *Euxoa segetis* (Schiff.), respectively, *vide* Hampson, 1894, 1903).
1856. *Agrotis dividens* Walker, *List Lep. Brit. Mus.*, 10, p. 342. (Type loc.—Port Natal) (Syn. of *A. segetis* (Schiff.), *vide* Hampson, 1894).
1856. *Agrotis aversa* Walker, *List Lep. Brit. Mus.*, 10, p. 345. (Type loc.—Punjab) (Syn. of *A. segetis* (Schiff.) and *Euxoa segetis* (Schiff.), respectively, *vide* Hampson, 1894, 1903).
1856. *Agrotis correcta* Walker, *List Lep. Brit. Mus.*, 10, p. 345. (Type loc.—North India). (Syn. of *A. segetis* (Schiff.) and *Euxoa segetis* (Schiff.), respectively, *vide* Hampson, 1894, 1903).
1860. *Agrotis denticulosa* Wallengren, *Wien. ent. Mon.*, 4, p. 168. (Type loc.—Caffraria) (Syn. of *Euxoa segetis* (Schiff.), *vide* Hampson, 1903).
- 1865(a). *Agrotis repulsa* Walker, *List Lep. Brit. Mus.*, 32, p. 696. (Type loc.—South Hindustan) [S. India] (Syn. of *A. segetis* (Schiff.) and *Euxoa segetis* (Schiff.), respectively, *vide* Hampson 1894, 1903).
- 1865(a). *Agrotis certificata* Walker, *List Lep. Brit. Mus.*, 32, p. 697. (Type loc.—Shanghai) (Syn. of *A. segetis* (Schiff.) and *Euxoa segetis* (Schiff.), respectively, *vide* Hampson, 1894, 1903).
1878. *Agrotis ingrata* Butler, *Ann. Mag. nat. Hist.*, (5) 1, p. 162. (Type loc.—Yokohama) (Syn. of *Euxoa segetis* (Schiff.), *vide* Hampson, 1903).

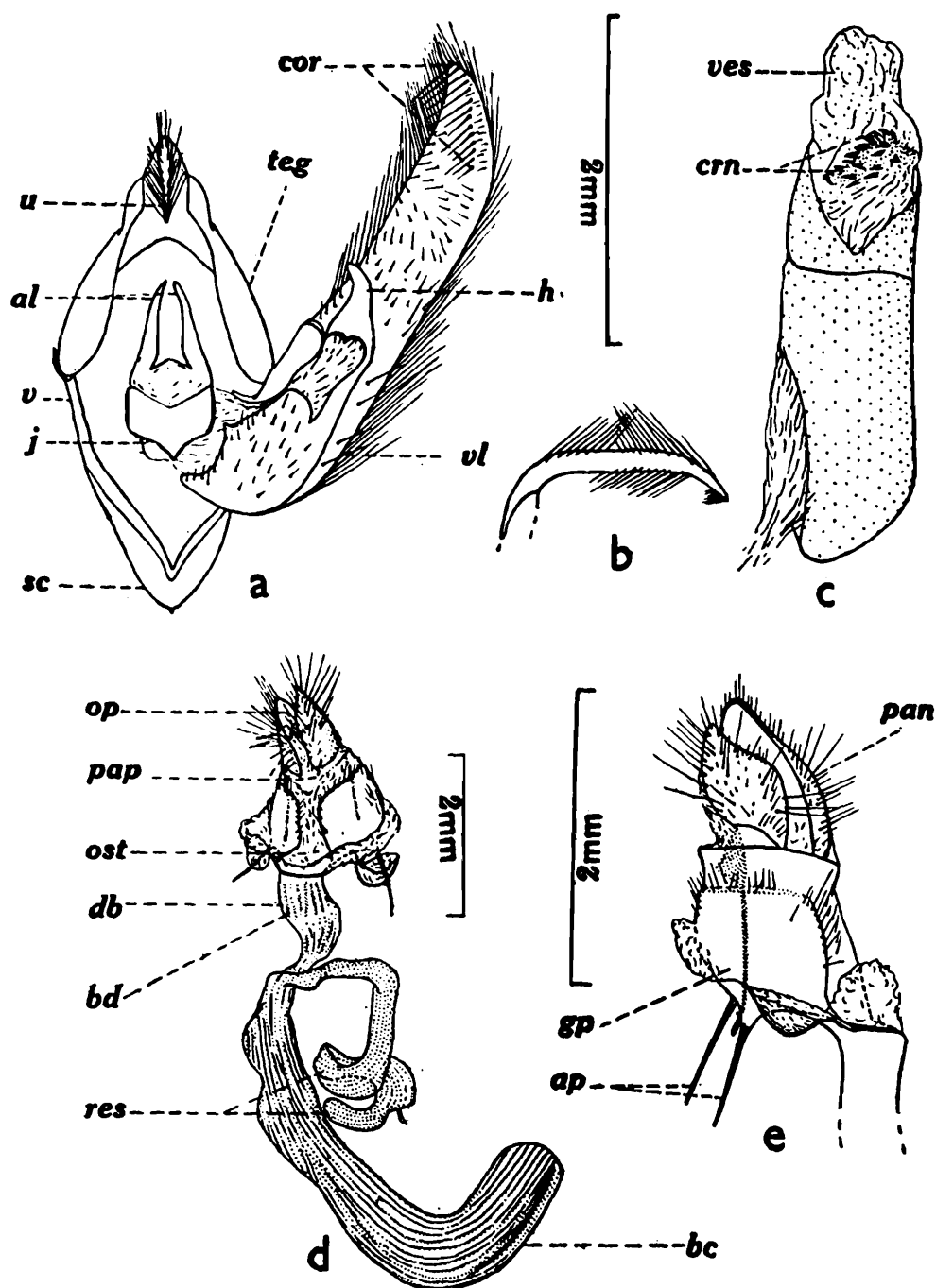
1881. *Agrotis segetum* (Schiff.) var. *pallida* Stgr., *Stett. ent. Zeit.*, p. 423 (Type loc.—Central Asien) (Syn. of *Euxoa segetis* (Schiff.), vide Hampson, 1903).
1881. *Agrotis fucosa* Butler, *Trans. ent. Soc. Lond.*, p. 179. (Type loc.—Tokei, Japan) (Syn. of *Euxoa segetis* (Schiff.), vide Hampson, 1903).
1886. *Agrotis lassa* Swinhoe, *Proc. zool. Soc. Lond.*, p. 444. (Type loc.—Mhow) (Syn. of *A. segetis* (Schiff.) and *Euxoa segetis* (Schiff.), respectively, vide Hampson, 1894, 1903).
1888. *Agrotis segetum* (Schiff.) : Cotes & Swinhoe, *Cat. Moths of India*, p. 309.
1894. *Agrotis segetis* (Schiff.) : Hampson, *Fauna Brit. India, Moths*, 2, p. 181.
1903. *Euxoa segetis* (Schiff.) : Hampson, *Cat. Lep. Phal*, 4, p. 167.
1905. *Euxoa segetis* (Schiff.) : Hampson, *J. Bombay nat. Hist. Soc.*, p. 455.
1909. *Euxoa segetis* (Schiff.) : Lefroy, *Indian Insect Life*, p. 445.
1909. *Euxoa segetum* (Schiff.) : Warren, in Seitz *Macrolepidoptera of the World*, 3, p. 35.
1914. *Euxoa segetis* (Schiff.) : Fletcher, *Some South Indian Insects*, p. 375.
1933. *Agrotis segetis* (Schiff.) : Corti, in Seitz *Macrolepidoptera of the World*, Suppl. 3, p. 43.
1941. *Euxoa segetis* (Schiff.) : Beeson, *Forest Insects*, p. 644.
- 1954(b). *Agrotis segetum* (Schiff.) : Boursin, *Bull. Soc. Fouad Ier entom.*, 38, p. 84.
1955. *Euxoa segetis* (Schiff.) : Lal, *Plant Protect. Bull.*, 7, pp. 2-7, 9, 27, 33.
1963. *Agrotis segetum* (Schiff.) : Singh, *Plant Protect. Bull.*, 11, pp. 5, 7, 30.
1964. *Agrotis segetum* (Schiff.) : Srivastava, *Entomology in India*, p. 85.
1964. *Euxoa segetum* (Schiff.) : Sohi, *Entomology in India*, p. 146.
1964. *Euxoa segetum* (Schiff.) : Mathur & Anand, *Entomology in India*, pp. 273-274.

Head with the frontal tufts and thorax pale brown to brownish ochreous. Antennae brownish. Eyes dark brown. Labial palpi dark on the outer sides. Collar with a dark brown line across. Fore wings pale brown, marked with brownish subbasal, antemedial and postmedial lines across the length; subbasal running straight from the costa to the base of anal vein, slightly interrupted at the cell, the other two lines waved, running from costal to the inner margin; claviform outlined with black; the orbicular and the reniform with brownish boundaries and fuscous centres; the subterminal area fuscous, with pale brown outer line and small dentate dark brown spots from veins R_3 to M_3 ; subterminal line indistinct at costa, brownish below, double and waved; cilia light brownish white. Hind wings whitish, the veins and the outer margin brown; cilia white, shining. Abdomen whitish brown.

Head with the frons (Text-fig. 1 a) produced medially, with a prominent conical structure. Antennae with the shaft having some eighty segments, strongly unequally bipectinate nearly up to basal two-thirds or less, *i.e.* those branches on the inner row long, the longest rami as long as three to four segments, the apical part simple and minutely ciliate; in the female the antennae simple and minutely ciliate. Labial palpi obliquely upturned, the third segment short, porrect. Fore wings with the orbicular round; claviform elongate usually small. Legs with the pair of tibial spurs subequal (Text-figs. 2 b, c), there being one pair on the middle tibiae and two pairs on the hind tibiae; spurs white at the base and the tip; fore tibia with a row of spines present laterally (Text-fig. 2, b), those at the extremity long and stout than the rest; middle and hind tibiae each with three rows of spines; tarsi each with three to four rows of spines. Frenulum consisting of three spines in the female.

Genitalia.—Male (Text-figs. 4a-c) with the uncus long and narrow,

the distal end bent slightly downwards, beset with long hair near the distal part and short setae near the tip; tegumen long and narrow, beset with hairs; vinculum u-shaped; saccus conical. Claspers about four times as long as width at the middle, lightly sclerotised; corona well developed, oblique, along the disto-ventral margin on mesal side; harpe horn-shaped, short and blunt, curved upward; clavus small and



TEXT-FIG. 4. *Agrotis segetum* (Schiff.): (a) male genitalia, ventral view, with the clasper stretched (b) uncus, lateral view (c) aedeagus (d) female genitalia, ventral view (e) Ovipositor and the genital enlarged. (Text-figs. a-c of same magnification).

glabrous; claspers broadest in the middle; costal margin produced basally into a slender, elongated membranous fold. Juxta semi-circular,

with a pointed tip towards the saccus and distally with distinct anellus lobes. Aedeagus short and stout, about four times as long as its width at the middle, with only slight differentiation into the base and the apex, the latter sclerotised and with a cluster of spinous protuberances. Female (Text-figs. 4 d-e) with the ostium bursae simple, the margin sclerotised; ductus bursae short, with sclerotised bands on the lateral and ventral side, leading into long, slender and non-tubular corpus bursae, the latter without signum but striated throughout and with sclerotised stripe on one side; from the point of union of the corpus bursae with the ductus bursae arises receptaculum seminalis which is flattened, irregularly shaped and longitudinally striated; ductus spermathecae arises from the latter and enters into the genital tube to open into common oviduct, the latter opening at the ovopore.

Wing expanse.—Males, 34-40 mm.; females, 34-38 mm.

Distribution.—Throughout India, Burma and Ceylon.

Material examined.—39 examples. INDIA: Himachal Pradesh; Solan, 1 ♂, —.vii. 1887 (*Swinhoe*), Kangra Valley, 2895.55 m. (9500 ft.), 1 ♀, —.vi. 1899, 3 ♂♂, 2 ♀♀, —.vii. 1899 (*G. C. Dudgeon*), Kulu, 1 ♂ (*Young*) [no further data]. Bihar; Champaran, 2 ♀♀, —.viii. 1891 (*L. deNiceville*) (on Indigo), Ranchi, 2 ♀♀ [no further data]. Maharashtra; Mahabaleshwar, 2 ♀♀, —.v. 1887 (*Swinhoe*), Poona, 536.44 m. (1760 ft.), 1 ♀ —.v. 1951 (*S.S.J.E.*), 548.63 m. (1800 ft.), 1 ♂ 26.x.1951 (*S.S.J.E.*), Bombay, 1 ♂, 3.iii.1951 (*S.S.J.E.*), 1 ♂, 14.iii.1951 (*A.E. Bean*), 1 ♂ 19.iii.—(*A.E. Bean*). Mysore; Mysore, 3 ♀♀, 2 ♂♂ [no date of collection] (*R.H. Morris*) (on coffee). Sikkim: 1 ♂, 1 ♀ [no date of collection] (*O. Möller*); 1 ♂, 1 ♀, 15.vii.1888 (*G.C. Dudgeon*).

YARKAUD: 2 ♂♂, 29.v.1874 (Yarkaud Mission, no further data available).

CEYLON: Pundaluoya, 1 ♂, 1 ♀, —.xii.1893, 1 ♂, —.ii.1902; Madulsima, 1 ♂, —.xi.1907, 1 ♀ [no further data] — (all *E.E. Green*); 2 ♂♂ (Colombo Museum) [no further data].

GERMANY: PRUSSIA: 1 ♂, 1 ♀ [no further data].

Host-range.—Bajra (*Pennisetum typhoideum* Rich.): Lal, 1955; Singh, 1963. Beet (*Beta vulgaris* Linn.): Fletcher, 1921. Cabbage (*Brassica oleracea* Linn.): Fletcher, 1914, 1917. Coffee (*Coffea arabica* Linn.): Cotes, 1896; Fletcher, 1914, 1917, 1921; Lal, 1955; Singh, 1963. Cotton (*Gossypium indicum* Lamk.): Sohi, 1964. Gram (*Cicer arietinum* Linn.): Lal, 1955; Singh, 1963; Srivastava, 1964. Indigo (*Indigofera tinctoria* Linn.): Barlow, 1900. Jowar (*Sorghum vulgare* Pers.): Lal, 1955; Singh, 1963. Lesser millets (*Panicum miliare* Linn.): Lal, 1955; Singh, 1963. Maize (*Zea mays* Linn.): Lal, 1955; Singh, 1963. Menthol (*Mentha arvensis* Linn.): Mathur & Anand, 1964. Peas (*Pisum sativum* Linn.): Lal, 1955; Singh, 1963. Potato (*Solanum tuberosum* Linn.): Fletcher, 1914, 1917; Lal, 1955. Sugarcane (*Saccharum officinarum* Linn.): Fletcher, 1921. Tobacco (*Nicotiana tabacum* Linn.): Fletcher, 1921.

Remarks.—Referrable to the genus *Agrotis* Ochsenheimer, it has sometimes been placed under *Euxoa* Hübner, along with two other common species, viz., *A. corticea* and *A. spinifera*, probably, since the publication of Hampson's (1903) catalogue (p. 177). He characterised the species as having pectinate antennae in male with moderate branches up to the basal half, the distal half serrate. These, however, do not

possess "bifurcate claspers". There seems to be no record of studies on the genitalia of this species.

It can be distinguished from the other species by the well defined colour pattern on the wings, especially the rounded orbicular; besides hind wings are semi-hyaline. Its male genitalia are characterised by the elongate lobes of the anellus. In the female genitalia, the ductus bursae is marked with sclerotised bands, corpus bursae is without the signum but there is a sclerotised stripe near the apical part on it.

Boursin (1955) transferred this species to the genus *Scotia* without assigning reason for the same but in the light of work done by Common (1958) there is no doubt it belongs to the genus *Agrotis*.

2. *Agrotis corticea* (Schifferrmüller)

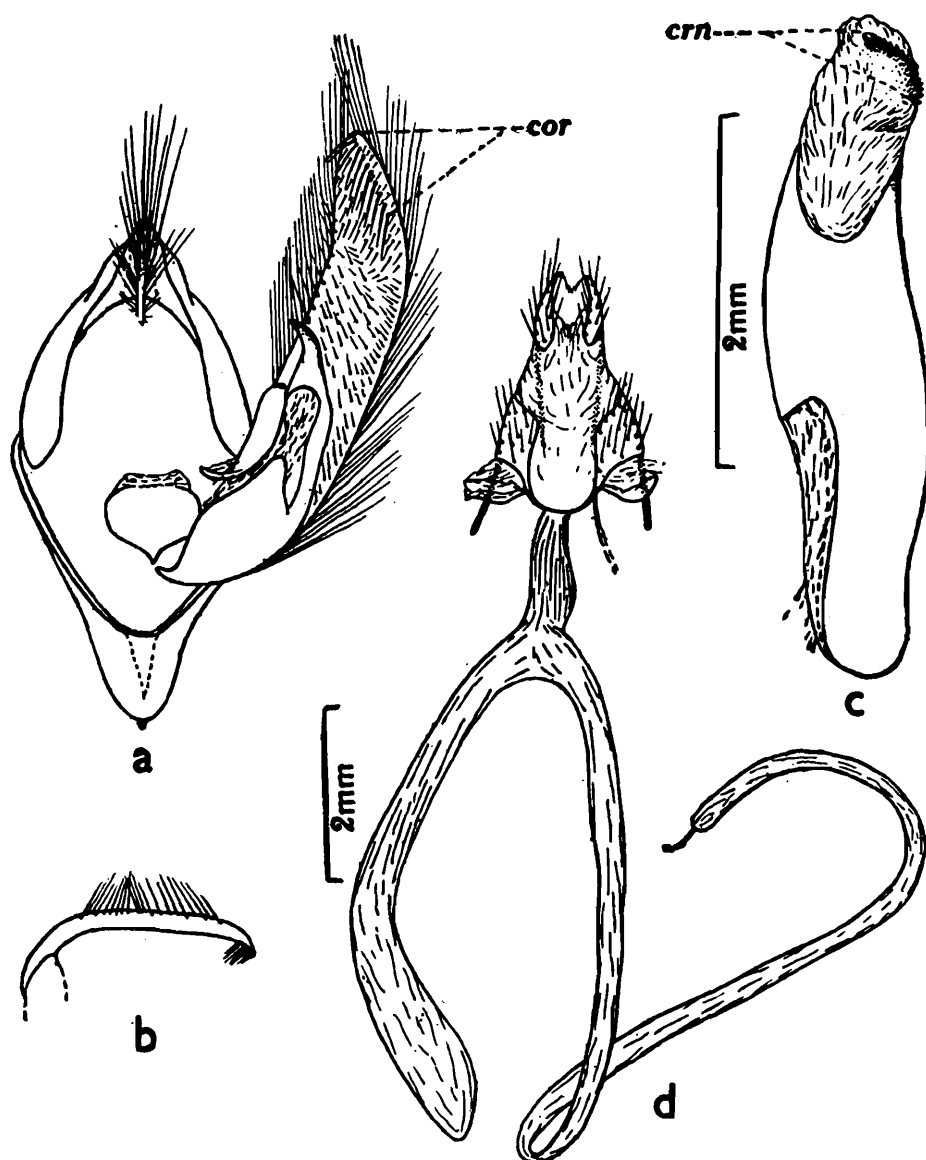
(Plate I, Fig. 2; Text-figs. 1b, 5 a-d)

- 1776. *Noctua corticea* Schifferrmüller, *Wien. Verz.*, p. 81. (Type loc.—Europe).
- 1850. *Agrotis sincerii* Freyer, *Neu. Beitr. Schmett.*, pl. 544, f. 2. (Type loc.—Switzerland) (Syn. of *Euxoa corticea* (Schiff.), vide Hampson, 1903).
- 1852. *Agrotis corticea* (Schiff.), Guénee, *Noctuelites-I*, 5, p. 281.
- 1856. *Agrotis transversa* Walker, *List Lep. Brit. Mus.*, 10, p. 354. (Type loc.—Ignotus) (Syn. of *Euxoa corticea* (Schiff.), vide Hampson, 1903).
- 1858. *Noctua obscura* Freyer, *Neu. Beitr. Schmett.*, pl. 628, ff. 1, 2 (Type loc.—Switzerland) (Syn. of *Euxoa corticea* (Schiff.), vide Hampson, 1903).
- 1891. *Agrotis corticea* (Schiff.) : Hampson, *Ill. Lep. Het. Brit. Mus.*, 8, p. 14.
- 1892. *Agrotis amurensis* Staudinger, *Rom. Mem.*, 6, p. 421. (Type loc.—Amur, U.S.S.R.) (Syn. of *Euxoa corticea* (Schiff.), vide Hampson, 1903; Warren, 1909).
- 1894. *Agrotis corticea* (Schiff.) : Hampson, *Fauna Brit. India, Moths*, 2, p. 181.
- 1903. *Euxoa corticea* (Schiff.) : Hampson, *Cat. Lep. Phal.*, 4, p. 172.
- 1905. *Euxoa corticea* (Schiff.) : Hampson, *J. Bombay nat. Hist. Soc.*, 16, p. 455.
- 1909. *Euxoa corticea* (Schiff.) : Lefroy, *Indian Insect Life*, p. 445.
- 1909. *Euxoa corticea* (Schiff.) : Warren, in Seitz *Macrolepidoptera of the World*, 3, p. 26.
- 1933. *Agrotis corticea* (Schiff.) : Corti, in Seitz *Macrolepidoptera of the World*, Suppl. 3, p. 44.

Head with the frontal tufts dark brown, mixed with blackish scales. Antennae dark brown. Labial palpi blackish brown on the outer sides, paler below, at the tips and on the inner side. Vertex and the collar dark brown, mixed with darker scales, the latter marked across the middle by a curved blackish brown line, the basal area paler. Thorax dark brown. Fore wings brown; stigmata less prominently outlined by dark brown lines; orbicular and reniform with pale annuli; the antemedial lines darker, interrupted in the middle by pale scales; the postmedial lines brown, rather poorly marked and almost like the ground colour; the area beyond the postmedial and up to the submarginal line pale brown, marked across by numerous striae of pale brown to brown colour; submarginal area brown, with the terminal line darker; the terminal series of dots almost of the same colour as the terminal line; cilia darker at the base than in the middle and at the tip. Hind wings with the veins and the submarginal line pale brown; cilia pale brown, darker in the middle. Legs darker than those in *A. segetum* (Schiff.) but with whitish band like in *A. segetum*, at the end of each segment of the tarsus and the tibial spur, the latter whitish at the base also. Abdomen pale brown.

Head with the frons (Text-fig. 1 b) sub-rounded, with an oblong scar

in the middle. Antennae bipectinate in the male, simple in the female. Labial palpi well developed, obliquely upturned, the second segment with projecting scales below and slightly in the front, the third segment porrect, slender. Fore wings with the stigmata almost as in *A. segetum* (Schiff.) except that claviform more elongate, orbicular usually small and round, the reniform slightly angled inwards at its lower extremity on the median nervure; antemedial lines double, not reaching costa; postmedial line double, dentate on the inner side; a series of dentate spots on terminal line present in between each vein, from apex to below vein Cu_1 , or along the termen. Legs with the tibial spines, the spurs and the rows of tarsal spines as in *A. segetum* (Schiff.).



TEXT-FIG. 5. *A. corticea* (Schiff.): (a) male genitalia, ventral view (b) uncus, lateral view (c) aedeagus (d) female genitalia, ventral view (Text-figs. a-c of same magnification).

Genitalia.—Male (Text-figs. 5 a-c) with the uncus, tegumen, vinculum and the claspers more or less similar to *A. segetum* (Schiff.). The claspers, however, more elongate, slightly raised in the middle and beset with fine, cream-white, long hairs; corona oblique, present

mesally on the disto-ventral margin. Juxta almost spherical, without lobes. Aedeagus stout, slightly widened between the base and the short distal part, the latter with the vesica protruded and beset with short spines. Female (Text-fig. 5 d) simple. Ostium bursae leading through unsclerotised ductus bursae, the latter with bands, into a long tubular corpus bursae which is broader proximally and without signum or sclerotised bands; the receptaculum seminalis long and tubular.

Wing expanse.—Male, 31 mm.; Female, 33 mm.

Distribution.—Reported as occurring in Europe and many states of India, (Hampson, 1903, p. 176) such as Kashmir, Himachal Pradesh, Punjab, Assam and Madras; also Sikkim.

Material examined.—3 examples. SIKKIM: 1523.98 m. (5000 ft.), 1 ♂, 28.ii.1887, 1 ♀ —.ix.1888 (G.C. Dudgeon); 2133.57 m. (7000 ft.), 1 ♂, —.iv.1890 (O. Möller).

Host range.—Lefroy (1909) recorded it as a 'pest in India'

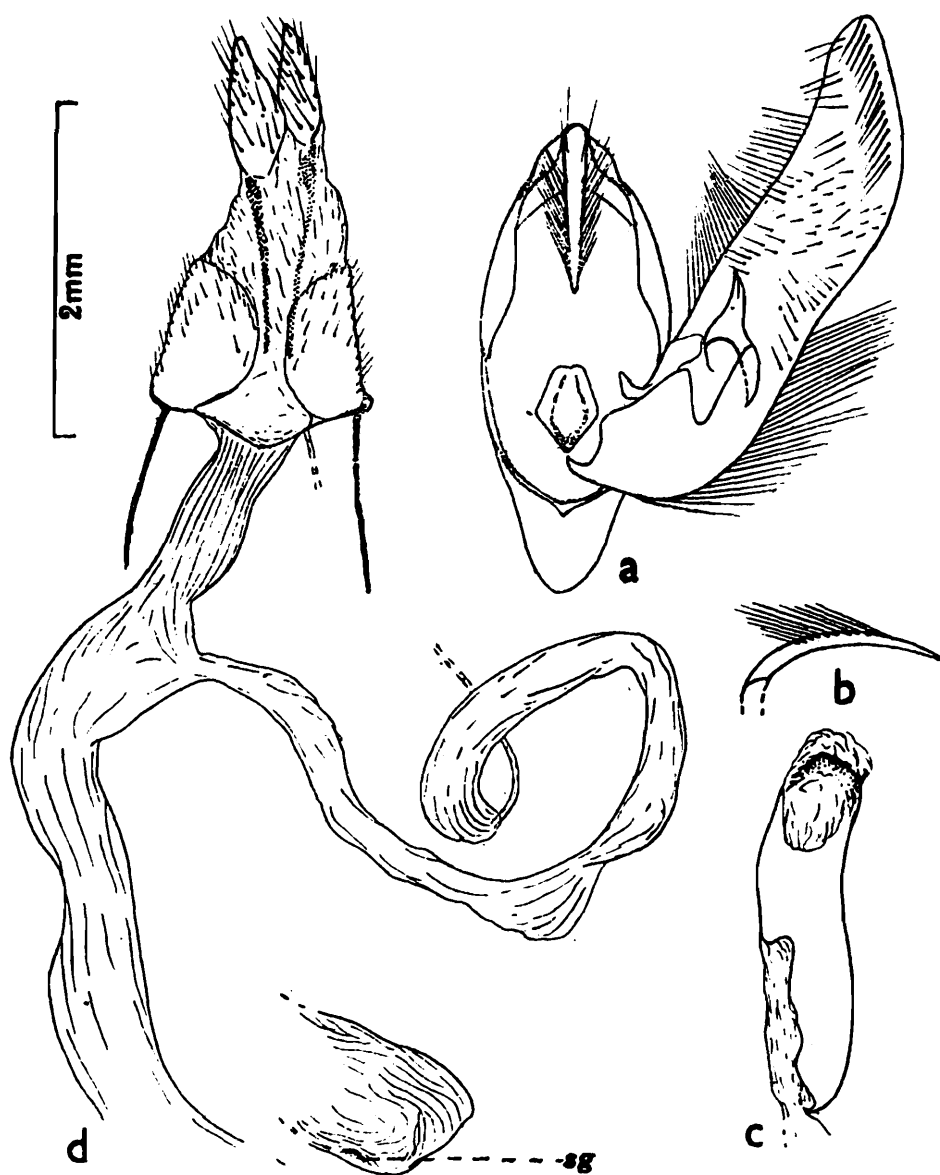
Remarks.—Referrable to the genus *Agrotis* Och., it is less common than *A. segetum* (Schiffermüller), in India. It closely resembles *A. segetum* in the shape of frons, but can be readily distinguished from it by the wings, especially the hind wings which are pale brown and not white and hyaline, as in *A. segetum*; the claviform in the fore wing also long. In the male genitalia the lobes of the anellus are absent, unlike the case in *A. segetum*. In the female genitalia sclerotised bands on the ductus bursae are absent; the corpus bursae and receptaculum seminalis are more or less tubular; the corpus bursae without signum, or sclerotised stripe unlike the case in *A. segetum* (Schiff.).

3. *Agrotis spinifera* (Hübner)

(Text-figs. 1c, 2d, 6 a-d)

- 1826. *Noctua spinifera* Hübner, *Eur. Schmett. Noct.*, p. 83. (Type loc.—Europe).
- 1827. *Telmia spinula* Hübner, *Verz. bek. Schmett.*, p. 288. (Syn. of *Euxoa spinifera* (Hübner), *vide* Hampson, 1903).
- 1848. *Agrotis biconica* Kollar, in C. F. Von Hugel's "*Kaschmir und das Reich der Sick*", 4, p. 480. (Type loc.—Kashmir) (Syn. of *Euxoa spinifera* (Hübner), *vide* Hampson, 1903).
- 1848. *Agrotis exigua* Kollar, in C.F. Von Hugel's "*Kaschmir und das Reich der Sick*", 4, p. 481. (Type loc.—Kashmir) (Syn. of *Agrotis biconica* Kollar and *Euxoa spinifera* (Hübner), *vide* Hampson, 1894, 1903, respectively).
- 1852. *Agrotis spinifera* (Hübner) : Guénee, *Noctuelites-I*, 5, p. 265.
- 1852. *Agrotis speculifera* Guén., *Noctuelites-I*, 5, p. 266. (Type loc.—Sicily) (Syn. of *Agrotis biconica* Kollar and *Euxoa spinifera* (Hübner), *vide* Hampson, 1894, 1903, respectively).
- 1852. *Agrotis aristifera* Guén., *Noctuelites-I*, 5, p. 266. (Type loc.—Inde-Centrale) (Syn. of *Agrotis biconica* Kollar and *Euxoa spinifera* (Hübner), *vide* Hampson, 1894, 1903, respectively).
- 1874. *Agrotis ferina* Felder and Rogenhofer, *Reise Novara*, pl. 110, fig. 12. (Type loc.—S. Africa) (Syn. of *Euxoa spinifera* (Hübner), *vide* Hampson, 1903).
- 1878. *Agrotis hodnae* Oberthur, *Et. Ent.*, 3, p. 45, pl. 5, fig. 8. (Type loc.—Algeria) (Syn. of *Euxoa spinifera* (Hübner), *vide* Hampson, 1903).
- 1882. *Agrotis spinifera* (Hübner) : Kirby, *European Butterflies and Moths*, p. 204.
- 1888. *Agrotis aristifera* Guén. : Cotes and Swinhoe, *Cat. Moths of India*, p. 306.
- 1891. *Agrotis biconica* Koll. : Hampson, *Ill. Lep. Het. Brit. Mus.*, 8, p. 7.

1894. *Agrotis biconica* Koll. : Hampson, *Fauna Brit. India, Moths*, 2, p. 182.
 1900. *Agrotis biconica* Koll. : Swinhoe, *Cat. East & Aust. Lep.*, pt. II, p. 7.
 1901. *Agrotis spinifera* (Hübner) : Staud., *Cat. Lep. Palaearc.*, p. 417.
 1903. *Euxoa spinifera* (Hübner) : Hampson, *Cat. Lep. Phal.*, 4, p. 177.
 1905. *Euxoa spinifera* (Hübner) : *J. Bombay nat. Hist. Soc.*, 16, p. 456.
 1909. *Euxoa spinifera* (Hübner) : Lefroy, *Indian Insect Life*, p. 445.
 1909. *Euxoa spinifera* (Hübner) : Warren, in Seitz *Macrolepidoptera of the World*, 3, p. 27.
 1921. *Euxoa spinifera* (Hübner) : Fletcher, *Proc. 3rd Ent. Mtg., Bull.*, 100, p. 23.
 1933. *Agrotis spinifera* (Hübner) : Corti & Draudt, in Seitz *Macrolepidoptera of the World*, Suppl. 3, p. 52.
 1941. *Euxoa spinifera* (Hübner) : Beeson, *Forest Insects*, p. 644.
 1955. *Agrotis spinifera* (Hübner) : Lal, *Plant Protect. Bull.*, 7, p. 36.
 1963. *Agrotis spinifera* (Hübner) : Singh, *Plant Protect. Bull.*, 11, pp. 7, 34.
 1964. *Agrotis spinifera* (Hübner) : Srivastava, *Entomology in India*, p. 85.
 1964. *Euxoa spinifera* (Hübner) : Sohi, *Entomology in India*, p. 146.



TEXT-FIG. 6. *A. spinifera* (Hübner) : (a) male genitalia, ventral view (b) uncus, lateral view (c) aedeagus (d) female genitalia, ventral view (Text-figs. a-c of same magnification).

Head and thorax grey white, mixed with pale brown and black scales. Frontal tufts brown. Antennae brown. Labial palpi dark brown on the outer sides, whitish at the tips and inner side. The collar with a very faint dark line across the middle, unlike *A. segetum* (Schiffermüller) where it is well marked. Fore wings at the base and along the costa, mixed with dark scales; the stigmata generally marked by a dark boundary; the claviform elongate, with dark brown centre, reaching vein Cu_{1+2} ; the orbicular and the reniform with brownish centre and with ochreous annuli; the former elliptical, with its posterior end produced into a point, often open above; the cell filled up, partly, with dark brown scales between the stigmata; the subbasal, antemedial and the postmedial lines faint; the area beyond the postmedial line pale, marked with elongated triangular dark brown patches up to the terminal line; the terminal series of dark brown triangular spots present; the cilia pale brown at the base and a dark brown band across it. Hind wings semihyaline white, with brownish tinge on the inner margin, veins and terminal line; the upper margin with shining brownish scales, grizzled all along the costa up to the apex. Abdomen pale brown. The legs with the tarsal segments and the spines coloured as in *A. segetum*; the tibial spurs and the tibiae pale on the inner side. Under side with the wings shining whitish to pale brown.

Head with the frons sub-rounded, with a small nearly oval scar. The antennae, about 75-80 segmented, bipectinate, with unequal short rami in the male, up to nearly two-thirds from the base, the distal part simple; the rami very short, the longest not exceeding the length of two segments in the middle of shaft; antennae wholly simple in the female. Labial palpi obliquely upturned, the second segment with projecting scales in front, the third segment porrect. The legs with the rows of tarsal spines as in *A. segetum* (Schiff.)

Genitalia.—Male (Text-figs. 6 a-c). More or less similar to *A. segetum* (Schiff.) from which it can be easily differentiated by the claspers which are about five times as long as the width at the middle and by harpe which is slightly shorter. Juxta pentagonal, with the base pointed downwards but without lobes. The aedeagus not differentiated into the base and the apex, the latter with its vesica protruded and spined. Female (Text-fig. 6 d) with the ostium bursae simple; the ductus bursae without sclerotised bands; the corpus bursae with an incomplete and elongate signum.

Wing expanse.—Males, 26.5-28 mm.; females, 27.5-36 mm.

Distribution.—India; Kashmir, Himachal Pradesh, Delhi, Uttar Pradesh, Rajasthan, Madhya Pradesh, Bihar, Bengal, Assam, Orissa, Andaman & Nicobar Is., Maharashtra, Mysore and Madras; Sikkim & Bhutan.

Besides the above, Hampson (1903) recorded it from the following localities: S. France; Spain; Italy; Sicily; Canaries; Algiers; Egypt; Eritrea; British East Africa; Mashonaland; Transvaal; Natal; Basutoland; Cape Colony; Syria; Persia; Ceylon; and Burma.

Material examined.—27 examples. INDIA: Himachal Pradesh; Solan, 1 ♀ [no date of collection] (*Swinhoe*), Kangra Valley, 1371.58 m. (4500 ft.), 1 ♀, —iv.1899 (*G. C. Dudgeon*), Kulu, 1 ♀ [no date of collection] (*Young*). Rajasthan; Sardarshahr, 1 ♀, —i.1957, 2 ♂♂,

15.v.1958, 3.viii.1958 (*T. G. Vazirani*), Dt. Bikaner, Lunkaransar, 1 ♀, 28.ix.1960 (*M. Chander*), Dt. Jaisalmer, 1 ♀, 29.viii.1960 (*B. Biswas*). Madhya Pradesh; Mhow, 2 ♂♂ [no date of collection] (*Swinhoe*). West Bengal; Calcutta, Behala, 1 ♀, 25.xi.1965 (*G. S. Arora*). Maharashtra; Poona, 1 ♀, 9.xi.1951, Bombay, 1 ♂, —.xii.1950, 1 ♀, 9.i.1951, 1 ♀, 19.iii.1951 (all *S.S.J.E.*). Sikkim: 548.63 m. (1800 ft.), 1 ♂, 2 ♀♀, —.vi.1896, —.iv, vi.1897 (*G. C. Dudgeon*).

CEYLON: Colombo, 1 ♂, —.viii.1912, 2 ♂♂, —.ii.1905, Kandy, 1 ♀, —.x.1906, 1 ♀, —.v.1907, 1 ♀, —.x.1907, Mahallupalama, 1 ♂, 1 ♀, —.viii.1900 (all *E. E. Green*).

PAKISTAN: Karachi, 1 ♀, [no date of collection] (*Karachi Mus.*).

Host range.—Cotton (*Gossypium indicum* Lamk.): Burt 1918; Fletcher, 1921; Sohi, 1964. Gram (*Cicer arietinum* Linn.): Fletcher, 1921; Chopra, 1928; Singh, 1963; Srivastava, 1964. Peas (*Pisum sativum* Linn.): Singh, 1963. Grasses: Fletcher, 1917, 1921. Indigo (*Indigofera tinctoria* Linn.): Barlow, 1900, 1903. Poppy (*Papaver somniferum* Linn.): Fletcher, 1917; Lal, 1955; Singh, 1963.

Remarks.—Referrable to the genus *Agrotis* Ochsenheimer by the typical characters of stout and longer tibial spines and well-developed corona on the claspers in the male genitalia. It resembles closely both *A. segetum* (Schiff.) and *A. corticea* (Schiff.) in as far as the pectination of antennae in the males and the structure of frons are concerned. But the length of rami is comparatively shorter here than in *A. segetum* (Schiff.); the frontal scar nearly oval, unlike in the preceding species. Fore wings with the stigmata, especially the orbicular and the claviform, different from the preceding species, the former elliptical, often open above, the latter long and slender. Hind wings with the veins drawn. Hampson (1903) classified it under a separate subgroup which he characterised as having "Antennae bipectinate with short fasciculate branches, the apical, part serrate", whereas the antennae, in the male, in the latter part are not serrate but simple and ciliate, the pectination confined only up to the basal half.

The structure of the male genitalia is more like that of *A. segetum* (Schiff.) except that the anellus lobes are absent here as in *A. corticea* (Schiff.). The female genitalia are with an incomplete signum on the corpus bursae but without sclerotised lines or bands; the ductus bursae without bands, unlike the case in *A. segetum* (Schiff.).

4. *Agrotis subspinifera* (Hampson) comb. nov.

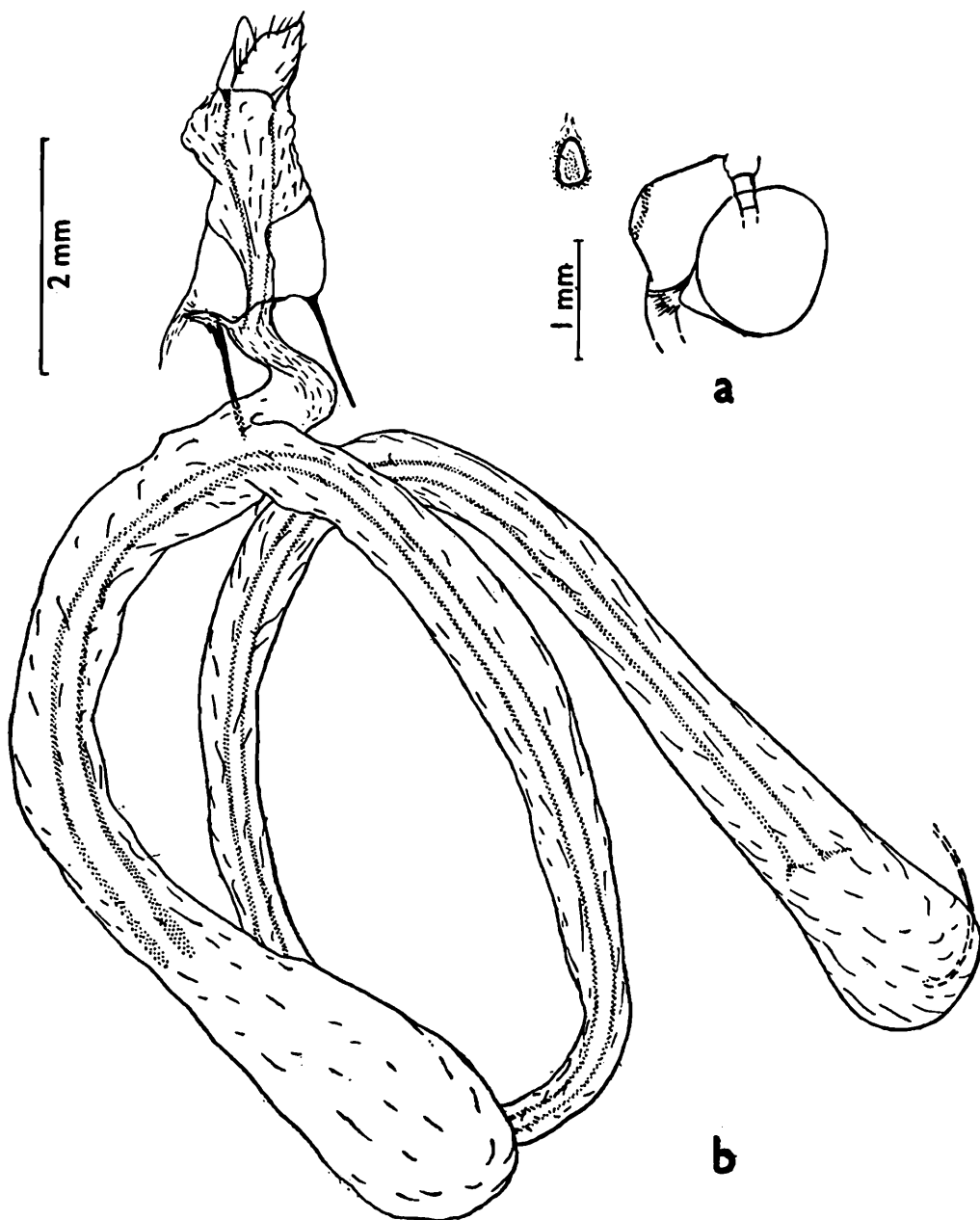
(Plate II, Fig. 1; Text-fig. 7)

1903. *Euxoa subspinifera* Hampson, *Cat. Lep. Phal.*, 4, pp. 205-206, pl. LXI, fig. 19, ♂ (Type loc.—Punjab, Ferozepur).

Head with the frontal tufts, thorax and abdomen ochreous, mixed with white scales. Labial palpi ochreous, mixed with dark scales on the outer side, paler below and on the innerside. Fore wings whitish, suffused with light brown above; costa, at the base and apex, irrorated with patches of dark scales which are continued along the outer margin up to tornus; the claviform very long, light brown in the centre and defined by dark scales; the orbicular long, open above and confluent with the reniform, defined by dark lines; veins beyond

the cell with slightly dark streaks; a subterminal line represented by white lunules from the apical margin to vein Cu_{1b} and defined by dark scales on both the sides, curved inwards in the middle and outwards at vein R_5 , the terminal series represented by dark patches, or lunules, followed by ochreous cilia through which passes a dark line. Hind wings white; the veins ochreous; the terminal line darker. Under side with the head, thorax and abdomen ochreous and the fore wings ochreous mixed with white scales and the hind wings white.

Head with the frons slightly sub-rounded, with a medial conical scar. The antennae simple, ciliate and about half the length of costa. The labial palpi well developed, obliquely upturned, the third segment correct. The hind wings with two frenulum spines. The legs with the tibiae and tarsi each with three rows of spines.



TEXT.-FIG. 7. *A. subspinifera* (Hampson): (a) the shape of frons, lateral view (b) female genitalia, ventral view.

Genitalia.—(Text-fig. 7) Ostium bursae simple, leading through

unsclerotised ductus bursae into a long and narrow corpus bursae, the end of which is enlarged and rounded; corpus bursae simple and without signum or stripes; receptaculum seminalis, meets at the point of union of corpus bursae with the ductus bursae, which is also extremely long being about three times as long as the corpus bursae, two lightly sclerotised ribbons running throughout the length of corpus bursae and receptaculum seminalis.

Wing expanse.—Females, 37-38 mm.

Distribution.—India; Punjab (Ferozepur), Rajasthan (Sikar).

Material examined.—Two examples. INDIA: Rajasthan, Sikar ♀ ♀, 10.xi.1960 (M. Chandra).

Remarks.—The males are not present with us at the time of study and have been described in details by Hampson (1903). From the females, the male can be differentiated by the antennae which are "strongly serrate & fasciculate" Easily referable to the genus *Agrotis* Ochs., on account of the stout fore tibial spines and a well-marked conical scar on the frons. It bears a strong resemblance with *A. spinifera* (Hübner) in coloration. In respect of the structure of the female genitalia it bears a close resemblance to *Agrotis corticea* (Schiff.) especially in the absence of signum on the corpus bursae and in the length of receptaculum seminalis. It appears to be an intermediate species between *A. corticea* (Schiff.) and *A. spinifera* (Hübner); it differs from the latter by the absence of the signum and from both the species by the presence of the sclerotised ribbons in corpus bursae.

Hitherto recorded only from the Punjab (Type loc.—Ferozepur), it is recorded here from the neighbouring State of Rajasthan for the first time.

5. *Agrotis ypsilon* (Rottenburg)

(Plate I, Fig. 3; Text-figs. 1d, 2 e-g, 8 a-d)

- 1776. *Noctua ypsilon* Rottenburg, *Naturf.*, 11, p. 141.
- 1776. *Noctua suffusa* Schiffermüller, *Wien. Verz.*, p. 80. (Syn. of *A. ypsilon* (Rott.), vide Hampson, 1894).
- 1782. *Phalaena idonea* Cramer, *Papil. Exot.*, 3, pl. 275 H. (Syn. of *A. ypsilon* (Rott.), vide Hampson, 1894).
- 1852. *Noctua robusta* Blanch., *Gay's Chile*, p. 75, pl. 6, fig. 9. (Type loc.—Chile) (Syn. of *A. ypsilon* (Rott.), vide Hampson, 1903).
- 1856. *Agrotis bipars* Walker, *List Lep. Brit. Mus.*, 10, p. 334. (Type loc.—Venezuela) (Syn. of *A. ypsilon* (Rott.), vide Hampson, 1903).
- 1860. *Agrotis frivola* Wallengren, *Wien. ent. Mon.*, 4, p. 169. (Type loc.—Montevideo) (Syn. of *A. ypsilon* (Rott.), vide Hampson, 1903).
- 1882. *Agrotis ypsilon* (Rott.): Kirby, *European Butterflies and Moths*, p. 205.
- 1888. *Agrotis suffusa* (Schiff.): Cotes & Swinhoe, *Cat. Moths of India*, p. 309.
- 1894. *Agrotis ypsilon* (Rott.): Hampson, *Fauna Brit. India, Moths*, 2, p. 182.
- 1900. *Agrotis ypsilon* (Rott.): Swinhoe, *Cat. East. & Aust. Lep. Het.*, Part II, p. 8.
- 1903. *Agrotis ypsilon* (Rott.): Hampson, *Cat. Lep. Phal.*, 4, p. 368.
- 1909. *Agrotis ypsilon* (Rott.): Lefroy, *Indian Insect Life*, p. 445.
- 1909. *Agrotis ypsilon* (Rott.): Warren, in Seitz *Macrolepidoptera of the World*, 3, p. 37, pl. 8c.
- 1917. *Agrotis ypsilon* (Rott.): Fletcher, *Rep. & Proc. 2nd. Ent. Mtg.*, pp. 8, 48, 79, 205, 269, 273, 278-284, 297.
- 1921. *Agrotis ypsilon* (Rott.): Fletcher, *Proc. 3rd. Ent. Mtg.*, Bull. 100, p. 24.
- 1933. *Agrotis ypsilon* (Rott.): Corti & Draudt, in Seitz *Macrolepidoptera of the World*, Suppl. 3, p. 43.
- 1941. *Agrotis ypsilon* (Rott.): Beeson, *Forest Insects*, pp. 644-645.
- 1945. *Rhyacia (Agrotis) ypsilon* (Rott.) Sevastopulo, *J. Bengal nat. Hist. Soc.*, 19, p. 120.

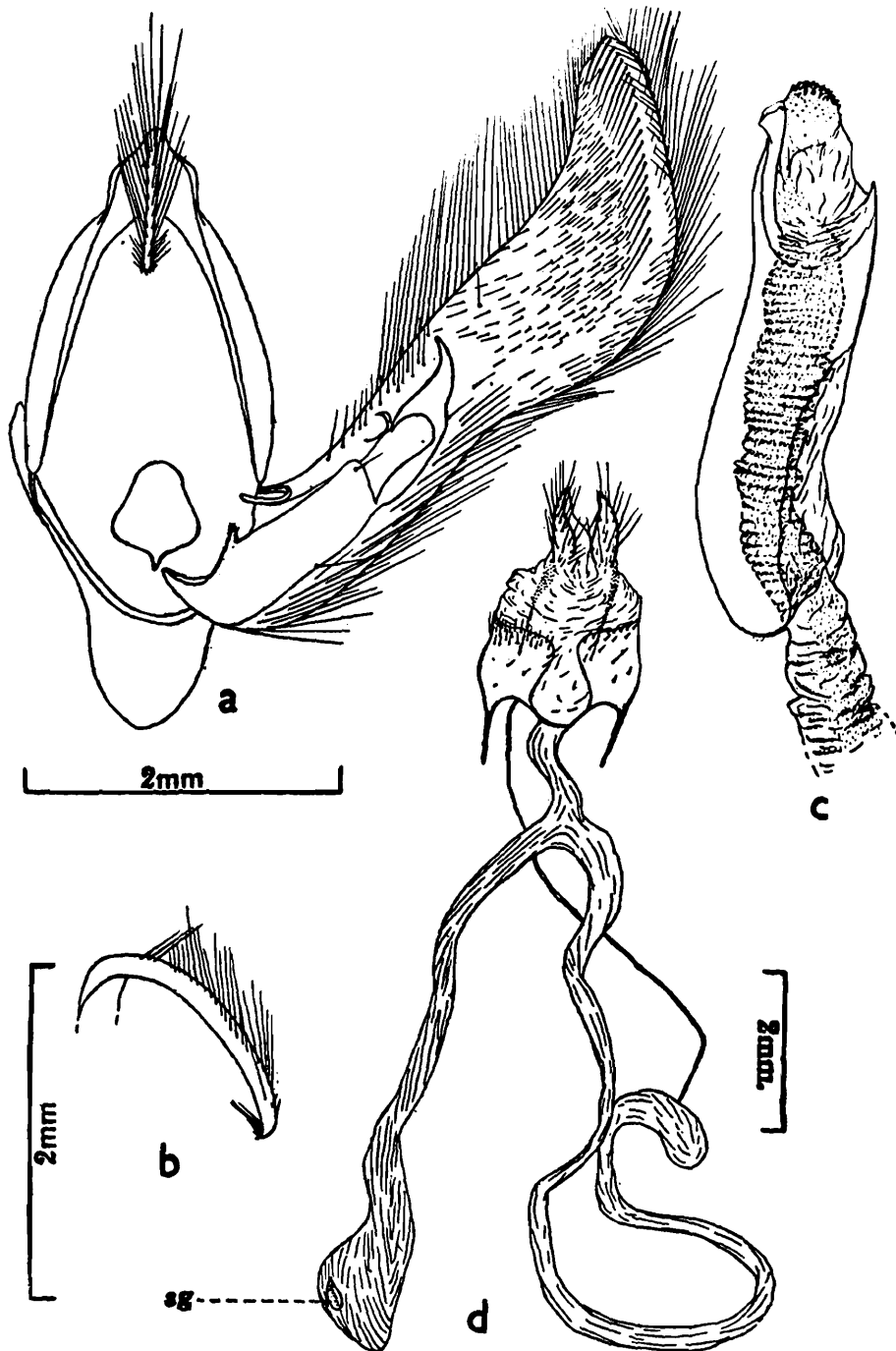
1954. *Agrotis ypsilon* (Rott.): Sibatani *et al.*, *Ann. ent. Soc. Amer.*, **47**, pp. 96, 98.
 1955. *Agrotis ypsilon* (Rott.): Kapur, *Indian J. Ent.*, **17**, pp. 289-294.
 1955. *Agrotis ypsilon* (Rott.): Lal, *Plant Protect. Bull.*, **7**, pp. 5, 9, 35.
 1958. *Agrotis ypsilon* (Rott.): Common, *Aust. J. Zool.*, **6**(1), pp. 72-75, 82.
 1958. *Agrotis ypsilon* (Rott.): Bhasin, Roonwal and Singh, *Indian For. Bull. (N.S.)*, **171**(2), pp. 65, 102.
 1959. *Agrotis ypsilon* (Rott.): Mathur and Singh, *Indian For. Bull. (N.S.)*, **171**(7), p. 76.
 1963. *Agrotis ypsilon* (Rott.): Singh, *Plant Protect. Bull.*, **11**, pp. 4, 5, 7, 24, 33, 34.
 1964. *Agrotis ypsilon* (Rott.): Srivastava, *Entomology in India*, pp. 85, 86.
 1964. *Agrotis ypsilon* (Rott.): Lal, *Entomology in India*, p. 187.
 1964. *Agrotis ypsilon* (Rott.): Mathur and Anand, *Entomology in India*, p. 276.

Head greyish brown. Frontal tufts brown, mixed with grey scales. Antennae dark brown; a dark brown streak on the inner side of the antennal base, running posteriorly. Labial palpi blackish brown, paler below and on the inner side. Collar marked across the middle by a narrow brownish line, with the inner line hardly reaching the middle, the outer line dark brown. Thorax and abdomen grey brown; with tufts on the tegulae; the basal segments of the abdomen and the tip pale brown to brown, or smoky brown. Fore wings brown, marked across by the slightly darker subbasal, antemedial and postmedial lines; the area beyond postmedial and submarginal lines paler, with dark brown double marks on veins Cu_{1a} , Cu_{1b} and $1A$, the inner ones touching the outer line of the postmedial lines; the stigmata with brown centres; the claviform with dark brown boundary; a small wedge-shaped dark brown patch beyond the reniform; submarginal line pale, the inner side between veins M_1 - M_2 and M_2 - M_3 dark brown, with a smoky brown patch at their bases; subterminal series of spots brown; cilia brown. Hind wings semi-hyaline white, with its base, along the costa, shining; the veins in the outer half and the terminal line brown. Under side with the fore wings whitish to pale brown at the base, irrorated with brown scales at the apex and the submarginal area. Body pale fuscous. Fore legs pale brown on the upper side, brown on the under side; tarsal segments and the tibial spurs as in *A. segetum* (Schiff.).

Head with the frons (Text-fig. 1 d) smooth, sub-rounded. Antennae about 90 segmented, bipectinate, with unequal rami nearly up to basal two-thirds in the male (Text-fig. 2 e); pectination comparatively shorter than in *A. segetum* (Schiff.), the longest rami as long as two to three segment at the middle of shaft, those on the inner side longer, on the outer side shorter, almost half the length of inner side; pectination at the base, on the outer side, negligibly small; antennae in the female wholly simple and minutely ciliate. Labial palpi obliquely up-turned. Fore wings with the stigmata present; the orbicular elliptical; the claviform moderate to elongate, reaching about mid-way between the antemedial and vein Cu_{1b} ; all the stigmata well defined by a black boundary. Legs (Text-figs. 2 f-g) with the tibiae and the tarsi having two and four rows of spines, respectively.

Genitalia.—Male (Text-figs. 8 a-c) with the uncus strongly curved, bent downward and beset with long hair; tegumen and vinculum long and narrow; saccus large. Claspers with the dorsal margin smooth but the ventral, near the distal end, strongly excurved and much broader than the base; corona consisting of a row of strong spines,

the number of spines being much more than in the preceding species ; costa produced into a short process ; harpe horn-shaped, rather straight. Juxta conical, without lobes. Aedeagus simple, about three times as long as its width at the middle, lightly sclerotised and undifferentiated, apex broadened, the vesica beset with short



TEXT-FIG. 8. *A. ypsilon* (Rott.) : (a) male genitalia, ventral view (b) uncus, lateral view (c) aedeagus (d) female genitalia, ventral view (Text-figs. b-c of same magnification).

black spines on the whole surface. Female (Text-fig. 8 d) with the ostium bursae simple, unsclerotised ; ductus bursae simple, short and bifurcates into two elongate but flattened tubular structures, the shorter one being the corpus bursae which is broad proximally and striated obliquely ; two signa present on the corpus bursae ; the receptaculum

seminalis long and uniformly broad, except at the base, and striated longitudinally.

Wing expanse.—Males, 40.5—42 mm.; Females, 41—48.5 mm.

Distribution.—Universally distributed.

Material examined.—50 examples. INDIA: Kashmir; 1 ♀, -.-. 1897 (J. G. Pilcher), 3 ♂ ♂ [no further data except “destructive to hop plants in Kashmir”] (J. L. Kaye). Himachal Pradesh; Simla, 2377.40 m. (7800 ft.), 1 ♂, -iv.1898 (J. G. Pilcher), Kangra Valley, 1371.58 m. (4500 ft.), 1 ♀, -vi.1899 (G. C. Dudgeon), Kulu, 2 ♂ ♂, 2 ♀ ♀ [no date of collection] (Young), Rhotang Pass, 4267.12 m. (14000 ft.), on snow, 1 ♂, 5.vi.1955, 1 ♀, 19.vi.1955, 4206.16 m. (13800 ft.), 8 ♂ ♂, 18 ♀ ♀, 19.vi.1955 (all A. P. Kapur) [Many more examples preserved in spirit]. Uttar Pradesh; Gonda, 2 ♀ ♀ [no date of collection] (J. Cockborn), 1 ♀ [no date of collection] (J. Christian), Sahabad, 3 ♂ ♂ [no date of collection] (J. Christian). Bihar; Patna, 1 ♂, -iii.1958 (Cent. Potato Res. Inst.). Bengal; Calcutta, 1 ♂, [no date of collection] (L. deNiceville). Sikkim: 1 ♂, -xi.1895 (G. C. Dudgeon).

CEYLON: Hakgala, 2 ♀ ♀, -iii.1907, 1 ♀, -v.1907 (all E. E. Green).

Host range.—Atropine (*Atropa belladonna* Linn.): Mathur and Anand, 1964. Bajra (*Pennisetum typhoideum* Rich.): Lal 1955; Singh, 1963. Barley (*Hordeum vulgare* Linn.): Cotes, 1891; Lal, 1955; Singh, 1963. Beet Root (*Beta vulgaris* Linn.): Fletcher, 1921. Cabbage (*Brassica oleracea* Linn.): Fletcher, 1917, 1921. Cha-chai (*Camellia sinensis* Linn.): Bhasin, Roonwal and Singh, 1958. Clover: Fletcher, 1921. Coffee (*Coffea arabica* Linn.): Cotes, 1891. Deodar (*Cedrus deodara* Roxb.): Bhasin, Roonwal and Singh, 1958. Gram (*Cicer arietinum* Linn.): Cotes, 1891; Fletcher, 1917, 1921; Lal, 1955; Singh, 1963; Srivastava, 1964. Ground nut (*Arachis hypogaea* Linn.): Fletcher, 1921. Guava (*Psidium guyava* Linn.): Mathur and Singh (1959). Hop plant (*Humulus lupulus* Linn.): Barlow, 1900. Indigo (*Indigofera tinctoria* Linn.): Fletcher, 1917. Jower (*Sorghum vulgare* Pers.): Lal, 1955; Singh, 1963. Lessermillets (*Panicum miliare* Linn.): Lal, 1955; Singh, 1963. Linseed (*Linum usitatissimum* Griseb.): Fletcher, 1921. Lucerne (*Medicago sativa* Linn.): Fletcher, 1917, 1921. Maize (*Zea mays* Linn.): Lal, 1955; Singh, 1963. Mustard (*Brassica campestris* Linn.): Fletcher, 1921. Oats (*Avena sativa* Linn.): Cotes, 1891; Singh, 1963. Onion (*Allium cepa* Linn.): Fletcher, 1917. Opium (*Papaver somniferum* Linn.): Cotes, 1889, 1891; Barlow, 1900, 1903; Fletcher, 1921; Lal, 1955; Singh, 1963. Peas (*Pisum sativum* Linn.): Cotes, 1891; Fletcher, 1917, 1921; Lal, 1955; Singh, 1963. Potato (*Solanum tuberosum* Linn.): Cotes, 1889, 1891; Fletcher, 1917, 1921; Lal, 1964. Tea (*Camellia theifera* Griff.): Cotes, 1891. Tobacco (*Nicotiana tabacum* Linn.): Fletcher, 1917, 1921; Lal, 1955; Singh, 1963. Wheat (*Triticum vulgare* Vill.): Cotes, 1891; Fletcher, 1921; Lal, 1955; Singh, 1963.

Remarks.—Referrable to the genus *Agrotis* Ochsenheimer, it is one of the most serious pest of agricultural crops and plants of forest and medicinal importance, which is distributed almost throughout the world. It was recorded from India as early as 1874 by Scott who referred it to Cotes (1889).

It resembles the preceding species in the bipectinate nature of the antennae, but differs from them in the frons being smooth and without any structure; in the stoutness of the body; tarsi with four rows of

spines. In respect of the male genitalia it bears general resemblance to the preceding species but for the juxta which is conical here ; besides, the coronal spines are in thick cluster. The female genitalia is characterised by the presence of two signa on the corpus bursae ; also the receptaculum seminalis is longer than the corpus bursae.

The species shows slight variation in its colour markings on the wings, especially in the large number of examples collected on snow (coll. *A. P. Kapur*), but in the various specimens examined the character of the genitalia (both male and female) were observed to be uniform.

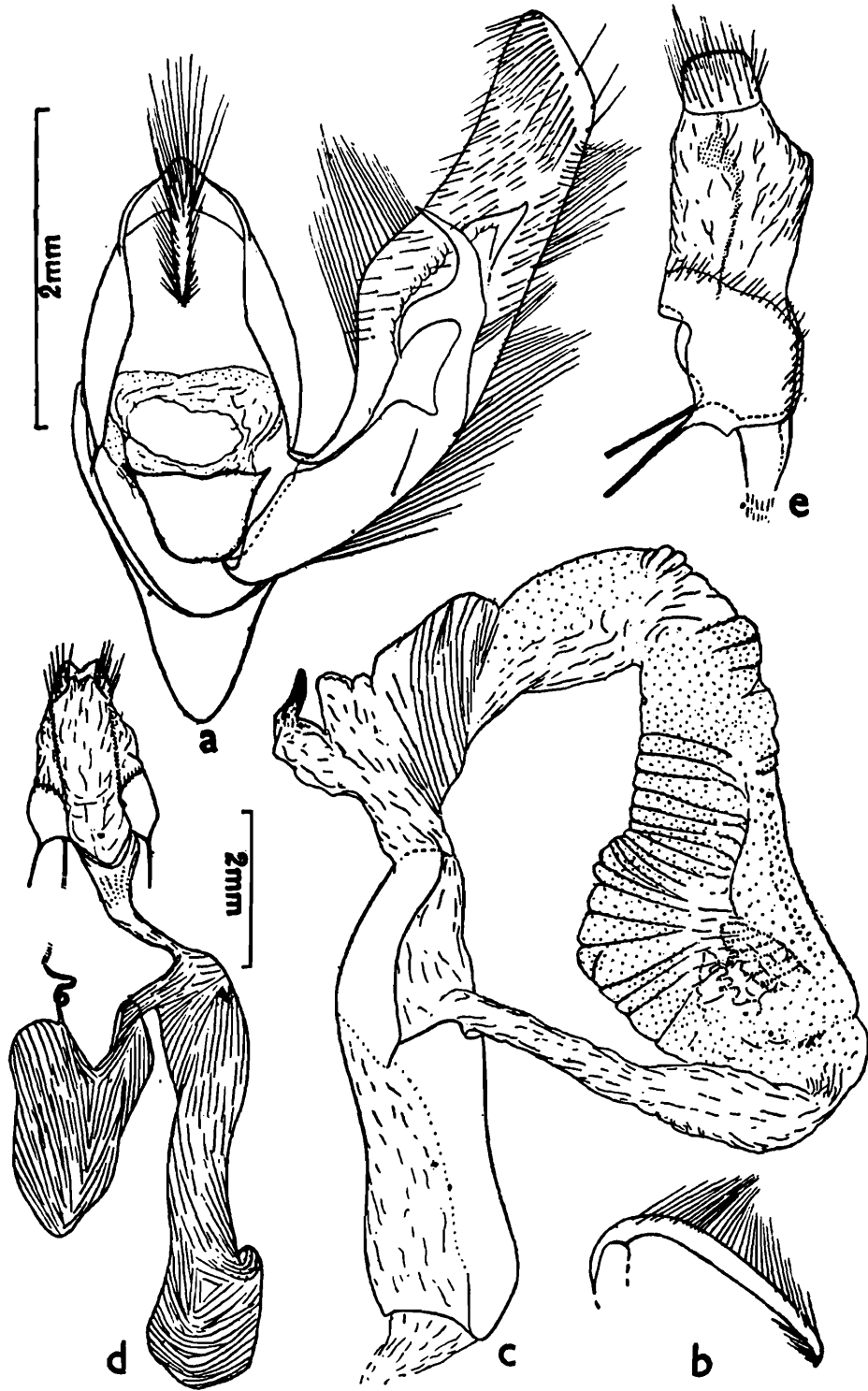
6. *Agrotis flammata* (Schiffermüller)

(Plate 1, fig. 4 ; Text-figs. 1 e, 2 h-j, 9 a-e)

1776. *Noctua flammata* Schiffermüller, *Wien. Verz.*, p. 80.
 1787. *Noctua flammata* Fabricius, *Mant. Inst.*, 2, p. 155.
 1822. *Ogygia flammata* (Schiff.) Hübner, *Verz. bek. Schmett.*, p. 225.
 1850. *Agrotis deleta* Kollar, *Denkschr. Wiss.*, 1, p. 53. (Syn. of *Agrotis flammata*, vide Hampson, 1903).
 1856. *Agrotis basiclavis* Walker, *List Lep. Brit. Mus.* 10, p. 346. (Type loc.-Hindustan) (Syn. of *Agrotis flammata* (Schiff.), vide Hampson, 1894, 1903).
 1882. *Agrotis flammata* (Schiff.) Kirby, *European Butterflies and Moths*, p. 199.
 1888. *Ochropleura flammata* (Schiff.) Cotes & Swinhoe, *Cat. Moths of India*, p. 313.
 1894. *Agrotis flammata* (Schiff.): Hampson, *Fauna Brit. India, Moths*, 2, p. 189.
 1900. *Chera flammata* (Fabricius) [nec. Schiff.] Swinhoe, *Cat East & Aust. Lep. Het.*, pt. II, p. 13.
 1903. *Agrotis flammata* (Schiff.): Hampson, *Cat. Lep. Phal.*, 4, p. 393.
 1909. *Agrotis flammata* (Fabr.) [nec. Schiff.]: Lefroy, *Indian Insect Life*, p. 445.
 1909. *Rhyacia flammata* (Schiff.) Warren, in Seitz *Macrolepidoptera of the World*, 3, p. 43, pl. 9g.
 1917. *Agrotis flammata* (Schiff.): Fletcher, *Rep. & Proc. 2nd Ent. Mtg.*, pp. 48, 94, 122.
 1921. *Agrotis flammata* (Schiff.): Fletcher, *Proc. 3rd Ent. Mtg.*, pp. 24-25.
 1933. *Rhyacia flammata* (Schiff.): Corti & Draudt, in Seitz *Macrolepidoptera of the World*, Suppl. 3, p. 64.
 1941. *Agrotis flammata* (Schiff.): Beeson, *Forest Insects*, p. 644.
 1954(b). *Ochropleura flammata* (Schiff.): Boursin, *Bull. Soc. Fouad Ier. entom.*, p. 84.
 1955. *Ochropleura flammata* (Schiff.): Boursin, *Veröff. zool. Stsamml. Münch. Teil-II*, 8, p. 13, pl. vi, fig. 13.
 1955. *Agrotis flammata* (Schiff.): Lal, *Plant Protect. Bull.*, 7, pp. 5, 7, 9, 35.
 1963. *Agrotis flammata* (Schiff.): Singh, *Plant Protect. Bull.*, 11, pp. 4, 5, 7; 24, 33.
 1964. *Agrotis flammata* (Schiff.): Srivastava, *Entomology in India*, p. 85.
 1964. *Agrotis flammata* (Schiff.): Sohi, *Entomology in India*, p. 146.

Head with the frontal tufts pale brown. Antennae brown. Eyes blackish brown. Labial palpi pale brown, pale below and on the inner side. Collar with posteriorly projecting scales, dark brown, coloured at their bases, thus forming a triangular patch on each side. Thorax pale brown to brown. Fore wings pale brown to brown or red brown ; costal fascia greyish brown ; an elongate dark brown spot present at the base between the median nervure and the inner vein 1A+2A ; stigmata with the outlines dark brown, except on the outer side of reniform ; centres pale, except in reniform where it is more or less fuscous ; cell area, from antemedial to the postmedial, brown ; a series of small triangular brown spots present at the margin ;

cilia pale brown with a continuous streak across the centre. Hind wings pale brown to brown, un-marked ; cilia pale brown. Legs brown on the upper side, with the whitish segmental ring on each tarsus ;



TEXT-FIG. 9. *A. flammatra* (Schiff.) : (a) male genitalia, ventral view (b) uncus, lateral view (c) aedeagus (d) female genitalia, ventral view (e) ovipositor and the genital plate enlarged (Text-figs. a-c, e of same magnification).

under side almost uniformly pale brown. Abdomen, both the upper and the under side, and the wings pale brown, the latter shining and devoid of any pattern, whatsoever of the upper side.

Head with the frons (Text-fig. 1e) smooth, sub-rounded and slightly produced in the middle; frontal tufts thickest below the bases of antennae, across and along the side of the frons, those on sides converging in the middle into a straight line. Antennae (Text-fig. 2h) simple in both the sexes, profusely ciliate in the male, minutely in the female. Labial palpi long and upturned, the third segment short, without projecting scales in front. Fore wings with the orbicular semi-circular, open above; claviform small, elongate, reaching only mid-way between the antemedial and the vein Cu_{1b} ; the antemedial, postmedial and submarginal lines double, waved, extending from the costal to the inner margin, except the antemedial which is interrupted at the costa. Thorax with the tufts of scales reaching up to the base of abdomen, the latter with the segmental tufts. Legs with one and two pair of spurs in the middle and the hind tibiae, respectively; tibiae and tarsi with only two and three rows (Text-figs. 2 i-j) of spines respectively.

Genitalia.—Male (Text-figs. 9 a-c) with the uncus curved downwards, beset with blackish brown setae on the dorso-lateral and on the under side near the tip; tegumen and vinculum as in the preceding species. Clasper elongate, about four times as long as its width at the middle; beset with long hair on both sides, with the mid-dorsal part slightly raised; harpe horn-shaped, curved strongly and pointed; a weakly developed ampulla present. Juxta almost quadrangular, narrowed basally, without lobes but sclerotised on sides. Aedeagus large, about thrice as long as its width at the middle, sclerotised only on one side longitudinally, leaving the remaining portion membranous; vesica large, beset with fine blackish short spines, scattered throughout except at the distal part which is with a single cornutal process. Female (Text-fig. 9 d) with the ostium bursae simple, having slightly sclerotised margin; ductus bursae slightly sclerotised; corpus bursae long, broad and semi-circular below, raised on one side into a small protuberance and obliquely striated throughout forming a definite pattern of small islands here and there; receptaculum seminalis more or less triangular.

Wing expanse.—Males, 41-55 mm.; females, 50-53 mm.

Distribution.—India; Kashmir, Himachal Pradesh, Punjab, Delhi, Uttar Pradesh, Rajasthan, Gujarat, Madhya Pradesh, Bihar, Bengal, Assam, Orissa, Andaman & Nicobars, Maharashtra, Mysore, Andhra Pradesh, Madras, Kerala. Also Sikkim and Bhutan.

Material examined.—26 examples. INDIA: Himachal Pradesh; Kangra valley, 1371.58 m. (4500 ft.), 1 ♂, 1 ♀—iv.1899, 1 ♂, 1 ♀, —v.1899, 1 ♂, 1 ♀—vi.1899, (all *G.S. Dudgeon*). Punjab, Punj-pul Nallah, 1981.16 m. (6500 ft.). At light, 1 ♀, —v.27 (*S. L. Hora*). Haryana; Kharar (Ambala), 1 ♂ 12.iv.1945 (*Miss Mathew*). Uttar Pradesh; Fategarh, 1 ♂ (*J. Cockborn*), Gonda, 2 ♂ ♂, 1 ♀ (*J. Cockborn*). Bihar; Chupra (Chhapra), 3 ♂ ♂, 2 ♀ ♀ (*J. A. Bourdillon*). Sikkim: 1 ♂ [no date of collection] (*O. Möller*), 548.63 m. (1800 ft.), 1 ♂, 1 ♀—v.1897 (*G. C. Dudgeon*). Bhutan: 1 ♂, —.1899 (*G. C. Dudgeon*). CHITRAL MISSION: 1523.98 m. (5000 ft.), 1 ♂, 18.vii. 1885, 1 ♂, 11.x.1885. NEPAL: Phalong karmo, near mouth of Khumbu glacier, 4571.94 m. (15,000 ft.), Khumbu, At light, 1 ♀, 3.iv.1954; Longmocha, longmocha valley, 4876.71 m. (16000 ft.), Khumbu, 2 ♂ ♂, 20.iii.1954 (all *B. Biswas*).

Host range.—Atropine (*Atropa belladonna* Linn.): Mathur & Anand, 1964. Bajra (*Pennisetum typhoideum* Rich.): Lal, 1955; Singh, 1963. Barley (*Hordeum vulgare* Linn.): Lal, 1955; Singh, 1963. Bhindi (*Hibiscus esculentus* Linn.): Fletcher, 1917. Cotton (*Gossypium indicum* Lamk.): Sohi, 1964. Gram (*Cicer arietinum* Linn.): Cotes, 1889, 1903; Fletcher, 1917, 1921; Lal, 1955; Singh, 1963; Srivastava, 1964. Jowar (*Sorghum vulgare* Pers.): Lal, 1955, Singh, 1963. Lesser millets (*Panicum miliare* Linn.): Lal, 1955, Singh, 1963. Linseed (*Linum usitatissimum* Griseb.): Cotes, 1889, 1903. Maize (*Zea mays* Linn.): Lal, 1955; Singh, 1963. Mustard (*Brassica campestris* Linn.): Cotes, 1889, 1903. Niger seed (*Guizotia abyssinica* Cass.): Fletcher, 1917. Oates (*Avena sativa* Linn.): Lal, 1955; Singh, 1963. Peas (*Pisum sativum* Linn.): Cotes, 1889, 1903; Lal, 1955; Singh, 1963. Poppy (*Papaver somniferum* Linn.): Cotes, 1889, 1891, 1903; Fletcher, 1921. Piazzi (*Asphodelus fistulosus* Linn.): Fletcher, 1921. Potato (*Solanum tuberosum* Linn.): Fletcher, 1921; Lal, 1955; Singh, 1963; Lal, 1964. Tobacco (*Nicotiana tabacum* Linn.): Fletcher, 1921; Lal, 1955; Singh, 1963. Wheat (*Triticum vulgare* Vill.): Lal, 1955; Singh, 1963.

Remarks.—Boursin (1954 b) states that most of the species recorded from Punjab, Kashmir and Spiti, actually belong to *Ochropleura herculea* Corti & Draudt and not to *Ochropleura flammatrix* (Schiff.). He differentiates *herculea* by the reddish brown ground colour of the fore wing and its strong colour markings, and the male genitalia. Later, in 1955, he figured the male genitalia of the specimens of *O. herculea* Corti & Draudt from Kashmir and Nepal and of *O. flammatrix* (Schiff.) from France. He lays considerable stress on the coloration in these species but from the extensive material before us we find this character to be quite variable. However, until types of the two species are examined for their genitalic and other characters, it is considered advisable to continue to regard the Indian examples as belonging to *A. flammatrix* (Schiff.).

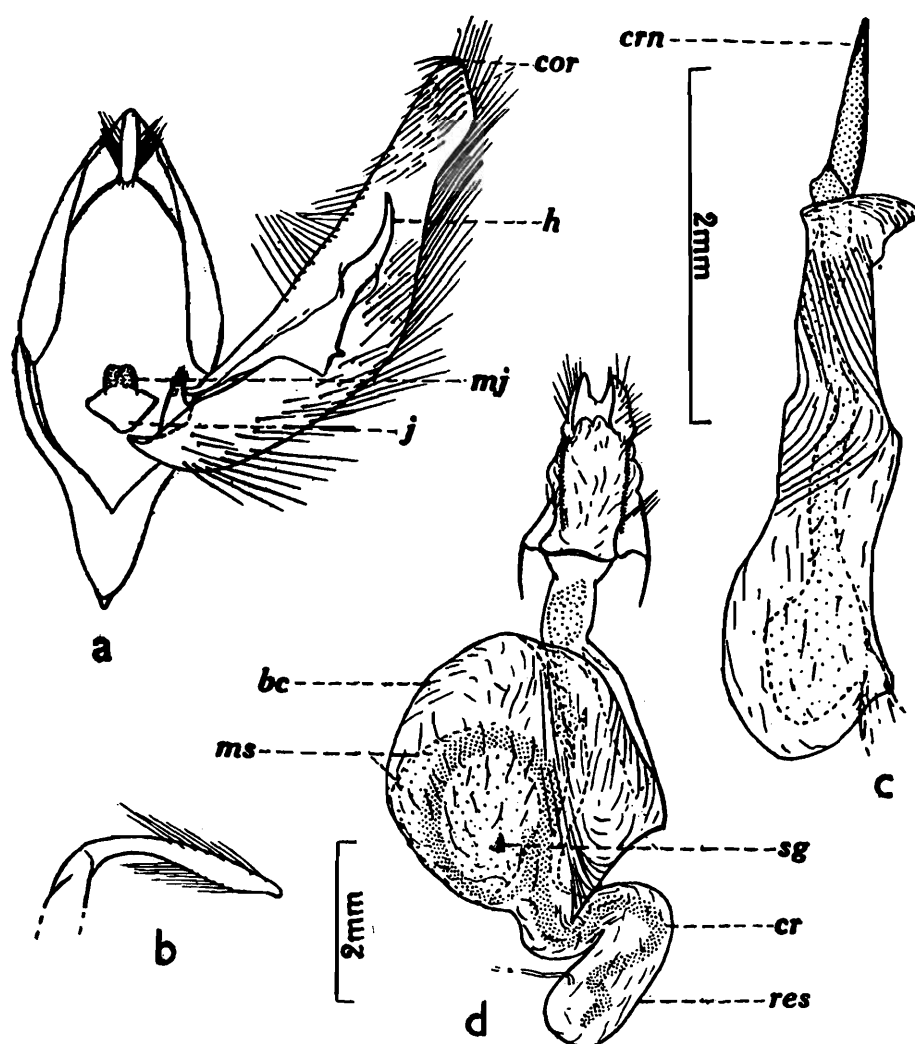
7. *Agrotis plecta* (Linnaeus)

(Plate I, fig. 5; Text-figs. 1 f, 10 a-d)

- 1761. *Phalaena noctua plecta* Linnaeus, *Fauna Svec.*, p. 321. (Type loc.—Sylvis).
- 1822. *Ochropleura plecta* (Linn.): Hübner, *Verz. bek. Schmett.*, p. 223.
- 1856. *Ochropleura vicaria* Walker, *List Lep. Brit. Mus.*, 10. (Type loc.—Cape Colony) (Syn. of *A. plecta* (Linn.), vide Hampson, 1903).
- 1882. *Agrotis plecta* (Linn.): Kirby, *European Butterflies and Moths*, p. 194, pl. 36, fig. 4a.
- 1894. *Agrotis plecta* (Linn.): Hampson, *Fauna Brit. India, Moths*, 2, p. 183.
- 1900. *Peridroma plecta* (Linn.): Swinhoe, *Cat. East & Aust. Lep. Het.* pt. II, p. 9.
- 1903. *Agrotis plecta* (Linn.): Hampson, *Cat. Lep. Phal.*, 4, p. 405.
- 1909. *Rhyacia plecta* (Linn.): Warren, in Seitz *Macrolepidoptera of the World*, 3, p. 44, pl. 9k.
- 1933. *Rhyacia (Diarsia) plecta* (Linn.): Corti & Draudt, in Seitz *Macrolepidoptera of the World*, Suppl. 3, p. 79.

Head with the frontal tufts greyish brown. Antennae dull brown. Eyes brown. Labial palpi mostly reddish. Vertex reddish brown posteriorly, the collar reddish brown, mixed with grey and with a dark brown line at its base. Thorax purple-reddish brown. Fore

wings purple-reddish brown except on the costa, postmedial and the inner margin near the base which are whitish ; the area beyond the sub-marginal line slightly fuscous ; the antemedial and postmedial lines reddish brown ; the claviform obsolete ; the orbicular reddish brown in the centre ; reniform with brown centre ; the series of terminal triangular spots blackish, and the cilia brown. Hind wings whitish, without markings, with the veins very lightly-pale brown. Fore legs brownish dorsally, pale ochreous laterally and ventrally. Abdomen greyish brown on both the dorsal and ventral sides. Under side with the fore wings having brown spots at the discocellulars ; a well-marked brown, uninterrupted, postmedial line and a subterminal series of brown spots ; hind wings also with a brown discocellular spot, irrorated with brown scales at the costa and a broken postmedial line brownish in colour.



TEXT-FIG. 10. *A. plecta* (Linn.) : (a) male genitalia, ventral view (b) uncus, lateral view (c) aedeagus (d) female genitalia, ventral view (Text-figs. a-c of same magnification).

Head with the frons (Text-fig. 1 f) smooth and flat. Antennae fasciculate in the male, simple in the female. Labial palpi obliquely upturned, the third segment short and porrect. Fore wings with the orbicular and the reniform clearly marked ; the former oval, open

above and pointed towards the base of the wings; the antemedial and postmedial lines single and waved, the former interrupted at the costa. Legs with one and two pairs of spurs in the middle and hind tibiae, respectively; the middle and hind tibiae and the first tarsus with three rows of spines, the second to fifth segments of tarsi with four to five rows of spines.

Genitalia.—Male (Text-figs. 10 a-c) with the uncus narrow basally, becoming broad from beyond the middle nearly up to the tip, the latter narrow, about half the width of middle; tegumen and the vinculum as in the preceding species; saccus conical, with a fine point at the end. Clasper about four times as long as its width at the middle, narrow distally, about half the width of the middle portion and with a weak coronal setae; harpe curved, horn-shaped, with a short projection near the base at the sacculus; clavus hairy. Juxta triangular, dome-shaped in the middle. Aedeagus about four times as long as its width at the middle, the base broad, gradually becoming narrow distally; vesica retracted in the normal course, striated-black on one side; cornuti well developed, long and sclerotised into a process which is about one-third of the body length and as wide as one-sixth of its length, at the middle. Female (Text-figs. 10 d) with the ostium bursae sclerotised, leading through ductus bursae into a flattened, almost circular, corpus bursae; with a short appendix in continuation with the latter at its base which serves the purpose of receptaculum seminalis; sclerotisation on the ductus bursae continuous with the corpus bursae on one side, with the inner wall of the latter folded and with several sclerotised ribbon-like structures which extend into the receptaculum seminalis; a fine duct, the ductus spermathecus, arises from the receptaculum seminalis to enter into the genital tube; a well developed signum present on the corpus bursae.

Wing expanse.—Males, 33.5 — 34 mm.; females, 35 — 36 mm.

Distribution.—India; Punjab (Hampson, 1894, p. 189). Also Sikkim and Ceylon (Hampson, 1903, p. 405).

Material examined.—4 examples. CEYLON: Ohiya, 2 ♂♂, 2 ♀♀, —.xi.1907 (E. E. Green).

Remarks.—Referrable to the genus *Agrotis* Ochsenheimer, due to the presence of well-developed harpe, and the cucullus bearing the corona. It can be readily distinguished from *A. segetum* (Schiff.), *A. corticea* (Schiff.), *A. spinifera* (Hübner), *A. subspinifera* (Hampson) and *A. ypsilon* (Rott.) by the fasciculate antennae in the male. With regard to the female, it is characterised by the presence of sclerotised coiled ribbons in the corpus bursae of the genitalia. On account of the latter structure it comes close to the genus *Amathes* Hübner. A well-defined median dome of the juxta in the male genitalia further helps in differentiating this species from the other species of the genus mentioned above.

8. *Agrotis beelsoni* sp. n.

(Plate II, fig. 2; Text-figs. 11 a-e)

Head, thorax and abdomen brown. Frontal tufts pale brown, followed by brown vertex, the latter with two dark brown patches on the inner side of each antenna. Antennae brown. Labial palpi

blackish on the outer sides up to the second segment, the third segment pale brown. Collar with a black brown line at its base. Fore wings brownish ; costal area whitish from the base to a little beyond the upper angle of the cell ; the orbicular semi-circular, not open above, with a pale brown centre and a greyish outer line ; the claviform obsolete ; area below the median nervure suffused with dark-reddish brown from the base to vein Cu_{1+} and up to the submedian fold, reddish posteriorly up to vein 1A and paler in the anal area ; reniform with a pale brown to brown centre, the outer line greyish but confluent on the upper and the lower margins with the ground colour of the wing ; the area between the orbicular and the reniform and also slightly beyond the latter dark-reddish brown in colour ; subbasal and the antemedial lines indistinct, the postmedial line double, wavy and slightly curved outwardly below the costa, thereafter incurved below vein M_3 and making an acute curve inwards in the submedian area before running obliquely to reach the inner margin ; of the double line mentioned above, some spots on the outer line prominent ; subterminal line greyish brown, indistinctly marked and wavy ; a terminal series of black spots present from the apex to the tornal angle. Hind wings whitish, semi-hyaline, with the veins pale brown. Under side of the wings greyish brown, the costal area irrorated with fuscous spots ; fore wings pale fuscous, with the postmedial series of small streaks up to vein Cu_{1b} ; the cell very dark ; hind wings whitish, with small discocellular spot. Fore legs with the tibiae and tarsi pale brown on the upper side. The tibiae of middle and hind legs darker ; tibial spurs pale at the base and the tip.

Head with the frons smooth. Antennae in the male ciliate, reaching a little beyond the upper angle of the cell of the fore wing. Labial palpi obliquely upturned. Legs with the spurs and spines as in *A. plecta* (Linn.).

Genitalia.—Uncus long, narrow at the base, broad from beyond the middle nearly up to the tip, the latter part narrow and blunt, about less than half the width of the broadest portion ; tegumen and vinculum long and narrow ; saccus conical. Clasper long, having its dorsal margin straight but smooth, the ventral margin incurved beyond middle towards the distal end, the latter half the width of the middle ; harpe long and narrow. Juxta broadly triangular, only slightly raised. Aedeagus well developed, long, about five times as long as its width at the middle, with its base broad and round, gradually narrowing distally, the latter with a well developed, long and narrow sclerotised process which is about one-third of the body length but as wide as one-eighth of its length.

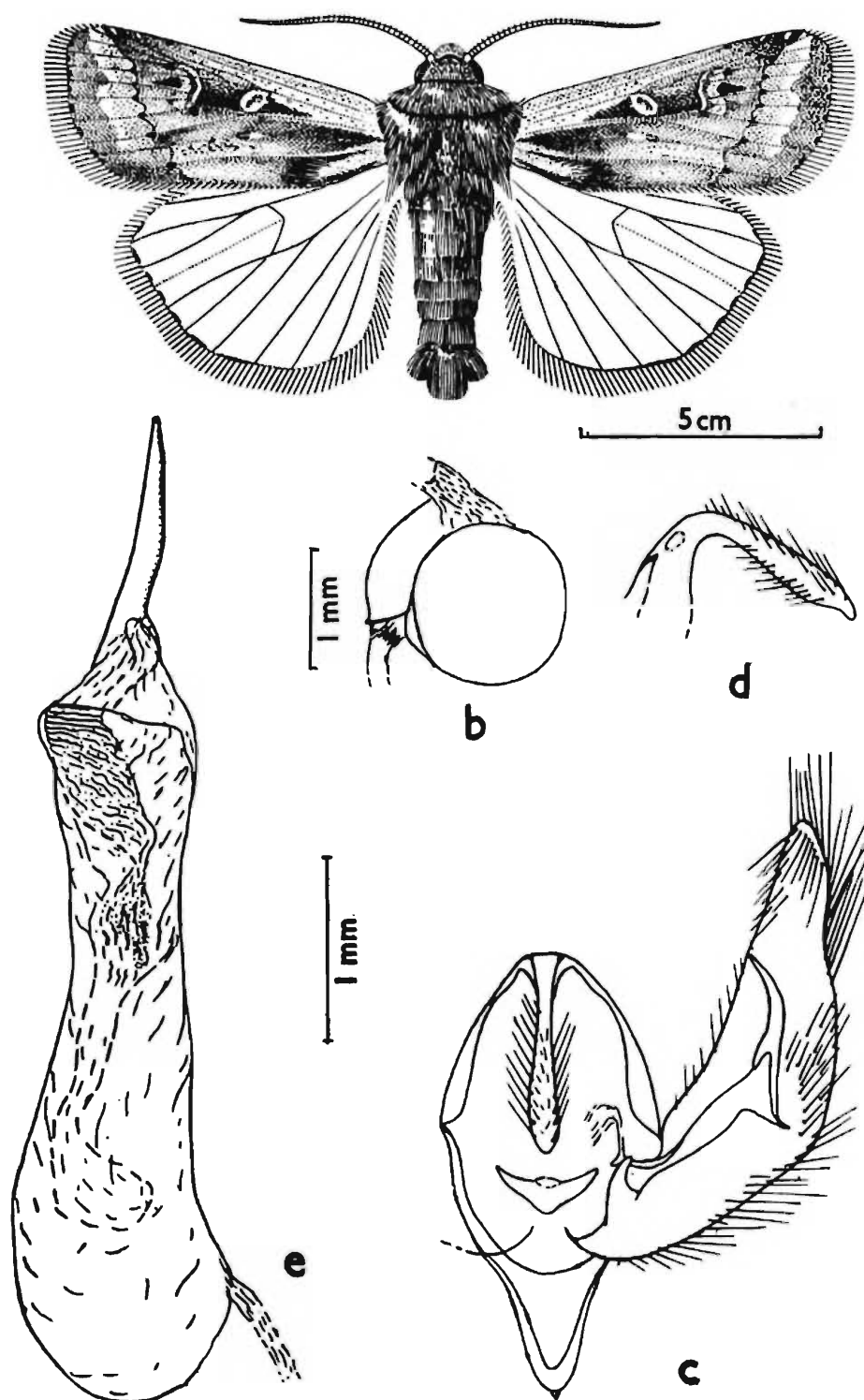
Female.—Not known.

Wing expanse.—28-29 mm.

Holotype.—One Male: Darjeeling, 2133.56 m. (7000 ft.), —.vi.1912, Govt. House Grounds. Five Paratypes: Darjeeling Govt. House Grounds, 3 ♂♂, 2133.56 m. (7000 ft.)—v.1912, 2 ♂♂, 2133.56 m. (7000 ft.)—vi.1912. (all in the Zoological Survey of India, Calcutta). (all Lord Carmichael).

Remarks.—*Agrotis beelsoni* sp. n., bears close resemblance to other species of *Agrotis* with regard to the venation and to *Agrotis plecta* (Linn.) both in the external characters and in the male genitalia. The most striking similarity between the two species being the costal

fascia on the fore wings, not extending beyond the discocellulars ; shape of smooth frons, ciliation of antennae, and spines on legs, etc., are other characters which show its close resemblance with *A. plecta* (Linn.). It can, however, be differentiated from *plecta* (Linn.) ex-



TEXT-FIG. 11. *A. beelsoni* sp. n. : (a) a complete sketch of the male, showing pattern of the wing (b) shape of the frons (c) male genitalia, ventral view (d) uncus, lateral view (e) aedeagus (Text-figs. c-e of same magnification).

ternally by the presence of blackish brown patch on the vertex near the inner side of each antenna ; by almost semi-circular orbicular ; and by the general coloration of the body and wings which, unlike in *A. plecta* (Linn.), are without purple tinge. In the male genitalia the two species show considerable resemblance with each other except in juxta which, in this species, is almost without dome-shaped structure in the middle. This difference in the two species is significant since the other species of *Agrotis* Ochs. are completely without such structure, almost as in *A. beasoni*, where as the presence of this character in *A. plecta* (Linn.) brings its affinities with the genus *Amathes* Hübner.

Genus *Amathes* Hübner

1822. *Amathes* Hübner, *Verz. bek. Schmett.*, p. 222.
 1894. *Amathes* Hübner: Hampson, *Fauna Brit. India, Moths*, 2, p. 180 (as Syn. of *Agrotis* Och.).
 1910. *Amathes* Hübner: Warren, in Seitz *Macrolepidoptera of the World*, 3, p. 150.
 1934. *Amathes* Hübner: Draudt, in Seitz *Macrolepidoptera of the World*, Suppl. 3, p. 150.
 1954(a). *Amathes* Hübner: Boursin, *Bonn. zool. Beitr.*, 5, p. 263.
 1954(b). *Amathes* Hübner: Boursin, *Bull. Soc. Found. Ier. ent.*, 38, p. 83.
 1955. *Amathes* Hübner: Boursin, *Veröff. zool. Stsamml. Münch.*, pp. 15-18.

Type of the genus : *Noctua litura* Linn. from Europe.

Distribution.—Widely distributed. Warren (1910) records the distribution of *Amathes* species from Europe (France, Switzerland, Italy, Hungary), Asia Minor, Russia (Armenia, Siberia), etc., but none from India. Lately however, Boursin (1955) recorded certain species from Nepal Expedition, and regarded the genus as distributed in the Himalayas in so far as the Indian subregion is concerned. We in this paper have dealt with four species of the genus of which three occur in the plains. One of the latter, *Amathes deraiota* (Hampson) is known from Ceylon only.

Diagnosis.—Frons smooth (Text-figs. 1 g-h). Antennae ciliate in both the sexes. Eyes large and glabrous. A well developed ocellus present behind each antenna. Proboscis fully developed. Labial palpi obliquely upturned, the third segment short and generally porrect, rarely upturned or reaching beyond the frons. Legs with two rows of spines on all the tibiae, the terminal spines on fore tibiae longer than the rest ; middle tibiae with a single pair and hind tibiae with two pairs of tibial spurs ; tarsi with three rows of spines, and a well developed arolium. Fore wings long and narrow ; stigmata present in the cell, which is generally wholly coloured ; frenulum consisting of a single spine in the male, with two or three spines in the female.

Venation.—The venation is almost constant in all the species of the genus and generally agrees with that of *Agrotis segetum* (Schiff.) except for the following. In the fore wing vein M_1 arise from below or above the upper angle of the cell ; and in the hind wing the veins M_1 and R_3 may be on a short or a long stalk.

Genitalia.—Male with the claspers smooth and rounded distally, without corona ; the setae sparse on the whole surface ; sacculus large, without clavus ; ampulla weak, extending to the ventral margin and generally protruding beyond it ; the harpe well developed. Juxta

triangular, provided with a dome in the middle. Aedeagus generally simple. Female genitalia generally of large size; corpus bursae variable in both shape and size; ostium bursae generally sclerotised, with the edge raised into a shallow cup.

Remarks.—*Amathes* Hübner was included under the subfamily Cucullianae, which is chiefly differentiated from Agrotinae by the presence of long, over-hanging lashes on the eyes, and by the absence of spines on the middle and the hind tibiae (Draudt, 1934, p. 151). However, in 1955, Boursin has included it in Agrotinae. Though he did not give any character or reason for the change our studies support this change on account of the presence of the tibial spines on all the legs and the absence of over-hanging lashes on eyes.

The present study is based on four species, viz. *Am. c-nigrum* (L.), *Am. deraiota* (Hampson), *Am. curviplena* (Walker) and *Am. consanguinea* (Moore) which are represented by 25 examples. Although Boursin (1955) treated *deraiota* as a subspecies of *c-nigrum* we have regarded it as a distinct species on the basis of the external and genitalic characters of the specimens from the type locality.

Out of the four species mentioned above *Am. c-nigrum* is the widely distributed and well known species on account of its being a pest of crops. The following keys are given for the identification of the species dealt with in this paper.

(a) *Based on the external characters*

1. Fore wings with the cell not filled up with colour between the base and stigmata; the orbicular round and closed; the claviform small; fore wings with small circular rings; Hind wing pale-ochreous brown ... *curviplena* (Walker)
- Fore wings with the cell filled up with colour between base and stigmata; the orbicular v-shaped or elliptical, open anteriorly; the claviform small or indistinct; fore wings without circular rings. Hind wings pale white to dark brown ... 2
2. Orbicular v-shaped, with the centre ochreous ... 3
- Orbicular oval, obliquely placed, with the centre pale brown ... *consanguinea* (Moore)
3. Claviform v-shaped; hind wings ochreous white ... *c-nigrum* (Linn.)
- Claviform obsolete; hind wings brown ... *deraiota* (Hampson)

(b) *Based on the male genitalia*

1. Uncus broadest in the middle, the distal end narrow. Juxta with the median sac broad, beset with fine setae ... *c-nigrum* (Linn.)

Uncus not broadest in the middle.

Juxta with the median sac narrow,
with or without spines 2

2. Uncus broad at the base, tapering gradually towards the distal end. Juxta with the median sac without spines. Aedeagus with a short tooth distally *deraiota* (Hampson)

Uncus broad at the base, with the dorsal surface bulged slightly, tapers gradually into a fine point. Juxta with the median sac beset with short spines. Aedeagus with several spines on the vesica *curviplena* (Walker)

(c) Based on the female genitalia

1. Corpus bursae large, with sclerotised ribbons, without stripes; ductus bursae heavily sclerotised *deraiota* (Hampson)
- Corpus bursae large or small, without sclerotised ribbons, with four stripes on it; ductus bursae lightly sclerotised 2
2. Corpus bursae as long and broad as the receptaculum seminalis; ductus bursae without bands *consanguinea* (Moore)
- Corpus bursae longer than the receptaculum seminalis; ductus bursae with or without bands 3
3. Ductus bursae with sclerotised bands; receptaculum seminalis oval *c-nigrum* (Linn.)
- Ductus bursae without bands; receptaculum seminalis as a short, blunt, lobe *curviplena* (Walker)

9. *Amathes c-nigrum* (Linn.)

-(Plate I, fig. 6 ; Text-figs. 1 g, 12 a-e)

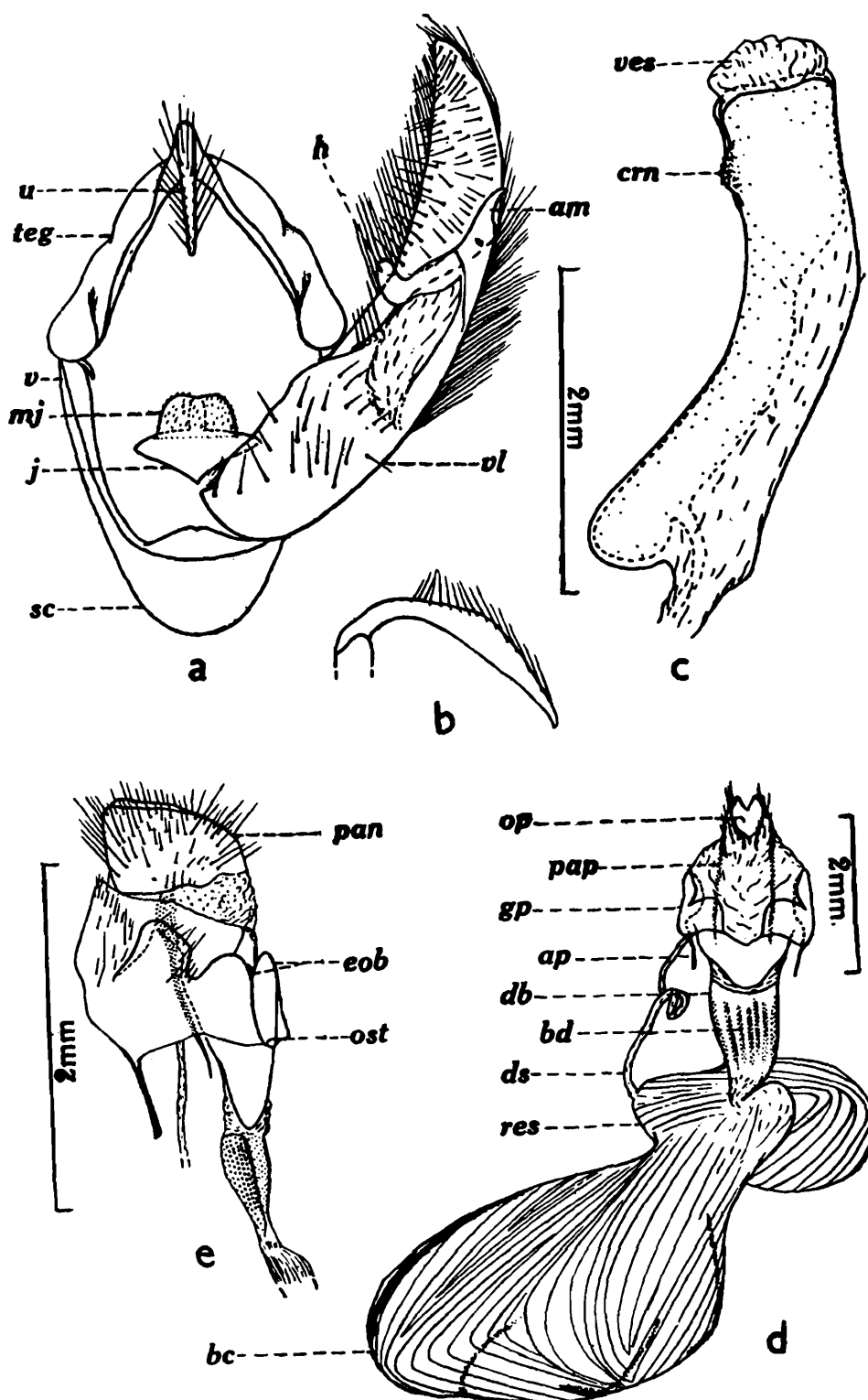
1758. *Noctua c-nigrum* Linnaeus, *Syst. Nat.*, 10th ed., p. 516. (Type loc.—Europe).
1787. *Noctua c-nigrum* Linn. : Fabricius, *Mant. Ins.*, 2, p. 154.
1822. *Megasema c-nigrum* (Linn.) : Hübner, *Verz. bek. Schmett.*, p. 223.
1867. *Graphiphora c-nigrum* (Linn.) : Moore, *Proc. zool. Soc. Lond.*, p. 54.
1882. *Agrotis c-nigrum* (Linn.) : Kirby, *European Butterflies and Moths*, p. 192.
1888. *Graphiphora c-nigrum* (Linn.) : Cotes & Swinhoe, *Cat. Moths of India*, 2, pp. 311-312.
1894. *Agrotis c-nigrum* (Linn.) : Hampson, *Fauna Brit. India, Moths*, 2, p. 188.
1900. *Chera c-nigrum* (Linn.) : Swinhoe, *Cat. East & Aust. Lep. Het.*, Part II, p. 13.
1903. *Agrotis c-nigrum* (Linn.) : Hampson, *Cat. Lep. Phal.*, 4, pp. 389-390.
1909. *Agrotis c-nigrum* (Linn.) : Lefroy, *Indian Insect Life*, p. 445.
1909. *Rhyacia c-nigrum* (Linn.) : Warren, in Seitz *Macrolepidoptera of the World*, 3, p. 43, pl. 98.
1921. *Agrotis c-nigrum* (Linn.) : Fletcher, *Proc. 3rd. ent. Mtg.*, 100, p. 24.
1933. *Rhyacia (Diarsia) c-nigrum* (Linn.) : Corti & Draudt, in Seitz *Macrolepidoptera of the World*, Suppl. 3, p. 79.
1935. *Rhyacia (Agrotis) c-nigrum* (Linn.) : Sevastopulo, *J. Darjeeling nat. Hist. Soc.*, 10, p. 61.

1941. *Agrotis c-nigrum* (Linn.) : Beeson, *Forest Insects*, p. 644.
 1955. *Amathes c-nigrum* (Linn.) : Boursin, *Veröff. zool. Stsamml. Münch.*,
 8, p. 15. (Syn. *A. c-nigrum deraiota* (Hampson)).
 1959. *Agrotis c-nigrum* (Linn.) : Mathur & Singh, *Indian For. Bull. (N.S.)*,
 171(7) p. 43.

Head pale or deep purple brown, mixed with white scales. Frontal tufts pale below, dark brown above. Antennae brown. Labial palpi dark brown, mixed with white up to the extremity of second segment, the latter pale, the third segment pale brownish. Vertex also dark brown. Collar whitish, marked with double pale brown band across it. Thorax and fore wings purple brown. Fore wings marked with double, black subbasal line extending from costa to vein 1A and interrupted at the cell; with some black suffusion beyond it in the submedian fold; antemedial line black and double, curved from costa to the inner margin, slightly faint below the cell; claviform v-shaped, faintly marked; orbicular brownish white, v-shaped, open above and confluent with the brownish-white medial costal area; reniform rufous above, with the centre brown and the boundary line black; the area in between stigmata in the cell filled up with chocolate brown colour; postmedial line black, double, excurved below the costa above vein R_5 and at M_3 ; thereafter incurved, slightly dentate and with some spots on the veins; a sinuous subterminal line present from the black striga on the costa, followed by a series of terminal short spots. Hind wings whitish, tinged with fuscous on the apical half; veins brown. Under side with the fore wing purple grey, marked across by faint postmedial line and a pale costal area from the base to near the apex; hind wings, whitish, with a postmedial line and a brown discocellular spot. Legs brown, with white bands on the tibial spurs and tarsi. Abdomen pale brown to brown.

Head with the frons (Text-fig. 1 g) smooth, only slightly or not at all produced forward. Antennae in both the sexes ciliate, reaching about two-thirds the length of costa from the base. Labial palpi well developed, obliquely upturned, the third segment short and porrect. Legs with three rows of spines on all the tarsal segments.

Genitalia.—Male (Text-figs. 12 a-c) with the uncus long, sharply bent downwards, with the base broad, the mid-dorsal area raised, the distal end narrow and pointed; tegumen short; vinculum long, slender v-shaped; saccus semicircular. Claspers simple, without corona, the setae sparse; ampulla weak, lightly sclerotised, extending up to the distal one-third and protruding beyond the ventral margin; harpe indistinct. Juxta triangular, sclerotised, dome-shape in the middle and beset with fine, dark spines, Aedeagus simple, mostly undifferentiated; vesica beset with fine spines. Female (Text-figs. 12 d-e) with the ostium bursae having its margin highly sclerotised and raised midventrally over the opening, into a u-shape or horse-shoe shape; ductus bursae small and narrow, distended in the middle, heavily sclerotised on the sides and the middle in the form of longitudinal bands; corpus bursae striated, large, balloon-shaped; receptaculum seminalis transverse oval, both the corpus bursae and the receptaculum seminalis striated longitudinally throughout except at the base, the former with three lateral and one sub-lateral stripes; ductus spermathecae arises from the receptaculum seminalis, long and uniformly narrow.



TEXT-FIG. 12. *Amathes c-nigrum* (Linn.): (a) male genitalia, ventral view (b) uncus, lateral view (c) aedeagus (d) female genitalia, ventral view (e) ovipositor and the genital plate enlarged (Text-figs. a-c of same magnification).

Wing expanse—Males, 39—47.5 mm.; females, 31.5—38.5 mm.

Distribution.—India; N.W. Himalayas, Punjab, Bihar, Maharashtra, Madras. Also Sikkim.

Material examined.—Seven examples. INDIA: Himachal Pradesh; Kulu, 1 ♀ (A. G. Young) [no date of collection]. Bihar; Ranchi, 2 ♀ ♀

(*W.H. Irvine*) [no date of collection]. Maharashtra ; Bombay, 1 ♂, 1 ♀, — vii.1884 (*Swinhoe*).

GERMANY: Prussia, 1 ♂, 1 ♀ (*A. Kricheldroff*).

Host range.—*Platanus orientalis* Linn.: Mathur and Singh, 1959. Potato (*Solanum tuberosum* Linn.): Fletcher, 1917, 1921. Lefroy (1909) and Beeson (1941) simply reported it as pest in India.

Remarks.—Referrable to the genus *Amathes* Hübner, it has a rather close similarity with *Am. deraiota* (Hampson). The latter was treated as a subspecies of *Am. c-nigrum* by Boursin (1955) but it is apparently a distinct species, as originally proposed by Hampson because it differs considerably in coloration on the wings and in the genitalic characters, especially by the presence of sclerotised stripes on the corpus bursae unlike the case in *Am. deraiota* (Hampson) which is without stripes or signum on the corpus bursae but with two sclerotised ribbons.

Present record from Bihar is the first from the locality.

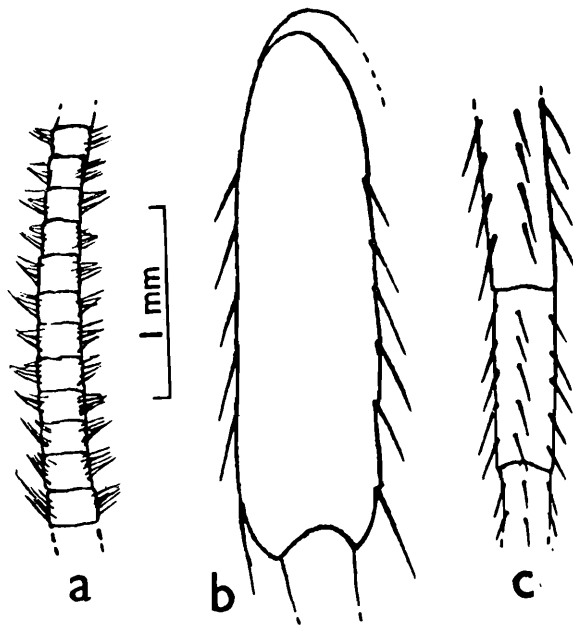
10. *Amathes deraiota* (Hampson)

(Plate I, fig. 7 ; Text-figs. 1 h, 13 a-c, 14 a-d)

1902. *Agrotis deraiota* Hampson, *J. Bombay nat. Hist. Soc.*, **14**, p. 198. (Type loc.—Maturatta, Ceylon).
 1903. *Agrotis deraiota* Hampson, *Cat. Lep. Phal.*, **4**, p. 391.
 1955. *Amathes c-nigrum deraiota* (Hampson): Boursin, *Veröff. zool. Stsamml. Münch.*, **8**, p. 15, pl. VII, fig. 24.
 1893. *Amathes c-nigrum* Hampson, [*nec.* Linn.] *Ill. Lep. Het.*, **9**, p. 94, p. 176, fig. 4. (Syn. of *A. deraiota* (Hampson), *vide* Hampson, 1903).

Head with the frontal tufts pale brown, irrorated with dark scales and marked with a black bar. Antennae brown. Labial palpi brown, mixed with dark scales and heavily fringed with the scales in the front. Vertex pale brown. Collar as in *Am. c-nigrum*, pale ochreous, except at the end which is chocolate brown. Thorax brown, with the tips of some scales grey. Abdomen grey brown. Fore wings pale-red brown, suffused with purplish grey, the female being slightly lighter in colour than the male ; cells filled up with chocolate brown colour between the stigmata ; claviform indistinct ; orbicular open above, v-shaped and confluent with the purple grey costal area ; subbasal line black and short, running from costa to vein 1A, interrupted at the cell ; antemedial line black, wavy and double from costa to the inner margin ; postmedial line indistinct, represented by short, black, double dots on the veins, excurved below the costa to vein M₃, thereafter incurved to the inner margin ; sinuous subterminal line defined by an elongate patch on the inner side near the apex, and running towards the inner margin ; the area beyond it up to the terminal line as well as the cilia purple tinged with fuscous ; the cilia slightly paler at their tips. Hind wings pale brown. Under side with the wings pale-brownish white ; fore wings sometimes tinged with fuscous ; postmedial line in both wings and an indistinct discocellular line in hind wings brown. Legs ochreous brown below, dark above ; the tibial spurs white at the base and the tip.

Head with the frons (Text-fig. 1 h) smooth and not produced. Antennae (Text-fig. 13 a) minutely ciliate in both sexes, profusely in the male than in female. Labial palpi obliquely upturned, the third segment short and porrect. Frenulum consisting of a single spine in the male and three spines in the female.



TEXT-FIG. 13. *Amathes deraiota* (Hampson): (a) Portions of antenna (b) fore tibia and (c) hind-tarsal segments (all of the same magnification).

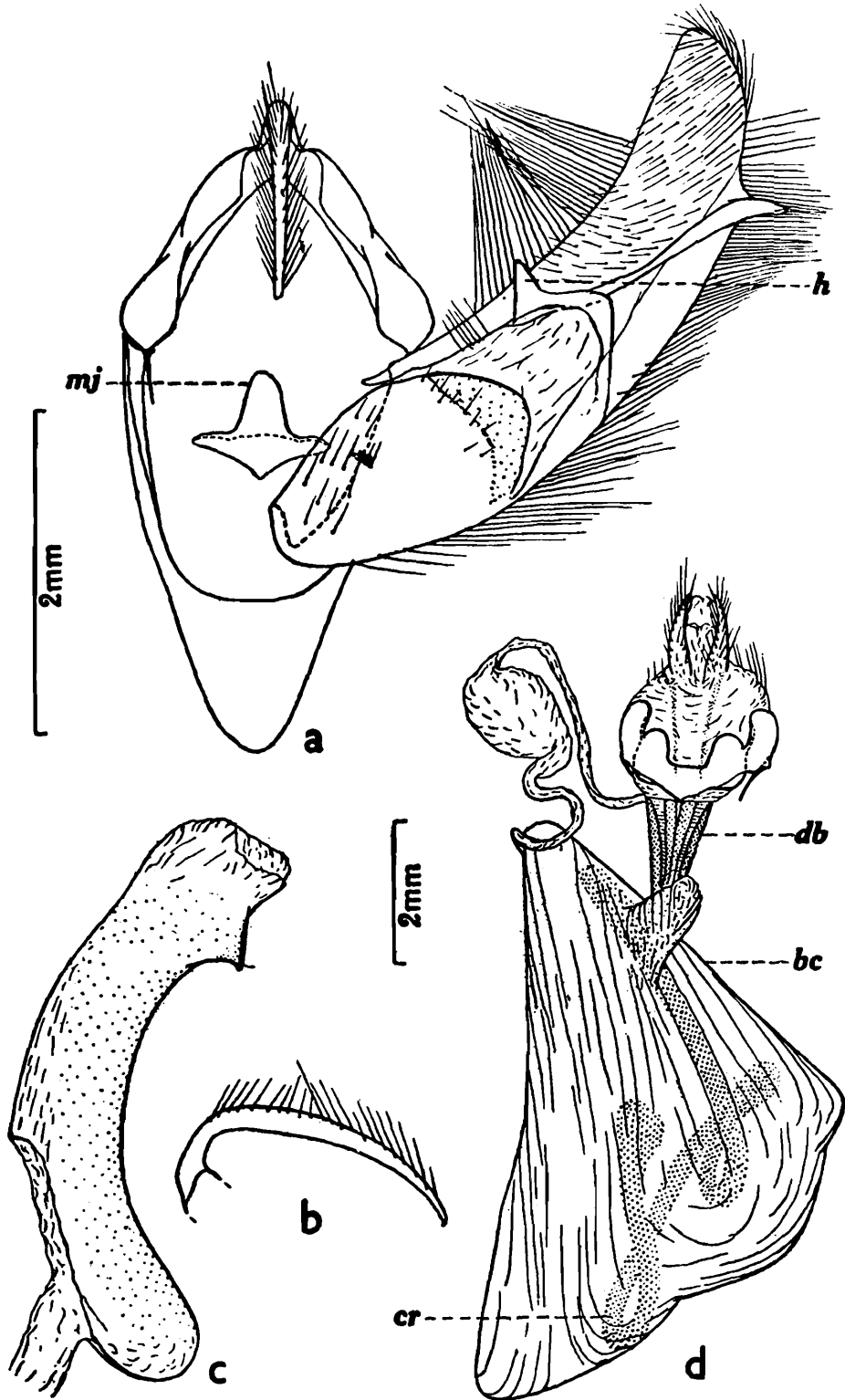
Genitalia.—Male (Text-figs. 14 a-c) with the uncus sharply bent downwards, gradually tapering into a fine point; tegumen and vinculum as in *Am. c-nigrum*; saccus also slightly more pointed than in the latter, claspers slightly broader; ampulla narrow and produced beyond the margin; harpe tapering and rather slender unlike in *Am. c-nigrum*. Juxta large, subtriangular, with a medial elongate dome which is without spines. Aedeagus sclerotised weakly and along one side, the other remaining membranous; the distal part with a short tooth. Female (Text-fig. 14 d) genitalia large; ostium bursae sclerotised as in *Am. c-nigrum*; ductus bursae sclerotised, broad distally; corpus bursae large, subtriangular, with two sclerotised ribbons in it, and without any stripes or signum and unlike the case in *c-nigrum* (fig. 14 d), receptaculum seminalis almost spherical in the middle.

Wing expanse.—Males, 38.5—40 mm; females, 43—44.5 mm.

Distribution.—Ceylon.

Material examined.—Four examples. CEYLON: Hakgala, 1 ♂, —.iii.1907, 2 ♀ ♂ —.iv.1907 (*E. E. Green*).

Remarks.—Referrable to the genus *Amathes*, it has a close resemblance to *Am. c-nigrum* (Linn.) specially in respect of the colour pattern on the wings. However, the two differ in details of the pattern and structure of the genitalia as described earlier under the account for *Am. c-nigrum*,



TEXT-FIG. 14. *Amathes deraiota* (Hampson): (a) male genitalia, ventral view (b) uncus, lateral view (c) aedeagus (d) female genitalia, ventral view (Text-figs. a-c of same magnification).

11. *Amathes curviplena* (Walker) comb. nov.

(Plate I, fig. 8 ; Text-figs. 15 a-e)

1865(b). *Orthosia curviplena* Walker, *List Lep. Brit. Mus.*, p. 715. (Type loc.—Darjeeling).

1888. *Orthosia curviplena* Walker: Cotes & Swinhoe, *Cat. Moths of India*, p. 297.
 1894. *Agrotis curviplena* (Walker): Hampson, *Fauna Brit. India, Moths*, 2, p. 185.
 1900. *Chera curviplena* (Walker): Swinhoe, *Cat. East & Aust. Lep. Het.*, Part II, p. 9.
 1903. *Richia curviplena* (Walker): Hampson, *Cat. Lep. Phal.*, 4, p. 596, pl. LXXVI, fig. 13.

Head with the frontal tufts and the vertex ochreous, with the tips of some scales rufous. Antennae brown. Labial palpi brown except at the extremity of the second segment and whole of the third segment which are ochreous. Thorax and fore wings ochreous, with the tips of some scales rufous, on the whole giving a slightly rufous tinge; the lines also rufous; subbasal line rufous and double, from costa to the submedian fold; the antemedial line rufous, double and waved, with an indistinct striga before it in the cell; an indistinct striga before it in the cell; an indistinct rufous medial line excurved at vein M_3 ; the postmedial line rufous and double, with the inner line heavily dentate; the subterminal line straight and oblique from apical margin; a fine, waved terminal line present, cilia ochreous; not filled up with a distinct colour in the area between stigmata; the claviform small and oval; the orbicular and reniform large, with their boundaries rufous. Hind wings ochreous, tinged with fuscous nearly up to the subterminal area; terminal line rufous; cilia ochreous. Abdomen ochreous, tinged with fuscous above. Under side with the fore wings tinged with fuscous up to the subterminal area, ochreous beyond it; hind wings and abdomen ochreous, the former marked with a rufous terminal line. Legs ochreous, tinged with pale brown, rarely with white bands on the spurs and tarsi.

Head with the frons smooth, subrounded, slightly produced forward. Antennae simple and ciliate in both sexes but with the cilia more profuse in the male. Labial palpi obliquely upturned, the third segment short and porrect.

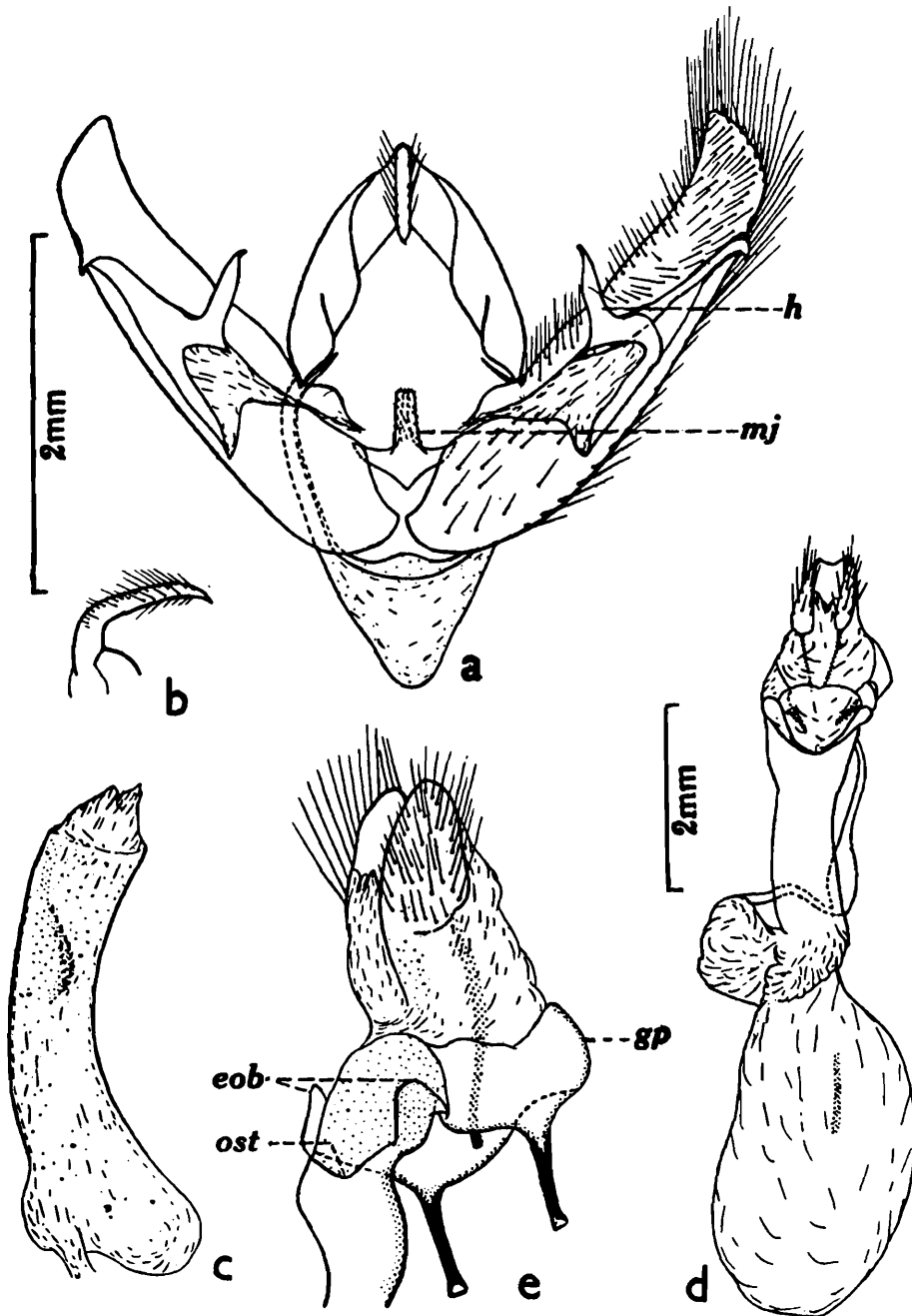
Genitalia.—Male (Text-figs. 15 a-c) with the uncus broad at the base, slightly curved dorsally, tapering into a fine point; tegumen short and broad; vinculum slender; saccus large and subtriangular. Claspers long, generally of uniform width throughout except near the distal end which is slightly narrow; cucullus without corona, the setae sparse; ampulla extending along the mesal side and protruding outside the ventral margin; harpe long and pointed. Juxta triangular, with the so-called median dome elongate, long and beset with fine setae. Aedeagus simple, lightly sclerotised, beset with short spines on the vesica. Female (Text-figs. 15 d-e) with the ostium bursae having its margin highly sclerotised, its edge formed into a horse-shoe shape cover over the opening; ductus bursae sclerotised, long and broad; corpus bursae striated longitudinally, with four stripes *i.e.*, two lateral, one dorsal and one ventral. From the left side, ventrally, the receptaculum seminalis arises as a small lobe; ductus spermathecae long and narrow except for the slight enlargement in the middle (fig. 15 d).

Wing expanse.—Males, 30—37.5 mm.; females, 33.5—36 mm.

Distribution.—India; West Bengal. Sikkim.

Material examined.—Nine examples. INDIA: West Bengal; Darjeeling, 2133.57 m. (7000 ft.), 2 exs. (? sex) [no further data] (Z. S. I. colln.). SIKKIM: 1 ♂, —x.1895 (*J. G. Pilcher*), 3 ♂♂, 1 ex. (? sex)

(*O. Möller*) [no date of collection]. 2 exs. (? sex) [no locality or any other data].



TEXT-FIG. 15. *Amathes curviplena* (Walker): (a) male genitalia, ventral view (b) uncus, lateral view (c) aedeagus (d) female genitalia, ventral view (e) ovipositor and the genital plate enlarged. (Text-figs. a-c, e of same magnification).

Remarks.—Referrable to the genus *Amathes* Hübner, it is characterised by the absence of any distinct colour between the stigmata in the cell, unlike the case in *Am. c-nigrum*, the subspherical shape of corpus bursae and in the position of four sclerotised stripes (bars) as described above.

12. *Amathes consanguinea* (Moore)

(Text-fig. 16)

- 1881(a). *Ochropleura consanguinea* Moore, *Proc. zool. Soc. Lond.*, p. 353. (Type loc.—Solan, Himachal Pradesh).
 1888. *Ochropleura consanguinea* Moore : Cotes & Swinhoe, *Cat. Moths of India*, p. 312.
 1903. *Agrotis consanguinea* (Moore) : Hampson, *Cat. Lep. Phal.*, 4, p. 396.
 1909. *Rhyacia consanguinea* (Moore) : Warren, in Seitz *Macrolepidoptera of the World*, 3, p. 44, pl. 9h.
 1933. *Rhyacia* (*Diarsia*) *consanguinea* (Moore) : Corti & Draudt, in Seitz *Macrolepidoptera of the World*, Suppl. p. 79.
 1955. *Amathes consanguinea* (Moore) : Boursin, *Veröff. zool. Stsamml. Münch.*, Teil II, 8, p. 15, p. VIII, f. 26.

Head with the frontal tufts and antennae brown to dark brown. Labial palpi dark brown up to the second segment, the third segment blackish, the tips of some scales greyish and black. Vertex dark brown. Collar pale ochreous, except at the tips which are dark. Thorax ochreous brown mixed with scales which are grey at the tips. Fore wings dark brown, with pale ochreous costal fascia to nearly two-thirds from base; the area of the cell between the stigmata and the base filled up with dark colour, stigmata defined by black boundaries; the claviform not as distinct as the orbicular and the reniform; the orbicular somewhat oblique, elliptical and open above but with the centre darker than the costal fascia; the reniform large and well defined; subbasal line reduced to a small spot on the costa; antemedial and postmedial lines black, wavy, double and indistinctly marked; subterminal line defined on the inner side by an oblique and short black bar. Hind wings dark brown to fuscous. Under side with the wings and the legs fuscous, except at the costal area and the inner area which are pale fuscous.

Head with the frons smooth. Antennae ciliate in the female. Labial palpi upturned, the second segment fringed with scales in the front, the third segment slight and upturned.

Venation same as in *Agrotis segetum* (Schiffermüller) (Text-figs. 3 a-b) except that veins $R_5 + M_1$ generally not stalked in hind wings.

Genitalia.—Female (Text-fig. 16) with the ostium bursae having its inner surface sclerotised; the margin sclerotised and formed into a u-shape cover over the opening; ductus bursae lightly sclerotised; corpus bursae large, bag like, with four patches *i.e.*, 3 sub-lateral and one ventral; receptaculum seminalis almost as large as the corpus bursae and membranous; genital tube short, with the ovipositor oblique.

Male not studied.

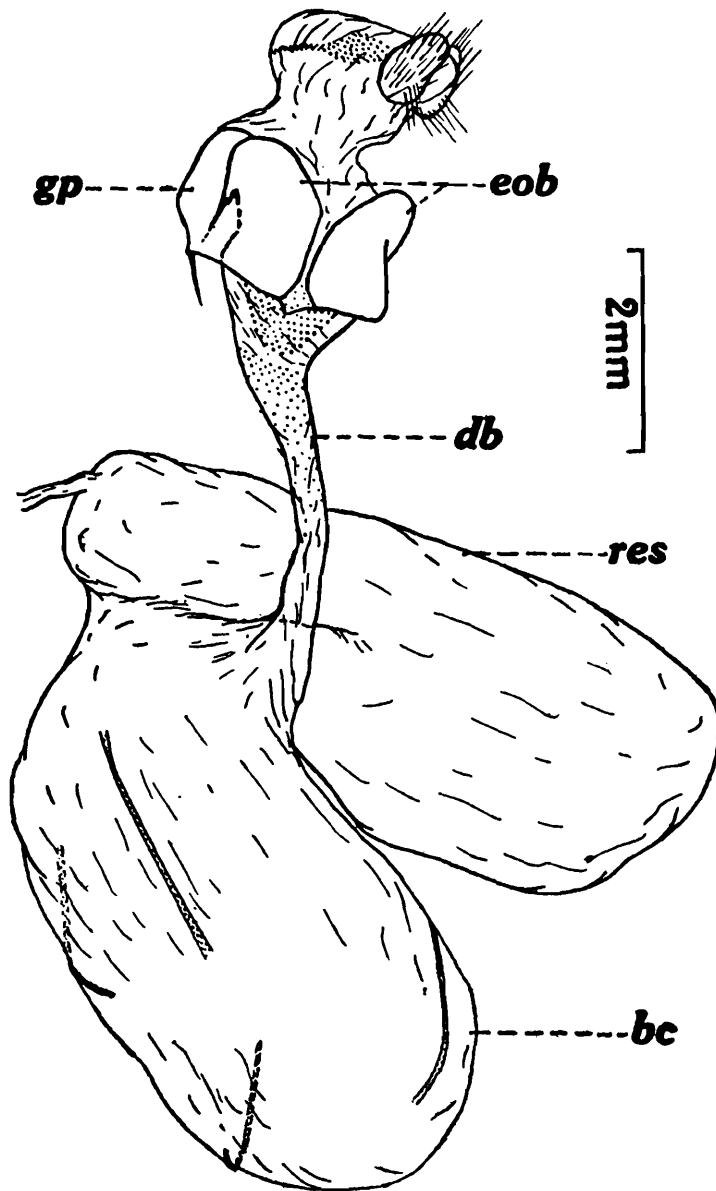
Wing expanse.—45 mm.

Distribution.—India; Kashmir and Himachal Pradesh. Also Tibet and China.

Material examined.—One example. INDIA: Himachal Pradesh; Kangra Valley, 1371.58 m. (4500 ft.), 1 ♀ —ix.1899 (*G. C. Dudgeon*).

Remarks.—There is only one female specimen from Kangra Valley (Himachal Pradesh) and is not in a well preserved condition. It is referable to the genus *Amathes* Hübner due to the presence of characteristic u-shape cover, which is as large as the 8th segment, over the ostium bursae, thus differing from, both *Am. c-nigrum* and *Am. curviplena*, though agreeing with the latter species, in general.

It, however, differs from the former by the sclerotisation on the inner surface of ostium bursae and in the size of receptaculum seminalis which is as large as the corpus bursae and in the position of sclerotised stripes.



TEXT-FIG. 16. *A. consanguinea* (Moore) : Female genitalia, latero-ventral view.

Genus *Diarsia* Hübner

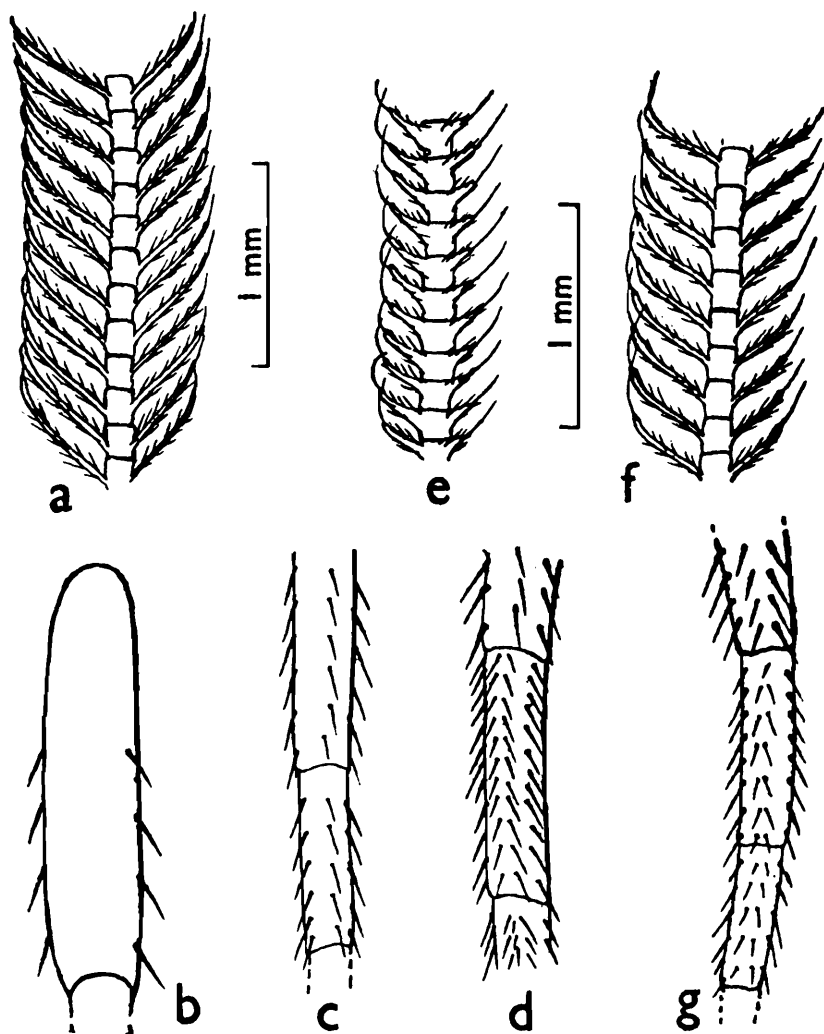
1822. *Diarsia* Hübner, *Verz. bek. Schmett.*, p. 227.
 1933. *Diarsia* Hübner : Corti & Draudt, in Seitz *Macrolepidoptera of the World*, Suppl. 3, p. 74.
 1954. *Diarsia* Hübner : Boursin, *Bonn. zool. Beitr.* 5, nos. 3-4, pp. 213-252, pls. ii-iv, vii-x, 101 figs.

Type of the genus : *Diarsia dahlii* (Hubner) from Europe.

Distribution.—India ; Burma ; Ceylon ; Japan ; W. China.

Diagnosis.—Frons (Text-figs. 1 i-j) smooth, flat or produced medially into a sub-rounded shape. Antennae (Text-figs. 17 a, f) strongly bipectinate in the male as in *D. ochracea* (Walker) and *D. ruptistriga*

(Walker) ; short biserrate in the male as in *D. postfusca* (Hampson) (Text-fig. 17 e) ; or ciliate in both sexes as in *D. cerastioides* (Moore), *D. erubescens* (Butler), *D. nigrosigna* (Moore), *D. putris* (Linn.), *D. rubicilia* (Moore) and *D. sicca* (Guén.). Eyes glabrous ; a well developed ocellus present behind each antenna. Proboscis fully developed. Labial palpi generally upturned, the third segment porrect or upturned. Legs (Text-figs. 17 b, c, d, g) with the tibiae longer than the first tarsal segment and beset with two rows of slender spines ; fore tibia shorter than the femur ; mid-tibia equal to the femur and having one pair of spur, the hind tibiae longer than femur and having two pairs of spurs ; tarsi with three rows of spines on the first tarsal segments, three to five rows on other segments ; a well developed arolium between the claws present. Frenulum consisting of a single spine in the male ; two to three spines in the female.



TEXT-FIG. 17. Portion of antennae and legs of the genus *Diarsia* : (a) antenna, (b) fore tibia and (c) hind tarsal segment of *D. ochracea* (Walker) (d) hind-tarsal segments of *D. nigrosigna* (Moore) ; (e) antenna of *D. postfusca* (Hampson) (f) antenna and (g) hind-tarsal segments of *D. ruptistriga* (Walker).

Venation as described in the case of *Agrotis segetum* (Schiff.) (Text-figs. 3 a-b) except in variation of the origin of veins R_s-M_1 in the hind wing and vein M_1 in the fore wing.

Genitalia.—Male well developed. Claspers with the cucullus well developed and differentiated, produced forwards disto-ventrally as in *D. ochracea* (Walker), *D. ruptistriga* (Walker), *D. cerastioides* (Moore), *D. rubicilia* (Moore) and *D. erubescens* (Butler), or not so as in *D. nigrosigna* (Moore) and *D. postfusca* (Hampson); most of the species are with an additional cluster of setae below the corona except in *D. sicca* (Guén.); ampulla short and blunt; clavus present only in *D. nigrosigna* (Moore), *D. rubicilia* (Moore) and *D. cerastioides* (Moore); harpe always present. Juxta variable in shape. Aedeagus with several short spines or a single hard structure on the vesica. The female genitalia is extremely variable and therefore given in details in the text. It had not been possible to generalise the characteristics.

Remarks.—The present study is based on nine species; viz. *D. cerastioides* (Moore), *D. erubescens* (Butler), *D. nigrosigna* (Moore), *D. rubicilia* (Moore), *D. putris* (Linn.), *D. sicca* (Guén.), *D. ochracea* (Walker), *D. ruptistriga* (Walker) and *D. postfusca* (Hampson), which have been placed under this genus by studying their external morphological and the genitalic characters, in the light of recent revisionary work of Boursin (1954a, 1954b, 1955). Except for *D. postfusca* (Hampson) and *D. sicca* (Guén.) others have been included by Corti & Draudt (1933) under *Rhyacia* (*Diarsia*), and latter in 1954(a) Boursin separated them as distinct species under the genus *Diarsia* Hübner. Two have been included in *Diarsia* Hübner, for the first time.

The following keys have been prepared on the basis of external and the genitalic characters, both in the male and the female.

(a) *Based on the external characters*

1. Antennae bipectinate or serrate in the male ... 2
 Antennae fasciculate in the male ... 4
2. Antennae with the branches short or long. Fore wings filled up with colour in the cell between the stigmata ... 3
 Antennae with the branches long. Fore wings not filled up with colour in the cell between the stigmata ... *ochracea* (Walker)
3. Antennae with the branches long. Labial palpi with the third segment long and upturned ... *ruptistriga* (Walker)
 Antennae with the branches short. Labial palpi with the third segment short and porrect ... *postfusca* (Hampson)
4. Labial palpi with the third segment porrect. Hind legs with three rows on all the tarsal segments ... *sicca* (Guén.)
 Labial palpi with the third segment variable. Hind legs with three or more than three rows of spines on second to fifth tarsal segment ... 5

5. Fore wings with one or more
stigmata not distinct in the cell ... 6
- Fore wings with all the stigmata
distinct in the cell ... 7
6. Fore wings with the reniform
distinct, the orbicular and clavi-
form obsolete; submarginal area
pale, marked with some distinct
streaks before it ... *rubicilia* (Moore)
- Fore wings with all the stigmata
indistinct; submarginal area pale,
marked with some indistinct
streaks ... *erubescens* (Butler)
7. Labial palpi with the third segment
variable. Fore wings not filled up
with colour between the stigmata ... 8
- Labial palpi with the second segment
upturned, the third segment
obliquely porrect. Fore wings filled
up with colour between the
stigmata ... *cerastioides* (Moore)
8. Labial palpi with the third segment
upturned. Fore wings with
ochreous fascia on the costa;
numerous small black streaks on
the veins in the area M_1 and M_2
in between the outer margin and
discocellular ... *putris* (Linn.)
- Labial palpi with the third segment
porrect or downwardly curved.
Fore wings without fascia and
streaks on the veins ... *nigrosigna* (Moore)

(b) Based on the male genitalia

1. Cluster of strong bristles below
the corona and ampulla present,
rarely absent below the ampulla;
saccus large. Juxta short and
broad. Aedeagus usually with the
spines well developed ... 2
- Cluster of such setae absent: saccus
short. Juxta long and broad, with
lateral prolongations. Aedeagus
simple and without cornuti ... *sicca* (Guén.)
2. Claspers with the cucullus narrow
and produced forwards disto-
ventrally ... 3
- Claspers with the cucullus not narrow
and not produced disto-ventrally ... 7
3. Clavus present ... 4
- Clavus obsolete ... 5

4. Uncus broad, abruptly ending in a point distally; saccus triangular. Claspers with the cucullus about half the width of the middle portion, not sharply differentiated ... *ochracea* (Walker)
- Uncus broad but flattened distally; saccus large and conical. Claspers with the cucullus narrow, less than half the width of the middle portion, sharply differentiated ... *ruptistriga* (Walker)
5. Ampulla short and thin, with bristles below it; harpe z-shaped ... *cerastioides* (Moore)
- Ampulla short and thick, without bristles below it; harpe not as above ... 6
6. Corona having a dense cluster of bristles below it and a few below ampulla; saccus large ... *rubicilia* (Moore)
- Corona not having any dense cluster below it and ampulla; saccus short ... *erubescens* (Butler)
7. Harpe and ampulla pointed and narrow. Juxta bifurcated into two narrow lobes distinctly. Aedeagus large, with numerous spines on the vesica ... *nigrosigna* (Moore)
- Harpe and ampulla not pointed, but broad at the end. Juxta small and not produced at the end into two lobes, but extended laterally. Aedeagus with a row of spines inside on the vesica ... *postfusca* (Hampson)

(c) *Based on the female genitalia*

1. Ostium bursae with the margin sclerotised and extending over the opening; corpus bursae large or small, with or without sclerotised ribbons; receptaculum seminalis present or absent ... 2
- Ostium bursae simple, with the margin not extending over the opening; corpus bursae large, with sclerotised ribbons; receptaculum seminalis absent ... *sicca* (Guén.)
2. Corpus bursae with ribbons ... 3
- Corpus bursae without ribbons ... 4
3. Corpus bursae long bladder like, with a single ribbon, receptaculum seminalis large and spherical ... *uptistriga* (Walker)
- Corpus bursae more or less cylindrical, with two ribbons; receptaculum seminalis elongate and broad, narrowing abruptly at its end ... *nigrosigna* (Moore)

- | | | |
|----|---|-----------------------------|
| 4. | Receptaculum seminalis present,
small | 5 |
| | Receptaculum seminalis absent | 7 |
| 5. | Corpus bursae with sclerotised
stripes on it | 6 |
| | Corpus bursae without stripes on it | <i>erubescens</i> (Butler) |
| 6. | Ductus bursae uniformly sclerotised;
corpus bursae short and broad | <i>ochracea</i> (Walker) |
| | Ductus bursae with two sclerotised
areas, one on each side; corpus
bursae long, with its base rounded | <i>postfusca</i> (Hampson) |
| 7. | Ductus bursae sclerotised fully or
partly; corpus bursae short and
broad | 8 |
| | Ductus bursae membranous; corpus
bursae long and narrow | <i>rubicilia</i> (Moore) |
| 8. | Ductus bursae long; corpus bursae
broad almost rounded | <i>cerastioides</i> (Moore) |
| | Ductus bursae short; corpus bursae
broad, more or less rounded at
the base only, the apical part
narrow | <i>putris</i> (Linn.) |

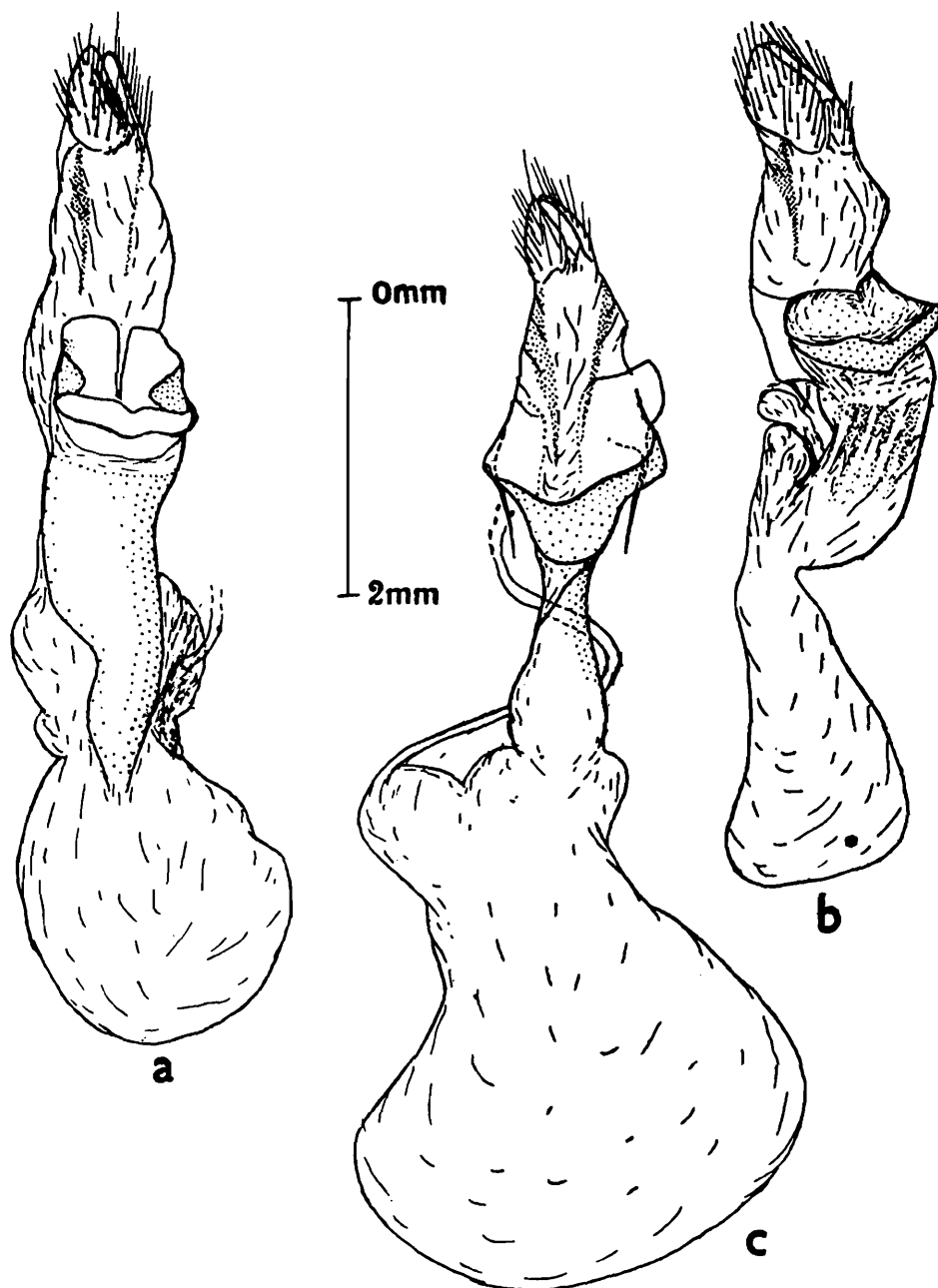
13. *Diarsia cerastioides* (Moore)

(Text-fig. 18 a)

1867. *Graphiphora cerastioides* Moore, *Proc. zool. Soc. Lond.*, p. 54. (Type loc.—Darjeeling).
 1888. *Graphiphora cerastioides* Moore : Cotes & Swinhoe, *Cat. Moths of India*, p. 310.
 1894. *Agrotis cerastioides* (Moore) : Hampson, *Fauna Brit. India, Moths*, 2, p. 185.
 1903. *Agrotis cerastioides* (Moore) : Hampson, *Cat. Lep. Phal.*, 4, p. 430.
 1909. *Rhyacia cerastioides* (Moore) : Warren, in Seitz *Macrolepidoptera of the World*, 3, p. 47.
 1954(a). *Diarsia cerastioides* (Moore) : Boursin, *Bonn. zool. Beitr.*, 5, pp. 219, 225, 249, pl. IX, fig. 35 ♂ genitalia).

Head with the frontal tufts, vertex and the thorax dark reddish brown, mixed with grey. Antennae with the base pale-ochreous brown, the shaft brown. Labial palpi dark brown up to the second segment. Fore wings dark reddish brown; the subbasal and antemedial lines indistinct, the postmedial lines dark, double and waved, excurved below the costa and in the middle, incurved below vein M_3 ; the subterminal line indistinct, curved outwards below vein R_5 ; the terminal line pale and indistinct; light brown colour present between the stigmata in the cell; the claviform indistinct; the orbicular almost rounded, with the centre red brown; the reniform almost red brown, both the stigmata defined by brown boundaries and greyish annuli. Hind wings brownish white, the veins darker. Under side with the fore wing dark-reddish brown; hind wings paler. Legs with the tibiae and the tarsi fuscous, tibial spurs with the pale bands at base and the tips present.

Head with the frons smooth. Antennae ciliate in both sexes, the ciliation profusely in the male than in the female. Labial palpi obliquely upturned, the third segment short and narrow. Legs with two rows of spines on all the tibiae and three rows on all the tarsal segments, rarely with four rows on the fore tarsi.



TEXT-FIG. 18. Female genitalia of (a) *D. cerastioides* (Moore); (b) *D. erubescens* (Butler); (c) *D. putris* (Linn.).

Genitalia.—Boursin has described its male genitalia in details. The main feature being that the uncus is strong, the claspers relatively short and broad; cucullus well differentiated, with slender bases; corona normal; harpe z-shaped, with broad bases; ampulla very short and thin; clavus obsolete. Aedeagus short and thick. (After Boursin, 1954, a). Female (Text-fig. 18 a) with the ostium bursae having its margin sclerotised, leading through the sclerotised ductus bursae;

corpus bursae almost rounded, without stripes and signum; receptaculum seminalis absent; ductus spermathecus, instead, arises from the basal part of corpus bursae which is slightly enlarged than the ductus bursae.

Distribution.—India; Himachal Pradesh, Punjab, Bengal. Also Sikkim.

Wing expanse.—Males, 34—37 mm.; females, 30—33 mm.

Material examined.—Four examples. INDIA: West Bengal, Darjeeling, 1 ♀, [no more data]. Sikkim: 1 ♀, 1.xi.1890 (G. C. Dudgeon), 2 ♂♂ (O. Möller) [no date of collection].

Remarks.—Referrable to this genus, it has some external characteristic features which agree with *D. erubescens* (Butler) and *D. rubicilia* (Moore), but, however, differs from them in the absence of receptaculum seminalis in the female genitalia and in the shape of corpus bursae, which is almost circular at base.

Though there are several specimens in the collection, only one, a female, had the intact abdomen, therefore the genitalia of the male could not be studied and in this regards the characters given by Boursin (1954, a) have been employed.

14 *Diarsia erubescens* (Butler)

(Text-fig. 18 b)

1880. *Orthosia erubescens* Butler, *Ann. Mag. nat. Hist.*, (5) 5, p. 224. (Type loc.—Neilgherries) (as Syn. of *A. descripta* (Bremer), and *A. dahlia* (Hübner), vide Hampson, 1894, 1903, respectively).
 1888. *Orthosia erubescens* Butler: Cotes & Swinhoe, *Cat. Moths of India*, p. 297.
 1891. *Chera erubescens* (Butler): Hampson, *Ill. Lep. Het. Brit. Mus.*, 8, p. 78, pl. 145, fig. 7.
 1894. *Orthosia erubescens* Butler: Hampson, *Fauna Brit. India, Moths*, 2, p. 185 (as a Syn. of *A. descripta* Bremer).
 1903. *Orthosia erubescens* Butler: Hampson, *Cat. Lep. Phal.*, 4, p. 423. (as a Syn. of *A. dahlia* (Hübner)).
 1954. *Diarsia erubescens* (Butler): Boursin, *Bonn. zool. Beitr.*, 5, pp. 225, 249-250, pl. iv, figs. 7 ♂, 8 ♀, pl. x, fig. 36 (♂ genitalia).

There is a single female specimen from Kulu (coll. Young) which is not in a well-preserved state especially for the description of its body colour and the pattern of the wings. Butler (1880) has described its coloration. Some of the diagnostic characters are as follows: Head with the vertex and the labial palpi in the front white. Fore wings above shining pinky brown; the base crossed by small dots; discoidal spots imperfectly represented by interrupted black outlines; the medial lines indistinctly greyish, and waved; the costa towards apex suffused with blackish. Hind wings pale-sericeous greyish brown, slightly cupreous upon the margin, whitish at the base. Under side with the wings shining chalky white, with pink brownish costal border; discocellular stigma and an abbreviated discal line greyish; fore wings with the discoidal area greyish. Abdomen greyish brown, with testaceous lateral and anal tufts; under side testaceous, washed at sides with dull reddish.

Head with the frons smooth. Antennae simple and ciliate throughout. Labial palpi obliquely upturned, thickly fringed with scales in the front, reaching the frons, with the third segment slight and porrect.

Legs with two rows of spines on all the tibiae ; tibial spurs with white band at the base and tip ; tarsal spines not distinct.

Genitalia.—Boursin (1954, a) has described the genitalia of which diagnostic characters are as follows. Uncus strongly expanded in the middle, flattened at the distal end. Claspers relatively short and very broad ; cucullus strongly differentiated, with narrow bases ; corona normal, without setae at the inner angle ; harpe short, broad and strong, blunt at the end ; ampulla very small and hardly beset with bristles below it, clavus absent ; saccus normal. Juxta v-shaped, with v-shaped processes. Aedeagus short and stout, armed with several densely settled cornutus. Female (Text-fig. 18 b) with the ostium bursae having sclerotised margin extended but, unlike the other species, not cup-shaped ; ductus bursae sclerotised, with number of stripes on its distal part ; corpus bursae broader basally than at the distal part, without stripes ; receptaculum seminalis small ; genital plate and the papilla anellus lightly sclerotised.

Wing expanse.—Female 34 mm.

Distribution.—Himalayan sub-tropical.

Material examined.—One example. INDIA : Himachal Pradesh ; Kulu, 1 ♀, (Young) [no date of collection].

Remarks.—Referred to this genus only in 1954(a), by Boursin, as an independant species, it was considered till then as a synonym of *A. descripta* (Brem.) along with *D. rubicilia* (Moore) and *D. nigrosigna* (Moore), (*vide* Hampson, 1894) or of *D. dahlii* (Hübner) (*vide* Hampson, 1903). Boursin identified them separately only on the basis of male genitalia, the female genitalia are described here for the first time. The two species, *viz.* *D. erubescens* (Butler) and *D. rubicilia* (Moore), which were considered as synonyms of *descripta*, however, differ from each other on account of indistinct stigmata in *D. erubescens* (Butler), this being distinct in *D. rubicilia* (Moore) ; the male genitalia are without dense cluster below the corona in *D. erubescens* (Butler) unlike in *D. rubicilia* (Moore) and the female genitalia with small receptaculum seminalis unlike the case in *D. rubicilia* (Moore) where it is obsolete.

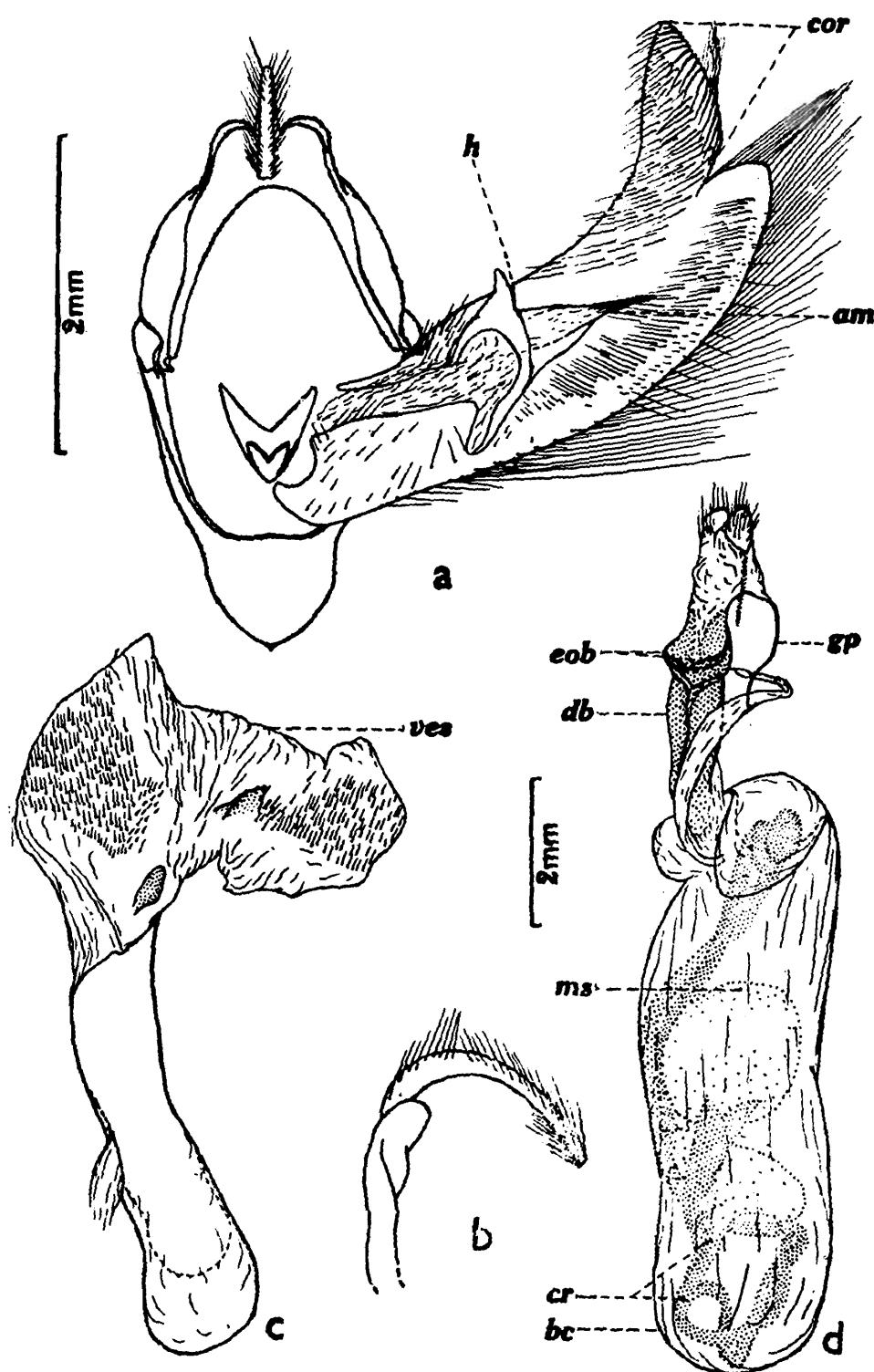
15. *Diarsia nigrosigna* (Moore)

(Plate I, fig. 9 ; Text-figs. 17 d, 19 a-d)

- 1881(a). *Graphiphora nigrosigna* Moore, *Proc. zool. Soc. Lond.*, p. 352, pl. 38, fig. 4. (Type loc.—Sikkim) (Syn. of *A. descripta* Bremer, *vide* Hampson, 1894 and *A. rubicilia* (Moore), *vide* Hampson, 1903).
- 1888 *Graphiphora nigrosigna* Moore : Cotes & Swinhoe, *Cat. Moths of India*, p. 311.
1894. *Graphiphora nigrosigna* Moore : Hampson, *Fauna Brit. India, Moths*, 2, p. 185. (as a Syn. of *Agrotis descripta* Bremer).
1903. *Graphiphora nigrosigna* Moore : Hampson, *Cat. Lep. Phal.*, 4, p. 426 (as Syn. of *A. rubicilia* (Moore)).
1909. *Rhyacia nigrosigna* (Moore) : Warren, in Seitz *Macrolepidoptera of the World*, 3, p. 46, pl. 10f. (as a Syn. of *Rhyacia rubicilia* (Moore)).
1933. *Rhyacia nigrosigna* (Moore) : Corti & Draydt, in Seitz *Macrolepidoptera of the World*, Suppl. 3, p. 76 (as a Syn. of *Rhyacia rubicilia* (Moore)).
- 1954(a). *Diarsia nigrosigna* (Moore) : Boursin, *Bonn. zool. Beitr.*, 5, pp. 225, 230, pl. II, figs. 15 ♂, 18 ♀, pl. VIII, fig. 12 (♂, genitalia).

Head with the frontal tufts and vertex ochreous brown. Antennae brown, except at the base which is ochreous brown. Labial palpi

dark brown on the outer sides up to the second segment, ochreous on the inner side, tip of second segment and the entire third segment. Fore wings ochreous brown; the subbasal line indistinct; the ante-medial and the postmedial lines indistinct, waved and pale brown; the claviform represented by a dark stigmata below the median nervure; the orbicular nearly round, with the boundaries brown; the reniform also defined by a brown boundary, with ochreous suffusion around its



TEXT-FIG. 19. *D. nigrosigna* (Moore): (a) male genitalia, ventral view (b) uncus, lateral view (c) aedeagus (d) female genitalia, ventral view (Text-figs. a-c of same magnification).

upper part and along the costa ; the subterminal line waved and pale ; the area beyond it suffused with fuscous ; the terminal line almost confluent with the ground colour except at the tornus where series of spots are present from vein M_2 to vein 1A. Hind wings pale brown, suffused with fuscous in the later portion. Abdomen fuscous brown, with the anal tufts slightly rufous. Under side with the body and both the wings pale brown, the fore wing tinged with dark suffusion in the cell. Legs on the under side pale brown generally up to the tibiae ; tarsal segments fuscous, irrorated with whitish scales ; tibial spurs fuscous, paler at base and the tip.

Head with the frons smooth and not produced forward. Antennae ciliate in the male, reaching as far as the cell angle. Labial palpi obliquely upturned and reaching the frons, the third segment short and thick. Legs with two rows of spines on all the tibiae, three on the first tarsal segment and four to five rows on second to fifth tarsal segments (Text-fig. 17 d).

Genitalia.—Male (Text-figs. 19 a-c) with the uncus narrow distally ; tegumen narrow ; vinculum short, sclerotised ; saccus globular. Claspers slightly sclerotised, broad and of uniform width almost throughout except at the base and the apex which are narrow ; with cleavage at two-thirds the length of the dorsal margin ; ampulla well developed, broadest at base, tapering gradually ; harpe also well developed and pointed ; clavus almost obsolete. Juxta bifurcate. Aedeagus large and simple, beset with many small spines on the vesica. Female (Text-fig. 19 d) with the ostium bursae having its margin sclerotised and of cup shape ; ductus bursae heavily sclerotised, broad mid-ventrally ; corpus bursae more or less cylindrical and membranous, without signum but with two sclerotised ribbons, each ending in a large membranous sac, receptaculum seminalis elongate and large.

Wing expanse.—Males, 34 — 44 mm. ; females, 39 — 41 mm.

Distribution.—India ; Kashmir, Himachal Pradesh, Punjab. Sikkim and Bhutan ; Himalayan subtropical.

Material examined.—Seven examples. Sikkim : 2 ♂♂, —.xii.1890, 1 ♂, 1 ♀ [no other data]. Bhutan : 1 ♂ —1896, 1 ♂ —.iii.1893. Rotung : 1 ♀, 23.xii.1911 (At light).

Remarks.—This species, was treated along with *D. erubescens* (Butler) as a synonym of *A. descripta* Brem. by Hampson in 1894, but was later, regarded by him (Hampson 1903) as a synonym of *rubicilia* (Moore). Boursin (1954a), however, considered it to be a valid species mainly on the basis of genitalic characters and placed it under the genus *Diarsia* Hübner. It differs externally from both *D. erubescens* (Butler) and *D. rubicilia* (Moore) on account of the absence of distinct colour between the stigmata. With regard to the male genitalia, it differs from the above mentioned two species in that the cucullus is neither narrow nor produced forward (Text-fig. 19 a). The female genitalia are characterised by the presence of well developed ribbons in the corpus bursae, the ribbons being absent in the other two species.

16. *Diarsia rubicilia* (Moore)

(Text-figs. 20 a-c)

1867. *Graphiphora rubicilia* Moore, *Proc. zool. Soc. Lond.*, p. 55. (Type loc.—Darjeeling).

1888. *Graphiphora rubicilia* Moore : Cotes & Swinhoe, *Cat. Moths of India*, p. 312.
1894. *Graphiphora rubicilia* Moore : Hampson, *Fauna Brit. India, Moths*, 2, p. 185 (as a Syn. of *A. descripta* Brem.).
1900. *Chera rubicilia* (Moore) : Swinhoe, *Cat. East & Aust. Lep. Het.*, Part. II, p. 9.
1903. *Agrotis rubicilia* (Moore) : Hampson, *Cat. Lep. Phal.*, 4, p. 426.
1909. *Rhyacia rubicilia* (Moore) : Warren, in Seitz *Macrolepidoptera of the World*, 3, p. 46, pl. 10f.
1933. *Rhyacia (Diarsia) rubicilia* (Moore) : Corti & Draudt, in Seitz *Macrolepidoptera of the World*, Suppl. 3, p. 76.
- 1954(a). *Diarsia rubicilia* (Moore) : Boursin, *Bonn. zool. Beitr.*, 5, p. 225, pl. x, fig. 40 (♂ genitalia).

Head with the frontal tufts and vertex reddish brown or slightly lighter in colour. Antennae brown. Labial palpi dark reddish upto the second segment, the tip of the latter and the third segment pale or ochreous. Thorax reddish brown. Abdomen greyish, the anal tufts tinged with rufous. Fore wings pale rufous, with slight purplish suffusion from the middle of costa to the subterminal area ; the sub-basal, antemedial and postmedial lines present, indistinct and rufous ; claviform indistinct, represented by some points at the extremity ; orbicular indistinctly round ; reniform with blackish boundary, with the colour of the centre same as the ground colour ; postmedial line produced into fine streaks on the veins ; subterminal line greyish ; terminal line represented by series of spots. Hind wings fuscous brown. Cilia reddish. Under side with both the wings pale red and the costal area deep red. Legs brownish ochreous on the outer sides up to the tibiae, tarsi dark fuscous ; tibial spurs fuscous except at base and the apex.

Head with the frons smooth. Antennae simple and ciliate in both sexes. Labial palpi upturned, reaching slightly beyond the frons, the third segment short and nearly porrect. Legs with two rows of spines on all the tibiae, three rows on the first tarsal segment and three to five rows on the second to fifth segment.

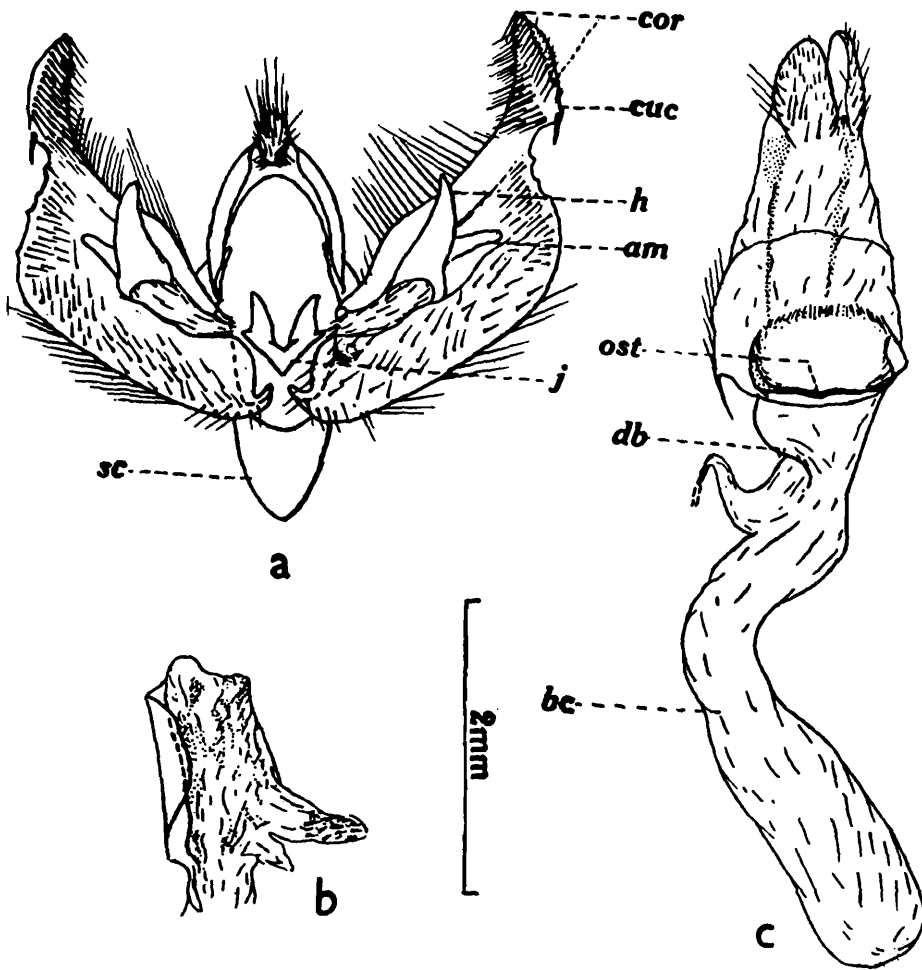
Genitalia.—Male (Text-figs. 20 a-b) with the uncus narrow at the base than the broad and flattened distal end, beset with setae above and below ; tegumen and vinculum narrow ; saccus large, almost semicircular. Claspers with the cucullus well differentiated and extending beyond the lower disto-ventral part ; harpe almost triangular and upturned ; ampulla straight and slender distally, without cluster of bristles below it ; clavus obsolete. Juxta broad v-shaped, acute at the base. Aedeagus sclerotised, short and beset with short spines on the vesica. Female (Text-fig. 20 c) with ostium bursae simple, the margin sclerotised ; ductus bursae not sclerotised, leading into a long tubular corpus bursae, the latter without signum and stripes ; receptaculum seminalis short, almost obsolete at the junction of the corpus bursae and ductus bursae. Genital plate and the ovipositor lightly sclerotised.

Wing expanse.—Males, 29-34 mm. ; females, 30-34 mm.

Distribution.—India ; Kashmir, Punjab, Bengal. Also Sikkim, Bhutan and Burma.

Material examined.—Eight examples. INDIA : West Bengal ; Darjeeling, 3 ♂♂, 1 ♀ [no further data]. Sikkim : 1 ♂, 3.iv.89 (J. C.

Pilcher), 2 ♀ ♀, [no date of collection] (G. C. Dudgeon). Bhutan: 1 ♂, —.ix.89 (G. C. Dudgeon).



TEXT-FIG. 20. *Diarsia rubicilia* (Moore): (a) male genitalia, ventral view (b) aedeagus (c) female genitalia, ventral view. (all of the same magnification).

Remarks.—This species was transferred to the genus *Diarsia* Hübner by Boursin (1954, a), as stated earlier. It differs from both *nigrosigna* (Moore) and *erubescens* (Butler) externally, by the colour pattern of the wings, and in the characters of the male genitalia especially in the shape of the cucullus which is narrow and is produced posteriorly. The female genitalia are characterised by the tubular and long corpus bursae.

17. *Diarsia putris* (Linn.)

(Text-fig. 18 c)

- 1764. *Phalaena noctua putris* Linn., *Faun. Svec.*, p. 315. (Type loc.—“Hortis”).
- 1823. *Noctua lignosa* Hübner, *Eur. Schmett. Noct.*, fig. 50. (Syn. of *A. putris*, vide Hampson, 1894, 1903).
- 1882. *Agrotis putris* (Linn.) : Kirby, *Eur. Butterflies & Moths*, p. 195.
- 1888. *Axylia triseriata* Moore, *Proc. zool. Soc. Lond.*, p. 409. (Type loc.—Kangra). (Syn. of *A. putris* (Linn.), vide Hampson, 1894, 1903).
- 1894. *Agrotis putris* (Linn.) : Hampson, *Fauna Brit. India, Moths*, 2, p. 186.
- 1903. *Agrotis putris* (Linn.) : Hampson, *Cat. Lep. Phal.*, 4, 452.

1909. *Rhyacia putris* (Linn.) : Warren, in Seitz *Macrolepidoptera of the World*, 3, p. 49, pl. 10 k.
 1933. *Rhyacia* (*Diarsia*) *putris* (Linn.) : Corti & Draudt, in Seitz *Macrolepidoptera of the World*, Suppl. 3, p. 80, pl. 12 b.

Head with the frontal tufts, vertex and the collar ochreous brown, the latter with a medial line and the tip rufous; frontal tufts with a dark fuscous line across the middle. Antennae ochreous brown to rufous at the bases, the shaft fuscous. Labial palpi tinged with rufous on the outer sides, paler on the inner side. Thorax and tegulae fuscous, the latter whitish on inner side. Abdomen fuscous. Fore wings ochreous; the costal area and the cell suffused with reddish brown; an indistinct subbasal line represented by two short striae at the base from the costa; antemedial line strongly incurved below the median nervure at vein 1A and again incurved below vein 1A; orbicular round or shortly oval, reniform s-shaped, defined by dark reddish brown boundary, with fuscous centre and ochreous annulus; postmedial line strongly dentate on the outer side, with the points ending in streaks on the veins; a rufous streak above and below vein M_2 from beyond the reniform to the outer margin; two rufous spots near the tornus, one at vein Cu_{1b} and another at vein 1A; a terminal series of black dots present. Hind wings whitish to ochreous, tinged with brown; cilia ochreous, with brown suffusion at some places. Under side with the fore wings ochreous brown, the anterior half tinged with fuscous nearly up to the subapical part; hind wings as on the upper side. Fore legs ochreous above throughout; femora fringed with dark fuscous scales; middle and hind legs ochreous at places on the tibiae and at the bases and tips of the spurs, otherwise wholly fuscous.

Head with the frons smooth. Antennae simple and mainly ciliate. Labial palpi upturned, reaching beyond the frons, the third segment short. Legs with two rows of spines on all the tibiae and three rows on the tarsi.

Genitalia.—Female (Text-fig. 18 c) with the ostium bursae lightly sclerotised; the margin not showing any modification, the genital plate much lighter in colour than the ovipositor; ductus bursae short, sclerotised and broader at the base, leading into the corpus bursae which is without signum or stripes; receptaculum seminalis absent.

Male not studied.

Wing expanse.—Females, 34-39 mm.

Distribution.—India; Himachal Pradesh, Bengal and Sikkim. Also China, Japan, Russia, Korea, Germany, Austria, Hungary, Switzerland, N. Spain, Italy, France and Britain.

Material examined.—Six examples. INDIA: Himachal Pradesh, Simla, 1 ♀ 2133.56 m. (7000 ft.) -vii.97 (*Pilcher*). West Bengal, Kurseong, 2 ♀ ♀ (Purchased) [no further data], Darjeeling, Government House, 1 ♀ [no further data]. Sikkim: 1 ♀ [no further data], 1 ♀, 9.x.1890 (*G. C. Dudgeon*).

Remarks.—The female genitalia is characterised by the simple ostium bursae, the absence of ribbons and absence of signum or stripes in corpus bursae. This brings it closer to *D. cerastioides* (Moore) and *erubescens* (Butler) but it differs from the latter by the absence of receptaculum seminalis and from the former by the short ductus bursae and the corpus bursae.

The species is recorded from West Bengal for the first time.

18. *Diarsia sicca* (Guén.) comb. nov.

(Text-figs. 1 i, 21 a-d)

1852. *Axylia sicca* Guénee, *Noctuelites-I.*, 5. p. 135. (Type loc.—M. N.).1881(a). *Axylia renalis* Moore, *Proc. zool. Soc. Lond.*, p. 341. (Type loc.—Sind Valley, Kashmir) (Syn. of *A. sicca* (Guén.), *vide* Hampson, 1903).1903. *Agrotis sicca* (Guén.) : Hampson, *Cat. Lep. Phal.*, 4, p. 451, pl. LXXI, fig. 30.

Head with the frontal tufts brownish ochreous, with a fuscous bar across it. Antennae fuscous. Labial palpi fuscous except at the tips which are brownish ochreous. Vertex and the collar ochreous, the latter rufous, with some dark scales at the tips. Thorax fuscous or brownish. Abdomen greyish brown. Fore wings brownish ochreous; the costal area purplish fuscous; subbasal line represented by a double streak from costa to the cell; an indistinct antemedial line strongly curved below the cell; orbicular small and round, with its centre brownish and the annulus dark; reniform with brownish centre and dark annulus; claviform represented by a small black dot at the extremity; cell, between the stigmata, filled up by the deep chocolate brown colour, that beyond the reniform extending in the form of streaks up to the outer margin; postmedial line double, produced into a double series of spots on the veins, bent outwards below the costa and thereafter incurved below vein M_3 ; subterminal line indistinct; a terminal series of black dots present. Hind wings brownish ochreous to ochreous, semi-hyaline. Under side with the wings irrorated with brown. Legs brownish above upto the tibiae; tarsi fuscous.

Head with the frons (Text-fig. 1 i) subrounded, produced forward but smooth. Antennae ciliate in both sexes, more profusely in the male. Labial palpi obliquely upturned, reaching the frons, the third segment short and porrect. Frenulum consisting of a single spine in the male and of three spines in the female. Legs with two rows of spines on all the tibiae, three rows on all the tarsi.

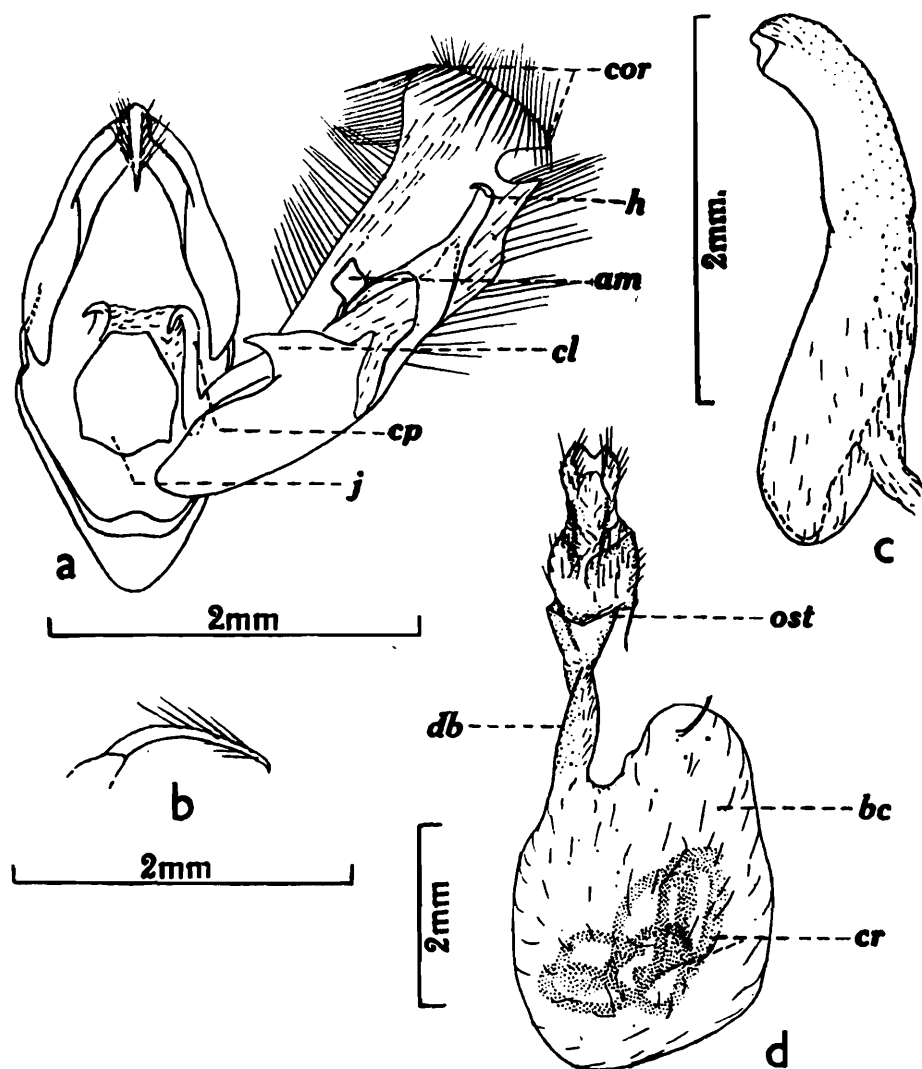
Genitalia.—Male (Text-figs. 21 a-c) with the uncus slender, bent almost at right angle to the tegumen, gradually tapering; tegumen slender; vinculum v-shaped; saccus short. Claspers short and broad, of uniform width throughout, with both the margins smooth, except near the disto-ventral margin which is slightly incised; corona represented by a distal row of marginal setae, rest of the setae sparse; harpe well developed and upturned; ampulla short; clavus present; costa produced basally into a fold which unites with anellus on each side. Juxta broad. Aedeagus slightly sclerotised and without cornuti. Female (Text-fig. 21 d) with the ostium bursae simple and unsclerotised; ductus bursae short and sclerotised; corpus bursae large, bulged on one side, with coiled sclerotised ribbons; signum absent; ductus spermathecae short and narrow, arising from the bulged portion of corpus bursae.

Wing expanse.—Male, 29-32 mm.; female, 31.5 mm.

Distribution.—India: Himachal Pradesh, Punjab.

Material examined.—Six examples. INDIA: Himachal Pradesh: Kangra Valley, 1371.58 m. (4500 ft.), 1 ♂, 1 ♀, -.vii.1899, 3 ♂♂, 1 ♀, -.vii.1899 (G. C. Dudgeon).

Remarks.—The species is characterised by the fasciculate antennae in the male; labial palpi with the third segment porrect, by the fore wing with the cell filled up by a distinct colour between the stigmata; and by the presence of three rows of spines on all the tarsal segments. It is further characterised by the male genitalia having distinct corona at the distal margin, having cucullus curved and tapering and presence of distinct clavus, ampulla and harpes (Text-fig. 21 a-c).



TEXT-FIG. 21. *Diarsia sicca* (Guén.): (a) male genitalia, ventral view (b) uncus, lateral view (c) aedeagus (d) female genitalia, ventral view.

Female genitalia are distinct on account of the simple ostium bursae and corpus bursae, the latter is without signum or sclerotised patches, further it has coiled ribbon and is devoid of receptaculum seminalis.

It is transferred to the genus *Diarsia* principally on account of the presence of fore tibial spines and the presence of distinct corona on the distal margin of claspers in the male. The fore tibial spines are short and slender in *Diarsia* unlike the case in the genus *Agrotis* where these are long and stout. Similarly the corona in *Agrotis* consists of an oblique row of setae situated much before the distal margin unlike the case in *Diarsia*.

19. *Diarsia ochracea* (Walker)

(Text-figs. 17 a-c, 22 a-d)

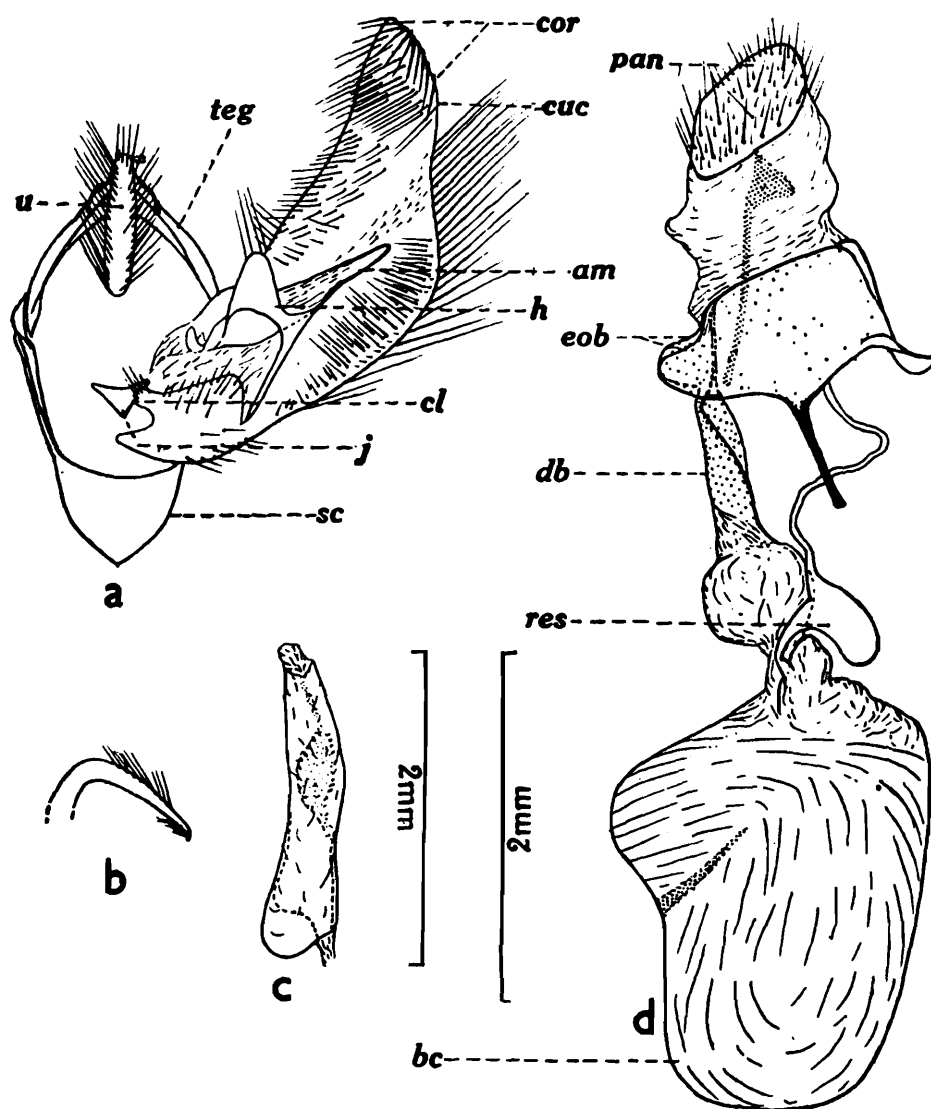
- 1865(b). *Oxira ochracea* Walker, *List Lep. Brit. Mus.*, 33, p. 657. (Type loc.—Ceylon).
 1887. *Graphiphora frontalis* Moore, *Lep. Ceylon*, 3, p. 35. (Type loc.—Ceylon) (Syn. of *ochracea* (Walker), vide Hampson, 1894, 1903).
 1889. *Graphiphora varia* Swinhoe, *Proc. zool. Soc. Lond.*, p. 412. (Type loc.—E. India) (Syn. of *ochracea* (Walker), vide Hampson, 1894, 1903).
 1894. *Agrotis ochracea* (Walker): Hampson, *Fauna Brit. India, Moths*, 2, p. 182.
 1900. *Agrotis ochracea* (Walker): Swinhoe, *Cat. East & Aust. Lep. Het.*, Part II, p. 8.
 1903. *Episilia ochracea* (Walker): Hampson, *Cat. Lep. Phal.*, 4, p. 480.
 1933. *Rhyacia (Diarsia) ochracea* (Walker): Corti & Draudt, in Seitz *Macrolepidoptera of the World*, Suppl. 3, p. 75.
 1954(a). *Diarsia ochracea* (Walker): Boursin, *Bonn. zool. Beitr.*, 5, p. 229, pl. vii, fig. 7 (♂ genitalia).

Head with the frontal tufts, vertex and the thorax brownish ochreous to ferruginous brown, rarely with fuscous tinge. Antennae with the shaft brownish ochreous above, up to the basal half, the branches and the under side fuscous brown in the male, brownish ochreous in a few basal segments in the female. Labial palpi deep-chocolate brown on the outer side up to the second segment, brownish ochreous at the end of second segment and the third segment and on the inner side. Fore wings ochreous, tinged with ferruginous, olive brown or rufous; the subbasal line double wavy, with a black spot in and below the cell; the antemedial line also double and wavy; the orbicular round, defined by brownish boundary, with the colour in the centre same as ground colour of the wing; claviform represented by a dot at its extremity; reinform defined by a brown boundary, the centre similar to ground colour of the wing, with a grey annulus and a fuscous patch at its lower part; medial line indistinct, the part from below the cell angle to the inner margin represented by rufous suffusion; the postmedial line double and waved, the outer line dentate and with the fine black and white dots on areas crossing the veins forming short streaks; the subterminal line brownish ochreous, with black suffusion on its inner side near the apex; terminal series of black points present. Hind wings fuscous brown; cilia ochreous or red brown. Abdomen fuscous brown. Legs brownish ochreous on the inner side, dark brown to fuscous above; tibial spurs whitish at the base and the tip. Under side brown to fuscous brown.

Head with the frons smooth. Antennae bipectinate, in the male strongly so in the basal 6/7th part, the branches nearly equal, the distal part simple and ciliate (Text-fig. 17 a); the shaft consisting of nearly 60 segments, with the pectination up to 45 segments, the longest rami about the length of four segments of the shaft in the middle; female with the antennae simple and finely ciliate. Labial palpi obliquely upturned, the third segment short and narrow, about half of the second segment. Tibiae and tarsi with two and three rows of spines, respectively (Text-figs. 17 b-c).

Genitalia.—Male (Text-figs. 22 a-c) with the uncus immediately bent downwards, ending into a point; tegumen and vinculum slender; saccus short, broad and triangular. Claspers broadest in the middle than at the base and apex; cucullus about the width of the middle part;

corona consisting of a row of strong setae on the distal margin and a cluster of densely settled setae below it; meso-ventral part, immediately below the ampulla, also beset with densely settled setae; ampulla almost straight; harpe broad and blunt dorsally but in the form of a membranous fold; costal margin smooth. Juxta short; clavus hairy. Aedeagus short and simple, with tooth-like cornuti at the apex. Female



TEXT-FIG. 22. *Diarsia ochracea* (Walker): (a) male genitalia, ventral view (b) uncus, lateral view (c) aedeagus (d) female genitalia, lateral view (Text-figs. a-c of same magnification).

(Text-figs. 22 d) with the ostium bursae sclerotised at the margin, cup-shaped; ductus bursae sclerotised; corpus bursae more or less quadrangular, without signum and ribbons but with small sclerotised stripes on it; receptaculum seminale as a short prolongation from near the point of union of ductus bursae with the corpus bursae.

Wing expanse.—Males, 28-29 mm.; females, 32-34 mm.

Distribution.—Ceylon.

Material examined.—Four examples. CEYLON: 1 ♀, -xii.1894, 1 ♂, -iii.1907, 1 ♀ -iv.1907 (Hakagala), 1 ♂, -x.1907 (all *E. E. Green*).

Host range.—Tea (*Camellia theifera* Griff.): Andrews, 1921.

Remarks.—Referred to the genus *Diarsia*, by Boursin 1954 (a), who stated that the species was restricted to Ceylon, contrary to the

earlier record given by Hampson (1903) from India, Japan, W. China, Tibet, etc., and excluded most of its synonyms, given by Hampson and recognised them as distinct species, viz. *D. deparca* (Butler), *D. ruptistriga* (Walker) and *D. stictica* Pouj.

The species is characterised by the presence of sexual dimorphism, especially in its colour-markings, the male being very much lighter in colour than the female; besides the antennae are bipectinate in the male. In respect of the genitalic characters it may be stated that the claspers are well developed and have a double set of setae on the cucullus; in the female genitalia signum is absent on the corpus bursae.

20. *Diarsia ruptistriga* (Walker)

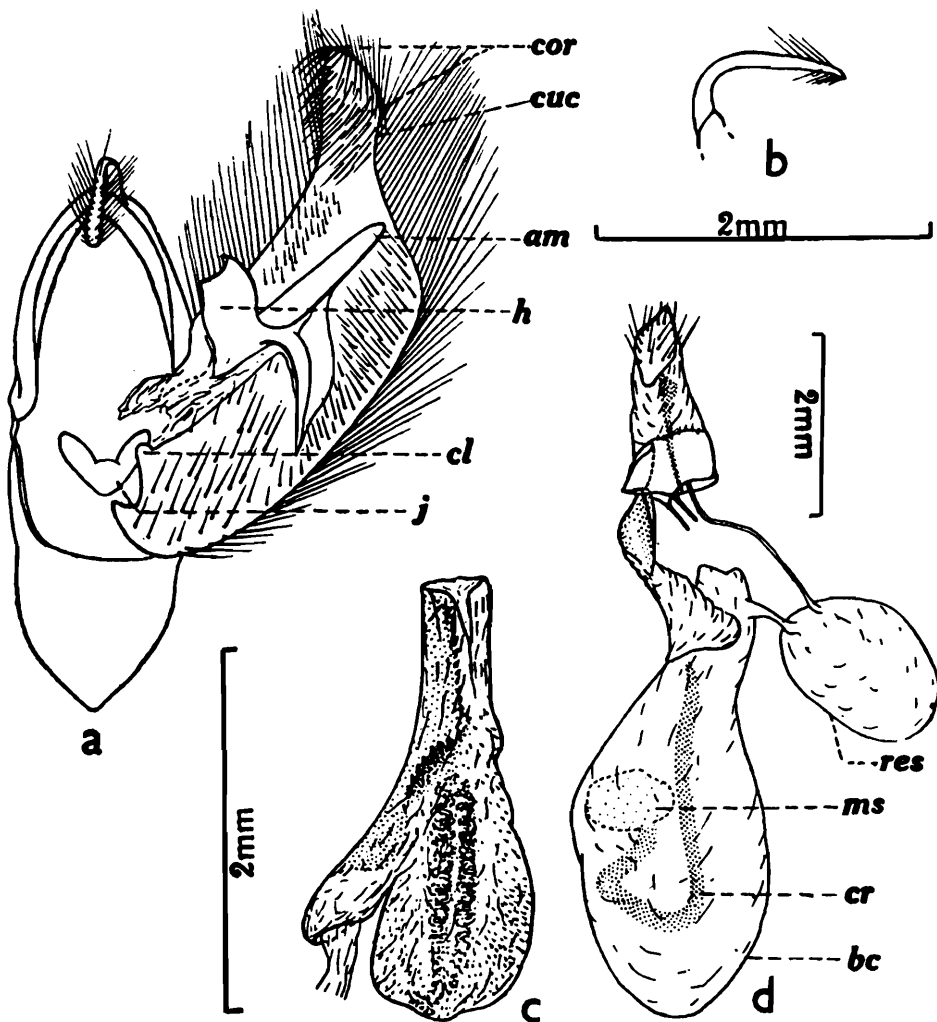
(Plate I, fig. 10; Text-figs. 17 f-g, 23 a-d)

- 1865(b). *Hadena ruptistriga* Walker, *List Lep. Brit. Mus.*, **33**, p. 739. (Type loc.—Ceylon).
 1893. *Amathes ruptistriga* (Walker): Hampson, *Ill. Lep. Het. Brit. Mus.*, p. 94.
 1894. *Hadena ruptistriga* Walker: Hampson, *Fauna Brit. India, Moths*, **2**, p. 182 (as Syn. of *A. ochracea* Walker).
 1903. *Hadena ruptistriga* Walker: Hampson, *Cat. Lep. Phal.*, **4**, p. 480 (as Syn. of *Episilia ochracea* (Walker)).
 1909. *Rhyacia ruptistriga* (Walker): Warren, in Seitz *Macrolepidoptera of the World*, **3**, p. 37.
 1954(a). *Diarsia ruptistriga* (Walker): Boursin, *Bonn. zool. Beitr.*, **5**, p. 229, p. VII, fig. 8 (♂ genitalia).

Head with the frontal tufts brownish, irrorated with black scales. Antennae deep brown. Labial palpi brownish ochreous, irrorated with deep chocolate brown or rufous on the outer side, paler at the end of second segment and the third segment. Collar oliver brown at the base. Thorax fuscous. Abdomen greyish brown. Fore wings ochreous to ferruginous brown, tinged with olive brown or grey brown; the subbasal line double and wavy, from costa to vein Cu₂, darker on the inner side, whitish on the outer side; the medial line double and wavy, slightly ochreous brown, brownish or rufous before the inner margin; claviform represented by a deep-chocolate brown line at its extremity; orbicular oblique and round, with brownish centre and grey annulus; reniform with a slight patch at its lower part, with grey annulus and brownish centre; the cell filled up by deep chocolate colour between the stigmata; the postmedial line double, dentate on the inner side, with small indistinct grey and black points on the veins on the outer side, the subterminal line starting from a deep-chocolate brown patch in the subapical area, ochreous on the outer side; the terminal line represented by a series of points. Hind wings fuscous or greyish brown. Legs ochreous to brownish ochreous below, deep-chocolate brown above, with ochreous bands at the end of tibiae and tarsi; tibial spurs ochreous at the base as well as the tips. Under side greyish brown to deep brown, irrorated with fuscous; the postmedial line and a discocellular spot on the hind wing prominent.

Head with the frons smooth. Antennae (Text-fig. 17 f) bipectinate in the male [in our specimen the distal portion of the antennae broken]; simple and ciliate in the female. Labial palpi obliquely

upturned, reaching the frons, the third segment longer and narrow than in *D. ochracea* (Walker) with which it was once considered synonymous. Legs with two rows of spines on all the tibiae, three rows on the first tarsal segment, three to four rows on second to fifth segment (Text-fig. 17 g). Frenulum consisting of a single spine in the male, two spines in the female.



TEXT-FIG. 23. *Diarsia ruptistriga* (Walker): (a) male genitalia, ventral view (b) uncus, lateral view (c) aedeagus (d) female genitalia, lateral view (Text-figs. a and c of same magnification).

Genitalia.—Male (Text-figs. 23 a-c) with the uncus broad at the base, flattened distally; tegumen and vinculum as in *ochracea* (Walker); saccus large and conical. Claspers with the dorso-distal portion oblique, much narrowed, becoming almost less than half the width of the middle of the clasper; corona well developed; ampulla straight, slender and long; harpe present as a sclerotised fold; clavus small. Juxta v-shaped. Aedeagus short and stout, with the cornutus appearing like the teeth of a saw. Female (Text-fig. 23 d) with the ostium bursae simple, without sclerotisation at the margin, nearly cup-shaped; ductus bursae sclerotised near the opening, the latter membranous; corpus bursae large, bag-like, with a sclerotised ribbon ending in a sac; from the corpus bursae arises another fine duct which enters into a spherical receptaculum seminalis.

Wing expanse.—Male, 28.5 mm.; females, 29-30 mm.

Distribution.—Ceylon.

Material examined—Eight examples. CEYLON: Pattipola, 2 ♀♀, -iii.1906; Hakagala, 1 ♂, -iii.1907, 1 ♀ -iv.1907; Ohiya, 4 ♀♀, -xi.1907 (all *F. E. Green*).

Remarks.—Boursin (1954, a) separated it as a distinct species from *D. ochracea* (Walker) and *D. stictica* (Pouj.). It is so far known only from Ceylon. It resembles *D. ochracea* (Walker) in the bipectinate nature of the antennae in the male, but differs from the latter species by the presence of distinct colour between the stigmata. In respect of the male genitalia it can be differentiated from *D. ochracea* (Walker) by the narrow and prominently produced cucullus, and by the shape of saccus; with regard to the female genitalia it can be easily differentiated from *D. ochracea* (Walker) by the presence of sclerotised ribbon in the corpus bursae.

21. *Diarsia postfusca* (Hampson) Comb. nov.

(Plate I, fig. 11; Text-figs. 1 j, 17 e, 24 a-d)

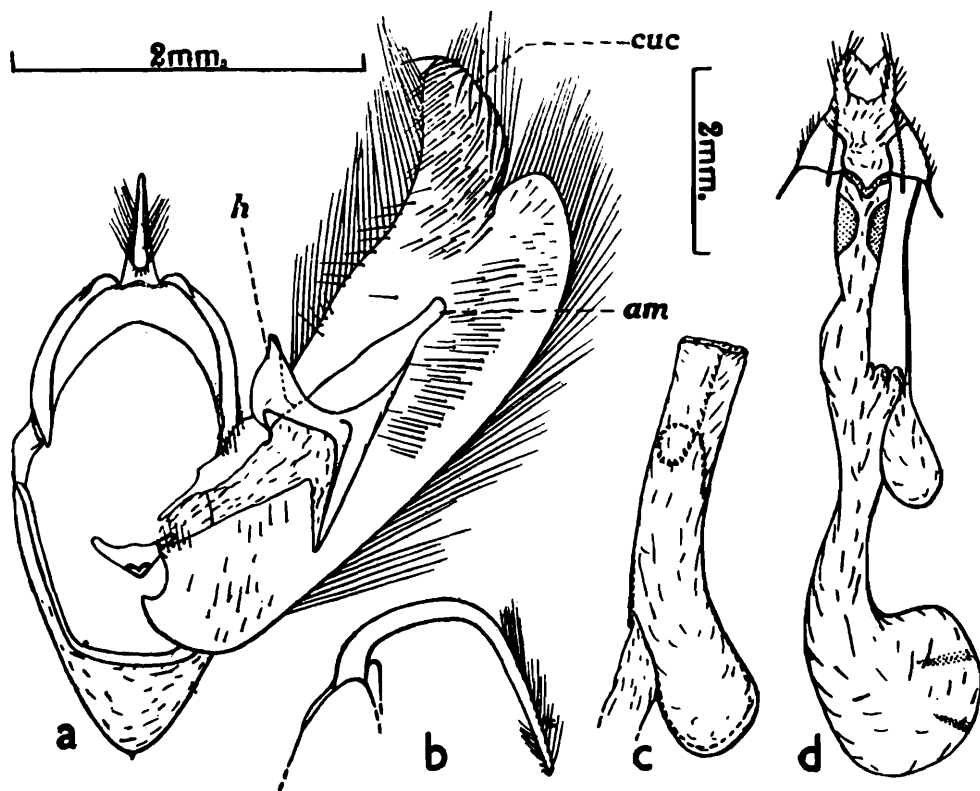
1896. *Agrotis postfusca* Hampson, *Fauna Brit. India, Moths*, 4, p. 508. (Type loc. — Ceylon).

1903. *Episilia postfusca* (Hampson), *Cat. Lep. Phal.*, 4, p. 477, pl. 72, fig. 22.

Head with the frontal tufts brownish ochreous. Antennae with the bases brownish ochreous, the shaft tinged with fuscous. Labial palpi deep-chocolate brown on the outer sides up to the second segment, paler on the inner side and the tips, the third segment brownish ochreous, irrorated with fuscous. Vertex brownish. Thorax brownish ochreous, tinged with fuscous. Abdomen brownish, with fuscous tinge. Fore wings whitish to brownish ochreous, tinged with olive yellow towards the costa and the inner margin; the subbasal line indistinct, double and wavy from costa to vein Cu_2 , with a dark brown dot at its base; the antemedial line double and wavy, excurved below the costa and strongly incurved below vein Cu_2 ; claviform represented only by a small streak or a dot at its extremity; orbicular and reniform large and whitish, the former obliquely round, the latter with its lower part generally with a patch; the area in the cell, between the stigmata, filled up by a deep chocolate colour, and deep-ferruginous brown beyond the medial line; the postmedial line double and wavy, excurved below costa and curved at vein M_3 towards the inner margin; the subterminal line confluent with the dark area before it; the area beyond the subterminal line tinged with olive yellow; the terminal line represented by a series of dark dots. Hind wings fuscous. Under side with both the wings whitish, tinged with fuscous; cilia yellow, tinged with fuscous. Legs heavily fringed with fuscous hair scales on the femur and tibiae on the inner side; fuscous brown above throughout, with white rings at the base of each tarsal segment, tibiae and the tibial spurs, the latter also whitish at the base.

Head with the frons (Text-fig. 1 j) smooth. Antennae (Text-fig. 17 e) shortly biserrate in the male, nearly, up to three-fourths from the base, the distal part ciliate and simple, as in the female. Labial palpi obliquely upturned, the third segment short and slender, porrect or

slightly ascending. Frenulum consisting of a single spine in the male, two spines in the female. Legs with two rows of spines on all the tibiae, three rows on all the tarsal segments.



TEXT-FIG. 24. *Diarsia postfusca* (Hampson): (a) male genitalia, ventral view (b) uncus, lateral view (c) aedeagus (d) female genitalia, ventral view (Text-figs. a-c of same magnification).

Genitalia.—Male (Text-figs. 24 a-c) with the uncus bent and curved like a bow, flattened distally; tegumen short and slender; vinculum slightly longer than the tegumen; saccus normal. Claspers almost as in *D. nigrosigna* (Moore), especially in regard to the cleavage in the distal margin of the clasper; raised mid-dorsally, becoming wider in the middle than at the base and apex; corona well developed; ampulla well developed and blunt at the end; clavus well developed. Juxta well developed, laterally extended but not distinctly bifurcated. Aedeagus simple, sclerotised, rounded at the base, with a row of spines inside the vesica and a few spines distally. Female (Text-fig. 24 d) with the ostium bursae having its margin sclerotised, cup-shaped; ductus bursae short and with sclerotised area on either side; corpus bursae without ribbons, more or less flask-shaped, with sclerotised stripes; receptaculum seminalis large and oval.

Wing expanse.—Male, 29 mm.; females, 34-35 mm.

Distribution.—Ceylon.

Material examined.—Four examples. CEYLON: Muskeliya, 1 ♀, — i.—, 1 ♂, —.ii.1905, 1 ♂, —.ii.—; Hakgala, 1 ♀ —.iii.1907 (all *E. E. Green*).

Remarks.—The species is characterised by the presence of bipectinate antennae in the male, the branches being short and appearing like serrations; it differs in this respect from both *D. ochracea* (Walker)

and *D. ruptistriga* (Walker) which possess prominent antennae with long pectinations. It however, resembles the latter on account of the presence of distinct colour between the stigmata which is not the case in *D. ochracea* (Walker). In respect of the male genitalia it differs from both the species mainly in the structure of the cucullus which is cleavaged. In the female genitalia, as is the case in *D. ochracea* (Walker), the corpus bursae is without ribbons, unlike the case in *ruptistriga* (Walker). It differs from the former, however, on account of flask like shape of corpus bursae.

Genus *Chersotis* Boisduval

1840. *Chersotis* Boisduval, *Gen. et Index-Meth.*, p. 103.
 1903. *Chersotis* Boisduval: Hampson, *Cat. Lep. Phal.*, 4, p. 364. (Syn. of *Agrotis* Ochs.).
 1933. *Rhyacia* (*Chersotis*) Hübner: Corti & Draudt, in Seitz *Macrolepidoptera of the World*, Suppl. 3, p. 59.
 1954(a). *Chersotis* Boisduval: Boursin, *Bonn. zool. Beitr.*, 5, No. 34, pp. 261-264.

Type of the genus.—*Chersotis rectangula* (Schiffermüller).

Distribution.—India, Sikkim, Tibet and Japan. Boursin (1954, a) has also recorded its distribution from central and eastern Asia, Siberia to Japan, N. China, Europe and North Africa.

Diagnosis.—Frons smooth and without prominence. Antennae ciliate in both the sexes. Eyes smooth and large. Ocelli well developed. Proboscis fully developed. Labial palpi upturned, the third segment porrect. Legs with two rows of short and slender spines on all the tibiae and three rows of spines on all the tarsi, terminal spines on fore tibiae longer than the others, the tibiae longer than the first tarsal segment; fore tibiae smaller than the femur, mid tibiae equal to the femur and hind tibiae longer the femur; mid tibiae with a pair of spurs, hind tibiae with two pairs of spurs; arolium well developed.

Venation almost constant and agrees in general with that of *Agrotis segetum* (Schiff.) (Text-figs. 3 a-b).

Genitalia.—Male with the uncus long and slender, or short and stout, slightly beset with short spines at the end. Claspers very short and stout, moderately broad, with the ends rounded; without corona, only small hairs or very fine bristles present; harpe well developed; clavus present, sometimes bulged; ampulla absent. Juxta short. Aedeagus mostly beset with one or two strong cornutus, sometimes absent. Female genitalia large and stout; corpus bursae without signum; receptaculum seminalis present.

Remarks.—Only one species, viz. *C. triangularis* (Moore), is available for study. It has been transferred to this genus for the first time, specially on the basis of the male genitalic characters, as described by Boursin (1954, a). It can easily be distinguished from the genera *Agrotis* Ochs., *Amathes* Hübner and *Diarsia* Hübner by the character of the tibial spines and by structure of the male genitalia as described above.

22. *Chersotis triangularis* (Moore) comb. nov.

(Plate I, fig. 12; Text-figs. 1 k, 25 a-d)

1867. *Ochropleura triangularis* Moore, *Proc. zool. Soc. Lond.*, p. 55. (Type loc.—Darjeeling).

1888. *Ochropleura triangularis* Moore: Cotes & Swinhoe, *Cat. Moths of India*, p. 313.
1891. *Ochropleura triangularis* Moore: Hampson, *Ill. Lep. Het. Brit. Mus.*, p. 14.
1894. *Agrotis triangularis* (Moore): Hampson, *Fauna Brit. India., Moths*, **2**, p. 189.
1900. *Chera triangularis* (Moore): Swinhoe, *Cat. East. & Aust. Lep. Het.*, Part II, p. 13.
1903. *Ochropleura triangularis* Moore: Hampson, *Cat. Lep. Phal.*, **4**, p. 388. (Syn. of *Agrotis stentsi* (Led.)).
1909. *Rhyacia triangularis* (Moore): Warren, in Seitz *Macrolepidoptera of the World*, **3**, p. 43, pl. 9f.
1933. *Rhyacia triangularis* (Moore): Corti & Draudt, in Seitz *Macrolepidoptera of the World*, Suppl. **3**, p. 63.

Head with the frontal tufts, vertex and thorax pale-purple brown. Antennae brown. Labial palpi dark brown on the outer side, pale on the inner side. Collar with an ochreous line across it near the base, deep-chocolate brown at the apex. Fore wings pale brown, the costal area ochreous white from base to near the upper angle of the cell, purple brown beyond the cell; the subbasal line obsolete, instead a dark streak above vein Cu_2 expanding to a triangular deep-chocolate brown coloured patch; the antemedial line indistinct from costa to the inner margin; claviform represented by a small spot at its extremity; orbicular small, semi-circular, open above and confluent with ochreous white fascia above; reniform with a fuscous centre and an ochreous lunule in it, the latter defined on its inner side by black; postmedial line minutely dentate, excurved below the costa and at the middle and thereafter oblique below vein M_3 ; subterminal line defined on the inner side by deep-chocolate brown streak and slight suffusion, followed below by three points; terminal line rufous. Hind wings fuscous. Abdomen greyish brown. Legs with the fore tibiae and the tarsi ochreous white above; the remaining portion purple brown to fuscous.

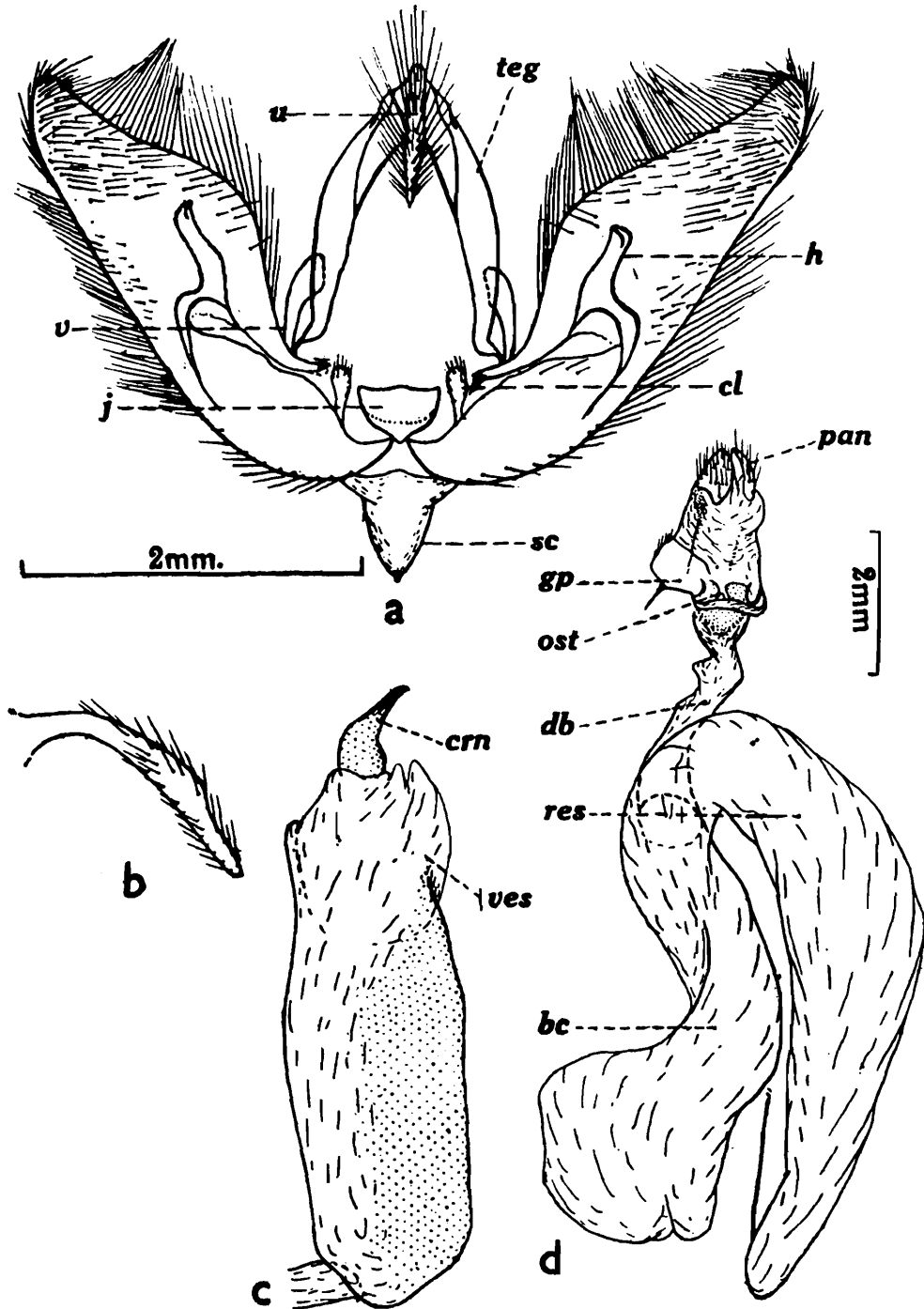
Head with the frons (Text-fig. 1 k) smooth and not produced medially. Antennae ciliate in both sexes. Labial palpi upturned, the third segment short and porrect. Legs with two rows of spines on fore tibiae, the terminal ones longer than the others, other tibiae rarely with three rows of spines; tarsi with three rows of spines; a well developed arolium present.

Genitalia.—Male (Text-figs. 25 a-c) with the uncus broad at the base, increasing in width from the middle up to three-fourths of the length, the distal part becoming narrow and dorsally flattened, almost half as wide as in the middle part; tegumen long and narrow; vinculum u-shaped; saccus small. Claspers simple, without corona, broadest in the middle; harpe present, slightly bent and pointed upwards; ampulla absent; clavus present at the base of clasper and beset with hairs. Juxta short. Aedeagus short and stout, with a very strong cornuti on the vesica. Female (Text-fig. 25 d) with the ostium bursae sclerotised on the sides, leaving a small unsclerotised area in the middle; ductus bursae short, slightly sclerotised, leading into a large membranous corpus bursae, the latter broad at the other end; receptaculum seminalis equally long, or slightly longer than the corpus bursae, the latter without signum, stripes or ribbons.

Wing expanse.—Males, 37—41 mm.; females, 38—41 mm.

Distribution.—India, Sikkim, Bhutan, Tibet, Siberia and Japan.

Material examined.—Five examples. INDIA: West Bengal, Darjeeling, 2133.56 m. (7000 ft.), 2 ♂♂ 1 ♀ [no further data]. Sikkim 1 ♂, (O. Möller) [no date of collection]. Bhutan: 1 ♂, 10.x.1894 (G. C. Dudgeon).



TEXT-FIG. 25. *Chersotis triangularis* (Moore): (a) male genitalia, ventral view (b) uncus, lateral view (c) aedeagus (d) female genitalia, ventral view (Text-figs. a-c of same magnification).

Remarks.—The species is referred to this genus for the first time, on the basis of studies of the male genitalia and other characteristics, as also given by Boursin (1954, a). *C. triangularis* (Moore) can be differentiated, externally, from those of the other genera by the character

of fore-tibial spines which are slender at the distal end of the tibiae and are longer than the rest, and by the male genitalia which is characterised by the absence of corona. It, however, resembles species of the genus *Amathes* generally in the above characters but is easily distinguished from the latter on account of the absence of ampula in the male genitalia, and in the well developed corpus bursae and receptaculum seminalis in the female.

V—SUMMARY

Species of *Agrotis* and the allied genera are commonly called the 'greasy cutworms' or the 'Surface cutworms', because their caterpillars are greasy in appearance and have the habit of cutting seedlings of a number of cultivated plants, whether the agricultural crops or plants of horticultural and medicinal importance. The range of host plants for each species has been given, where possible.

The present study is based on twentytwo species represented by about 250 specimens, which come from what may be conventionally called the Indian region, including namely Burma, Ceylon, India and Pakistan. Most of the specimens are deposited in the National Zoological Collections at the Zoological Survey of India, Calcutta.

The taxonomic revision is based both on the external morphological characters, such as the pectination of antennae in the male, the shape and structure of frons, the wing pattern and the character of tibial spurs and spines; the male genitalic characters are extremely useful in separating the genera as well as the species.

Most of the species dealt with here, were formerly considered as belonging to the genus *Agrotis* Ochsenheimer (1816), (*Sens. lat.*). Lately, however, mainly due to the studies made by Boursin (1954 [a, b], 1955) several of them were transferred to other genera, such as *Diarsia* Hübner (1822), *Rhyacia* Hübner (1822), *Amathes* Hübner (1822) and *Chersotis* Boisduval (1854). Boursin, however, did not have before him as extensive a material from India as the present authors have. As a result of our studies, we find that some species continue to remain under the genus *Agrotis* Ochsenheimer, several others clearly belong to other genera such as *Amathes*, *Diarsia* and *Chersotis*. Our findings are also supported by the recent work of Common (1958) on the genus *Agrotis* as based on the Australian species.

Keys for the identification of genera and species dealt with have been given at the appropriate places.

New combination for the following species have been proposed in the paper. (1) *Agrotis subspinifera* (Hampson); (2) *Amathes curviplena* (Walker); (3) *Diarsia sicca* (Guén.); (4) *Diarsia postfusca* (Hampson); and (5) *Chersotis triangularis* (Moore).

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EXPLANATION OF THE ABBREVIATIONS

al	--	anellus lobes
am	—	ampulla
ap	—	anterior apodemes
ar	—	areole
bc	—	corpus bursae
bd	—	bands on ductus bursae
cl	—	clavus
cor	—	corona
cp	—	costal process or prolongation
cr	—	sclerotised ribbons
crn	—	cornutus/cornuti
cuc	—	cucullus
dc	—	discocellular cell
ds	—	ductus spermathecus
eob	—	sclerotised plate over the ductus bursae
fr	—	frons
gp	—	genital plate
h	—	harpe
j	—	juxta
mj	—	median dome-shape structure of juxta
ms	—	membranous sac/s of the ribbons
op	—	ovopore
ost	—	ostium bursae
pan	—	ovipositor with papilla anales
res	—	receptaculum seminalis
sc	—	saccus
sg	—	signum/sclerotised stripes on corpus bursae
teg	—	tegumen
u	—	uncus
v	—	vinculum
ves	—	vesica
vl	—	clasper/valve

PLATE 1

- FIGS.—1. *A. segetum* (Schiffermüller) (♂)
2. *A. corticea* (Schiffermüller) (♂)
3. *A. ypsilon* (Rottenburg) (♂)
4. *A. flammatra* (Schiffermüller) (♂)
5. *A. plecta* (Linn.) (♂)
6. *Amathes c-nigrum* (Linn.) (♂)
7. *A. deraiota* (Hampson) (♂)
8. *A. curviplena* (Walker) (♂)
9. *Diarsia nigrosigna* (Moore) (♂)
10. *D. ruptistriga* (Walker) (♂)
11. *D. postfusca* (Hampson) (♂)
12. *Chersotis triangularis* (Moore) (♂)

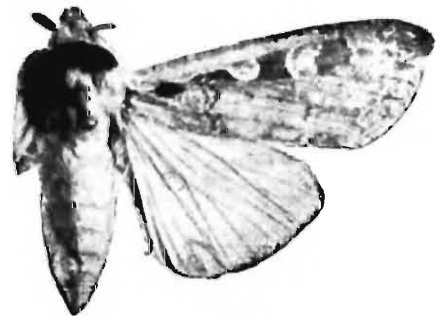


10 mm

1



6



4



10 mm

2



3



5



8

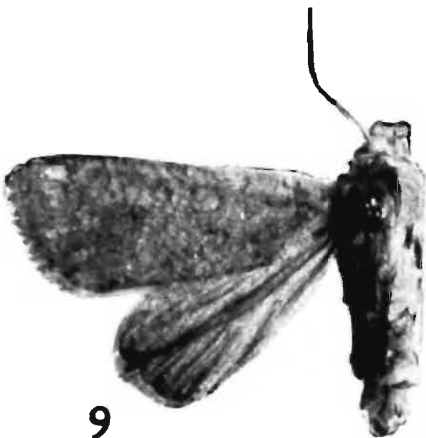


11

10 mm



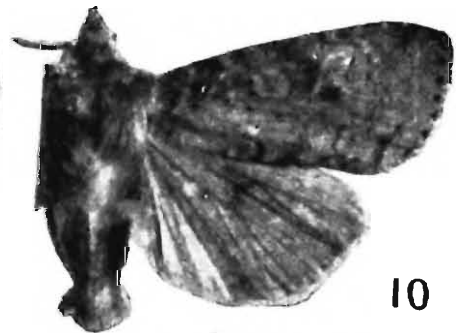
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9



12

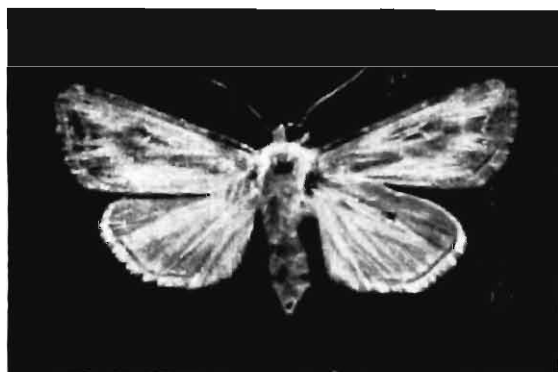


10

10 mm

PLATE 2

- FIGS.—1. *Agrotis subspinfera* Hampson (♀)
2. *Agrotis beelsoni* sp. n. (♂)



1 3cm



3cm

2

**Anatomical notes on four species of *Ochetostoma* Leuckart & Rüppell
(Echiura) together with a list of the species of the genus**

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(With 2 Text-figures)

I—INTRODUCTION

The material which forms the basis of this paper was obtained from the Zoological Survey of India, Calcutta. A part of this work was done in the laboratory of the ZSI during May and June, 1964. Spengel (1912) separated the genera *Thalassema* Lamarck, *Ochetostoma* Leuckart and Rüppell and *Listriolobus* Spengel, and the basis of the distinction of the genera was primarily the longitudinal muscle layer of the body wall. The latter is of uniform thickness in *Thalassema*, thickened into bundles interrupted by intervals in *Ochetostoma*, and the bundles not interrupted by intervals in *Listriolobus*. It is often hard to make this distinction between *Ochetostoma* and *Listriolobus* considering the work involved in the process as has been hinted by Wharton (1913) and stated clearly by Bock (1942, p. 13). There are further difficulties in making the distinction between young specimens of *Ochetostoma* and *Listriolobus*. Between *Ikedosoma* Bock and *Ochetostoma* the difference is long extensible proboscis as also numerous gonoducts arranged in pairs of groups in the former. The arrangement of the muscles of the body wall is identical in the two genera.

The number of muscle bands, and the number and the location of the gonoducts are important criteria for the determination of quite a few of the species of *Ochetostoma*. Notwithstanding, the dimension of the basis of the taxonomic consideration of the species of this genus has increased with the increase of knowledge of the group. Besides *O. erythrogrammon* (Leuckart and Rüppell) which has been described by many authors, morphological accounts of the species are generally brief. In the description of a few species, the interbasal muscle, the neurointestinal vessel, and the rectal coecum have been mentioned. A few species are remarkably characterised by the modification of the posterior extremity of the body (e.g. *atlantedei* Wesenburg-Lund, *mercator* Wesenburg-Lund, *arkati* (Prashad)). There is, however, special problem with the species *caudex* (Lampert), *stuhlmani* (Fischer), *leptodermon* (Fischer), and *kokotoniense* (Fischer), which together with *erythrogrammon* and *palense* (Ikeda), have been regarded by Sato (1939, p. 357) as conspecific. To us the species *palense* seems to be a distinct one from *erythrogrammon* on the basis of the absence of the rectal caecum. With the information at hand it is not possible to separate the rest of the species from *erythrogrammon*. Fisher (1946,

p. 241) has put in his key the species *griffini* along with these conspecific forms, to which we add *sorbillans*.

In this paper we have given anatomical notes on *O. erythrogrammon*, *O. kempi*, *O. australiense*, and *O. bombayensis*, which should facilitate recognising the species. Besides, an upto date list of the species of *Ochetostoma* together with a brief key has been incorporated.

We record here our indebtedness to the past and the present Directors of the Zoological Survey of India, Dr. M. L. Roonwal and Dr. A. P. Kapur respectively, for facilities throughout the work. Our grateful thanks are due to Professor V. Lakshminarayanan, Director of Birla Institute of Technology and Science, Pilani, and to Dr. G. P. Sharma, Head of the Department of Zoology, Panjab University, Chandigarh, for their keen interest in the work.

II—SYSTEMATIC ACCOUNT

Ochetostoma erythrogrammon (Leuckart and Rüppell)

(Text-fig. 1)

Ochetostoma erythrogrammon Leuckart and Rüppell, 1828 ; Spengel, 1912 ; Fischer, 1926 ; Sato, 1935, 1939 ; Stephen, 1952 ; Stephen and Robertson, 1952 ; Wesenburg-Lund, 1954, 1959.

Thalassema erythrogrammon Drasche, 1881 ; M. Muller, 1852 ; Greeff, 1879 ; Sluiter, 1883, 1890 ; Rietsch, 1886 ; Shipley, 1899, 1902.

Thalassema caudex Lamper, 1883 ; Rietsch, 1886 ; Shipley, 1898, 1899 ; Sluiter, 1902 ; Wharton, 1913 ; Prasad, 1935.

Thalassema kokotoniense Fischer, 1892, 1895, 1914 ; Shipley, 1899 ; Sluiter, 1902 ; Ikeda 1904.

Thalassema stuhlmani Fischer, 1892, 1895, 1914 ; Augener, 1903.

Thalassema leptodermon Fischer, 1892 ; Sluiter, 1902 ; Augener, 1903.

Thalassema griffini Wharton, 1913.

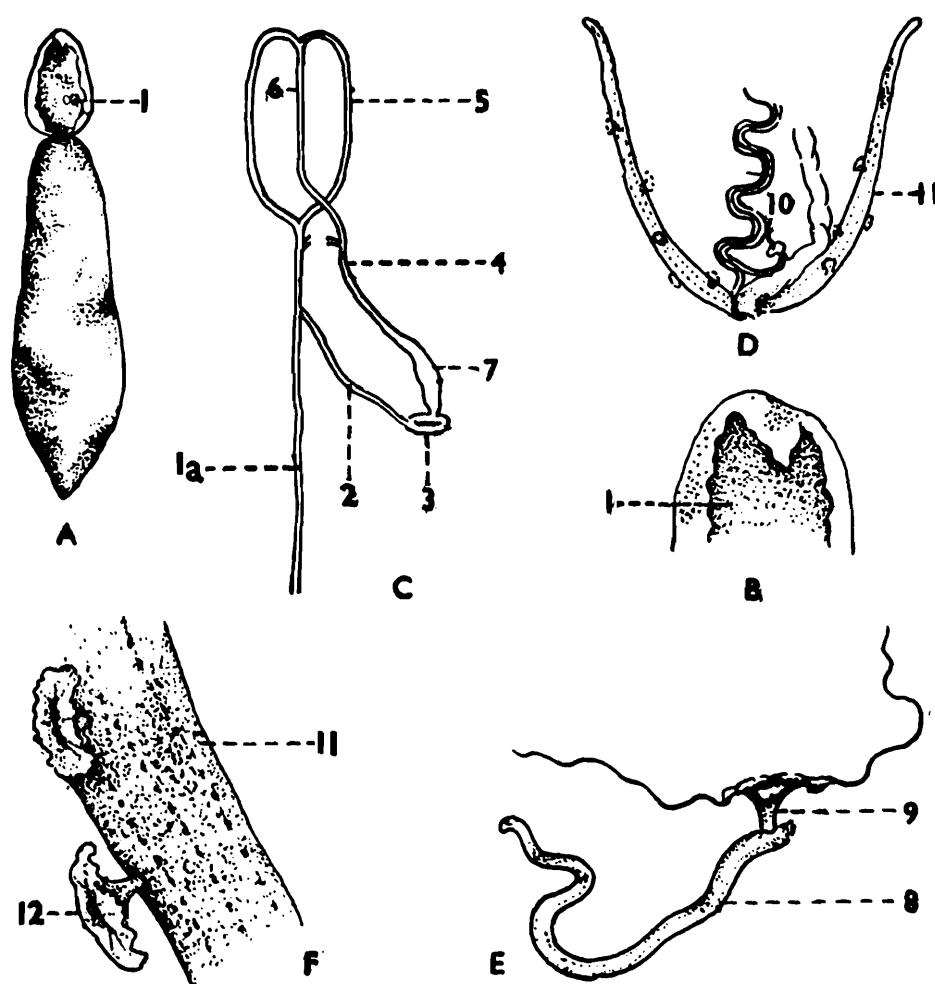
Thalassema sorbillans Lampert, 1883.

Altogether 3 specimens have been examined, a list of which has been presented below.

MATERIAL : (1) & (2) Coll. Dr. K. K. Tiwari of Zoological Survey of India, Calcutta : 2 exs., Port Blair (Andaman Island : Bay of Bengal), August, 1961 ; 52 mm. & 19 mm. body length, 14 mm. & 8 mm. proboscis length ; 16 & 14 muscle bands. (3) Coll. Marine Survey : 1 ex., West of Octaria Bay (Andaman Island), date unknown, 73 mm. body length, 29 mm. proboscis length, 14 muscle bands.

The preserved specimens were pinkish grey in colour. A sharp constriction marks the junction of the proboscis and the trunk. The proboscis is narrow anteriorly. Besides, the margin of the proboscis is thin and inflected ventrally leaving a central fleshy pad (Text-fig. 1, A and B-1). The body is covered with conspicuous papillae throughout. The papillae are round to oval in shape and are arranged transversely ; there are sharp grooves between the transverse rows.

The vascular system (Text-fig. 1, C) consists of a ventral vessel (C-1a), a neurointestinal (C-2) connecting the ventral with the ring sinus (C-3), and a dorsal (C-4). Posteriorly the ventral vessel terminates on the rectal caecum (Text-fig. 1, D-10). Near the junction of the proboscis and the trunk both the dorsal and the ventral vessels send off branches towards the pharynx. It could not be ascertained whether these branches are connected with a system of 'nuchal ring' (Prashad, 1919*b*, as adopted from Spengel, 1880). The ventral vessel is bifurcated in the proboscis, the 2 limbs run as 2 lateral vessels (C-5) along the margin of the proboscis to unite with the median vessel (C-6) at the tip.



TEXT-FIG. 1. Diagrams of *Ochetostoma erythrogrammon* (Leuckart and Rüppell).

A. Entire view, showing the central fleshy pad of the proboscis ; B. Proboscis ; C. Vascular system ; D. Posterior end showing the disposition of ventral vessel, rectum and anal vesicle ; E. Gonoduct with nephrostome ; F. Anal vesicles with funnels.

1. Central fleshy pad ; 1a. Ventral vessel ; 2. Neurointestinal ; 3. Ring sinus ; 4. Dorsal vessel ; 5. Lateral vessel ; 6. Median vessel, 7. Heart ; 8. Gonoduct ; 9. Nephrostome ; 10. Rectal caecum ; 11. Anal vesicles ; 12. Funnels.

There are 3 pairs of large gonoducts, the first pair being in front of the setae. The second pair is the largest, and the largest gonoducts (left-61 mm. ; right-47 mm.) that we have seen in any echiurid. Each gonoduct is a tubular organ (Text-fig. 1, E-8) provided with a funnel like gonostome (E-9) near the gonopore ; the margin of the funnel is produced into a pair of filamentous lips. The anal

vesicles are 2 long tubular sacs (Text-fig. 1, D and F-11) with short stalked funnels (F-12) throughout the vesicle.

Distribution.—Tropical West Africa, South Africa, East Africa, Andaman and Nicobar Islands, Red Sea, East Indies, Japan, West Indies, North Caroline Islands, Tahiti.

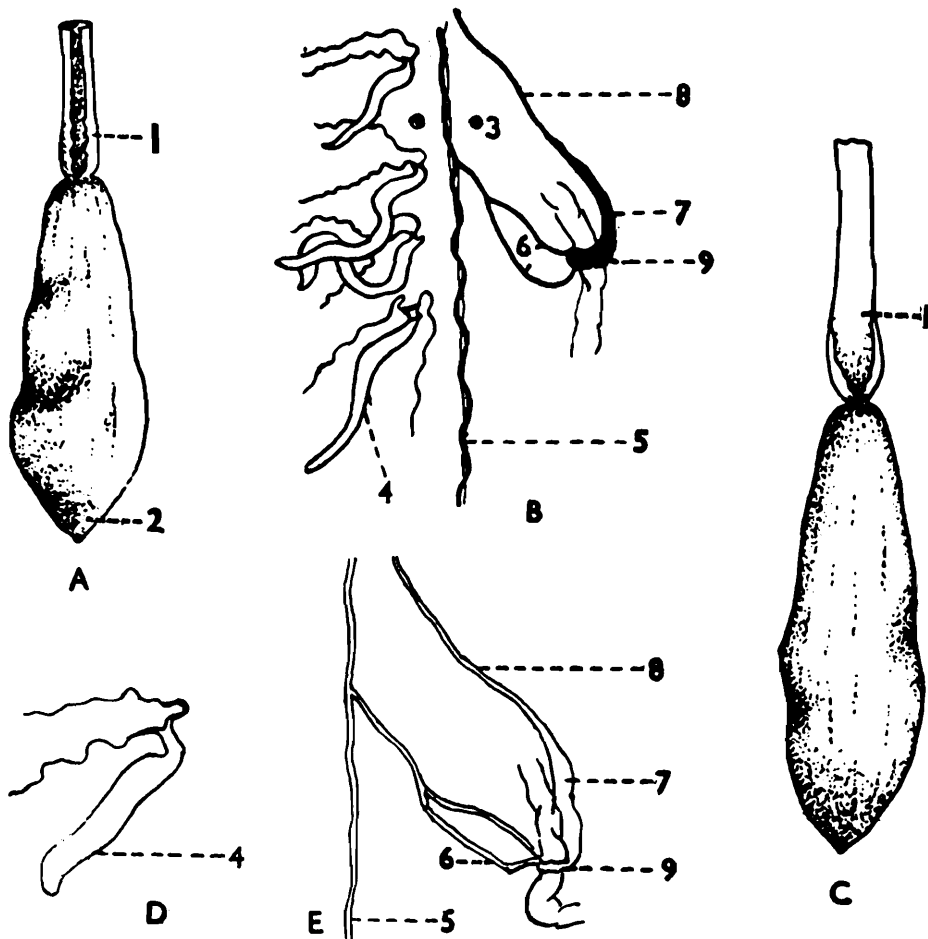
***Ochetostoma kemp* (Prashad)**

(Text-fig. 2, A & B)

Thalassema kemp Prashad, 1919, 1935.

Ochetostoma kemp: Fisher, 1946.

Only one specimen has been examined, collected by Lt. Col. R. B. Sewell from the Mcpherson Strait (Andaman Island) on 29.i.24, and described by Dr. B. Prashad (1935, p. 41). The proboscis of the specimen is nearly tubular, whose lateral margins are slightly indented. The body is covered with rounded papillae, which are prominent towards the posterior end. The extreme posterior end of



TEXT-FIG. 2. A, B, and D *Ochetostoma kemp* (Prashad); C and E *Ochetostoma australiense* Edmonds.

1. Proboscis; 2. Entire body; 3. Ventral setae; 4. Nephridia; 5. Ventral vessel; 6. Neurointestinals; 7. Heart; 8. Dorsal vessel; 9. Ring sinus.

the body is devoid of papillae, and is made of concentric fleshy rings. In this respect this specimen does not conform with the type specimen of Prashad (1919*b*). There are 20 muscle bands which are inconspicuous at the posterior end. The 2 setae are golden yellow in colour, and are encased in a muscular sheath. An interbasal muscle is absent.

There are 4 pairs of gonoducts, the first pair being presetal. All the gonoducts are fairly large and their gonostomes are as in *O. erythrogrammon* (Text-fig. 2, B and D-4).

The vascular system (Text-fig. 2, B) consists of a ventral (B-5), 2 neurointestinals (B-6), a ring sinus, a heart, and a dorsal (B-9, 7, and 8 respectively). The 2 neurointestinals are separate throughout their length, which unite close to its opening in the ventral vessel at about the level of the ventral setae (B-3). A rectal caecum is absent, and the ventral vessel terminates on the rectal wall. The anal vesicles are long tubular sacs, studded with short stalked funnels.

Prashad (1919*b*, p. 337) named and described the species, characterised by 20 longitudinal muscle bands and 4 pairs of nephridia, all the nephridia being postsetal. He amended his description (1935, pp. 40-41) in his article on *Thalassema* in the Indian Museum, where he stated "In general appearance *Thalassema caudex* resembles *Thalassema kempi* Prashad, but the latter species, as I have confirmed by a re-examination of the type and the specimen recorded below, has four and not three pairs of segmental organs. My description of this species, however, needs correction in that the anterior two pairs of segmental organs are situated in front of the setae." The first note of correction is contrary to his description of the type in which he has mentioned 4 pairs of segmental organs (Prashad, 1919*b*, p. 336). The second note of correction, however, needs further amendment as there is only one pair of presetal gonoducts in the present specimen and not two pairs. The position of the gonoducts could not be compared with the type as the latter was not available. Fisher (1946, p. 241) in his key for the species of *Ochetostoma* has placed *kempi* under 4 pairs of 'nephridia' posterior to the setae. To our knowledge *O. kempi* has not been reported by any body after Prashad (1935). The position of the gonoducts is clear in this specimen, and we are inclined to regard this species as characterised by 4 pairs of gonoducts of which the first pair is presetal.

Distribution.—Ross Island (Andaman Islands).

***Ochetostoma australiense* Edmonds**

(Text-fig. 2, C and E)

Ochetostoma australiense Edmonds, 1960.

Only one specimen has been studied, collected by the Marine Survey from the west of Octaria Bay, Andaman Islands. The exact date of collection could not be known. The specimen measures 109 mm in length of which the proboscis is 41 mm. The latter is nearly a flat structure with its margin slightly undulated (Text-fig. 2, C-1); its surface almost smooth with imperceptible marks of papillae. There are 14 longitudinal muscle bands. The first pair of the 3 pairs of gonoducts are situated in front of the setae. The vascular system (Text-fig. 2, E) consists of a ventral (E-5), 2 neurointestinals (E-6), a ring sinus (E-9), a heart (E-7) and a dorsal (E-8). The neurointestinals emerge as one from the ventral vessel and bifurcates into two, which open separately into the ring sinus. The anal vesicles are long (3/4 of the length of the body) and tubular, studded with short stalked funnels.

Edmonds (1960) has named and described the species *australiense* which is characterised by 11-14 muscle bands. To us the trenchant character appears to be the neurointestinals. Both *erythrogrammon* and *australiense* have 3 pairs of nephridia, the first pair being presetal, and variable number of muscle bands. The species *australiense* has 2 neurointestinals (Edmonds, 1960, pp. 94-95, Figure 4) while *erythrogrammon* has one.

Distribution.—Eastern coast of Australia, Andaman Islands.

***Ochetostoma bombayensis* (Prashad and Awati)**

Thalassema bombayensis Prashad and Awati, 1929; Awati and Deshpande, 1936; Awati, 1936.

Only one complete specimen has been studied, collected by the Marine Survey from Port Blair (Andaman Islands). The exact date of collection could not be ascertained. The specimen is 32 mm. long of which the proboscis is 12 mm. The body is covered with conspicuous papillae which are prominent towards the posterior end. The proboscis is smooth and its margin is without any modification. There are 12 longitudinal muscle bands running from the anterior to the posterior end. The first pair of the 4 pairs of gonoducts are situated in front of the setae. The gonoducts are small in size.

In the species *bombayensis* the number of gonoducts varies from 4 to 5 pairs, and the longitudinal muscle bands from 10 to 11 (Prashad and Awati, 1929). The only point of difference from *bombayensis* is one additional muscle band in this specimen, which could be the result of splitting of one of the bands. It seems probable since variation in the number of muscle bands has already been observed in *bombayensis*, as in a few other species of this genus. Besides *O. bombayensis*, the 2 species which are nearer to this one are *O. decameron* and *O. kempi*, both of which have 4 pairs of gonoducts. In *O. kempi* the first pair of gonoducts are presetal, in which respect *O. kempi* is similar to the present specimen; but *O. kempi* has 20 longitudinal muscle bands. Besides, its extreme posterior end is modified, which make *kempi* distinct from the present specimen. In *O. decameron* 2 pairs of gonoducts lie in front of the setae and 2 behind (Lanchester, 1905, p. 35). The species *bombayensis*, therefore, seems to be characterised by 4 to 5 pairs of gonoducts, the first pair being in front of the setae, and 10-12 longitudinal muscle bands.

Distribution.—Coasts of Bombay and Andaman Islands.

The following species belong to the genus *Ochetostoma*.

- | | | | | |
|----|------------------------------------|-----|----|--|
| 1. | With 7 pairs of gonoducts | ... | 2 | |
| | With 5 pairs of gonoducts or less | ... | 3 | |
| 2. | First pair of gonoducts presetal ; | | | |
| | 12 longitudinal muscle bands | ... | | <i>zanzibarens</i> Stephen and Robertson, 1952 |
| | All the gonoducts postsetal ; 7 | | | |
| | longitudinal muscle bands | ... | | <i>senegalense</i> Stephen, 1960 |
| 3. | With presetal gonoducts | ... | 4 | |
| | Without presetal gonoducts | ... | 10 | |
| 4. | Gonoducts 5 pairs | ... | 5 | |
| | Gonoducts less than 5 pairs | ... | 6 | |

5. 3 pairs of gonoducts presetal ;
10 longitudinal muscle bands ... *hornelli* (Prashad), 1920
1 pair of gonoducts presetal ; 10-
12 longitudinal muscle bands ;
gonoducts occasionally 4 pairs ... *bombayensis* (Prashad and Awati),
1929
6. Presetal gonoducts 1 pair ... 7
Presetal gonoducts 2 pairs ; 10
longitudinal muscle bands ... *decameron* (Lanchester), 1905
7. Gonoducts 4 pairs in all ; 20
longitudinal muscle bands ... *kempi* (Prashad), 1919
Gonoducts 3 pairs in all ... 8
8. Rectal caecum present ... 9
Rectal caecum absent ; 15 longi-
tudinal muscle bands ... *palense* (Ikeda), 1924
9. Single neurointestinal vessel ;
longitudinal muscle bands vary
from 14-19 ... *erythrogrammon* (Leuckart and
Rüppell), 1828
caudex (Lampert), 1883
stuhlmani (Fischer), 1892
leptodermon (Fischer), 1892
kokotoniense (Fischer), 1892
sorbillans (Lampert), 1883
griffini (Wharton), 1913
- 2 neurointestinal vessels ; 11-14
longitudinal muscle bands ... *australiense* Edmonds, 1960
10. Gonoducts 2 pairs ; muscle bands
less than 10 ... 11
Gonoducts as above ; muscle bands
more than 10 ... 15
11. Circumanal area not modified ... 12
Circumanal area modified ... 14
12. Interbasal muscle absent ... 13
Interbasal muscle present ; 7-8
longitudinal muscle bands ... *capensis* Jones and Stephen, 1954
13. Muscle bands 8 in number which
fuse into a continuous sheath at
the posterior end ... *octomyotum* Fisher, 1946
6-8 muscle bands separate
throughout ... *formosulum* (Lampert), 1883
14. Smooth circumanal ring ; 8 muscle
bands ... *arkati* (Prashad), 1935
Annular frills around the circum-
anal ring ; 7 muscle bands ... *septemyotum* DattaGupta and
Menon, 1963
15. Anal disc with subulate papillae ... 16
No such modification ... 17
16. With oesophageal diverticulum ;
13 muscle bands ... *atlantidei* Wesenburg-Lund, 1959
Without oesophageal diverti-
culum ; muscle bands 13 ... *mercator* Wesenburg-Lund, 1954
17. Variable muscle bands ... 18
Not so ... 20
18. Anal vesicles characteristically
modified ; muscle bands 17-19 ... *baronii* (Greeff), 1879
Not as above ... 19
19. Muscle bands 10-11 ... *hupferi* (Fischer), 1892
Muscle bands 16-17 ; interbasal
muscle present ... *edax* Fisher, 1946
20. 13 muscle bands ... *pellucidum* (Fischer), 1895
14 muscle bands ... *manjuyodense* (Ikeda), 1905

III — SUMMARY

Ochetostoma erythrogrammon and *O. australiense* are reported from the Andaman and Nicobar islands. Anatomical features of the species *erythrogrammon* conform with the earlier accounts except that the nephridia of the specimens collected from Port Blair are extremely large. *O. australiense* has 2 neurointestinals, otherwise the species is comparable with *erythrogrammon*. A re-examination of a duplicate of *O. kempfi* reveals that the species is characterised by 20 longitudinal muscle bands, and 4 pairs of nephridia of which the first pair is presetal instead of the first two pairs. The longitudinal muscle bands in *O. bombayensis* have been known to vary from 10-11, although in the present case the number is 12. *O. bombayensis* thus has 4-5 gonoducts with 1 pair presetal, and 10-12 longitudinal muscle bands.

An upto date list of the species of *Ochetostoma* together with a brief key for the species has been incorporated.

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THE FISHES OF RIVER TAWI AND ITS TRIBUTARIES (JAMMU & KASHMIR STATE) WITH NOTES ON ECOLOGY

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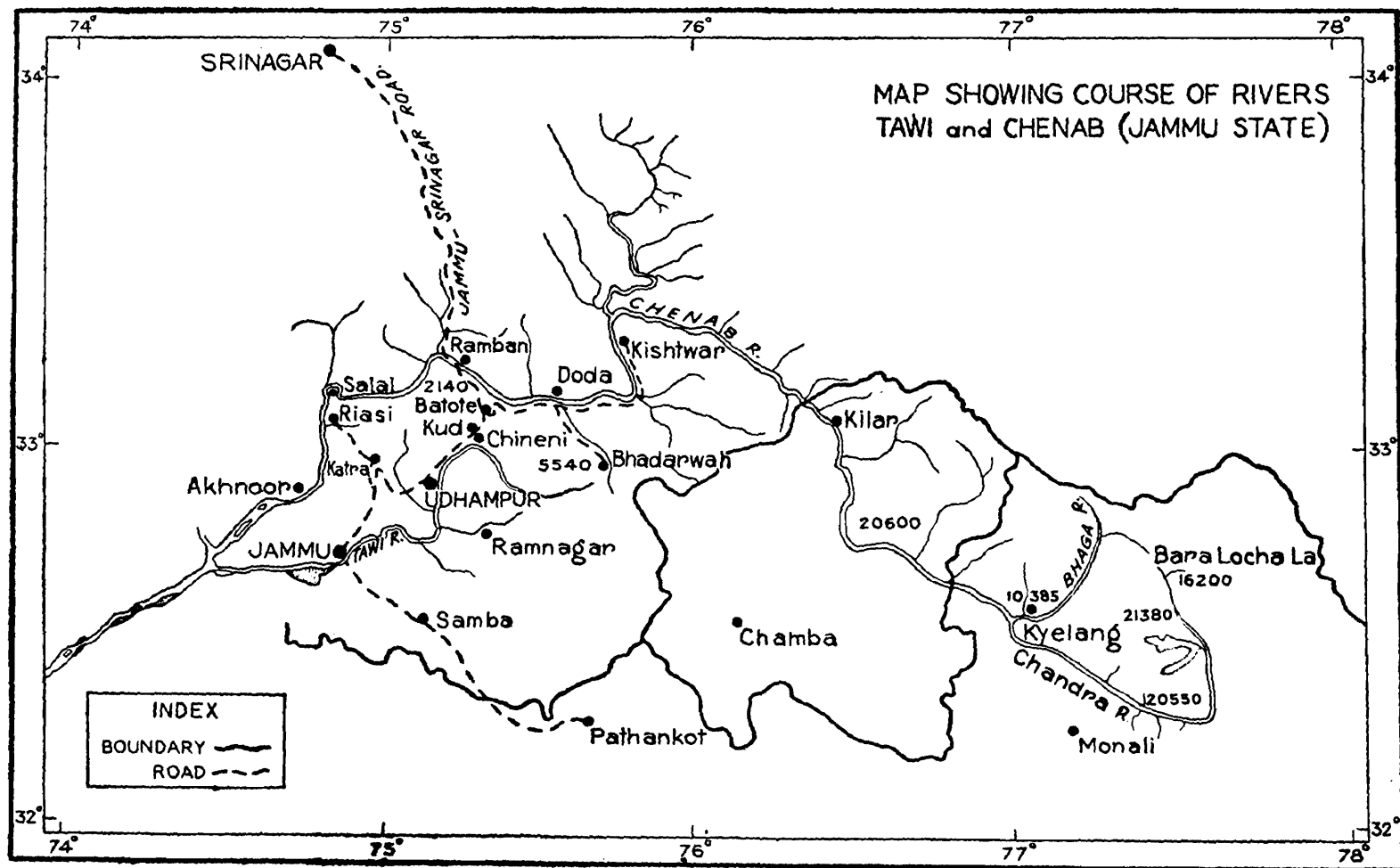
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I—INTRODUCTION

The fish fauna of Kashmir has been receiving considerable importance since 1838 when Heckel published 'Fische aus Caschmir', and thence after many important contributions have been made by Vigne (1842), Heckel (1844), Steindachner (1866), Chaudhuri (1909), Hora (1936b), Mukerji (1936), Misra (1949), Hora *et al.* (1955), Silas (1960) and Das and Subla (1963, 64). It appears quite surprising that the fish fauna of Jammu has never been studied by any of the above mentioned workers except a passing remark made by Silas (1960, 70) about the presence of a few fishes in this area. Although the scenic beauty of Jammu does not claim a reputation equivalent to that of Kashmir, this vast hilly land abounds in rivers and nullas of no less faunistic consequence than those of Kashmir.

Considering paucity of knowledge of the fish fauna of Jammu, an initial attempt was made by Zoological Survey of India, during September-October, 1964, to carry out a survey of the fish fauna of the river Tawi and its tributaries from a point nearly 9 kms. up-stream from Chineni town (Lat. 33.0', Long. 75.15', Alt. 1128 Mts.) down to the vicinity of the Indo-Pakistan border which lies nearly 19 kms. down-stream from Jammu city (Lat. 32.40', Long. 74.50', Alt. 503 Mts.). In the present paper the fish fauna of the river Tawi and its tributaries, together with notes on the ecology and fisheries of that area, is presented. Altogether 38 species belonging to 10 families of 5 orders of the Division Euteleostei of the Class Teleostomi



are included here, all of which are definitely recorded for the first time from river Tawi and are based on the collections made by the author (except one species, *Wallago attu*, for which no specimens were collected). The notes on the ecology and the fisheries of the area given here are also based on the personal and direct observations made in the field by the author.

II—THE RIVER TAWI

The river Tawi emerges out from a glacier tank, known as 'Kailash Kund' which lies at the top of 'Mahakailash choti' (Alt. approximately 3965 M.). The river flows down the southern face of the 'Mahakailash choti' in the form of a small stream and later gathers water from a large number of small streams on the way. Through a long circuitous hilly path it flows diagonally across Jammu area, roughly in the north-east to south-west axis (Pl. 4, Fig. 1; Map. 1). At Jammu it enters into plains and finally mingles with river Chenab within the boundry of Pakistan. It is bordered on both sides by high and low hills throughout its course. The bed of the river is narrow at many places with steep hills on both sides, while at some other places the bed is very wide. In winter months the river shrivels up in the form of a small nulla. It flows throughout the year but its tributaries are of two types; the perennial and the seasonal nullas. The perennial ones contain water throughout the year, the quantity of water being tremendous during rainy season and small during the other seasons of the year. During rains plenty of earth and stones flow down the nullas and due to the dirty colour and unknown depth of the huge body of water, fishing is impossible, rather perilous. The seasonal nullas become active only in rainy season, when high columns of water flow through them. The seasonal nullas contain no fishes. All these nullas either singly or conjointly fall into the river Tawi.

Through the course of the river, the water falls at many places even from a height of 3-5 meters (Pl. 4, Fig. 2). The small streamlets are formed by collecting water from a large number of springs coming out of the side of hills. At many places, the outlet of the spring is stone-lined, where the water collects in the form of a small pool and then flows out in the form of a streamlet. Such a ditch or a pool is called by the local name 'Bauli' (Pl. 4, Fig. 4).

III—SYSTEMATIC LIST OF FISHES

Order: CYPRINIFORMES Berg, 1940

Family: CYPRINIDAE (Bon., 1837) Gill, 1861

Scientific names	Local Name
(1) <i>Chela (Chela) cachi</i> (Ham.)	—
(2) <i>Oxygaster bacaila</i> (Ham.)	Daryai chaahl
(3) <i>Barilius bendelisis</i> (Ham.)	Pathrill chaahl
(4) <i>Barilius vagra</i> (Ham.)	—
(5) <i>Barilius barila</i> (Ham.)	—
(6) <i>Barilius shacra</i> (Ham.)	—
(7) <i>Barilius modestus</i> Day	Pathrili chaahl

Scientific names	Local Name
(8) <i>Danio devario</i> (Ham.)	—
(9) <i>Esomus danrica</i> (Ham.)	—
(10) <i>Schizothorax plagiostomus</i> Heckel	Alwaan
(11) <i>Garra gotyla gotyla</i> (Gray)	Khront
(12) <i>Tor putitora</i> (Ham.)	Mahseer
(13) <i>Tor mosal</i> (Ham.)	Soltihi
(14) <i>Puntius ticto</i> (Ham.)	Marakhi
(15) <i>Puntius sarana sarana</i> (Ham.)	Tichir
(16) <i>Puntius sophore</i> Ham.	—
(17) <i>Labeo dero</i> (Ham.)	Kayehri
(18) <i>Labeo dyocheilus</i> (McClelland)	Bharata
(19) <i>Labeo bata</i> (Ham.)	—
(20) <i>Aspidoparia morar</i> (Ham.)	—
(21) <i>Cirrhinus mrigala</i> (Ham.)	—
(22) <i>Crossocheilus diplochilus</i> (Heckel)	Bootal
Family: COBITIDAE (Swainson, 1839) Gill 1893	
(23) <i>Botia birdi</i> Chaudhuri	—
(24) <i>Lepidocephalus guntea</i> (Ham.)	—
(25) <i>Noemacheilus botia</i> (Ham.)	Tralwat
(26) <i>Noemacheilus corica</i> (Ham.)	Tralwat
(27) <i>Noemacheilus prashari</i> Hora	Tralwat
Order: SILURIFORMES Greenwood <i>et al.</i> , 1966.	
Family: SILURIDAE (Cuv., 1817) Gill, 1872.	
(28) <i>Wallago attu</i> (Bl. & Schn.)	Mallee
Family: BAGRIDAE (Bleeker, 1858; Günther, 1864) Gill, 1893	
(29) <i>Mystus (Aorichthys) seenghala</i> (Sykes)	Seeng
Family: AMBLYCIPITIDAE Regan, 1912.	
(30) <i>Amblyceps mangois</i> (Ham.)	chhota keengar
Family: SISORIDAE Gill, 1872	
(31) <i>Glyptothorax pectinopterus</i> (McClelland)	Keengar
Order: CHANNIFORMES Greenwood <i>et al.</i> , 1966.	
Family: OPHIOCEPHALIDAE (Bon., 1831) Bleeker, 1859	
(32) <i>Channa orientalis</i> Schn.	Mooree
(33) <i>Channa punctatus</i> (Bloch)	—
(34) <i>Channa marulius</i> (Ham.)	Sol
Order: PERCIFORMES Berg, 1940.	
Suborder: MASTACEMBELOIDEI Greenwood <i>et al.</i> 1966.	
Family: MASTACEMBELIDAE (Günther, 1861) Gill, 1893	
(35) <i>Mastacembelus armatus</i> (Lacépède)	Garoj
(36) <i>Mastacembelus pancalus</i> (Ham.)	—
Suborder: PERCOIDEI Berg, 1940	
Family: BADIDAE Liem, 1970.	
(37) <i>Badis badis</i> (Ham.)	—
Order: ATHERINIFORMES Greenwood <i>et al.</i> , 1966.	
Suborder: EXOCOETOIDEI Berg, 1940.	
Family: BELONIDAE Gill, 1872	
(38) <i>Xenentodon cancila</i> (Ham.)	Tarakla

IV—SYSTEMATIC NOTES

Genus *Chela* Hamilton, 1822(1) *Chela (Chela) cachinus* (Ham.)

1822. *Cyprinus (Chela) cachius* Hamilton, *Fishes of Ganges*, pp. 258, 384. (Type-locality: The Ganges, near the commencement of delta).

1958. *Chela (Chela) cachius*: Silas, *J. Bombay nat. Hist. Soc.*, **55**, pp. 64-66.

Material.—(i) 35 exs., Choe nulla, 16.8 kms west of Jammu, 19.10.1964 (ii) 2 exs., a branch of Tawi near Jammu city, 19.x.1964. (Size: 28-43 mm.).

Remarks.—It is characterised by the sharp edged abdomen, dorsal fin in the posterior half of the body, outer pelvic rays elongated, the predorsal scales not extending to the interorbital space, and the absence of a symphysial knob in the lower jaw.

It is found in slow moving nullas with muddy bottom, by the side of the river Tawi in the plains. This species is found only in the lower reaches of this river. It is a small laterally compressed fish and can be reared in aquaria.

Distribution.—Fresh waters of Jammu & Kashmir, West Bengal, Assam, Orissa, Madhya Pradesh, Madras and Mysore states; Pakistan and Burma.

Genus *Oxygaster* van Hasselt, 1823(2) *Oxygaster bacaila* (Ham.)

1822. *Cyprinus bacaila* Hamilton, *Fishes of Ganges*, pp. 265, 384 (Type-locality: Fresh water rivers of all gangetic provinces).

1959. *Oxygaster bacaila*: Misra, *Rec. Indian Mus.*, **57**, p. 140.

Material.—(i) 4 exs., River Tawi near Jammu city, 16.x.1964 and 24.x.1964. (Size: 75-127 mm.).

Remarks.—The fish can be distinguished by its cutting abdomen, the dorsal fin in the posterior half of the body, the outer rays of the pelvic fins not produced, the predorsal scales extending to interorbital region and the presence of a symphysial knob in the lower jaw. It is mostly found in slow moving waters in the lower reaches of the river Tawi. It is not of much commercial value but fishermen use them as bait for other big fishes. It could, however, serve as poor man's diet.

Distribution.—Fresh waters of Jammu & Kashmir, Punjab, Uttar Pradesh, Bihar, West Bengal, Orissa; Nepal and Pakistan.

Genus *Barilius* Hamilton, 1822(3) *Barilius bendelisis* (Ham.)

1807. *Cyprinus bendelisis* Hamilton, *Journey Mysore*, **3**, p. 345, pl. 32 (Type locality: rivers of Mysore).

1822. *Cyprinus (Barilius) bendelisis*: Hamilton, *Fishes of Ganges*, pp. 272, 385, pl. 3, fig. 77.

1822. *Cyprinus (Barilius) chedra* Hamilton, *Ibid.*, pp. 273, 385.

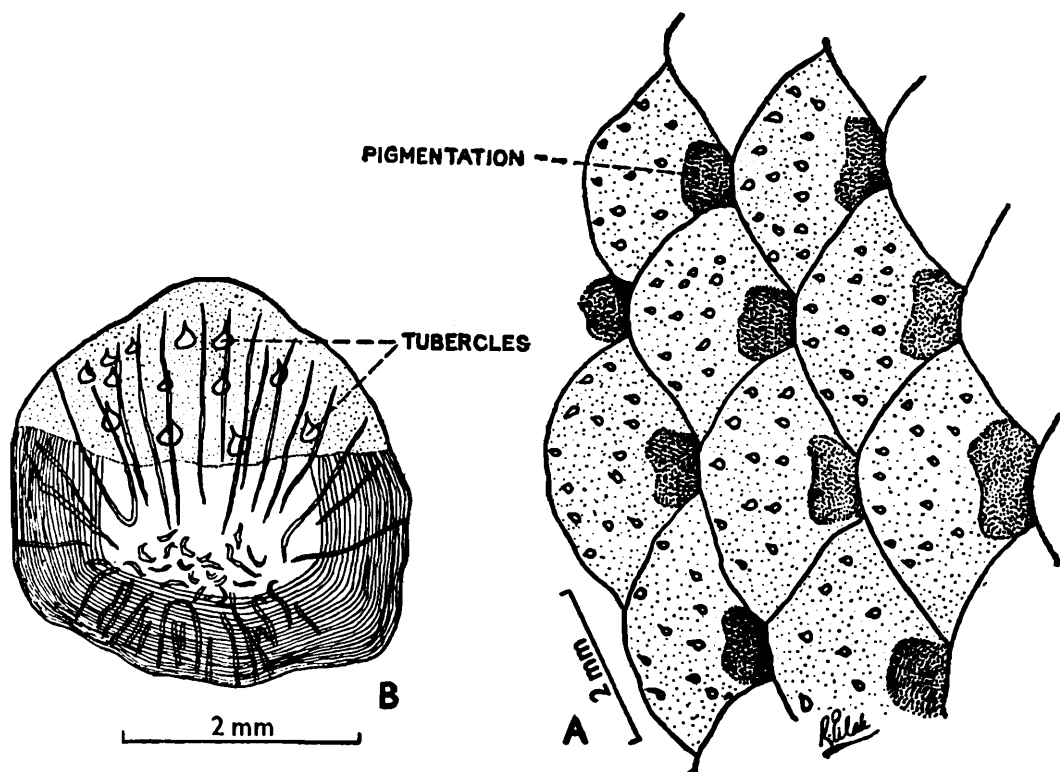
1822. *Cyprinus (Barilius) coosa* Hamilton, *Ibid.*, pp. 272, 385.

1924. *Barilius dogarsinghi* Hora, *Rec. Indian Mus.*, **22**, p. 191, fig. 3 (Type-locality: Manipur).

1959. *Barilius bendelisis*: Misra, *Ibid.*, **57**, p. 141.

Material.—(i) 2 exs., Power station, Udhampur 6.ix.1964 (ii) 17 exs., Birwan nulla, 6.ix.1964 (iii) 6 exs., Nadal nulla, after union with Nadiali nulla, Dist Udhampur, 6.ix.1964 (iv) 2 exs., Birwan nulla, Udhampur, 6.ix.1964 (v) 6 exs., Kawa dabar, Udhampur, 7.ix.1964 (vi) 6 exs., Devak nulla, Udhampur, 8.ix.1964 (vii) 1 ex., Siaran nulla, Udhampur, 9.ix.1964 (viii) 9 exs., Dhanodi nulla, nearly 4.5 kms. west of Udhampur, 10.ix.1964 (ix) 1 ex., Ramnagar nulla, 24 kms. east of Udhampur, 14.ix.1964 (x) 9 exs., a small nulla near Gudhar village, Dist. Udhampur, 18.ix.1964 (xi) 5 exs., Dudder nulla, Dist. Udhampur, 18.ix.1964. (xii) 10 exs., River Tawi, south of village Gudhar, Dist. Udhampur, 21.ix.1964. (xiii) 3 exs., a dabar by the side of Dudder nulla, Village Gudhar, Dist. Udhampur, 22.ix.1964 (xiv) 38 exs., Jhajjar nulla, 2 kms. east of P.W.D. Rest House, Jhajjar, Dist. Udhampur, 5.x.1964. (xv) 77 exs., Jhajjar nulla, 6 kms. downstream from P.W.D. Rest House, Jhajjar, Dist. Udhampur, 6-7.x.1964 (xvi) 72 exs., Junhi nulla, Village Jhajjar, Dist. Udhampur, 8-11.x.1964 (xvii) 85 exs., river Tawi, near Jammu city, 21-23.x.1964 (xviii) 30 exs., Nagrota nulla, Village Nagrota, Dist. Jammu, 27.x.1964 (xix) 15 exs., Pulin nulla, near Nagrota, Dist. Jammu, 7.x.1964. (xx) 56 exs., Sarande nulla, 2 kms. north of Nagrota, Dist. Jammu, 29.x.1964. (large number of examples are young, size: 23-127 mm.).

Remarks.—This is a very common species found in this area. The characters of the species are quite variable within the limits of the species. In most of them the anal fin has three spines and 8-9 branched rays. However, in the present collection there are specimens approximating *B. chedra* Ham. (pl. 3, figs. 3 & 4). In these specimens the scales are covered over with small tubercles arranged in two irregular rows (Text-fig. 1, a & b). The tubercles



TEXT-FIG. 1. (A) Showing arrangement, colouration and tubercles in scales of specimen of *Barilius bendelisis* (Ham.) (B) One scale of the same enlarged to show structures,

impart the fish a rough texture. There are big tubercles on the anterior tip of the snout, on the space anterior to the orbit and below the narial opening, and on the whole of the ventral side of the lower jaw. After dissection it has been confirmed that the tuberculated snout is present uniformly in male and female specimens and this character cannot be accredited to the difference of sexes alone. In one specimen from Jhajjar nulla the back is dark and only 5 colour bands, in the form of blotches, are present in the region of the body posterior to the dorsal fin. The dark blotches remain far above the lateral line. The anal fin of this species contains 10 branched rays and 3 spines. This specimen resembles *B. cocsa* Ham. Recently, the varieties *chedra* and *cocsa* have been synonymised with *bendelisis*. The author has, however, a feeling that they may have independent status. An analysis of the characters of *chedra* and *cocsa*, in comparison with *bendelisis*, is in progress and when completed the results will be published elsewhere.

Distribution.—Fresh waters of Jammu & Kashmir, Punjab, Himachal Pradesh, Uttar Pradesh, Bihar, West Bengal, Assam, and Madras : Pakistan and Ceylon.

(4) *Barilius vagra* (Ham.)

(Pl. 3, figs. 5, 6).

1822. *Cyprinus* (*Barilius*) *vagra* Hamilton, *Fishes of Ganges*, pp. 269, 385 (Type-locality: The Ganges at Patna).

1959. *Barilius vagra* : Misra, *Rec. Indian Mus.*, **57**, p. 143.

Material.—(i) 3 exs., Thalli nulla, Dist. Udhampur 7.ix.1964 (ii) 11 exs., Sakanwahi bauli, near Udhampur 7.ix.1964 (iii) 16 exs., Dudder nulla, Dist. Udhampur 20.ix.1964 (iv) 1 ex., River Tawi, village Gudhar, Dist. Udhampur, 21.ix.1964 (v) 14 exs., Kud nulla, village Chineni, Dist. Udhampur 24.ix.1964 (vi) 8 exs., Jhajjar nulla, Dist. Udhampur, 5.x.1964 (vii) 1 ex., Bauli at Mian ka Bag, Dist. Udhampur, 7.x.1964 (viii) 3 exs., Junhi nulla, Dist. Udhampur, 8.x.1964 (ix) 2 exs., Union of Junhi and Jhajjar nullas, Dist. Udhampur, 9.x.1964. (Size: 44-122 mm.).

Remarks.—It is a fish of small size and is common in the nullas and river Tawi. The material studied here agrees with the description given by Day (1878). The points of distinction of this species from *B. barila* Ham. are given under the remarks of the latter species.

Distribution.—Fresh waters of Jammu & Kashmir, Punjab, along of base of Himalaya in Uttar Pradesh, Bihar, West Bengal, Assam ; Nepal, Pakistan and Ceylon.

(5) *Barilius barila* (Ham.)

(Pl. 3, figs. 7, 8)

1822. *Cyprinus* (*Barilius*) *barila* Hamilton, *Fishes of Ganges*, pp. 267, 389. (Type-locality: rivers of North Bengal).

1959. *Barilius vagra* : Misra, *Rec. Indian Mus.*, **57**, p. 141.

Material.—(i) 15 exs., River Tawi, near Nagrota and Jammu, 16-24.x.1964 (ii) 21 exs., a branch of river Tawi, Jammu, 24-30.x.1964 (iii) 24 exs., Nagrota nulla, Nagrota, Dist. Jammu, 27.x.1964 (iv) 29

exs., Pullin nulla, Nagrota, Dist. Jammu, 28.x.1964 (v) 9 exs., Sarande nulla, Dist. Jammu, 29.x.1964. (Size: 30-105 mm.).

Remarks.—It is quite a common species of the lower reaches of river Tawi, although it is not a food fish of the area. Along with other small species of *Barilius*, it is made use of by the fishermen as a bait on hooks for other bigger and commercially important fishes.

Day (1878) overlooked the mandibular barbels; there are 4 small barbels instead of 2. Thus the separation of this species from others, on the basis of the number of barbels, as done by Day (1878), is not tenable. The study of the present collection brings out many other differences from the description of Day (1878), such as, there are 22 rows of pre-dorsal scales instead of 18 and the number of colour bands is also less than 14-15 in many of these specimens.

Hora (1921) based the identification of this species on the inequality of the two lobes of the caudal fin. By the present material it has been found that this character is variable within the species and cannot be used as a taxonomic character. This species resembles *B. vagra* Ham. in many characters, but a clear distinction can be made between them in the following characters.

<i>Barilius barila</i> Ham.	<i>Barilius vagra</i> Ham.
(1) The colour bands are long and extend from the back to the lateral line. (pl. 3, figs. 7, 8).	(1) The colour bands are small and remain much above the lateral line. (pl. 3, figs. 5, 6).
(2) The maxillary barbels extend upto $\frac{1}{3}$ rd of the orbit.	(2) The Maxillary barbels extend upto the middle of the orbit.

Distribution.—Fresh waters of Jammu & Kashmir, Delhi, Uttar Pradesh, Madhya Pradesh, Bihar, West Bengal, Assam, Manipur, Orissa and Mysore; Pakistan.

(6) *Barilius shacra* (Ham.)

1822. *Cyprinus (Barilius) shacra* Hamilton, *Fishes of Ganges*, pp. 271, 385. (Type-locality: Kosi river).

1878. *Barilius shacra*: Day, *Fishes of India*, p. 590.

Material.—1 ex., Choe nulla, 15 kms. west of Pammu, 18.x.1964. (size: 70 mm.)

Remarks.—This is a rare species in that area and is represented in the present collection by only one specimen. It shows slight difference from the description given by Day (1878). The anal rays are $3/8$, scales along the lateral line are 59 with $6\frac{1}{2}$ rows of scales between the base of the pelvic fin and the lateral line and the middle of the dorsal fin rays bears a faint black band. There are no colour bands in this species.

Distribution.—Fresh waters of Jammu & Kashmir, Punjab, Uttar Pradesh, Bihar, West Bengal, Orissa, Assam; Pakistan.

(7) **Barilius modestus** Day

1872. *Barilius* (*Pachystomus*) *modestus* Day, *J. Asiat. Soc. Bengal*, **41**, p. 4.
(Type-locality: Ravi river at Lahore, West Pakistan).
1878. *Barilius modestus* Day, *Fishes of India*, p. 589.

Material.—1 ex., a small nulla, near village Gudhar, Dist. Udhampur. (Size : 105 mm.).

Remarks.—This is a rare fish in the area. The single specimen in the present collection agrees with the description given by Day (1878).

Distribution.—Fresh waters of Jammu & Kashmir, Punjab ; Afghanistan and Pakistan.

Genus **Danio** Hamilton, 1822(8) **Danio devario** (Ham.)

1822. *Cyprinus* (*Danio*) *devario* Hamilton, *Fishes of Ganges*, pp. 341, 393, pl. 6, fig. 94. (Type-locality: Rivers and ponds of Bengal).
1934. *Danio devario* : Hora & Mukerji, *Rec. Indian Mus.*, **36**, p. 133.

Material.—(i) 6 exs., Choe nulla, 15 kms. west of Jammu, 18.x.1964
(ii) 1 ex., a branch of river Tawi, near Jammu city, 19.x.1964. (Size: 62-75 mm.).

Remarks.—It occurs in stagnant pools with muddy basin and plenty of water weeds. They move in shoals. In life they have a beautiful bluish and bright yellow lines on the sides. It is an important larvivorous fish and also an ornamental aquarium fish.

Distribution.—Fresh waters of Jammu & Kashmir, Punjab, Himachal Pradesh, Uttar Pradesh, Bihar, West Bengal, Assam, Orissa, Madhya Pradesh, Gujarat ; Pakistan.

Genus **Esomus** Swainson, 1839(9) **Esomus danrica** (Ham.)

1822. *Cyprinus danrica* Hamilton, *Fishes of Ganges*, pp. 325, 390, pl. 16, fig. 88.
(Type-locality : Ponds and ditches of Bengal).
1878. *Nuria danrica* : Day, *Fishes of India*, p. 583.
1928. *Esomus danrica* Hora & Mukerji, *Rec. Indian Mus.*, **30**, p. 49.

Material.—(i) 16 exs., Choe nulla, 15 kms. west of Jammu city, 18.x.1964 (ii) 1 ex., branch of Tawi near Jammu city, 19.x.1964. (Size: 52-78 mm.).

Remarks.—It is a small sized fish and is found in slow moving waters with muddy bottom and plenty of weeds. It is one of the efficient larvivorous fishes and helps control the population of mosquitoes. But no effort appear to have been made in the state by the Health Department to make use of this as well as other fishes of this nature.

Distribution.—Fresh waters of Jammu & Kashmir, Punjab, Uttar Pradesh, Bihar, West Bengal, Assam, Orissa, Gujarat, Madras ; Pakistan, Bangla Desh, Burma, Ceylon, Malaya, Archipelago, Thailand.

Genus **Schizothorax** Heckel, 1838.(10) **Schizothorax plagiostomus** Heckel

(Pl. 1, figs. 5, 6)

1838. *Schizothorax plagiostomus* Heckel, *Fische aus Caschmir*, p. 16, pl. 1, figs. a-m. (Type-locality : Kashmir).

1877. *Oreinus plagiostomus* : Day, *Fishes of India*, p. 530.

1919. *Schizothorax plagiostomus* : Misra, *J. zool Soc. India*, 1, p. 40.

Material.—(i) 18 exs., Kud nulla, near Chineni, Dist. Udhampur, 24.ix.1964 (ii) 17 exs., Mandir Dasala nulla, near Chineni, Dist. Udhampur, 25.ix.1964 (iii) 20 exs., Bini-sangh nulla, Chineni, Dist. Udhampur, 28.ix.1964 (iv) 18 exs., Katal nulla, Chineni, Dist. Udhampur (v) 3 exs., Motor Shed nulla, Chineni, Dist. Udhampur, 30.x.1964 (vi) 15 exs., River Tawi, Chineni, Dist. Udhampur, 1.x.1964. (Size: 40-320 mm.).

Remarks.—It is characterised by the cylindrical body, minute scales and a suctorial disc on the lower jaw. It is well adapted to the fast currents of high altitudes and is not met with in Tawi at an altitude lower than 760 meters. In the specimens of the present collection there is plenty of difference in colouration and the size and shape of the ventral suctorial disc. In the present lot, there appear to be two races, one with numerous dark spots on the dorso-lateral sides and the suctorial disc wide, and the second with a few spots or none and the suctorial disc narrow. A study of the races of this species, on this line, is in progress and the results will be published elsewhere. The local people consider it a very tasty fish and call it 'Indian Salmon'

Distribution.—Fresh waters of Jammu & Kashmir, Assam, Eastern Himalaya ; Pakistan, Afghanistan, Bhutan, Sikkim.

Genus **Garra** Hamilton, 1822(11) **Garra gotyla gotyla** (Gray)

1832. *Cyprinus gotyla* Gray, *Ill. Indian Zool.*, London, pl. 88, figs. 3, 3a.

1964. *Garra gotyla gotyla* : Menon, *Mem. Indian Mus.*, 14(3) p. 233.

Material.—(i) 6 exs., Sakanwahi bauli, Udhampur, 7.ix.1964 (ii) 2 exs., Thalli nulla, Udhampur, 7.ix.1964 (iii) 2 exs., Devak nulla, Udhampur, 8.ix.1964 (iv) 3 exs., Ramnagar nulla, 25 kms. east of Udhampur, 14.ix.1964 (v) 2 exs., Jhajjar nulla, Dist. Udhampur, 6.x.1964 (vi) 50 exs., River Tawi, near Jammu, 16-24.x.1964. (Size: 35-179 mm.)

Remarks.—It is quite a common fish of the area. Small groups of this fish can be seen rasping off algal encrustations from the stones in the midst of the stream in river Tawi and its tributaries. The fish is able to withstand the force of the fast flowing water due to the presence of a sucker on the ventral side of the head. In young examples there is a black spot at the base of the caudal fin. All the specimens of the present collection differ from the description of this species given by Menon (1964) in having the orbit completely in the posterior half of the head.

Distribution.—Fresh waters of Jammu & Kashmir, Punjab, Uttar Pradesh, Assam ; Pakistan and Bangla Desh,

Genus *Tor* Gray, 1833(12) *Tor putitora* (Ham.)

1822. *Cyprinus putitora* Hamilton, *Fishes of Ganges*, pp. 303, 388 (Type-locality: Eastern parts of Bengal).
 1959. *Tor putitora*: Misra, *Rec. Indian Mus.*, **57**, p. 1950.

Material.—(i) 1 ex., Birwan nulla, Udhampur, 6.ix.1964 (ii) 33 exs., Nadiali nulla, Udhampur, 6.ix.1964 (iii) 2 exs., Kawa daber, by the side of river Tawi, Udhampur, 7.ix.1964 (iv) 7 exs., Siaran nulla, Udhampur, 8.ix.1964 (v) 5 exs., Dhanodi nulla, Udhampur, 10.ix.1964 (vi) 6 exs., Dudder nulla, Dist. Udhampur, 19-20.ix.1964 (vii) 27 exs., River Tawi, near Udhampur, 21.ix.1964 (viii) 36 exs., Jhajjar nulla, Dist. Udhampur, 5-13.x.1964 (ix) 1 ex., Junhi nulla, Udhampur, 8.x.1964 (x) 1 ex., union of Junhi and Jhajjar nullas, Dist. Udhampur, 9.x.1964 (xi) 36 exs., River Tawi, near Jammu, 16-24.x.1964 (xii) 1 ex., a branch of Pullin nulla, Jammu, 28.x.1964 (xiii) 8 exs., Sarande nulla, Jammu, 29.x.1964. (Size: 25-275 mm.).

Remarks.—It is one of the important commercial fishes of the area and is a common species found in the river Tawi, right from Jammu upto Chineni. It is well adapted to various altitudes and temperatures.

Distribution.—Fresh waters of Jammu & Kashmir, Punjab, Himachal Pradesh, Uttar Pradesh, West Bengal, Assam; Nepal and Pakistan.

(13) *Tor mosal* (Hamilton)

1822. *Cyprinus (Cyprinus) mosal* Hamilton, *Fishes of Ganges*, pp. 306, 388 (Type-locality: Kosi River).
 1934. *Barbus hexastichus*: Hora & Mukerji, *Rec. Indian Mus.*, **36**, p. 127.
 1940. *Barbus (Tor) mosal*: Hora, *J. Bombay nat. Hist. Soc.*, **41**, pp. 784-794.

Material.—(i) 4 exs. Jhajjar nulla, Dist. Udhampur, 6.x.1964. (Size: 27-35 mm.).

Remarks.—It is not a very common species and in the present collection it is represented by only a few young specimens.

Distribution.—Jammu and Kashmir, along Himalaya in Uttar Pradesh, Assam and Sikkim.

Genus *Puntius* Hamilton, 1822(14) *Puntius ticto* (Ham.)

1822. *Cyprinus (Puntius) ticto* Hamilton, *Fishes of Ganges*, pp. 314, 389, pl. 8, fig. 87 (Type-locality: South eastern parts of Bengal).
 1939. *Puntius ticto*: Hora, Misra & Malik, *Rec. Indian Mus.*, **41**, p. 270.

Material.—(i) 1 ex., Birwan nulla, Udhampur, 6.ix.1964 (ii) 2 exs., a small bauli near Nadiali nulla, Udhampur, 6.ix.1964 (iii) 1 ex., a small streamlet, nearly 2 kms. east of Udhampur, 7.ix.1964 (iv) 17 exs., a bauli at Mian ka Bagh, Udhampur, 7.ix.1964 (v) 22 exs., Thalli nulla, Udhampur, 7.ix.1964 (vi) 8 exs., Siaran nulla, Udhampur, 8.ix.1964 (vii) 21 exs., Devak nulla, Udhampur, 8.ix.1964 (viii) 62 exs., Dhanodi nulla, Udhampur, 8-10.ix.1964 (ix) 5 exs., Siaran nulla, Udhampur, 9-10.ix.1964 (x) 39 exs., Puthi Khad nulla, Udhampur,

12.x.1964 (xi) 45 exs., a small streamlet near village Tikri, Dist. Udhampur, 12.x.1964 (xii) 28 exs., Choe nulla, near Jammu, 18.x.1964 (xiii) 35 exs., River Tawi, Jammu, 19-24.x.1964. (Size: 18-80 mm.).

Remarks.—It is quite a variable species. The usual caudal and shoulder spots are present with incomplete lateral line and no barbels. In one specimen tip of the posterior dorsal rays is black as in the case of *P. conchoni* Ham. but the height of the body in this specimen is 3.2 times in the total length and thus it is kept under *P. ticto* Ham. This fish is not of much commercial value except that it can be kept in the aquaria. It moves slowly in showls of hundreds in dabers, formed in the course of slow moving nullas. This species is absent in the main Tawi river.

Distribution.—Fresh waters throughout India ; Pakistan, Burma, Ceylon and Thailand.

(15) *Puntius sarana sarana* (Ham.)

1822. *Cyprinus* (*Puntius*) *sarana* Hamilton, *Fishes of Ganges*, pp. 307, 389. (Type-locality: ponds and rivers of India).

1963. *Puntius sarana sarana* : Menon, *Spolia Zey.*, 30 (1), p. 68.

Material.—(i) 1 ex., Choe nulla, nearly 15 kms. west of Jammu city, 18.x.1964 (ii) 7 exs., a branch of river Tawi, Jammu city, 19.x.1964. (Size: 81-112 mm.).

Remarks.—It is a common species found in this area. The lateral bands are faintly represented in some specimens and usually a dark spot is present at the base of the caudal. This fish has four barbels and the last undivided ray of the dorsal fin is serrated.

Distribution.—Fresh waters throughout India ; Pakistan, Burma, Ceylon, Thailand and China.

(16) *Puntius sophore* Ham.

1822. *Puntius sophore* Hamilton, *Fishes of Ganges*, pp. 310, 389. (Type-locality: Ponds of Bengal).

1877. *Barbus stigma* Day, *Fishes of India*, p. 579.

Material.—(i) 2 exs., Garhi nulla, Udhampur, 12.ix.1964 (ii) 10 exs., Choe nulla, nearly 15 kms. west of Jammu city, 18.x.1964 (iii) 6 exs., River Tawi, Jammu city, 20.x.1964. (Size: 44-85 mm.).

Remarks.—The species bears a characteristic black spot across the base of the middle of the dorsal fin rays. In some specimens a faintly marked dark spot is present at the base of the caudal. It is found in very slow moving waters or in big dabers, with plenty of vegetation. It is a good aquarium fish and has larvivorous habits.

Distribution.—Fresh waters throughout India at low altitudes and plains ; Pakistan, Burma and China.

Genus *Labeo* Cuvier, 1817

(17) *Labeo dero* (Ham.)

(Pl. 1, figs. 3, 4. Pl. 2, figs. 1, 2)

1822. *Cyprinus dero* Hamilton, *Fishes of Ganges*, pp. 277, 385, pl. 17, fig. 78. (Type-locality: Brahmaputra river).

1877. *Labeo diplostomus* : Day, *Fishes of India*, p. 540.
 1936. *Labeo dero* : Hora, *Rec., Indian Mus.*, **38**, p. 320.
 1936. *Labeo dero* : Hora & Misra, *Ibid.*, **38**, p. 340.
 1965. *Schismatorynchus* sp. Tandon, *Curr. Sci.*, **34**, p. 640.

Material.—(i) 4 exs., Nadal nulla, Udhampur, 10.ix.1964 (ii) 1 ex., Duddar nulla, Udhampur, 12.ix.1964 (iii) 42 exs., Jhajjar nulla, Dist. Udhampur, 6-13.x.1964 (iv) 1 ex., Junhi nulla, Dist. Udhampur, 8.x.1964 (v) 2 exs., Choe nulla, nearly 15 kms. west of Jammu, 18.x.1964 (vi) 117 exs., River Tawi, at many places near Jammu, 19-30.x.1964 (vii) 2 exs., Sarande nulla, Dist. Jammu, 24-29.x.1964. (Size: 46-232 mm.).

Remarks.—It is an important food fish of the area. There is well pronounced sexual dimorphism in this species as studied by Hora and Misra (1936). In the present collection the males are proportionately better represented than the females. In many specimens it has been observed that the maxillary barbels on one or both the sides are bifid. In some specimens an additional barbel like structure is also observed near the maxillary barbel. These could be fortuitous variations of little taxonomic importance. A sort of proboscis is formed on the snout in males. There are large number of pores on the snout and they are plugged by spiny tubercles.

Distribution.—Fresh waters of Jammu & Kashmir, Punjab, Himachal Pradesh, Uttar Pradesh, West Bengal, Assam ; Pakistan and China.

(18) *Labeo dyocheilus* (McClelland)

(Pl. 2 figs. 3, 4)

1839. *Cyprinus dyocheilus* McClelland, *Asiatic Researches*, **19**, 268, 330, pl. 37, fig. 1. (Type-locality: Assam).
 1936. *Labeo dyocheilus* : Hora, *Rec. Indian Mus.*, **38**, p. 340.

Material.—(i) 1 ex., Junhi nulla, Dist. Udhampur, 8.x.1964 (ii) 117 exs., River Tawi at various places, Dist. Jammu, 16-30.x.1964 (iii) 2 exs., Choe nulla, nearly 15 kms. west of Jammu city, 18.x.1964 (iv) 3 exs., Sarande nulla, Dist. Jammu, 29.x.1964. (Size: 46-177 mm.).

Remarks.—It is an important food fish of the area and is relished by the local people. The material in the present collection agrees with the description given by Day (1877) except that in these specimens the pectorals do not reach the ventral fins and the latter do not reach the anal. A study of the racial analysis of this species is in progress and the results will be published elsewhere. The material from river Tawi appears to belong to a variety.

Distribution.—Fresh waters of Jammu & Kashmir, Punjab, Uttar Pradesh, Assam ; Pakistan, Sikkim.

(19) *Labeo bata* (Ham.)

1822. *Cyprinus bata* Hamilton, *Fishes of Ganges*, pp. 283, 386. (Type-locality: Rivers and ponds of Bengal).
 1959. *Labeo bata* : Misra, *Rec. Indian Mus.*, **57**, p. 159.

Material.—(i) 1 ex., Choe nulla, nearly 15 kms. west of Jammu city, 18.x.1964. (Size: 115 mm.).

Remarks.—This species is found in slow moving waters of nullas by the side of the river Tawi in the plains. It is characterised by the presence of a tubercle inside the lower jaw above the symphysis, a few black marks near about the 4th or 5th scale on the lateral line and about 37-40 scales along the lateral line.

Distribution.—Fresh waters of Jammu & Kashmir, Punjab, Uttar Pradesh, Bihar, Madhya Pradesh, Orissa, West Bengal, Assam, Andhra Pradesh ; Pakistan.

Genus *Aspidoparia* Heckel, 1843

(20) *Aspidoparia morar* (Ham.)

1822. *Cyprinus morar* Hamilton, *Fishes of Ganges*, pp. 264, 381. (Type-locality: Jamuna and Tista rivers).

1959. *Aspidoparia morar*: Misra, *Rec. Indian Mus.*, **57**, p. 147.

Material.—(i) 71 exs., River Tawi at various places near Jammu city, 16-23.x.1964. (Size: 53-110 mm.).

Remarks.—This species is found in the lower reaches of the river Tawi and is found among the species of the genera *Barilius* and *Oxygaster*. It is characterised by the absence of the lower lip.

Distribution.—Fresh waters of Jammu & Kashmir, and plains of all Indian states except the peninsular states ; Pakistan, Burma and Thailand.

Genus *Cirrhinus* (Oken) Cuvier, 1817

(21) *Cirrhinus mrigala* (Ham.)

1822. *Cyprinus mrigala* Hamilton, *Fishes of Ganges*, pp. 279, 386. (Type-locality: Ponds and Freshwater rivers of Gangetic Provinces).

1959. *Cirrhinus mrigala*: Misra, *Rec. Indian Mus.*, **57**, p. 157.

Material.—(i) 1 ex., River Tawi, Jammu, 20.x.1964. (size: 123 mm.).

Remarks.—It is not a very common species of this area. It is found usually in slow moving waters or in dabers by the side of the nullas and feeds on debris and algal incrustation on mud. Ordinarily it is a slow moving fish but at the time of danger it becomes very agile. It is an important food fish.

Distribution.—Fresh waters throughout India ; Pakistan and Burma.

Genus *Crossocheilus* van Hasselt, 1823

(22) *Crossocheilus diplochilus* (Heckel)

(Pl. 2, 3, fig. 1, 2, 5, 6)

1838. *Barbus diplochilus* Heckel, *Fische aus Caschmir*, p. 53, pl. 10, fig. 1. (Type-locality: Kashmir).

1934. *Crossocheilus punjabensis*: Mukerji, *J. Bombay nat. Hist. Soc.*, **37**, p. 53.

1938. *Crossocheilus punjabensis*: Hora & Misra, *Ibid.*, **40**, p. 31, pl. 11, fig. 4.

Material.—(i) 4 exs., Nadiali nulla, Udhampur, 6.ix.1964 (ii) 27 exs., Devak nulla, Udhampur, 8.ix.1964 (iii) 6 exs., Siaran nulla, Udhampur, 8-9.ix.1964 (iv) ex., Ramnagar nulla, Dist. Udhampur, 14.ix.1964 (v) 2 exs., Dudder nulla, Udhampur, 19.ix.1964 (iv) 1 ex., Union of Junhi and

Jhajjar nullas, Dist. Udhampur, 9.x.1964 (vii) 1 ex., Dhanodi nulla, Udhampur, 10.ix.1964 (viii) 1 ex., River Tawi, Jammu city, 20.x.1964. (ix) 2 exs., Sakanwahi bauli, Udhampur, 7.ix.1964. (Size: 39-127 mm.).

Remarks.—The study of a large number of specimens from the present lot indicates that there is lot of variation in characters of this species. The length of snout is contained 2.1-3.0 times in the length of the head. The length of the head lies 4.6-5.1 times in the standard length of the head. The length of the dorsal fin may be equal, more or may be less than the depth of the body below it. The colour of the body is much lighter than that of *C. latius* (Ham.).

There are two interesting specimens from Sakanwahi bauli (Pl. 2, figs. 5, 6) which are much darker in colour and comparatively longer than other specimens of *C. diplochilus*. The length of the snout lies 2.1-2.2 times in the length of the head. The length of the head lies 5 times in the standard length. The diameter of the eye is contained 3.6-3.8 times in the length of the head. The length of the dorsal fin is more than the depth of the body below it.

These two specimens could be referable to *C. latius* (Ham.) *forma typica*, which was restricted to Brahmaputra and Gangetic river systems by Mukerji (1934). Hora and Mukerji (1935) and Hora and Misra (1938) have shown the presence of *C. latius forma typica* in Naga hills (Assam) and in Deolali (Bombay Presidency) respectively. Hora and Mukerji (1935) separated the Assamese and Burmese forms as a separate species; *C. burmanicus* Hora because of the fact that both *forma typica* and the Assamese and Burmese form of *C. latius* were found co-existing in the Naga Hills. For the time being these two specimens from Jammu are kept under *C. diplochilus* which is a regional species. If more specimens resembling these and conforming to *C. latius forma typica* are procured in future from Jammu, it would be interpreted only in one way that *C. latius* is a widely distributed species that co-exists in the eastern Himalaya with *C. burmanicus* and in the western Himalaya with *C. diplochilus* (Heckel).

Distribution.—Fresh waters of Jammu & Kashmir, Punjab, Himachal Pradesh and Uttar Pradesh.

Genus *Botia* Gray, 1831

(23) *Botia birdi* Chaudhuri

1877. *Botia geto* Day (nec Hamilton), *Fishes of India*, p. 606, pl. 154, fig. 2.

1909. *Botia birdi*: Chaudhuri, *Rec. Indian Mus.*, **3**, p. 339. (Type-locality: Sirhind canal at Rupar, Dist. Ambala, Panjab).

1922. *Botia birdi*: Hora, *Rec. Indian Mus.*, **24**, p. 319.

Material.—(i) 1 ex., Jhajjar nulla, Dist. Udhampur, 5.x.1964. (Size: 225 mm.).

Remarks.—Only one dead specimen was 'procured in the shallow stream by the side of Jhajjar nulla. The rare species is difficult to procure because of its typical habit to live under huge stones or in crevices between big stones. It is a bottom feeder and is very agile.

Distribution.—Jammu & Kashmir, Punjab; Pakistan.

Genus *Lepidocephalus* Bleeker, 1863(24) *Lepidocephalus guntea* (Ham.)

1822. *Cobitis guntea* Hamilton, *Fishes of Ganges*, pp. 353, 394. (Type-locality: Ponds and fresh water rivers of Bengal).
 1822. *Cobitis balgara* : Hamilton, *Ibid.*, pp. 356, 394. (Type-locality: Kosi river).
 1878. *Lepidocephalichthys guntea* : Day, *Fishes of India*, p. 609.
 1878. *Lepidocephalichthys guntea* : var. *balgara* Day, *Ibid.*, p. 609, pl. 156, fig. 12.

Material.—(i) 31 exs., a small bauli by the side of Nadiali nulla, Udhampur, 6.ix.1964 (ii) 23 exs., a stream by the side of Birwan nulla, Udhampur, 6.ix.1964 (iii) 1 ex., a ditch near Siaran nulla, Udhampur, 9.ix.1964 (iv) 24 exs., Dhanodi nulla, Udhampur, 10.ix.1964 (v) 5 exs., Choe nulla, 15 kms. west of Jammu, 18.x.1964. (Size: 18-74 mm.).

Remarks.—The study of these specimens indicates that the characters of the origin of the dorsal fin in relation to that of the ventral fin and the relation of the depth of the body to total length are variable within the species. *L. balgara* is an intraspecific variant of *L. guntea*. It is a bottom feeder and feeds on small larvae and insects along with algae on mud.

Distribution.—Jammu & Kashmir, Punjab, throughout India except Mysore and south of Kistna river and Malabar coast ; Pakistan, Ceylon.

Genus *Noemacheilus* van Hasselt, 1823(25) *Noemacheilus botia* (Ham.)

1822. *Cobitis botia* Hamilton, *Fishes of Ganges*, pp. 350, 394. (Type-locality: Rivers of North-eastern Bengal).
 1878. *Nemacheilus botia* : Day, *Fishes of India*, p. 614.
 1878. *Nemacheilus botia* var. *aureus* Day, *Ibid.*, p. 614.

Material.—(i) 1 ex., Birwan nulla, Udhampur, 6.ix.1964. (ii) 6 exs., a small bauli by the side of Nadiali nulla, 6.ix.1964 (iii) 127 exs., Dhanodi nulla, Udhampur, 10.ix.1964. (iv) 8 exs., Jhajjar nulla, Dist. Udhampur, 6-13.x.1964. (v) 61 exs., River Tawi, Jammu city, 19-23.x.1964. (Size: 13-78 mm.).

Remarks.—It is quite a common species in muddy ditches by the side of a nulla. The height of the body of the specimens of the present lot is less than that described by Day (1878). The depth of the body lies 6-6.6 times in the total length (against $4\frac{3}{4}$ in total length mentioned by Day). There are 5 '>' shaped bars on the caudal fin while Day (1878) mentioned 7 such bars. Day (1878) stated that in some specimens the preorbital has a projection which is movable below the orbit (*N. botia*) but in others (*N. bilturio*) it is concealed under the skin. It has been observed in the present collection that the specimens with a preorbital movable process are males while those without it are females.

Day (1878) recognised a subspecies, *N. botia aureus* Day, collected from Poona, with 9-10 branched rays in the dorsal fin and the lateral line incomplete. In the present collection there are many specimens with 10 or 11 branched rays and with incomplete lateral line. The lateral line is a variable character and hence 'aureus' should be an

intraspecific variant of *botia*. A comparison of the present material with those from Ceylon Museum also yields the same result.

Distribution.—Fresh waters of Jammu & Kashmir, Punjab, Uttar Pradesh, Himachal Pradesh, West Bengal, Assam, Bihar; Pakistan, Ceylon.

(26) **Noemacheilus corica** (Ham.)

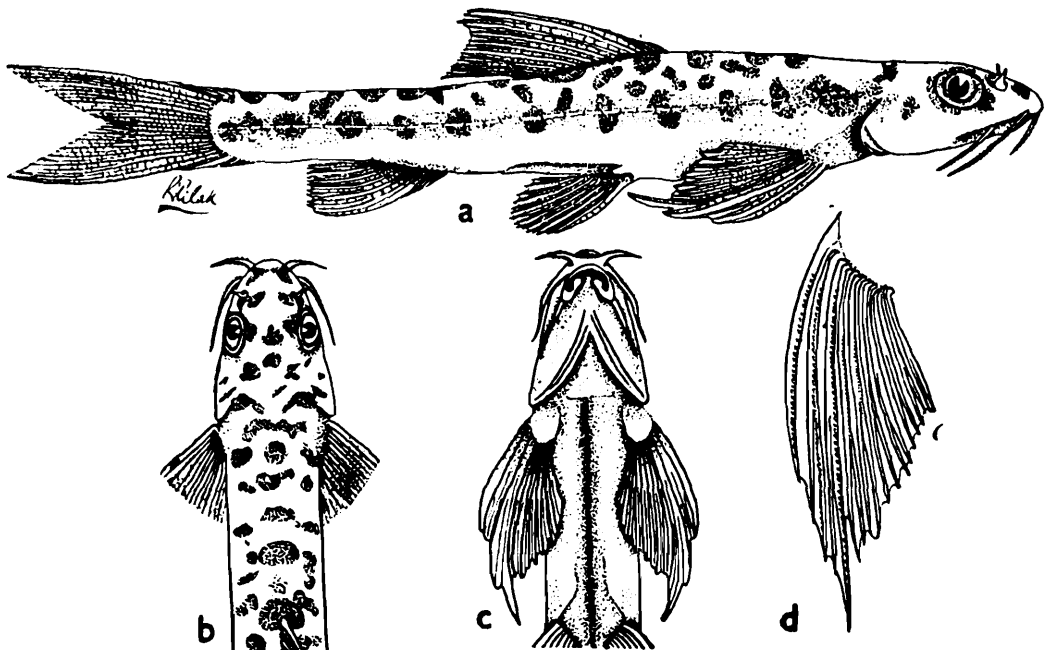
(Text-fig. 2, a-d)

1822. *Cobitis corica* Hamilton, *Fishes of Ganges*, pp. 359, 395. (Type-locality: Kosi river).

1878. *Nemacheilus corica*: Day, *Fishes of India*, pp. 613, 616, pl. 156, fig. 1.

Material.—(i) 20 exs., Tawi river, Jammu city, 21-22.x.1964 (ii) 1 ex., Nagrota nulla Jammu city, 27.x.1964 (iii) 14 exs., Sarande nulla, Jammu city, 29.x.1964. (Size: 22-41 mm.).

Remarks.—It has been observed that the description of this species given by Day (1878) is meagre and also shows difference when compared with the present material, hence the material from Jammu has been described here in detail.



TEXT-FIG. 2. *Noemacheilus corica* (Ham.) (a) Lateral view of the fish. (b) Dorsal view of the anterior part of body. (c) Ventral view of the anterior part of body. (d) A pectoral fin enlarged.

D 4/8-9, P 1/9-10, V 1/7, A 3/5, C 17.

The body is moderately elongated with the dorsal profile gradually rising from the tip of the snout to the origin of the dorsal fin. The ventral surface is also slightly arched. The head length is contained 5.3-6.0 times in the standard length.

The tip of the snout is rounded. The lips are fleshy. The lower lip is interrupted in the middle. There are three pairs of barbels. The rostral pair reaches the front edge of the orbit and the mandibular pair is slightly longer. There are minute nodular outgrowths on the barbels, making their texture rough.

The membranous flaps between the nostrils is directed ventrally up and ends in a fine tendril simulating a barbel.

The eyes are visible from the ventral side. The major portion of the eyes lies in the anterior half of the head. The eye is contained 3-3.5 times in the length of the head. The length of the longest ray of the dorsal fin is more than the depth of the body below it but less than the length of the pectoral fin. Its origin lies nearer to the tip of the snout than the base of the caudal fin. The pectoral fin is longer than the head. Its third outer ray is longer than all the rays and reaches the middle of the base of the pelvic fin. Each pectoral ray bears on its outer side a row of fine projections which make the surface of the fin rather rough. On the outer side of the base of each pelvic fin there is a small axillary process. The pelvic fin extends slightly posterior to the anal opening, but does not reach the anal fin. The length of the anal fin is more than the depth of the body. The caudal fin is elongated and deeply forked. The two lobes of the caudal fin are nearly of the same length. The length of the caudal fin is contained 4.4-4.8 times in the total length and 3.4-3.8 times in the standard length.

The height of the body is contained 8.5-9.0 times in the total length and 6.6-7.0 times in the standard length.

The length of the caudal peduncle is contained 7.2-8.0 times in the total length and 5.5-6.2 times in the standard length. The least height of the caudal peduncle is contained 1.6-2.0 times in its length.

The lateral line is complete and reaches the centre of the base of the caudal fin. The scales are minute and are absent on the head and the ventral side of the body.

In some specimens a small fleshy process, directed posteriorly, is present on the anterior border of the eye. According to Hora (1922), this could be a character of male specimens in loaches. Hence there is sexual dimorphism in this species.

Colouration:—The ground colour of the body is yellowish brown. There is a row of deep brown blotches along the lateral line. The blotches remain distinct, anterior to the dorsal fin while in the posterior region of the body they may, in some cases, amalgamate with one another, forming a sort of band extending upto the base of the caudal fin. There is a row of smaller dots of similar colour on the dorsal anterior aspect. This row extends from the posterior end of the head to a place just above the origin of the anal fin. In some specimens these dots are very light and the posterior ones fade out. Along the mid-dorsal line of the body there is a row of bigger blotches. The blotches are single in the region posterior to the dorsal fin while those lying anterior to the dorsal fin, may be single or broken up into smaller ones.

There is a very lightly stippled band across the dorsal fin rays. The other fins do not bear any markings.

Locality: The lower reaches of river Tawi and small nullas flowing into it, Jammu and Kashmir state.

Habits:—This fish has always been found in small streams by the side of the river Tawi, with sandy bed and clear water not deeper than 0.5 meters. On approach, the fish darts into the sand and hides

itself completely. After a few seconds, it moves a little, the sand over the region of the head washes off and only a pair of eyes are exposed which clearly watch the movements of those who chase it. On further approach it dashes out of the sand and swims swiftly. The best way to catch this fish is to sweep it along with the sand where it gets burried, with the help of a small water net.

Distribution.—Jammu & Kashmir, Punjab, West Bengal, Assam.

(27) *Noemacheilus prashari* Hora

(Pl. 3, figs. 9, 10)

1933. *Nemachilus prashari* Hora, *Rec. Indian Mus.*, **35**, p. 189, pl. 5, figs. 1, 2. (Type-locality: North of Kohat city, N. W. Frontier, Pakistan).

Material.—(i) 13 exs., Bali nulla, Udhampur, 11.ix.1964 (ii) 15 exs., a choe, 18 kms. east of Udhampur, 13.ix.1964 (iii) 24 exs., Kud nulla, Udhampur, 24.ix.1964 (iv) 25 exs., Mandir Dasala nulla, Udhampur, 25.ix.1964 (v) 5 exs., Motor Shed nulla, Udhampur, 27.ix.1964 (vi) 28 exs., Mandir Dasala nulla, Dist. Udhampur, 29.ix.1964 (vii) exs., a branch of Binisangh nulla, Dist. Udhampur, 28.ix.1964 (viii) 94 exs., River Tawi, Dist. Udhampur, 1.x.1964 (ix) 10 exs., Samroli nulla, Dist. Udhampur, 2.x.1964 (x) 2 exs., Arsa nulla, Dist. Udhampur, 2.x.1964 (xi) 33 exs., River Tawi, Dist. Udhampur, 2.x.1964 (xii) 12 exs., Junhi nulla, Dist. Udhampur, 8-9.x.1964 (xiii) 36 exs., Jhajjar nulla, Udhampur, 10-13.x.1964 (xiv) 20 exs., River Tawi, Jammu city, 20-23.x.1964 (xv) 2 exs., Nagrota nulla, Jammu, 27.x.1964. (Size: 16-82 mm.).

Remarks.—The specimens collected from the river Tawi and its tributaries have been kept under *N. prashari* Hora, although they exhibit many differences from this as shown below. Unfortunately, the type material of *N. prashari* is not traceable in the collection of Zoological Survey of India for sake of comparison and hence only the description and figure given by Hora (1933 a) have been compared here. A comparison has also been made with another closely allied species from Punjab, *N. punjabensis* Hora. The points of comparison are presented in table 1.

Genus *Wallago* Bleeker, 1851

(28) *Wallago attu* (Bl. & Schn.)

1801. *Silurus attu* Schneider, *Syst. Ichth. Blochii*, p. 378, pl. 75. (Type-locality: Malabar).

1877. *Wallago attu*: Day, *Fishes of India*, p. 479.

Material.—No specimen was collected.

Remarks.—This fish has not been actually caught in the river Tawi but according to information of the local fishermen, the fish comes from river Chenab and travels up to a height of about 1075 meters in the river Tawi for a month or so during the monsoon, and then goes back to its original habitat.

Distribution.—Freshwaters of Jammu & Kashmir, Punjab, Himachal Pradesh, Uttar Pradesh, Bihar, West Bengal, Manipur, Assam, Orissa,

Bombay, Gujarat, Madras, Malabar ; Pakistan, Burma, Ceylon, Malaya Archipelago, Thailand, Laos, Cambodia, Viet-Nam, W. Yunan.

Genus **Mystus** (Gronow) Scopoli, 1777.

(29) **Mystus (Aorichthys) seenghala** (Sykes)

1839. *Platystomus seenghala* Sykes, *Trans. Zool. Soc. London*, **2**, p. 371, pl. 65, fig. 2. (Type-locality: Mota mula river, Poona).
1953. *Mystus (Osteobagrus) seenghala* : Jayaram, *Rec. Indian Mus.*, **51**, p. 550.

Material.—(i) 1 ex., Choe nulla, 15 kms. west of Jammu, 18.x.1964. (Size: 324 mm.).

Remarks.—This is a commercially important fish of this area and is liked much by the people. It is quite common in the lower reaches of river Tawi.

Distribution.—Jammu & Kashmir, Punjab, Delhi, Uttar Pradesh, Bihar, West Bengal, and in the South India it extends upto Kistna river ; Pakistan, Burma, Yunnan.

Genus **Amblyceps** Blyth, 1858

(30) **Amblyceps mangois** (Ham.)

1822. *Pimelodus mangois* Hamilton, *Fishes of Ganges*, pp. 199, 379. (Type-locality: Nathpur, Northern Bihar).
1933. *Amblyceps mangois* : Hora, *Rec. Indian Mus.*, **35**, p. 617.

Material.—(i) 1 ex., Jhajjar nulla, Dist. Udhampur, 11.x.1964. (ii) 19 exs., Tawi river, Jammu, 17-30.x.1964. (Size: 26-49 mm.).

Remarks.—This fish remains hidden under the pebbles and small stones in shallow waters at the base of hills and rarely found above an altitude of about 914 meters. The colouration of the specimens is uniformly reddish. In the present collection the caudal fin is deeply bifid in all the specimens, the dorsal lobe being slightly longer than the ventral. None of the specimens showed any sign of truncated caudal fin as shown by Hora (1933 b). Regarding its distribution Hora (1933 b) remarked that the species has not been definitely recorded from any place west of Kangra valley. However, its presence in Tawi river extends its range of distribution to area west of Kangra valley.

Distribution.—In rapid running streams at base of Himalayas Northern Burma, Thailand.

Genus **Glyptothorax** Blyth, 1860

(31) **Glyptothorax pectinopterus** (McClelland)

(Pl. 1, Figs. 1,2)

1842. *Glyptosternon pectinopterus* McClelland, *Calcutta J. Nat. Hist.*, **2**, p. 587. (Type-locality: Simla hills, Punjab).
1954. *Glyptothorax pectinopterus* : Menon, *Rec. Indian Mus.*, **52**, p. 47.

Material.—(i) 9 exs., Devak nulla, Udhampur, 8.ix.1964 ; (ii) 1 ex., Dhanodi nulla, Udhampur, 9.ix.1964 ; (iii) 7 exs., Kud nulla, Dist.

TABLE 1.

Comparison of the characters of *Noemacheilus prashari* from Tawi River with those of *N. prashari* and *N. punjabensis* from Pakistan.

S. No.	Characters	<i>N. prashari</i> Hora from river Tawi and its tributaries (Jammu & Kashmir state)	<i>N. prashari</i> Hora from Kohat; N.W.F. Provinces, Pakistan	<i>N. punjabensis</i> Hora from Salt range, Pakistan
1.	Fin ray count	D 3-4/7, P 1/9-10, V 1/7, A 3/5, C 18	D 2/7, P 9, V 7, A 2/5, C 18	D 2/7, P 1/9, V 1/7, A 2/5
2.	Total length/head length	5.1 — 5.8 (mean 5.3)	5.3 — 5.7	5.2 (in young) to 6.1 in adult.
3.	Standard length/head Length	4.0 — 4.8 (mean 4.3)	4.4 — 4.8	4.1 — 5.1
4.	<u>Width of head at eye</u>			
	Height of head at occiput	Almost equal	Almost equal	Height of head at occiput more.
5.	Greatest width of head			
	Length of head behind the nostril	Almost equal	Almost equal	Almost equal
6.	<u>Length of snout</u>			
	Postorbital length of head	Almost equal	Almost equal	Almost equal
7.	Total length/depth of body	6.6 — 10.6 (mean 8.6)	6.8 — 8.1	9.0
8.	Standard length/depth of body	5.4 — 8.8 (mean 7.1)	5.4 — 6.8	5.5 — 7.4
9.	Head length/pectoral fin length	Pectoral shorter than head and away from the ventrals by a distance equal to more than half the length of pectoral.	Pectoral shorter than head and separated from ventrals by a considerable distance.	Pectoral longer than head and separated from ventrals by a distance equal to half of its own length.
10.	<u>Length of pectoral</u> <u>Length of ventral</u>	almost equal in many but ventral is usually smaller than pectoral.	Almost equal	Ventral smaller than pectoral.

11.	<u>Length of caudal peduncle</u> Least height of caudal peduncle	1.0 — 1.6 (mean 1.2)	1.4 — 1.6	1.1 — 1.8
12.	Number of bars on the lateral side	9-15 (mean). There may be one, two or more interrupted bars at the end (near caudal base)	15 — 17	11 — 13
13.	Lateral line	Complete in one example, it usually stops near the end of ventral fin or slightly behind.	Disappears above the base of ventral fin.	Complete.
14.	Commencement of dorsal fin	Either nearer to caudal base or midway between the anterior end of snout and caudal base. Arises always in advance of ventrals.	Nearer to base of caudal than tip of snout. Arises opposite to that of ventral.	Equidistant or somewhat nearer the base of caudal than tip of snout.
15.	Bars on caudal	2-4 ' > ' shaped wavy bars,	2 Wavy bars in distal half of caudal.	Bars faint with greyish band across middle of their length.
16.	Bars on dorsal	1-2 cross bars	One oblique band in middle of dorsal.	Band faintly marked.
17.	Spot on base of caudal	An elongated 2 piece black bar at base of caudal	Usually an interrupted band at base of caudal.	Dark band at base of caudal.
18.	Situation of eye	Middle of head	Middle of head.	In anterior half of head.
19.	Spot on dorsal	One black spot on first 2-3 rays of dorsal	One spot of dark colour on anterior 3 rays.	Spot on first two rays.
20.	<u>Length of head</u> Length of caudal fin	Caudal may be smaller, equal or longer than head.	Caudal smaller or equal.	Caudal longer than head.

Udhampur, 24.ix.1964 ; (iv) 2 exs., Motor Shed nulla, 27.ix.1964 ; (v) 10 exs., Junhi nulla, 8.x.1964 ; (vi) 5 exs., union of Junhi and Jhajjar nullas, Dist. Udhampur, 9.x.1964 ; (vii) 5 exs., Jhajjar nulla, Dist. Udhampur, 10.x.1964 ; (viii) 16 exs., Puthi Khad nulla, Dist. Udhampur, 12.x.1964 ; (ix) 172 exs., River Tawi at various places, Jammu, 16-24.x.1964. (Size: 29-77 mm.).

Remarks.—This species is quite common in nullas where there are small stones and the blepharocерid larvae are in abundance. Probably the fish feeds on blepharocерid larvae. The specimens in the present collection agree with the description given by Day (1877) and Menon (1954) except that the pectoral fins are not longer than the head. In life the stripes on the mid-dorsal side and the tip of the caudal fin are golden yellow. In spirit the colour fades away and becomes whitish yellow.

Distribution.—Jammu & Kashmir, Punjab, Himachal Pradesh, Uttar Pradesh ; Pakistan.

Genus *Channa* (Gronow) Scopoli, 1777

(32) *Channa orientalis* Schn.

1801. *Channa orientalis* Schneider, *Syst. Ichth. Blochii*, p. 496, pl. 90, fig. 2. (Type-locality: Indian orientali).
 1822. *Ophiocephalus gachua* : Hamilton, *Fishes of Ganges*, pp. 68, 367, pl. 21, fig. 21. (Type-locality: Ponds and ditches of Bengal).
 1876. *Ophiocephalus gachua* : Day, *Fishes of India*, p. 367.
 1918. *Ophiocephalus harcourt-butlari* Annandale, *Rec. Indian Mus.*, 14, p. 54 text-fig. 2 ; pl. 2, fig. 7 ; pl. 4, fig. 16.17. (Type-locality: Fort stedman, a town on the shore of Inle lake Burma).
 1960. *Channa orientalis* : De Witt, *Stanford Ichth. Bull.*, 7, 81.

Material.—(i) 4 exs., Nadiali nulla, Udhampur, 6.ix.1964 ; (ii) 1 ex., a small bauli near village Tinaur, Udhampur, 6.ix.1964 ; (iii) 18 exs., Birwan nulla, Udhampur, 6.ix.1964 ; (iv) 3 exs., Thalli nulla, Udhampur, 7.ix.1964 ; (v) 1 ex., Devak nulla, Udhampur, 8.ix.1964 ; (vi) 4 exs., Dhanodi nulla, Udhampur, 10.ix.1964 ; (vii) 1 ex., Siaran nulla, Udhampur, 10.ix.1964 ; (viii) 9 exs., Garhi nulla, Udhampur, 12.ix.1964 ; (ix) 11 exs., Jhajjar nulla and its surroundings, Dist. Udhampur, 6-11.x.1964 ; (x) 12 exs., Choe nulla, Dist. Jammu, 18.x.1964 ; (xi) 1 ex., Sarande nulla, Jammu, 29.x.1964. (Size: 25-128 mm.).

Remarks.—This is a widely distributed species and is usually found in small ditches by the side of the nullas or in slow moving waters. Mostly it inhabits marshy places and is not found in fast running brooks. Day (1877) mentioned that a dark blotch is sometimes present on the last five rays of the dorsal fin in young examples of this species. In the present collection there are two young specimens of this species from a marshy tract of land by the side of Jhajjar nulla, Dist. Udhampur, and they bear two rounded black blotches on the dorsal fin, one on the last 5 rays and the other on the 6th and the 7th rays from behind.

Distribution.—Freshwaters throughout India, Andaman ; Pakistan, Burma, Ceylon, Afghanistan, Malaya Archipelago, Thailand, Laos, Cambodia, Viet-Nam, Yunnan, Hainan.

(33) *Channa punctatus* (Bloch)

1797. *Ophicephalus punctatus* Bloch, *Naturl. Ausland. Fische*, 7, p. 139, pl. 358. (Type-locality: Rivers and lakes of Coromandel coast).
 1960. *Channa punctatus*: De Witt, *Stanford Ichth. Bull*, 7, 82.

Material.—(i) 2 exs., Choe nulla, Jammu, 18.x.1964 (ii) 4 exs., a branch of River Tawi, Jammu, 19-21.x.1964. (Size: 43-181 mm.).

Remarks.—This species is found only in very slow moving marshy nullas not above an altitude of 360 meters. It is a fairly common species and is eaten by the poor people.

Distribution.—Freshwaters throughout India; Pakistan, Burma, Ceylon, Malaya, China.

(34) *Channa marulius* (Ham.)

1822. *Ophiocephalus marulius* Hamilton, *Fishes of Ganges*, pp. 65, 367, pl. 17, fig. 19. (Type-locality: Ganges).
 1876. *Ophiocephalus marulius*: Day, *Fishes of India*, p. 363.

Material.—(i) 1 ex., Choe nulla, 15 kms. west of Jammu, 18.x.1964. (Size: 345 mm.).

Remarks.—It is a common species found in muddy and slow moving nullas by the side of river Tawi and is a commercially important fish. A large black ocellus is clearly seen at the upper part of the base of the caudal fin.

Distribution.—Freshwaters of Jammu, West Bengal, Bombay, Mysore, Kerala, Gujarat; Pakistan, Burma, Ceylon, Thailand, China.

Genus *Mastacembelus* Scopoli, 1777(35) *Mastacembelus armatus* (Lacépède)

1800. *Macrognathus armatus* Lacépède, *Hist. Nat. Poiss.*, 2, p. 286. (Type-locality: unknown).
 1956. *Mastacembelus armatus*: Sufi, *Bull. Raffles Mus.*, 27, p. 134, pls. 25, 26, figs. 29-32.

Material.—(i) 13 exs., a small bauli by the side of Nadiali nulla, Udhampur, 6.ix.1964; (ii) 13 exs., Dhanodi nulla, Udhampur, 10.ix.1964; (iii) 1 ex., River Tawi Dist. Udhampur, 21.ix. 1964; (iv) 3 exs., Jhajjar nulla, Dist. Udhampur, 10-13.x.1964; (v) 1 ex., Junhi nulla, Dist. Udhampur, 8.x.1964; (vi) 21 exs., River Tawi, Dist. Jammu, 17-30.x.1964. (Size: 19-338 mm.).

Remarks.—This is a very commonly found species at quite high altitudes in river Tawi as well as in its tributaries. Due to its shy habits it remains hidden under and between the stones. The flesh of this fish is considered very delicious by the local people who are seen hunting them under the stones.

Distribution.—Fresh and brakish waters throughout India; Pakistan, Burma, Ceylon, Malaya, Thailand, Sumatra, Hainan, China.

(36) *Mastacembelus pancalus* (Ham.)

1822. *Macrognathus pancalus* Hamilton, *Fishes of Ganges*, pp. 30, 364. (Type-locality: Tanks of Gangetic Provinces).
 1956. *Mastacembelus pancalus*: Sufi, *Bull. Raffles Mus.*, 27, p. 120.

Material.—(i) 1 ex., a branch of River Tawi, Jammu city, 19.x.1964. (Size: 75 mm.).

Remarks.—Only a young example is represented in the present collection. It is a species of the plains in slow and shallow waters. This fish is not available above an altitude of 366 meters. It is of little commercial importance. It can be easily recognised from the other species of its genus, found in this area, in having the caudal fin free from the dorsal and the anal.

Distribution.—Fresh and brakish waters throughout India ; Pakistan.

Genus *Badis* Bleeker, 1853

(37) *Badis badis* (Ham.)

1822. *Labrus badis* Hamilton, *Fishes of Ganges*, pp. 70, 368, pl. 25, fig. 23.
(Type-locality: Ponds and ditches of Gangetic Provinces).
1875. *Badis bucharani* : Day, *Fishes of India*, 128, pl. 31, fig. 6.

Material.—(i) 4 exs., Choe nulla, 15 kms. west of Jammu city, 18.x.1964. (Size: 27-35 mm.).

Remarks.—The examples of this species were captured from a muddy slow moving nulla by the side of river Tawi in plains. This species has not earlier been recorded from any locality west of Kali river. The presence of this species in river Tawi shows its uniform distribution along southern face of Himalaya.

Distribution.—Freshwaters along southern face of Himalayas ; Pakistan, Burma.

Genus *Xenentodon* Regan, 1911

(38) *Xenentodon cancila* (Ham.)

1822. *Esox cancila* Hamilton, *Fishes of Ganges*, pp. 213, 380. (Type-locality: Ponds and small rivers of Gangetic Provinces).
1938. *Xenentodon cancila* : Shaw & Shebbeare, *J. Asiat. Soc. Bengal*, 3, p. 108.

Material.—(i) 2 exs., a branch of river Tawi, Jammu city, 19.x.1964. (Size: 177-228 mm.).

Remarks.—Two specimens of this species were captured from a slow moving nulla by the side of river Tawi. Ordinarily this fish swims like an arrow on the surface of water and can be easily caught with a water net. It is not a very common species in the area. The specimens in the present collection agree with the description given by Day (1877).

Distribution.—Freshwaters throughout India ; Bangladesh, Pakistan, Burma, Malaya, Ceylon.

V—A KEY TO THE IDENTIFICATION OF FISHES OF RIVER TAWI

1. Body much elongated and eel shaped. .(2)
Body neither much elongated nor eel shaped. .(3)
2. The dorsal and anal fins confluent with caudal. .. *Mastacembelus armatus* (Lac.)

- The dorsal and anal fins distinct from the caudal. .*Mastacembelus pancalus* (Ham.)
3. Both jaws produced into a beak shaped structure. .*Xenentodon cancila* (Ham.)
- Jaws not produced into a beak shaped structure (4)
4. Suprabranchial accessory respiratory organs present ; head snake like. .(5)
- Suprabranchial accessory respiratory organs absent ; head not snake like. .(7)
5. Lateral line scales 60-70 ; dorsal with 45-55 rays. .*Channa marulius* (Ham.)
- Lateral line scales 37-45 ; dorsal with 29-37 rays. (6)
6. Body with vertical bands. .*Channa orientalis* (Bl. & Schn.)
- Body without vertical bands. .*Channa punctatus* (Bl.)
7. Dorsal with distinct spinous and soft parts. .*Badis badis* (Ham.)
- Dorsal without distinct spinous and soft parts (8)
8. Scales absent ; pectoral fin with a strong and hard spine. (9)
- Scales present ; pectoral fin without a spine. (12)
9. Dorsal fin spineless. *Wallago attu* (Bl. & Schn.)
- Dorsal fin with a spine. (10)
10. Anterior nostrils widely separated from the posterior. .*Mystus (Aorichthys) seenghala* (Sykes)
- Anterior and posterior nostrils close together. .. (11)
11. Adhesive apparatus on chest present. .*Glyptothorax pectinopterus* (McClelland)
- No adhesive apparatus present on chest. .*Amblyceps mangois* (Ham.)
12. Three pairs of barbels. (13)
- None, one or two pairs of barbels. (17)
13. An erectile spine present near the orbit. (14)
- No erectile spine present near the orbit. (15)
14. Caudal forked ; body with oblique cross bands. .*Botia birdi Chaudhuri*
- Caudal entire ; body with dark festooned blotches. .*Lepidocephalus guntea* (Ham.)
15. Third and fourth rays of pectoral fin produced upto ventrals .*Noemacheilus corica* (Ham.)
- Rays of pectoral fins not produced much.. . (16)

16. 7 branched rays in dorsal ; 9-15
bars on side of body .*Noemacheilus prashari* Hora
10-12 branched rays in the dorsal ;
body irregularly blotched. .*Noemacheilus botia* (Ham.)
17. Abdomen keeled. (18)
Abdomen not keeled. (19)
18. Outer pelvic rays produced. .*Chela (Chela) cachi* (Ham.)
Outer pelvic rays not produced. .*Oxygaster bacaila* (Ham.)
19. Lower jaw with a knob at the
symphysis, fitting into emargination
of upper jaw (Except *Esomus*) ; lateral
line markedly curved downward behind
the base of pectoral. (20)
No symphysial knob in lower jaw (Except
Cirrhinus) ; lateral line with slight,
if at all, downward bend. (26)
20. Maxillary barbels very long reaching
beyond pelvic base ; no syphysial
knob in lower jaw
Maxillary barbels short or absent ;
symphysial knob in lower jaw present. (21)
21. Cleft of mouth shallow ; sub-orbital
bones not broad. .*Danio devario* (Ham.)
Cleft of mouth deep, extending to below
the eye ; sub-orbital bones prominent. (22)
22. Sides of body silvery .*Barilius modestus* Day
Sides of body with vertical bars. (23)
23. Anal with 10-12 branched rays (24)
Anal with 7-8 branched rays. (25)
24. Colour bands long and extend from
back to lateral line ; maxillary
barbel extends upto $\frac{1}{3}$ rd of the
orbit..... .*Barilius barila* (Ham.)
Colour bands small and remain much
above lateral line ; maxillary
extends upto middle of orbit .*Barilius vagra* (Ham.)
25. Lateral line scales 40-43 . .*Barilius bendelisis* (Ham.)
Lateral line scales 60-70.....*Barilius shacra* (Ham.)
26. Anal opening surrounded by a sheath
of large tile like scales ; lateral
line scales 108-110. .*Schizothorax plagiosomus* Heckel
Anal opening not surrounded by a sheath of large
tile like scales ; lateral line scales
less than 90. .(27)
27. Upper lip separated from snout by a deep
groove ; no sucker on the chin. (28)
Upper lip not separated from the snout by a groove ;
the chin bears a sucker. .*Garra gotyla gotyla* (Gray)

28. Lower lip not continuous with the upper. .*Crossocheilus diplochilus* (Heckel)
Lower and upper lips continuous at the corners of the mouth. .(29)
29. A symphysial knob present in lower jaw. .*Cirrhinus mrigala* (Ham.)
No symphysial knob in lower jaw. .(30)
30. Lower lip absent ; origin of dorsal fin distinctly posterior to the ventrals but not extending above the anal. .*Aspidoparia morar* (Ham.)
Lower lip present ; origin of dorsal fin nearly opposite the ventrals or anterior to them. .(31)
31. Mouth terminal or subterminal. .(32)
Mouth inferior .(36)
32. Lower lip with a continuous transverse fold forming a posteriorly free median lobe. .(33)
Lower lip with an interrupted fold and no free median lobe formed. .(34)
33. Head 4-4.5 and height 5.5-7.0 times in total length. *Tor putitora* (Ham.)
Head 5-6 and height 4.5-5.0 times in total length. *Tor mosal* (Ham.)
34. Barbel: absent .(35)
Barbels two pairs. .*Puntius sarana sarana* (Ham.)
35. Last spine of dorsal fin serrated ; lateral line incomplete ; no dark mark at base of dorsal fin.....*Puntius ticto* (Ham.)
Last spine of dorsal fin entire ; lateral line complete ; a dark mark at base of dorsal fin rays.....*Puntius sophore* Ham.
36. Scales along lateral line 37-40. .*Labeo bata* (Ham.)
Scales along lateral line 41-44. .(37)
37. Dorsal fin with 9-10 branched rays ; inner surface of lower lip papillated. .*Labeo dero* (Ham.)
Dorsal fin with 11 branched rays ; inner surface of lower lip beset with transverse folds. .*Labeo dyocheilus* (McClelland)

VI—THE FISHING METHODS USED IN THE AREA

A variety of different legal and illegal methods of fishing are practised in this area and are described below. According to the regulations, only those persons who possess a valid fishing license, issued by the Department of Fisheries and Fish Preservation, Srinagar, (J. & K.), can fish in the waters of river Tawi and its tributaries. In spite of a large number of fisheries-watchers posted by the Department of Fisheries, Srinagar, along the river Tawi and its tributaries, illegal fishing by unapproved methods is widely in practice.

Illegal methods of fishing

(a) *Blasting*—A gun-powder cracker, similar to the one used for blasting rocks on a road under construction, is used to blast a portion of the water where the fish is presumably in plenty. As a result of a strong jerky motion some fishes get stunned, become unbalanced and even die of shock—so much so that all forms of aquatic life of the blasted area is more or less completely wiped out. A few fishes which float upon the surface of the water are caught by the poachers and the rest are simply washed down by the strong current. Those fishes which survive this shock are not likely to breed. Thus this method is a kind of death blow to the fishing industry of that area and, if remained unchecked, may cause an extermination of aquatic fauna.

(b) *Poisoning*—Some people mix the seeds of a local herb, named 'Bichchoo Booti', in wheat flour and throw small pallets of the flour in water. Those fishes which eat the pallets feel extremely uneasy, get unbalanced, and float helplessly on the surface of the water. The floating fish is then caught. Such fishes lose their body colouration and become more or less colourless. The poison, probably, acts on the nervous control of the fish.

(c) *Chlorination*—At some places along the river, big ditches are formed. The water in these ditches (locally called 'Dabers') is more or less still, although connected with the main stream. In case there are some fishes, people put bleaching powder in the ditch, and as a result of chlorine action, the fishes helplessly float on the surface of the water and are caught easily.

(d) *Tin-trapping*—The bottom feeding fishes are trapped in small tins, bearing a small hole (nearly 5 cm. diameter) on its top. The tin contains some food as a bait and is placed at the bottom of water in a ditch by the side of the river or a nulla. The fishes enter the tin through the hole and are lifted out immediately before they go out. Some people apply the same method with the help of a wide mouthed basin, by tying over its opening a piece of cloth. A hole of a suitable size is pierced in the centre of the cloth and some food, as bait, is put in the basin. Once a fish enters the hole, it finds it difficult to escape.

Legal methods of fishing

Hook and line and cast net (1 sq. inch mesh size) are allowed to be operated in the waters of that state by the Department of Fisheries and Fish Preservation, Srinagar. At certain portions of the river near Jammu town, the use of cast net is prohibited. Such portions of the river act as fish sanctuaries where fishes have a free and uninterrupted terrain to live and breed.

For the purpose of scientific studies (faunistic studies) fishes of even little commercial value, whatsoever, are also important and are required to be collected. For this purpose certain special devices, in addition to those mentioned above, were employed by the present author to catch certain fishes which live among small stones, pebbles and under big rocks etc. The methods employed are described below.

(a) *Dredging*—A special dredging device has been designed and used in the field. The dredge is a bag of copper wire netting with a 'D' shaped cross section (Size: 30 × 45 cm.). The mouth of the bag is strengthened by a thick copper or brass sheet. A threaded strong nail is welded to the rim and a strong bamboo rod, with a nut welded to its tip can be fixed to it. The dredge can be operated through heap of stones and pebbles under water where fishes like *Noemacheilus*, *Glyptothorax* and *Amblyceps* get into it and are caught easily. The dredge is a good replacement for cloth water net, which gets worn out soon in a stony bed and does not stand the pressure of strong current of water.

(b) *Fine mesh nylon water nets*—Special strong nylon cloth (fine mesh) nets of the shape of dredge described above, were prepared. The net is supported by a bamboo pole and is moved quickly through water. Fishes of small sizes such as *Chela*, *Danio*, *Esomus*, *Barilius*, *Oxygaster*, etc., are easily caught in this manner. At many places, where the bed contains stones, the net is simply held in water against the current and some of the stones towards the upstream are moved so that the fishes adhering to them get washed into the net placed immediately behind.

(c) *Diversion of the channel*—At certain places, where the water in a channel is not very deep and it flows in a part of its bed, a portion of the channel can be diverted by putting a bandh across it. The fishes which hide below the stones flutter out in the partly dried portion of the channel and can be easily caught. This method has also been employed by Dr. S. L. Hora for collection of hill stream fishes.

VII—MIGRATION

Most of the species of fishes are common both to the river Tawi and the nullas flowing into it. Only perennial nullas are inhabited by the aquatic fauna. There is an intermigration of aquatic fauna between the river Tawi and the various nullas flowing into it. During and after rainy season, the aquatic fauna, particularly fishes, ascend into the nullas and during the winter season and early summer, they again return back to the river where water is still plentiful.

In the river Tawi itself there is a remarkable difference in the fish fauna occurring at high altitudes and that occurring at low altitudes. In addition to those species which stick to their particular habitat, there are some like *Mystus* (*Aorichthys*) *seenghala*, *Wallago attu* and *Tor putitora*, which are capable of moving as far up as to the height of 1200 metres during summer months. According to local fishermen species of *Mystus* and *Wallago* are completely absent in this river after the rainy season.

There are two phenomena of fish migration in this river as under:—

(1) The migration of fish fauna between river Tawi and its tributaries. The fishes ascend into the nullas, probably, due to two reasons (a) for sake of reproduction because the flow of the water in the nullas is much less as compared to the main river and the fishes find there convenient and quiet holes for breeding, (b) for sake of safety of their young ones, which spend most of their time in nullas

till they grow up in order to withstand the rigours of the flow of the mountain river.

(2) The up and down movement of the fish fauna at various altitudes in the river Tawi itself.

The phenomenon of fish migration in the river Tawi is interesting from physiological and ecological points of view. Some of the climatic and physiological factors which govern this phenomenon need careful study and analysis. The dependence of the fishes on other vertebrate and invertebrate animals could also control these movements. The migration of fish in river Tawi is a sort of micro-migration.

According to local fishermen, during floods the waters of the river Chenab and river Tawi get mixed up near their confluence. The fishes from river Chenab ascend into Tawi during this time. Moreover, small nullas come out of the river Chenab and join river Tawi before it finally mixes with Chenab. In the plains, i.e. a few kms. down from Jammu town, the fish fauna of the side branches of the river Tawi resembles that of the nullas coming out of the river Chenab. This is a clear indication that during floods the Chenab fishes come up into Tawi and after the water recedes down, some of them remain in the side branches of Tawi where the water is shallow and slow moving.

VIII—THE BED

The bed of the river Tawi as well as its tributaries contains huge stony boulders which have been washed down from the hilly sides through heavy rains (Pl. 4, figs. 5, 6) and at places still down there are only pebbles and sand (Pl. 4, figs. 7, 8). In no section of the river or its tributaries at altitudes higher than 500 meters there is any trace of aquatic vegetation because it gets uprooted easily and does not stand. The only form of vegetation observed is the deposition of a layer of algal mass on the stones under water. The vegetable feeders eat these algae while the insectivorous ones feed on the insects and their larvae entangled in the algal mass. On the sides of the nullas, where rain-water collects between stony boulders, thick growth of marshy plants exists. This forms a good habitat for young and larval fishes as well as species of *Channa*. Hora (1936 a) made some observations regarding the smooth and rough rocks in the bed of hill streams and their relationship with the aquatic fauna. The tributaries of the river Tawi have two types of beds:

(a) In some nullas the small stones are covered with layers of calcium carbonate and get adhered to each other firmly. The surface of stones is rough.

(b) In many other places the stones are small, smooth and not united firmly with one another (Pl. 4, fig. 3). They are not covered by layer of calcium carbonate. Hora (1936 a) referred Auden and correlated the rough deposition of calcium carbonate on stones with hard water of the stream whereas the smoothness of stones to the softness of the water. However, it has been observed that the tributaries of river Tawi with small and smooth stones, having a deposition of small amount of algae and having a few blepharocerid

larvae offer a good habitat for *Glyptothorax pectinopterus*. This species of fish is altogether absent in the nullas with rough stones which get strongly adhered to each other as well as to the substratum. The presence of *Glyptothorax pectinopterus* is directly correlated with the presence of blepharocerid larvae on which this insectivorous fish feeds. The blepharocerid larvae probably find a convenient habitat among smooth stones. This relationship offers a chain of interdependence i.e. *G. pectinopterus* on blepharocerid larvae and the latter on the smooth stones. In the plains the bed consists of fine stony sand and at some places there is mud. The muddy banks invariably bear a thick growth of grasses and reeds.

A particular difference has been observed in the manner of feeding of two phytophagous fishes viz. *Schizothorax plagiostomus* Heckel and *Garra gotyla gotyla* (Gray). *S. plagiostomus*, while feeding on the algal layer from the surface of a stone under water, makes crescent shaped impressions on the stones; *G. gotyla gotyla* makes a straight and irregular type of impression on the stones. The impression is formed where the algal mass has been rasped away by the fish. The difference in the pattern of feeding-marks on stones can be attributed to the fact that *Garra* possesses a suction disc by the help of which it can fix itself on stone and can withstand the current of water. While fixing itself on the stone covered with algae and moving forward against the current it makes a straight but irregular feeding mark on the stone. On the other hand the suction disc on the ventral side of the lower jaw of *Schizothorax* does not enable the fish to fix itself on the stone while it feeds on algae from a rock under strong current of water. It rasps off algae in small instalments making a series of crescentic impressions on the rock.

IX—ZOOGEOGRAPHICAL REMARKS

The fishes in the higher reaches of the river Tawi and its tributaries are no doubt hill-stream fishes but not fishes of torrential stream, except one genus i.e. *Schizothorax*. The fishes probably migrated to the western Himalaya from the eastern Himalaya in the Pleistocene. The only fossil record of freshwater fishes in this part of Himalaya is that of *Schizothorax* sp. of the Pleistocene age (Hora, 1937). This substantiates the view that the torrential fish fauna of eastern Himalaya did not migrate to the west up to the early Pleistocene due to unfavourable ecological conditions created by the presence of a gap between the eastern and western Himalaya (Krishnan, 1952, Menon, 1954). The majority of the fishes of the western Himalaya are not truly torrential and migrated from the eastern parts only before the gap was bridged i.e. in the early Pleistocene. After a comparison of the fish fauna of the Kashmir Valley (Silas, 1960, Das and Subla, 1964) with that of river Tawi and its tributaries it can be deduced that the former shows central asiatic elements while the latter is purely Himalayan.

X—ACKNOWLEDGEMENTS

The author feels grateful to Dr. M. L. Roonwal, Retired Director and Dr. A. P. Kapur, Director, Zoological Survey of India, for all the help, guidance and encouragement during the course of this work.

Thanks are due to Mrs. M. Mansukhani, Superintending Zoologist, for going through the manuscript and suggesting improvements and to Mr. G. M. Malik, Director, Department of Fish and Fish Preservation, Jammu and Kashmir, Srinagar, for his help in various ways in the field. The author has great appreciation for the cooperation given by the District Forest Officer, Udhampur (J. & K.).

XI—SUMMARY

1. Thirty-eight species of fishes have been recorded for the first time from river Tawi and its tributaries (J. & K. State). The important variations shown by the different species have been noted. *Noemacheilus corica* (Ham.) has been redescribed in detail while the material of *Noemacheilus prashari* Hora has been thoroughly compared with those of *Noemacheilus prashari* from Kohat (Pakistan) (published account alone) and of *N. punjabensis* Hora from Salt Range (Pakistan). A list of the material studied is given. A key to the identification of the 38 species has been added.

2. A record of the illegal and unapproved fishing methods practised by the poachers in the waters of river Tawi and its tributaries has been made. The fishing methods employed by the author and allowed by the Department of Fisheries and Fish Preservation, Jammu & Kashmir are also described in brief.

3. Two types of the phenomenon of micro-migration of fishes observed in river Tawi and its tributaries are described. The migration of fishes, it is held, is related to climatic and physiological factors which need a careful study.

4. The relationship of the species of fishes with the particular type and make up of the bed of the river and nullas has been noted, particularly in the case of *Glyptothorax pectinopterus*. The feeding habits of *Garra gotyla gotyla* (Gray) and *Schizothorax plagiostomus* Heckel have been studied.

5. The study of the fishes of the area shows that they constitute purely Himalayan fauna. They are not purely torrential fishes and could have migrated to their present abode only in the Pleistocene.

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PLATE I

- Plate I, Fig. 1 & 2. *Glyptothorax pectinopterus* (McClelland)—Lateral and ventral views.
3 & 4. *Labeo dero* (Ham.)—Lateral and ventral views of male.
5 & 6. *Schizothorax plagiostomus* Heckel—Lateral and ventral views.

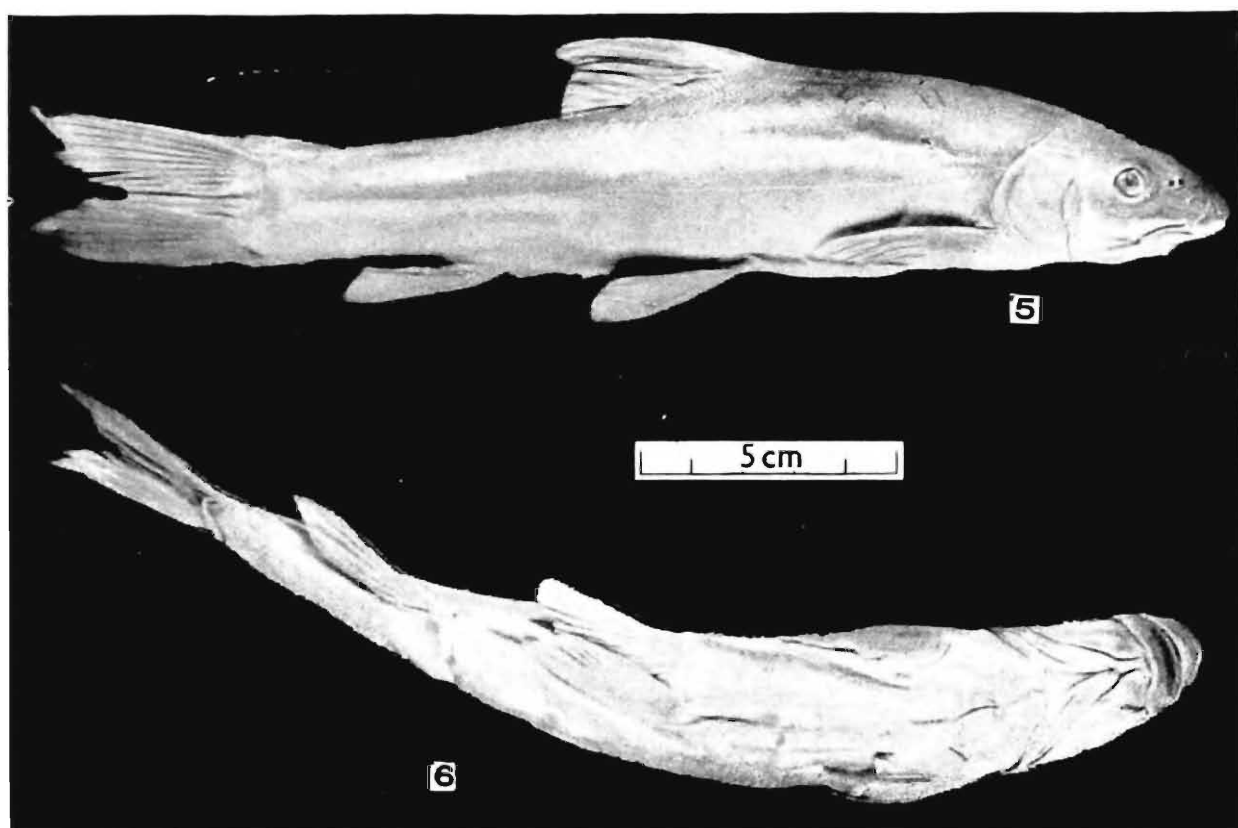
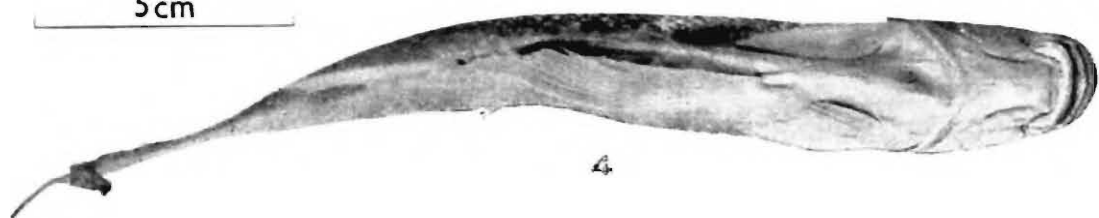
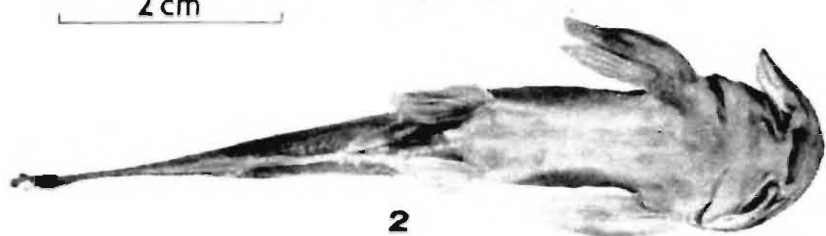
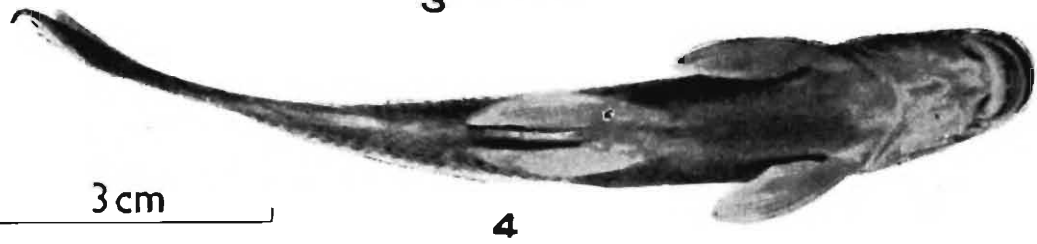
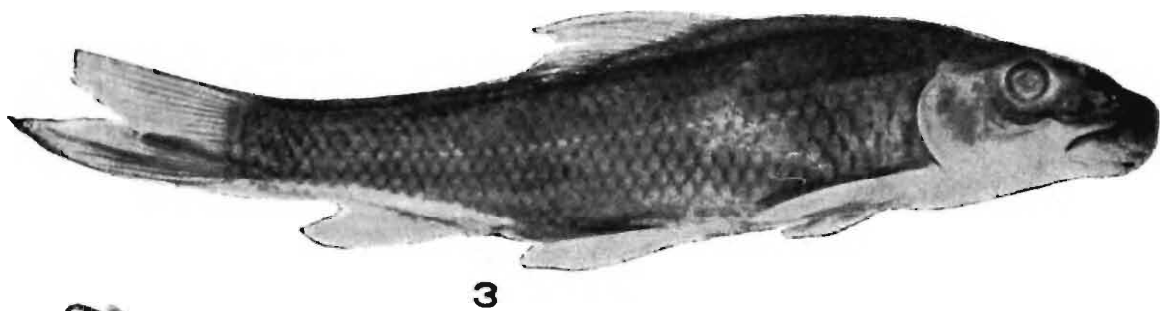


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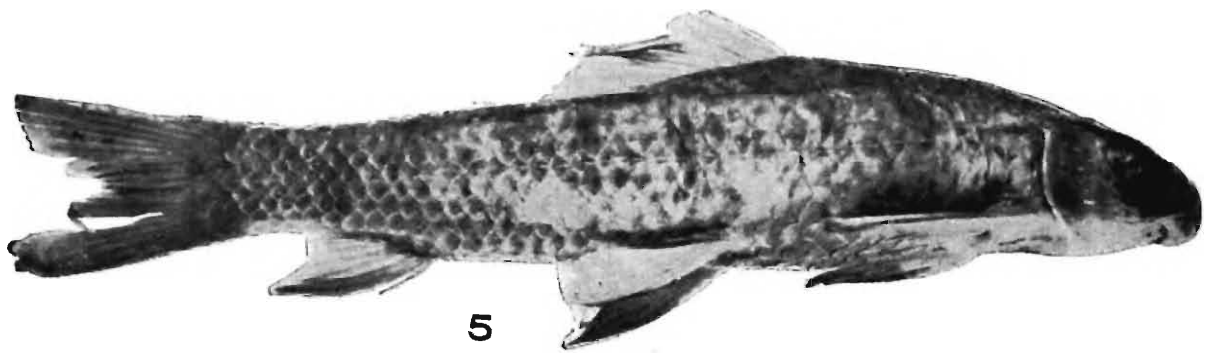
- Plate II, Fig. 1 & 2. *Labeo dero* (Ham.)—Lateral and ventral views of female.
3 & 4. *Labeo dyocheilus* (McClelland)—Lateral and ventral aspects.
5 & 6. *Crossocheilus diplochilus* (Heckel)—Lateral and ventral aspects. (darker with pointed snout.)



5cm



3cm



3cm

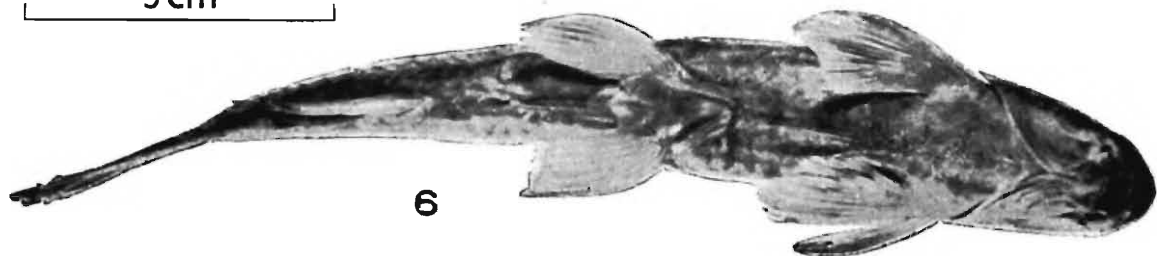


PLATE III

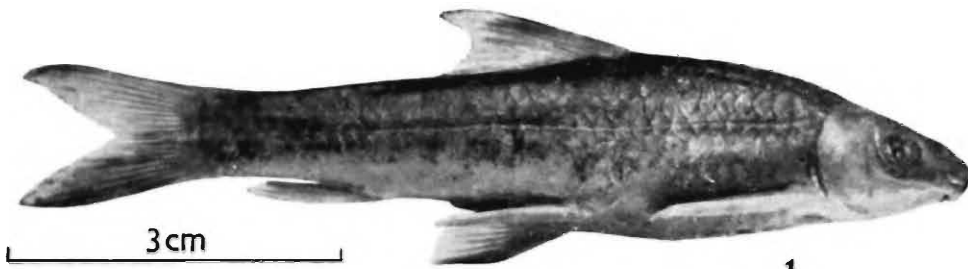
Plate III, Figs. 1 & 2. *Crossocheilus diplochilus* (Heckel)—Lateral and ventral aspects.

3 & 4. *Barilius* ~~*Dendelisis*~~ (Ham.)—Lateral and ventral aspects

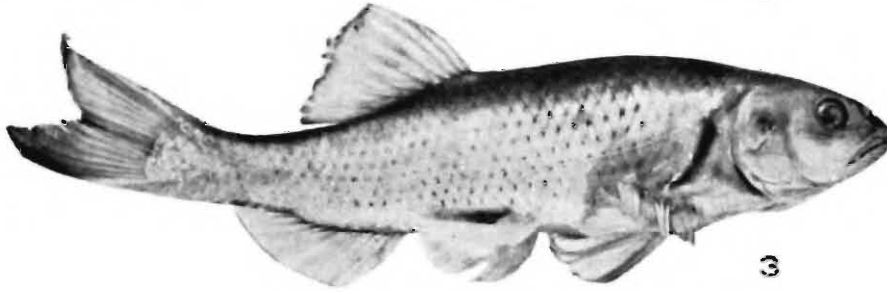
5 & 6. *Barilius* ~~*vagra*~~ (Ham.)—Lateral and ventral views.

7 & 8. *Barilius barila* (Ham.)—Lateral and ventral views.

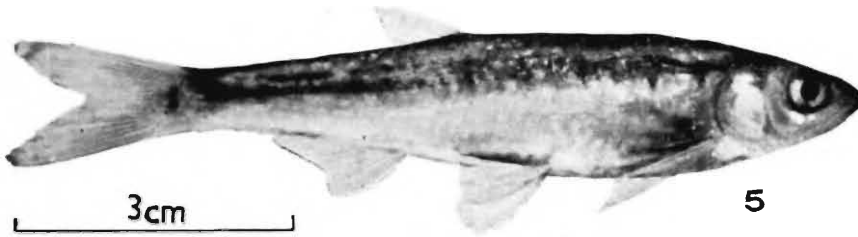
9 & 10. *Noemacheilus prashari* Hora—Lateral and ventral views.



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3



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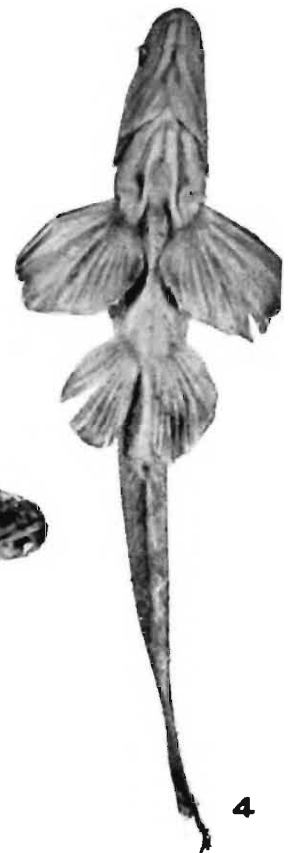
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10



2



4

PLATE IV

- Plate IV, Figs. 1. Showing the course of river Tawi—a view from a hill.
2. A water fall in the course of a branch of river Tawi, nearly 8 kms. east of Udhampur.
3. Small smooth stones in bed of Tawi near Nagrota.
4. A typical bauli near Udhampur.
5. Huge stones in the bed of motor-shed nulla near Chineni.
6. Huge stony boulders in the bed of river Tawi.
7. Small stones in bed of Tawi near Jammu city.
8. River Tawi, nearly 15 kms. down stream from Jammu city, showing sandy & muddy banks.



1



2



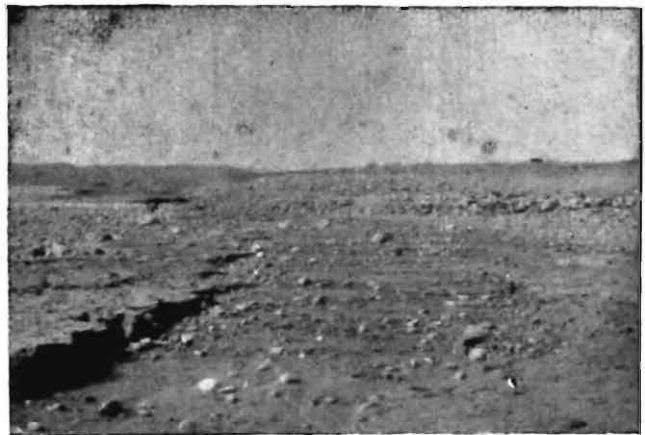
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8

CONTRIBUTIONS TO THE STUDY OF BAGRID
FISHES. 8 SYSTEMATIC POSITION OF HAMILTON'S
PIMELODUS RAMA AND *PIMELODUS*
CHANDRAMARA (SILUROIDEA:
BAGRIDAE)

By

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(With 1 Text-figure and 1 Plate)

I — INTRODUCTION

Hamilton (1822) described *Pimelodus rama* from the Brahmaputra river in Assam, and *Pimelodus chandramara* from the Atrai river in Bengal. He considered the two species as related and separated them by the following characters.—

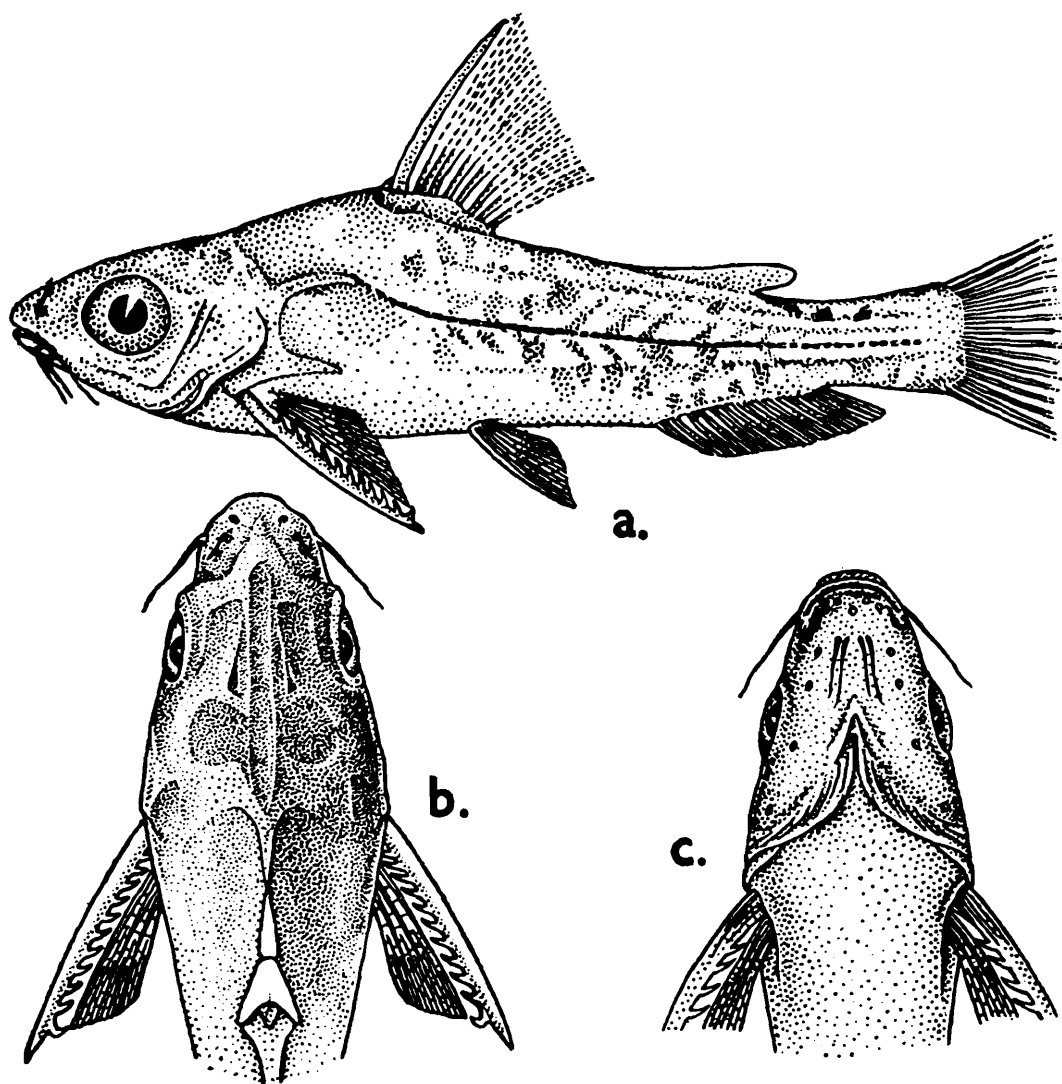
<i>P. rama</i>	<i>P. chandramara</i>
Six barbels.	Two barbels.
Diaphnous, yellowish without dots. Black spot on nape, divided into four lobes.	Diaphnous, with clusters of black dots ; golden stripe along lateral line.

Swainson (1839) considered both these species under his genus *Silonia* which course Valenciennes (1840) also adopted. Blyth (1860), after examining Hamilton's manuscript drawings in the Asiatic Society at Calcutta, pointed out for the first time that the unpublished figure of *chandramara* had six barbels distinctly shown, contrary to Hamilton's statement that the species had only two barbels. He considered the species as synonymous with each other and assigned them to his genus *Batasio*. Bleeker (1862) provisionally proposed the genus *Rama* for *P. rama*. Günther (1864) however, considering *P. rama* and *P. chandramara* as different, assigned the former species to *Rita* Bleeker without comment, and the latter to *Mystus* Scopoli with a query. Day (1877) identifying a specimen from the Brahmaputra river as *P. rama*, assigned it to the genus *Leiocassis* Bleeker, but Regan (1913) in his revision of *Leiocassis* doubted the assignment. Shaw and Shebbeare (1938) like Day, obtained certain specimens from the Mahanadi river near Siliguri and referred them to *Leiocassis rama*. Hora and Law (1941) considered *chandramara* and *rama* as synonymous and placed them provisionally under *Rama*. They examined Day's

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Rec. zool. Surv. India, **65** (1-4) [1967] 1971.

specimen, also present in the Zoological Survey of India (ZSI. 1111), from the Brahmaputra river and correctly reassigned it to *Batasio* to which genus Shaw and Shebbeare's material should also be referred to.

Recently Rossel (1964) in his report on the collection of fishes made by the German-Indian expedition 1955/58 recorded six specimens, 29-33 mm. in standard length, from Mikir Hills, Kaziranga, Assam, as belonging to *Rama rama*. Through the kind courtesy of Dr. W. Ladiges of Zool. Staatinstitut and Zool. Museum, Hamburg, I have examined four specimens of this lot. Rossel seems to have missed the minute, heavily pigmented nasal barbels. These specimens are referable to *Batasio tengana* (Hamilton) (Text-fig. 1).



TEXT-FIG. 1. Rossel's specimen of "*Rama rama*", misidentification for *Batasio tengana* (Hamilton). a. Lateral view ; b. Dorsal view of head and body ; c. Ventral view of head and body.

It will be seen that considerable confusion prevails regarding the generic status of these two species. This paper discusses this problem and indicates the probable systematic status of the two species.

II — SYSTEMATIC POSITION

It may be stated at the outset that *P. rama* and *P. chandramara* are not synonymous with each other. An examination of the illustrations

(Plate I) and descriptions of the two species shows the following differences.—

P. rama

Dorsal profile deeply arched. Rayed dorsal fin inserted far in advance of the origin of pelvic fin.

Anal fin with about 12 rays.

Pectoral fin with about six rays. Cleithral process short.

Upper lip overhanging the snout.

Dorsal spine serrated; fin with seven rays.

A black spot on the nape and shoulder. A black longitudinal stripe along the lateral line.

P. chandramara

Dorsal profile gently elevated. Rayed dorsal fin inserted just above origin of pelvic fin.

Anal fin with about 14 rays.

Pectoral fin with about 9 rays. Cleithral process long.

Upper lip not overhanging the snout.

Dorsal spine smooth; fin with six rays.

No black spots; body speckled with dots.

In both the species six barbels are clearly seen in the illustrations of Hamilton. By virtue of their possessing only three pairs of barbels these species cannot be assigned to *Mystus* Scopoli, *Leiocassis* Bleeker, or *Batasio* Blyth which all possess four pairs of barbels. They cannot be referred to *Silonia* Swainson also, because of the short anal fin.

However, the number of barbels has been controversial and it is quite likely that there may be more or less number of barbels, especially since Hamilton's descriptions and illustrations of these two species have been very defective and inadequate. Thus, in the description of *chandramara* the count of anal fin rays is stated as 17, whereas in the illustration it is only 12.

The available data and the differences as could be ascertained from the illustrations and descriptions indicate that *rama* and *chandramara* are distinct species. Their generic status is, however, vague. It is pertinent to point out that excepting Hamilton, no ichthyologist ever seems to have seen a specimen of these species, and no "type specimens" are also known to exist in any of the world museums.

In the light of the above discussion and pending discovery of specimens of these species, the two are kept provisionally under the genus *Rama*. The generic status of *Rama* can be best determined only by actual examination of these interesting fishes. The following synonymies will indicate the generic change detailed in the foregoing paragraphs. The description is based on the characters known so far, from Hamilton's descriptions and illustrations.

III—DESCRIPTION

***Rama rama* (Hamilton)**

1822. *Pimelodus rama* Hamilton, *An account of the fishes found in the River Ganges and its branches*, pp. 176, 377, pl. iii, fig. 55 (type locality, River Brahmaputra, Assam).

1839. *Silonia diaphnia* : Swainson, *The natural history and classification of fishes* 2. p. 305.
 1860. *Batasio rama* : Blyth, *J. Asiat. Soc. Beng.*, **29**, p. 149.
 1864. *Pimelodus rama* : Günther, *Catalogue of the Fishes in the British Museum*, **5**, p. 92.
 1877. *Leiocassis rama* : Day, *The Fishes of India*, p. 451, pl. cxv, fig. 2 (River Brahmaputra, Assam; misidentification).
 1889. *Leiocassis rama* : Day, *The Fauna of British India including Ceylon and Burma*, Fishes, **1**, p. 163, fig. 65 (Assam and East Bengal).
 1941. ? *Rama rama* : Hora & Law, *Rec. Indian Mus.*, **43**, p. 69 (Assam).
 1948. ? *Rama rama* : Hora, *Rec. Indian Mus.*, **46**, p. 69 (North Bihar and Assam).
 1964. *Rama rama* : Rossel, *Mitt. Hamburg. Zool. Mus. Inst.*, Hamburg, **61**, p. 151 (misidentified; Mikir-Hills, Kaziranga, Assam).

Specimen studied.—No specimen seen by me.

Description.—Body short and compressed. Dorsal profile deeply arched. Head large and slightly depressed. Snout sharply conical or obtusely pointed, but not produced. Jaws subequal and narrow. Villiform teeth on premaxillaries, prevomer and mandibular in bands. Eyes superior, small and in anterior part of head. Orbital rims fused with eye. Supraoccipital covered with skin and with a backward extending process about 2 times longer than wide at its base and extending to the predorsal plate. Three pairs of barbels: one maxillary, one mandibular; one nasal. Maxillary barbels reach eye; others shorter. Gill membranes free from each other and also from the isthmus.

Origin of rayed dorsal fin above half pectoral fin; with seven rays and a spine. Longest ray of dorsal fin not extending to adipose dorsal fin when depressed. Dorsal spine serrated. Adipose dorsal fin short, low, smooth and posteriorly free. Pectoral fins horizontally inserted and with a spine. Pectoral spine with 12 strong, antrorse teeth over posterior margin. Cleithral processes less than half pectoral spine length. Pelvic fins inserted on ventral surface, far away from below the last ray of dorsal fin; with six rays. Pelvic fin reaches anal fin origin. Longest anal ray not reaching caudal fin; anal fin with about 12 rays. Caudal fin deeply emarginate. Lateral line simple, arched above pectoral fin.

COLOUR.—Pale yellow above and on sides, dull beneath. A large black spot divided into four lobes may be present on the nape; another similar, but undivided spot on the shoulder.

Distribution.—Assam, North Bihar, river Brahmaputra: INDIA. BANGLADESH.

Rama chandramara (Hamilton)

1822. *Pimelodus chandramara* Hamilton, *An account of the fishes of the River Ganges and its tributaries*, pp. 162, 375 (type locality, River Atrai, W. Bengal and Bangladesh).
 1840. ? *Silundia chandramara* : Valenciennes, *Histoire Naturelle des Poissons*, **15**, p. 49 (River Atrai).
 1860. *Batasio chandramara* : Blyth, *J. Asiat. Soc. Beng.*, **29**, p. 149.
 1864. ? *Macrones chandramara* : Günther, *Catalogue of the Fishes in the British Museum*, **5**, p. 75.
 1877. *Pimelodus chandramara* : Day, *The Fishes of India*, p. 451 (as a synonym of *Leiocassis rama*).

1941. *Pimelodus chandramara* : Hora & Law, *Rec. Indian Mus.*, **43**, p. 32 (as a synonym of *Rama rama*).
1948. *Pimelodus chandramara* : Hora, *Rec. Indian Mus.*, **46**, p. 68.

Specimen studied.—No specimen seen by me.

Description.—Body short and compressed. Dorsal profile gently elevated. Head large and depressed. Snout rounded and not produced. Jaws subequal. Villiform teeth on premaxillaries, and mandibular in bands. Eyes large and protuberant and in anterior part of head. Orbital rims fused with eye. Supraoccipital covered with skin or not covered and with a backward extending process; no interneural shield. Three pairs of barbels: one maxillary, one mandibular and one nasal. Gill membranes free from each other along postero-lateral borders, but completely free from isthmus.

Origin of rayed dorsal fin above end of pectoral fin; with six rays and a spine. Adipose dorsal fin short, low, smooth and with the posterior margin free. Longest ray of dorsal fin not extending to adipose dorsal when depressed. Dorsal spine smooth. Pectoral fins horizontally inserted and with a spine. Pectoral spine with about 6 to 8 antrorse teeth over posterior margin. Cleithral processes half pectoral spine length. Pelvic fins inserted on ventral surface, below the last ray of dorsal fin. Pelvic fins not reaching anal fin origin. Longest anal ray not reaching caudal fin; anal fin with about 14 rays. Caudal fin deeply emarginate. Lateral line simple.

Colour.—According to Hamilton, diaphnous all over, with black dots on sides. A golden stripe on either side of lateral line.

Distribution.—River Kosi, Malda, river Mahananda, Purnea: INDIA. River Atrai, Dinajpur, Rangpur: BANGLADESH.

IV — ACKNOWLEDGEMENTS

I am thankful to Dr. W. Ladiges, Zool. Staatinstitut und Zool. Museum, Hamburg for readily lending me the material of "*Rama rama*" and to the Director, Zoological Survey of India for his kind permission to borrow the material.

V — SUMMARY

The systematic position of two species of Hamilton, *Pimelodus rama* and *Pimelodus chandramara*, is discussed. It is pointed out that these two species are rare in that no ichthyologist except Hamilton seems to have seen specimens of these species. The probable status of these species in the family Bagridae is elucidated. A brief description based on published illustrations and data is reconstructed, to facilitate easy identification for future field collectors.

VI — REFERENCES

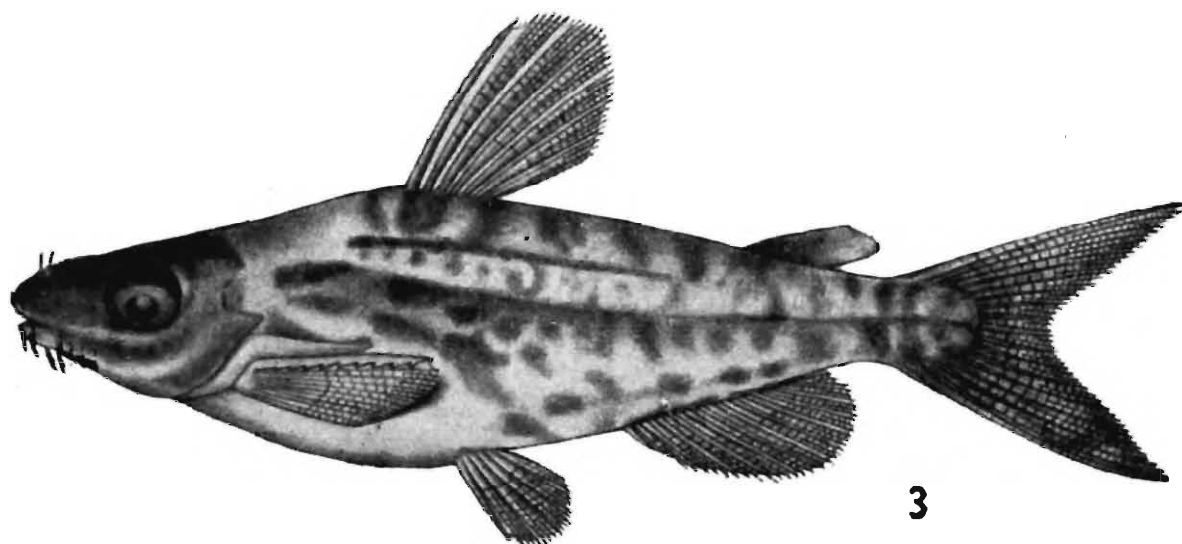
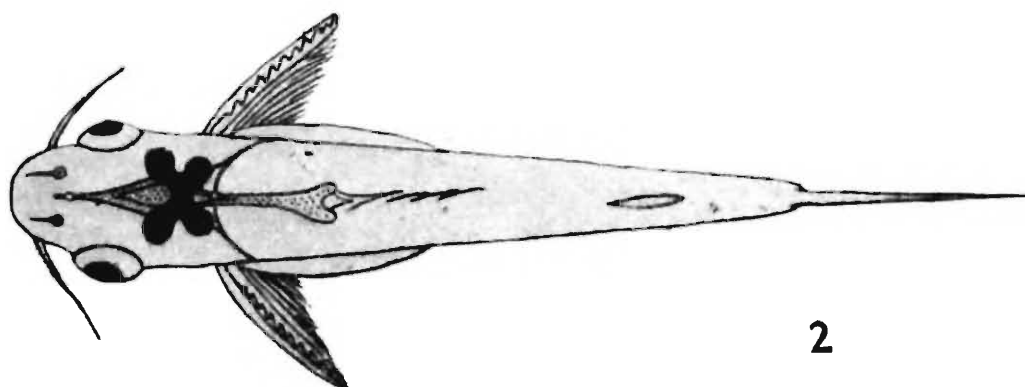
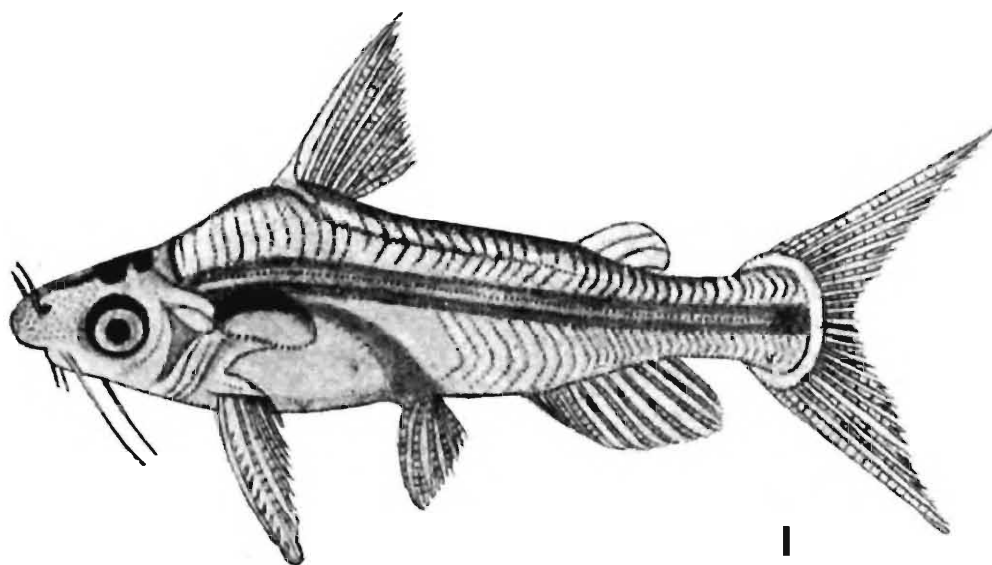
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PLATE 1

- Fig. 1. Enlarged photograph of the original illustration of Hamilton of *Pimelodus rama*. From Volume IV, fig. 25 of "Zoological Drawings" in the Asiatic Society, Calcutta. Lateral view of the fish.
- Fig. 2. Same as above. View from above.
- Fig. 3. Enlarged drawing of Hamilton's original illustration of *Pimelodus chandramara*. From Volume IV, fig. 13 of "Zoological Drawings" in the Asiatic Society, Calcutta.

PLATE I



ON SOME FISHES FROM THE MADRAS COAST WITH DESCRIPTION OF A NEW SPECIES OF THE FAMILY CLINIDAE

By

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(With 1 Text-figure)

I—INTRODUCTION

The fishes treated in this paper were collected along the south-east coast of India during the period 1964-1967 by the staff of the Southern Regional Station, Zoological Survey of India. The collection contains seventy-six species belonging to fifty six genera and forty families. Although small, the collection is interesting, as it includes a hitherto undescribed species of the family Clinidae. Most of the species in the collection have a wide distribution and need no special remarks. Such species as *Ambassis interrupta* Bleeker, *Ostorhynchus endekataenia* (Bleeker) and *Triacanthus weberi* Chaudhuri, which have not so far been recorded from the Madras coast, are noteworthy. The list of species, description of of the new clinid, redescription of the new records and discussion of the taxonomic position of some the sciaenids are given in the following pages.

II—SYSTEMATIC LIST OF THE COLLECTIONS

Class ELASMOBRANCHII
Order LAMNIFORMES
Family CARCHARINIDAE

1. *Scoliodon palasorrah* (Cuvier)

Order RAJIFORMES
Family TRYGONIDAE

2. *Dasyatis (Amphotistius) imbricata* (Bloch and Schneider)

Order TORPEDINIFORMES
Family TORPEDINIDAE

3. *Narcine brunnea* Annandale

Class TELEOSTOMI
Order CLUPEIFORMES
Family DUSSUMIERIIDAE

4. *Dussumieria acuta* Valenciennes

Family CLUPEIDAE

5. *Pellona ditchela* Valenciennes

Family ENGRAULIDAE

6. *Stolephorus baganensis* Hardenberg
7. *Stolephorus commersonii* Lacépède
8. *Stolephorus indicus* (van Hasselt)
9. *Stolephorus tri* (Bleeker)
10. *Thryssa dussumieri* (Valenciennes)
11. *Thryssa purava* (Hamilton)

Order CYPRINIFORMES

Family PLOTOSIDAE

12. *Plotosus canius* Hamilton

Family TACHYSURIDAE

13. *Tachysurus nenga* (Hamilton)

Order MUGILIFORMES

Family SPHYRAENIDAE

14. *Sphyraena chrysotaenia* Klunzinger

Family MUGILIDAE

15. *Mugil kelaartii* Günther
16. *Mugil vaigiensis* Quoy and Gaimard

Order POLYNEMIFORMES

Family POLYNEMIDAE

17. *Polydactylus indicus* (Shaw)

Order PERCIFORMES

Family LATIDAE

18. *Lates calcarifer* (Bloch)

Family AMBASSIDAE

19. *Ambassis interrupta* Bleeker

Family SERRANIDAE

20. *Epinephelus chlorostigma* (Valenciennes)
21. *Epinephelus merra* Bloch
22. *Epinephelus tauvina* (Forskål)
23. *Epinephelus undulosus* (Quoy and Gaimard)

Family THERAPONIDAE

24. *Therapon jarbua* (Forskål)
25. *Autisthes puta* (Cuvier)
26. *Pelates quadrilineatus* (Bloch)

Family APOGONIDAE

27. *Apogon frenatus* Valenciennes
28. *Archamia lineolata* (Cuvier)
29. *Ostorhynchus endekataenia* (Bleeker)

Family SILLAGINIDAE

30. *Sillago sihama* (Forskål)

Family CARANGIDAE

31. *Alectis indicus* (Rüppell)
32. *Carangoides malabaricus* (Schneider)

Family LUTIANIDAE

33. *Lutianus johnii* (Bloch)

Family LIOGNATHIDAE

34. *Gazza minuta* (Bloch)
35. *Gerres abbreviatus* Bleeker
36. *Leiognathus bindus* (Valenciennes)
37. *Leiognathus blochii* (Valenciennes)
38. *Leiognathus dussumieri* (Valenciennes)
39. *Leiognathus equulus* (Forsk.)
40. *Leiognathus lineolatus* (Valenciennes)
41. *Leiognathus splendens* (Cuvier)
42. *Secutor ruconius* (Hamilton)

Family SCOLOPSIDAE

43. *Scolopsis leucotaenia* (Bleeker)

Family SCIAENIDAE

44. *Johnius belengerii* (Cuvier)
45. *Johnius dussumieri* (Cuvier)
46. *Johnius carutta* Bloch
47. *Johnius* sp.
48. *Umbrina dussumieri* Valenciennes
49. *Umbrina macroptera* Bleeker
50. *Wak axillaris* (Cuvier)
51. *Wak sina* (Cuvier)

Family SPARIDAE

52. *Rhabdosargus sarba* (Forsk.)

Family MULLIDAE

53. *Upeneus tragula* Richardson

Family LABRIDAE

54. *Anampses* sp.

Family BLENNIIDAE

55. *Blennius cristatus* Linnaeus
56. *Entomacrodus vermiculatus* (Valenciennes)

Family CLINIDAE

57. *Helcogramma indicus* sp. n.

Family CALLIONYMIDAE

58. *Callionymus lineatus* (Cuvier and Valenciennes)

Family TRICHIURIDAE

59. *Leputracanthus savala* (Cuvier)

- Family STROMATEIDAE
60. *Parastromateus niger* (Bloch)
- Family GOBIIDAE
61. *Acentrogobius cyanomos* (Bleeker)
- Family PERIOPHTHALMIDAE
62. *Boleophthalmus boddaerti* (Pallas)
- Family SCORPAENIDAE
63. *Apistus carinatus* (Bloch and Schneider)
64. *Parascorpaena bleekeri* (Day)
- Family SYNANCEIDAE
65. *Minous monodactylus* (Bloch and Schneider)
- Order PLEURONECTIFORMES
- Family BOTHIDAE
66. *Pseudorhombus arsius* (Hamilton)
- Family CYNOGLOSSIDAE
67. *Cynoglossus lingua* Hamilton
- Order TETRADONTIFORMES
- Family TRIACANTHIDAE
68. *Pseudotriacanthus strigilifer* (Cantor)
69. *Triacanthus biaculeatus* (Bloch)
70. *Triacanthus weberi* Chudhuri
- Family LAGOCEPHALIDAE
71. *Gastrophysus lunaris* (Bloch)
72. *Gastrophysus scleratus* (Gmelin)
73. *Lagocephalus inermis* (Schlegel)
74. *Troquigener oblongus* (Bloch)
- Family TETRAODONTIDAE
75. *Chelonodon patoca* (Hamilton)
- Order LOPHIIFORMES
- Family ANTENNARIIDAE
76. *Antennarius hispidus* (Bloch)

III—SYSTEMATIC ACCOUNT

Family AMBASSIDAE

Ambassis interrupta Bleeker

1852. *Ambassis interrupta* Bleeker, *Nat. Tijdschr. Ned.-Indie*, **3**, p. 696 (type loc: Ceram, Batavia, Java).
1875. *Ambassis interrupta*: Day, *Fish. India*, p. 53, pl. 15, fig. 5.

2 specimens, 48-58 mm. in standard length, Kovelong, 5.vii.66.
 D. VII.1.9; A. III.8; 1.25; Predorsal scales 12; Gill-rakers 6+1+25.

Mouth oblique, chin prominent. Maxilla reaches below front border of orbit. Supraorbital ridge with a posteriorly directed spine. Interoperculum with 13 serrations. Lateral line interrupted below 8th dorsal spine and continued a few scales further back along median line. Colour-in-alcohol-yellowish brown. Opercles, lateral median band on body and caudal silvery. Membrane between second and third dorsal spine dusky.

Remarks.—This species has previously been reported only from the Andamans, the East Indies and the Philippines. This is the first record of this species from the East coast of India.

Family APOGONIDAE

***Ostorhynchus endekataenia* (Bleeker)**

1852. *Apogon endekataenia* Bleeker (*nec.* Day), *Nat. Tijdschr. Ned.-Indie*, 3 p. 419 [type loc: Banka].

1 specimen, 84 mm. in standard length; Cape Comorin, 22.xii.64.

Remarks.—Though this species has a wide geographical range of distribution from the East coast of Africa through Ceylon, the Andamans to the East Indies, the Philippines, Australia and Tasmania, it was recorded only recently by us (Talwar & Sen, 1967) from the north-east coast of India.

Family SCIAENIDAE

***Johnius* sp.**

2 specimens, 37-64 mm. in standard length, 28.xii.64.

D.X.I. 28; A. II. 7; P. 17; Gill rakers 6+14.

Depth of body 0.9 in head length. Eye in anterior half of head. Preopercle crenulate; its angle rounded. Mouth terminal, lower jaw included with five symphyseal pores. Teeth villiform, outer row of upper jaw and inner row of lower jaw enlarged, not caninoid. Second anal spine strong, equals first anal ray. Gas bladder T-shaped of the otolithini-type.

Remarks.—It has not been possible to specifically determine these two specimens. They have the *Johnius* type of gas bladder but the strong second anal spine suggests relationships with *Nibea* or a genus allied to it.

***Umbrina dussumieri* Valenciennes**

1833. *Umbrina dussumieri* Valenciennes, *Hist. nat. Poiss.*, 5, p. 481 (type loc: Coromandel coast).

1876. *Umbrina dussumieri*: Day, *Fish. India*, p. 183, pl. 43, fig. 23.

1 specimen, 69 mm. in standard length, Thondi, 13.i.65.

Remarks.—The generic position of this barbel bearing species is still uncertain. Chu, Lo and Wu (1963) gave no generic importance to the mental barbel and hence accommodated this species in *Johnius*. Since there was already a *Johnius dussumieri* (without a barbel), Chu *et. al* (*l.c.*) used the synonym *Johnius amblycephalus* for the barbel bearing species. Trewavas (1964) accommodated this species in *Dendrophysa* but subsequently (1965) restricted *Dendrophysa* to its

type species, *D. russelli* (Cuvier) only. The generic relationship of this species is under study.

Umbrina macroptera Bleeker

1853. *Umbrina macropterus* Bleeker, *Nat. Tijdschr. Ned.-Indie*, **4**, p. 254 (type loc: Sumatra).
 1876. *Umbrina macroptera*: Day, *Fish. India*, p. 182.

1 specimen, 80 mm. in standard length, Madras, 5.xi.66.

Remarks.—The generic position of this barbel bearing species is also uncertain. Trewavas (1964) accommodated it in *Dendrophysa* but subsequently separated it out since *D. macroptera* has a gas bladder similar to *Johnius* and suggested that the species should be accommodated in *Johnius* or a genus closely allied to it. The genus *Johnius* as is now understood is used to include species without a barbel. A new genus would probably have to be erected to accommodate *U. dussumieri* and *U. macroptera*. Further studies are in progress.

Wak axillaris (Cuvier)

1830. *Corvina axillaris* Cuvier, *Hist. nat. Poiss.*, **5**, p. 113 (type loc: Malabar coast).
 1876. *Sciaena axillaris*: Day, *Fish. India*, p. 188, pl. 43, fig. 6.
 1963. *Wak axillaris*: Chu, Lo & Wu, *Fish. China*, p. 33.

3 specimens, 30-46 mm. in standard length, Tuticorin, 27.xii.64.

5 specimens, 72-98 mm. in standard length, Madras, 5.xi.66.

Remarks.—This species has a gas bladder of the pseudotolithine type. The genera to which this species was earlier assigned have either the otolithine or sciaenine type of gas bladder. Studies on the generic position of this species are in progress and the results will be published elsewhere.

Family CLINIDAE

Helcogramma indicus sp. n.

[Text-fig. 1]

Description.—Dorsal III. XIII. 9-10; height of first dorsal spine three fourths in first spine of second dorsal; first dorsal originates above hind border of preopercle.

Anal I. 17; origin below 7th spine of second dorsal.

Pectoral 15-16, the upper 9 rays divided, the lower 6-7 rays simple. Pelvic 2; jugular, inner ray the longer; rays bound together at their base by a membrane.

Scales in the lateral series 33-34, composed of both pored and unpored scales; lateral line separated from base of second dorsal fin by six scales.

Gill rakers on first gill arch (one paratype examined) 5 short stumps; gill filaments about $\frac{1}{2}$ eye diameter. Gill membranes united but free from isthmus.

Depth of body 21.15-23.07; head length 30.76-32.85; postorbital length of head 12.85-15.38; snout length 8.19-10.00; length of maxilla 11.42-11.53; length of pectoral fin 33.33-36.53; length of pelvic fin

21.79-22.85; length of second dorsal fin base 30.76-34.28; length of third dorsal fin base 20.51-23.07; length of anal fin base 37.17-40.98; length of first dorsal spine 12.82-15.38; length of third spine of second dorsal 14.28-17.30; all in percent of standard length. Eye diameter 29.16-30.43, postorbital length 39.13-50.0; snout length 25.0-31.25; length of first dorsal spine 39.13-50.0; all in percent of head length.

Mouth slightly oblique, large; maxilla extending upto midpoint of eye; interorbital space narrow, about $\frac{1}{2}$ eye diameter. Short lobate tentacle above orbit and nostril. Lateral line concavely curved downward behind pectoral fin thence continuing along mid-lengthwise axis of body. Caudal rounded. Teeth conical, arranged in bands, outer most row in both jaws slightly enlarged; vomer with a V-shaped patch of minute teeth; a small patch of teeth at head of palatine. Scales — otenoid; absent on head, nape and pectoral base. Colour-in-alcohol — reddish brown with 5-6 indistinct cross bars; each scale outlined with dark pigment spots. Pectorals with five cross bands; first dorsal dusky, the other vertical fins with 2-3 rows of brown spots. Orbital tentacle black, nasal tentacle pale. Pectoral with a dark ocellus.

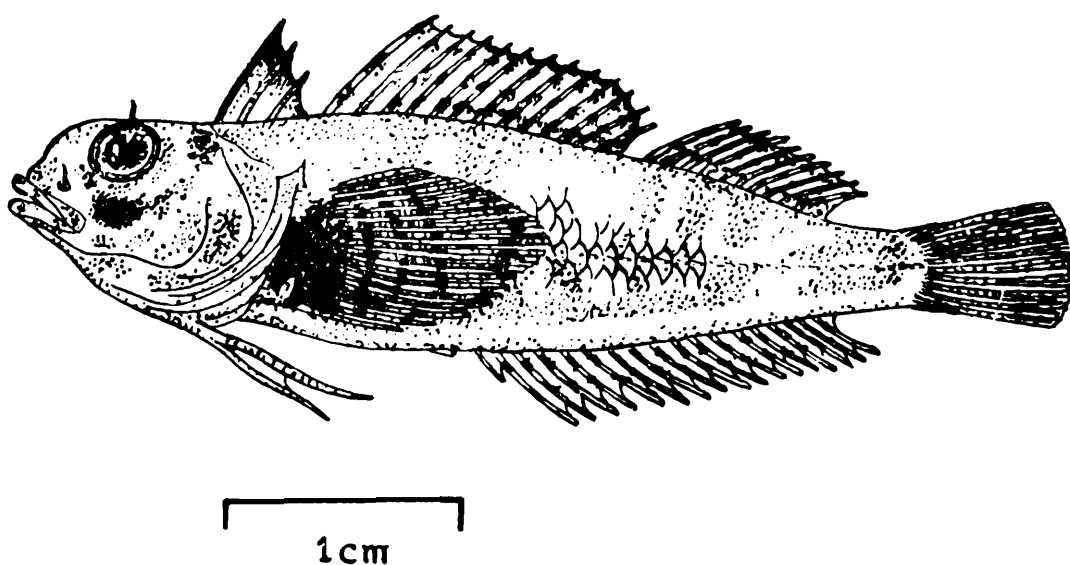
Material.—Holotype: 39 mm. in standard length; Cape Comorin (Tamil Nadu, South India); Southern Regional Station of the Zoological Survey of India; 22.xii.64. Deposited Zoological Survey of India, F. 6074/2. Paratypes: Three specimens, 26.0, 30.5 and 35.0 mm. in standard length; Reg. No. F. 6075/2, other data as the holotype.

Measurements (in mms.) and Meristic Counts

	<i>Holotype</i>		<i>Paratypes</i>	
		1	2	3
Pelvic fin length	8.5	8.0	6.5	5.5
Total length	47.0	43.0	36.5	31.5
Standard length	39.0	35.0	30.5	26.0
Body depth	9.0	8.0	6.5	5.5
Head length	12.0	11.5	10.0	8.0
Postorbital length	5.5	4.5	4.0	4.0
Snout length	3.5	3.5	2.5	2.5
Maxilla length	4.5	4.0	3.5	3.0
Eye diameter	3.5	3.5	3.0	2.5
Pectoral fin length	13.0	12.5	11.0	9.5
Pelvic fin length	8.5	8.0	6.5	5.5
Dorsal fin	III.XIII.10	III.XIII.9	III.XIII.9	III.XIII.10
Anal fin	I.17	I.17	I.17	I.17
Pectoral fin	9+7	9+7	9+7	9+7
I. l. scales	34	33	34	34

Remarks.—The new clinid is referable to the genus *Helcogramma* McCulloch and Waite, 1918 as redefined by Schultz (1960). This genus is usually referred to the family Clinidae but sometimes separated from it and grouped in the family Tripterygiidae.

Helcogramma indicus sp. n. agrees well with Day's (1876) description of *Tripterygium trigloides* (Bleeker). Day (l.c.) based his account on a drawing from Sir Walter Elliot's collection of fishes from the Waltair coast. Weber (1913) and Herre (1953) were uncertain about the systematic status of Day's *trigloides*. Though Day's description is brief, it appears to be the present new species.



Text-fig. 1. *Helcogramma indicus* Talwar and Sen.
— Sketch of the holotype.

The new species is most closely related to *Helcogramma trigloides* (Bleeker) and *Helcogramma obtusirostre* (Klunzinger). The three species have the first dorsal with three spines, and scales are absent on head, breast and pectoral fin base. The new species differs from *H. trigloides* (Blkr.) and *H. obtusirostre* (Klunz.) in having lesser number of scales in the lateral series (33-34 vs 36-55) and in having an orbital and nasal tentacle. Further, the head of *H. obtusirostre* (Klunz.) is completely covered with small black specks. This is the fourth record of a representative of the Clinidae from Indian waters, the species recorded earlier are: *Paracristiceps filifer* (Steindachner), *Tripterygion fasciatum* Weber and *Cristiceps helei* Day.

Family TRIACANTHIDAE

Triacanthus weberi Chaudhuri

1910. *Triacanthus weberi* Chaudhuri, J. & *Proc. Asiat. Soc. Bengal* **6** (9), p. 497, fig. 1 (type loc: Bay of Bengal).

1 specimen, 130 mm. in standard length, Cape Comorin, 22.xii.64.
D V. 22 ; A 19 ; P 13 ; C 14.

Depth of body slightly more than the length of head and both about 3.0 in standard length. Eye diameter 3.2 in head length, equals interorbital width. Eight incisors in each jaw, the lower slightly prominent and prolonged.

Remarks.—This specimen agrees well with the syntypes of this species. Chaudhuri (1910) described the species on the basis of 11 specimens from the Arakan coast, mouth of the Hooghly river and the Orissa coast. Subsequent to the original discovery, this is the first report of this species and the present record extends its distribution to the south-east coast of India.

IV—SUMMARY

This paper is based on a collection of fishes from the south-east coast of India. Although small, the collection is interesting, as it

includes a hitherto undescribed species of the family Clinidae. Most of the species in the collection have a wide distribution and need no special remarks. Such species as *Ambassis interrupta* Bleeker, *Ostorhynchus endekataenia* (Bleeker) and *Triacanthus weberi* Chaudhuri, which have not been recorded earlier from the Madras coast, are noteworthy. A detailed description of *Helcogramma indicus* sp. n. is given in the paper.

V—ACKNOWLEDGEMENTS

The authors are thankful to Dr. A. P. Kapur, Director, for his sustained encouragement during the course of this study and to Dr. A. G. K. Menon, Superintending Zoologist, Zoological Survey of India for kindly going the manuscript critically.

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EMBRYOLOGY OF THE RED COTTON BUG *DYSDERCUS*
CINGULATUS (FABRICIUS) (PYRRHOCORIDAE:
HETEROPTERA: INSECTA) III—ORGANOGENY*

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I—INTRODUCTION

The following is a further account of the embryology of *Dysdercus cingulatus* (Fabricius) dealing with development from the time of germ layer formation, to the time those germ layers become differentiated into the Digestive system, Excretory system, Tracheal system and the Nervous system found in the first instar of the bug.

II—THE DIGESTIVE SYSTEM

The development of the alimentary canal begins with the formation of a stomodaeal invagination in the anterior region of the embryo at the 40th hour of incubation. The stomodaeal invagination gives rise to the pharynx, oesophagus and crop. The proctodaeal invagination follows about 6 hours later in the posterior region and gives rise to the hind-gut and the Malpighian tubules. The Malpighian tubules arise as evaginations from the blind anterior end of the proctodaeum. The alimentary canal of a fully formed embryo of *Dysdercus cingulatus* consists of (a) fore-gut, (b) mid-gut, and (c) hind-gut.

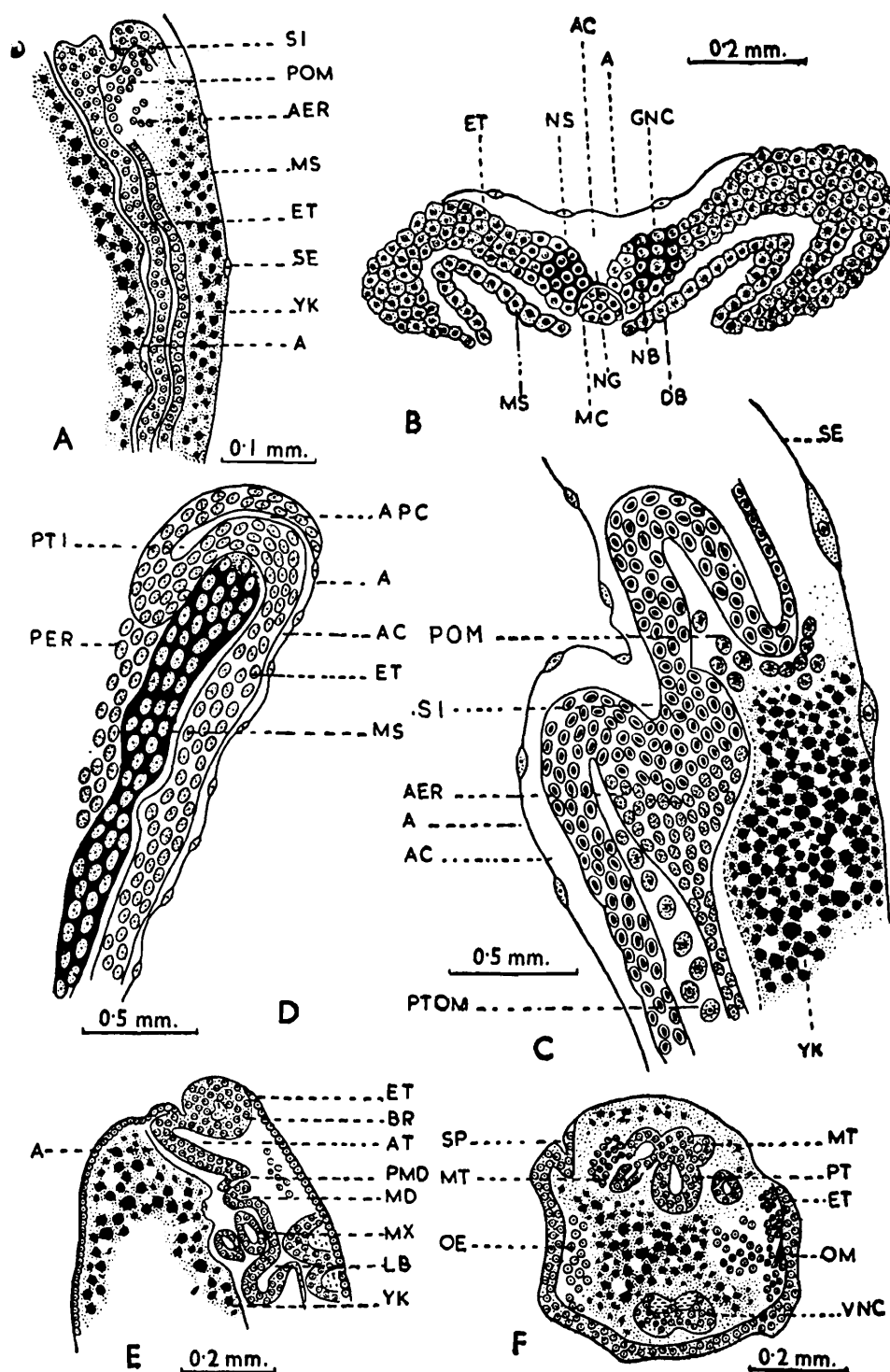
(a) *The Fore-Gut*: The ectodermal invagination to form the stomodaeum is the beginning of the fore-gut formation. It appears as a shallow ectodermal depression on the antero-ventral surface (Text-fig. 1, A, SI). This depression gradually deepens and comes to occupy a position between the mesodermal layer and the outer most serosa (Text-fig. 1, C, SI). Its external opening marks the position of the future mouth. A discontinuous layer of mesoderm extends all along the outer surface of the germ band, and a group of mesodermal cells are found lying immediately posterior to the stomodaeal invagination (Text-fig. 1, A, AER).

At first, the lumen of the stomodaeum is a shallow pit (Text-fig. 1, A, SI) which becomes gradually deeper and gets narrower after some-time. It thus assumes the form of an elongated blind tube (Text-fig. 4, A). Its wall is composed of densely packed columnar cells.

As the stomodaeal invagination deepens some of the mesodermal cells, present at the posteriorly growing blind end are pushed laterally into the cavity of the antenna, while others that still remain there separate from the posterior mesodermal layer, and form the anterior endoderm rudiment of the midgut (Text-fig. 1, A, SI, AER). The displaced mesodermal cells which were pushed into the cavity of the antenna by the deepening of the stomodaeum constitute the pré-oral mass of mesoderm (Text-fig. 1, A, C, POM).

*Part 2 of this series appeared in *Proc. Zool. Soc., Calcutta*, **23**: 119-137 (1970).

***Contribution No. 145 from the School of Entomology, St. John's College, Agra.
Rec. Zool. Surv. India, **65** (1-4) [1967] 1971.

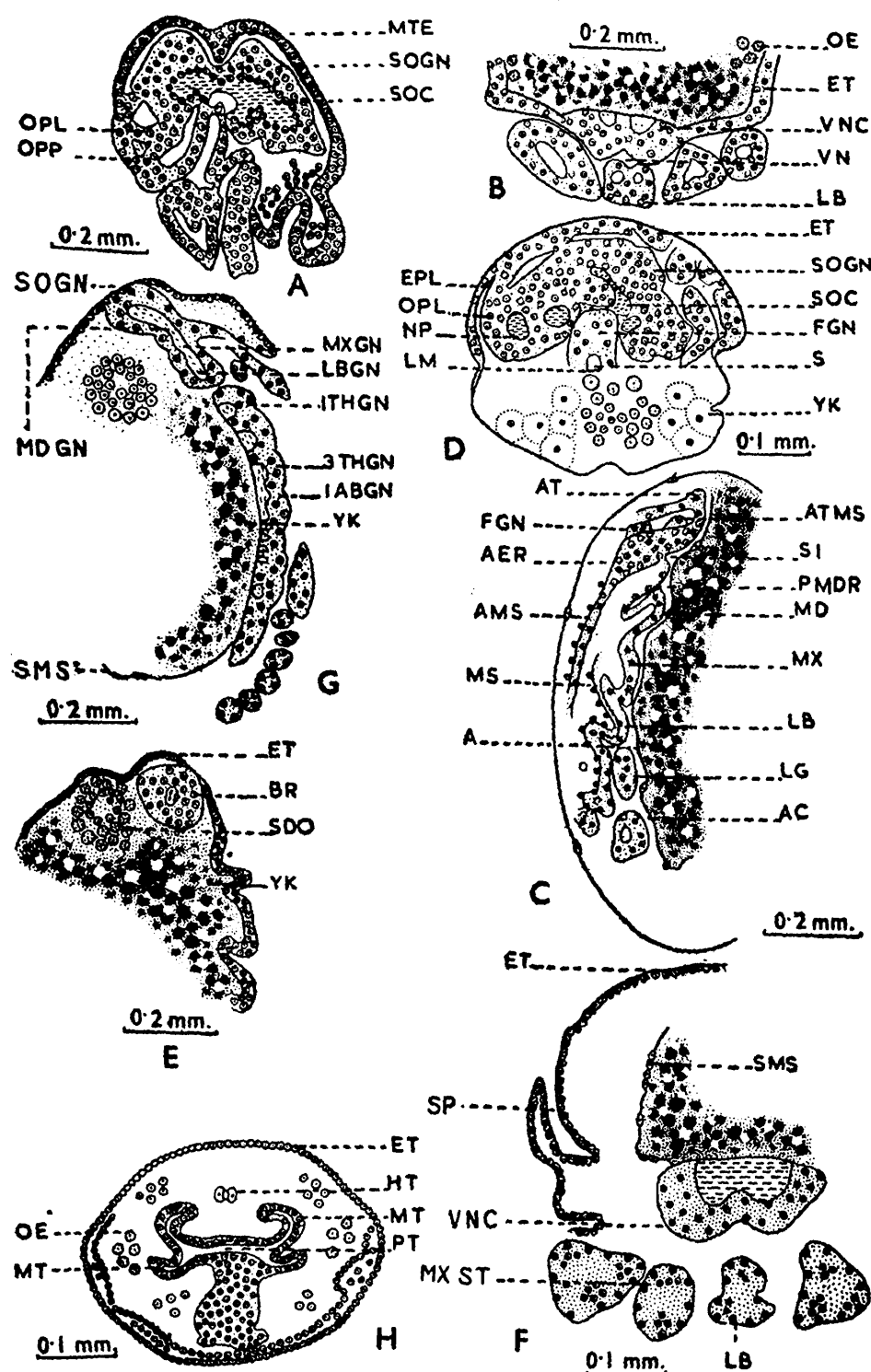


TEXT-FIG. 1. Organogeny of *Dysdercus cingulatus* (Fabr.)

- Fig. A. L. S. of an egg of 40 hours, showing the stomodaeal invagination and the scattered mesodermal cells in front of it.
 Fig. B. T. S. of an egg of 44 hours through the middle region showing the differentiation of neuroblasts and the formation of nerve swellings.
 Fig. C. L. S. of an egg of 44 hours through the anterior end.
 Fig. D. L. S. of an egg of 46 hours through the posterior end.
 Fig. E. L. S. of an egg of 56 hours through the anterior end.
 Fig. F. T. S. of an egg of 68 hours through the posterior end.

A little later, at the 44th hour of development the mass of cells that remained in front of the stomodaeum (anterior endoderm rudiment) becomes so closely associated with the stomodaeal invagination that it seems as if the anterior endodermal component is being proliferated from the stomodaeal invagination itself (*i.e.* from the ectoderm),

(Text-fig. 1, C, SI, AER). The anterior mid-gut rudiment extends out in the form of two narrow strands as far as the labial segment at the 68th hour of development (Text-fig. 2, C, AER, AMS).



TEXT-FIG. 2. Organogeny of *Dysdercus cingulatus* (Fabr.)

- Fig. A. T. S. of an egg of 68 hours through the anterior end.
 Fig. B. T. S. of an egg of 68 hours through the middle region to show the ventral notch.
 Fig. C. L. S. of an egg of 68 hours showing the anterior mid-gut strands.
 Fig. D. T. S. of an egg of 72 hours through the anterior end.
 Fig. E. L. S. of an egg of 76 hours through the anterior end.
 Fig. F. T. S. of an egg of 76 hours showing deepening of the spiracle into an elongated blind tube.
 Fig. G. L. S. of an egg of 76 hours showing the supra oesophageal ganglion, and the mandibular, maxillary and labial ganglion.
 Fig. H. T. S. of an egg of 80 hours through rectal region.

As the development of the embryo advances, the stomodaeum elongates and assumes the form of a definite channel, which after 100 hours of development is distinguishable into an anterior sac like pharynx, and a posterior narrow tubular oesophagus (Text-fig. 3, D, PH, O). After another 8 hours of development this tube further elongates and gets distended at its blind end to form the crop (Text-fig. 4, A, CR). It is worthwhile to note here that on the dorsal wall of the pharynx is present a group of small irregular cells which presumably give rise to the stomatogastric nervous system later (Text-fig. 2, C, FGN). The distal wall of the dilated crop thins down to a single layered, almost membranous wall called the limiting membrane. It forms a sort of partition between the cavity of the stomodaeum and the endodermal component of the mid-gut (Text-fig. 4, A, LM).

Thus the fore gut forms a definite channel after five days of development. It extends backwards between the supra and the sub-oesophageal ganglion. The fore gut remains short until blastokinesis is completed, after which its length rapidly increases and it grows in the anterior direction.

The stomodaeal musculature is derived from the preoral and partly also from the post-oral masses of mesoderm (Text-fig. I, C, POM, PTOM).

(b) *The Mid-gut*: The development of the mid gut can conveniently be studied by dividing the entire mid gut into an (i) anterior mid gut, and (ii) posterior mid gut.

(i) *The anterior mid-gut*: The anterior mid-gut rudiment arises as a mass of proliferating cells at the blind end of the stomodaeum after about 42 hours of development. As stated before, this mass of cells is derived from the anterior most cells of the inner layer, lying just in front of the blind end of the stomodaeal invagination. This group of cells becomes heaped up just in front of the stomodaeal invagination and forms a rounded swelling (Text-fig. 1, C, AER). These cells (of the anterior mid-gut rudiment) spread over the stomodaeum and become almost confluent with it, so much so, that they are almost indistinguishable from the ectodermal cells of the stomodaeum. At a slightly later stage, the anterior endoderm rudiment extends a little further posteriorly in the form of two thin ribbons. Mellanby (1936) in *Rhodnius prolixus* Stal and Butt (1949) in *Oncopeltus fasciatus* Doll and Seidel (1924) in *Pyrrhocoris apterus* Linn., have also recorded that the anterior mid-gut rudiment arises in the form of a mass of proliferating cells from the mesodermal layer. As development proceeds, the anterior endoderm rudiment (the mid gut rudiment) extends further to the posterior side. A thin layer of mesoderm intervenes between the rapidly growing anterior mesenteron and the germ band.

(ii) *The posterior mid-gut*: The posterior mid-gut rudiment arises at the 46th hour of development in the same way as the anterior one (Text-fig. 1, D, PER), i.e., from the posterior portion of the mesodermal layer, which becomes so closely associated with the proctodaeal invagination, that it seems as the posterior mid gut rudiment is being proliferated from the ectodermal cells of the proctodaeum.

A very thick layer of mesoderm lies between the proctodaeal invagination and the germ band but it loses connection with the posterior mid-gut rudiment, which in its turn grows anteriorly separately (Text-fig. 1, D, MS).

After 108 hours of development the anterior mid-gut strands grow posteriorly over the yolk and become invested externally by the splanchnic layer of mesoderm (Text-fig. 4, A, & 5, F, AMS, SMS). Similarly the posterior mid-gut strands also grow over the yolk towards the anterior side and come to lie in apposition to the outer splanchnic mesodermal layer (Text-fig. 4, B, PMS, SMS). Both the anterior and the posterior mesenteron strands growing towards each other over the yolk ultimately meet one another and become fused after about 116 hours of development, thereby enclosing the yolk from all sides (Text-fig. 5, A, MG, MGE). The two anterior and posterior mid-gut ribbons, whose cells were rather loosely arranged now form a compact epithelium, thus giving rise to a simple mid-gut. The mid-gut cells become enlarged and are recognized by their hyaline cytoplasm and a distinct nucleus.

In some cases as in *Melanoplus differentialis* Thomas, (Stuart, 1935) the yolk cells take part in the formation of the mid gut.

In *D. cingulatus*, though the primary yolk cells have been observed in the middle of the egg, in the early stages of development, they have not been observed to take part in the formation of the mid gut epithelium. They disappear at an early stage of development. The anterior and the posterior endoderm rudiments in this case arise from the anterior and posterior ends of the inner layer (mesoderm) respectively. The anterior and posterior mass of mesodermal cells become associated with the stomodaeum and proctodaeum respectively and form the anterior and posterior mid-gut (endoderm) rudiments. Hence the mode of formation of mid-gut in *D. cingulatus* is similar to that described by Seidel (1924) for *Pyrrhocoris apterus*, Mellanby (1936) for *Rhodnius prolixus* and Butt (1949) for *Oncopeltus fasciatus*. It is thus concluded that the anterior and posterior mid gut rudiments are mesodermal in origin in the case of *D. cingulatus*.

(c) *The Hind-Gut*: It arises as an ectodermal invagination at the posterior end of the germ band, at the 46th hour of development. It develops six hours after the formation of the stomodaeal invagination. The proctodaeal invagination elongates along the outer surface of the germ band towards the side of serosa (Text-fig. 1, D, PTI). It is known that in insects in general, the stomodaeal formation precedes the proctodaeal development as is the case in *D. cingulatus*, but Sehl (1931) in *Ephestia* and Farooqi (1963) in *Athalia proxima* Klug, record the reverse condition.

A mass of cells is present just in front of the blind end of the proctodaeal invagination. This represents the posterior mesenteron rudiment of the mid-gut (Text-fig. 1, D, PER), and is derived from the cells of the inner layer (mesoderm). The posterior endoderm rudiment becomes attached to the blind end of the invaginating proctodaeum and it appears that the ectodermal cells of the blind end of the proctodaeum are giving rise to the posterior mid-gut rudiment. The wall of the blind end forms a partition between the cavity of the proctodaeum and the component of the mid-gut.

At this stage, the lumen of the proctodaeal invagination is in direct continuation with the amniotic cavity (Text-fig. 1, D). In fact the dorsal wall of the proctodaeal invagination is continuous with the amnion itself (Text-fig. 1, D, APC). Thus the cavity enclosed posteriorly between the amnion and the germ band is known as the amnio-proctodaeal cavity, which in course of time will give rise to the proctodaeum proper.

The proctodaeum after the completion of the blastokinesis differentiates into a pyriform rectum, which communicates with the exterior through a small opening representing the future anal aperture.

The early development of the proctodaeum in *D. cingulatus* is very similar to that recorded in *Oncopeltus fasciatus*, by Butt (1949) and in *Pyrilla perpusilla* Walker by Sander (1956). In all the above mentioned cases the dorsal wall of the proctodaeum is amniotic in origin while the ventral wall is formed by the germ band. The musculature of the proctodaeum is derived from the dense mesodermal layer which lies in the last abdominal segment between the proctodaeum and the germ band (Text-fig. 1, D, MS). These cells spread over the walls of the growing proctodaeum and envelope it along its whole length.

The ectodermal wall between the proctodaeal lumen and the mid-gut ruptures only when the embryo is about to hatch. The partition between the stomodaeum and the mid-gut also ruptures at about the same time, thereby establishing a communication between the fore-gut and the hind gut through the mid-gut.

III—THE EXCRETORY SYSTEM

The Development of Malpighian Tubules: The Malpighian tubules arise as hollow ectodermal outgrowths from the blind end of the proctodaeum at the 68th hour of development (Text-fig. 1, F, MT). There are two pairs of Malpighian tubules in *Dysdercus cingulatus*. At the 80th hour of development, they elongate considerably and appear as long narrow tubes. All of them open by a separate opening into the lumen of the proctodaeum (Text-fig. 2, H, MT). Each tubule pushes its way into the mesoderm surrounding the proctodaeum, which later on forms a thin envelope round each tubule.

In origin, the Malpighian tubules are ectodermal, for they arise as outgrowths of the proctodaeal wall, far back from the posterior mesodermal component of the mid-gut. Their ectodermal origin is confirmed by the presence of a thin ectodermal septum at the blind end of the proctodaeum, which separates their places of origin from the anteriorly lying mesodermal component. Mellanby (1936) in *Rhodnius prolixus* states that the Malpighian tubules arise from the proctodaeum close to its blind end, and that they appear to be ectodermal structures. The ectodermal origin of the Malpighian tubules has been recorded in other groups of insects by Carriere and Burger (1897) in *Chalicodoma muraria* Ratz, Wheeler (1889) in *Leptinotarsa decemlineata*, and by Nelson (1915) in *Apis* (Hymenoptera).

According to Henson (1932) in *Pieris brassicae* Linnaeus, the functional parts of the tubule are derived from the endoderm. Srivastava and Bahadur (1961) while describing the development of the Malpighian tubules in *Dysdercus koenigii* consider Henson's view

to be highly probable. In *D. cingulatus* no evidence has been found to substantiate the endodermal origin of the Malpighian tubules.

IV—THE TRACHEAL SYSTEM

The tracheal system of *Dysdercus cingulatus* consists of the spiracles, the spiracular invaginations and the tracheae. It first makes its appearance in the 56th hour stage as eleven pairs of ectodermal invaginations which mark the position of the spiracles. The paired invaginations arise before the process of blastokinesis has been completed, even before the development of the appendages is well advanced.

Out of the eleven pairs of spiracles the first three belong to the pro, meso and meta-thoracic segments (Text-fig. 3, G, SP. 1, SP. 2, SP. 3 and 4, F, 1THSP, 2THSP, 3THSP) and the rest eight to the first eight abdominal segments. According to Singh (1923) in the females of *Dysdercus cingulatus*, there is, in addition, one degenerate spiracle on the ninth abdominal segment which loses its connection with the trachea in the later stages and thus becomes closed. Hence, in both the sexes, there are no spiracular openings on the last two abdominal segments. The observation of Singh (1923) with regard to the presence of a spiracle on the 9th abdominal segment in the female, gets no support from the present embryological studies.

It has been noted that a little before the hatching of the insect, the prothoracic spiracle closes. Thus there are only ten pairs of functional spiracles in the first larval instar, which are retained in the adult insect also. Mellanby (1936) has observed three pairs of thoracic and eight pairs of abdominal spiracles in *Rhodnius prolixus*. She states that all these persist except the eighth abdominal, which soon closes.

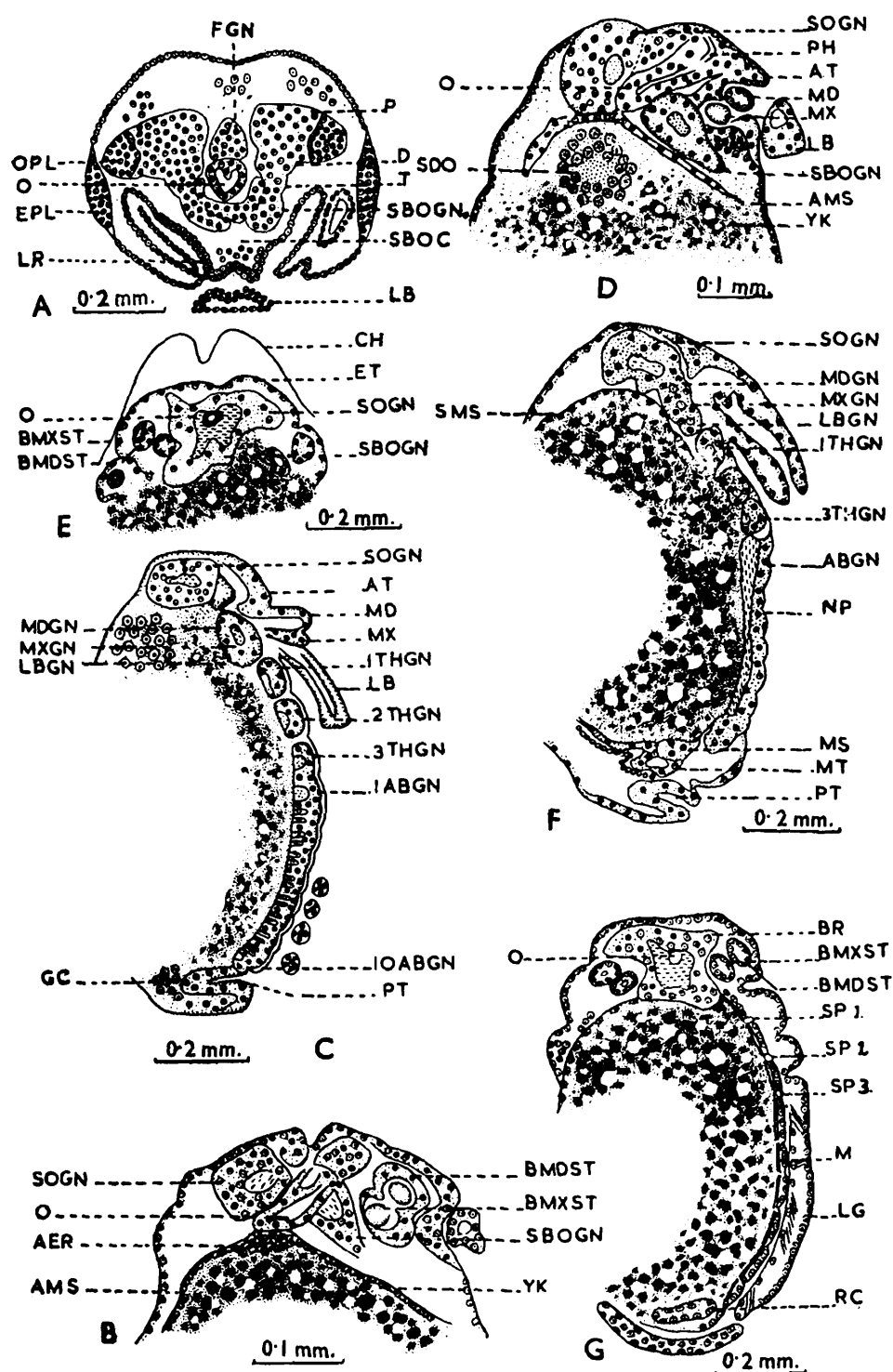
As already described in *D. cingulatus*, the first pair of thoracic spiracles close a little before the egg hatches. Thus out of the ten remaining pairs of spiracles, the first two pairs belong to the thorax and the rest, to the first eight abdominal segments.

It is interesting to note that during the later stages of development an anterior shifting of the thoracic spiracles occurs, as a result of which the mesothoracic spiracle comes to occupy a position between the pro- and the mesothoracic segment and the metathoracic spiracle moves forward to occupy a position between the meso- and metathoracic segment.

According to Singh (1923) in the adult insect, the thoracic spiracles are situated between the pro- and meso-thorax and between the latter and the metathorax. Grove (1909) and Davidson (1913) believe that the first pair of thoracic spiracles belong to the prothorax, while Murray (1914) and Savage (1914) state that they belong to the mesothoracic segment. During the course of the present investigations it has been observed that the first pair of functional spiracles belong to the mesothorax and the second to the metathorax.

A pair of abdominal spiracles are present near the anterodorsal corner of the first eight abdominal segments (Text-fig. 1, F).

As the embryo grows older, the spiracular invaginations which arose as slight ectodermal inpushings deepen to form a small blind elongated tube (Text-fig. 2, F). From the blind end of the



TEXT-FIG. 3. Organogeny of *Dysdercus cingulatus* (Fabr.)

Fig. A. T. S. of an egg of 80 hours through the anterior end.

Fig. B. L. S. of an egg of 84 hours through the anterior end.

Fig. C. L. S. of an egg of 88 hours showing the complete nervous system and the proctodaeal invagination at the posterior end.

Fig. D. L. S. of an egg of 100 hours through the anterior end.

Fig. E. T. S. of an egg of 100 hours through brain.

Fig. F. L. S. of an egg of 100 hours showing the fusion of abdominal ganglia.

Fig. G. F. S. of an egg of 104 hours showing the pro-, meso- and meta-thoracic spiracles.

spiracular tube, arise two well defined trachea simultaneously, one of which is directed towards the anterior end and the other towards the posterior end at the 116th hour of development (Text-fig. 5, C,

ANTR, PTR). The two longitudinal lateral tracheal trunks which run throughout the length of the body are connected to each other by ventral transverse tracheal commissures passing below the ventral nerve cord (Text-fig. 5, D, TTR). The author, therefore, believes that immediately after their origin from either side the ventral commissures give off small branches towards the dorso-anterior and ventro-posterior direction. The former branches ramify profusely over the viscera without forming a commissure and constitute the dorsal tracheal system, whereas the latter branches ramify below the viscera to form the ventral tracheal system.

The external opening of the spiracular invaginations which were earlier very wide, become reduced to narrow clefts. The head and the prothorax presumably receive their tracheal supply from the anterior branch of the first thoracic spiracle, while the posterior branch joins the longitudinal trunk.

V—THE NERVOUS SYSTEM

The nervous system begins to make its appearance at the 44th hour of development. The brain and the nerve cord are ectodermal in origin and develop from specialized ectodermal cells known as the neuroblasts. The neuroblasts become recognizable at an early stage of development, even before the segmentation of the germ band is initiated. They are differentiated on either side of the median portion of the germ band throughout its length (Text-fig. 1, B, NB) and are easily distinguished from the rest of the ectodermal cells, (known as the dermatoblasts) by their large size, a massive nucleus and a comparatively faintly stained cytoplasm.

(A) *The Ventral Nerve Cord:*

After 44 hours of development, before the neuroblasts are completely segregated, an invagination appears along the entire mid-ventral longitudinal line of the germ band. This invagination deepens to form the neural groove (Text-fig. 1, B, NG). Simultaneously, the neuroblasts multiply, as a result of which, two rows of swellings appear, one on either side of the neural groove. These are known as the neural swellings and follow a segmental arrangement (Text-fig. 1, B, NS). The neural swellings will form the segmental ganglia of the nerve cord later on. Thus, two parallel chains of nerve swellings result along the entire length of the embryo. The wedge shaped area which lies in between the neural swellings forms the median cord.

The ectodermal cells (dermatoblasts) which are situated beneath the neuroblasts, become crowded together and arrange themselves to form an outer layer, the dermatogen (Text-fig. 1, B, DB). Unlike the cells of the lateral cords, those of the median cord are not covered externally by the dermatoblasts. The cells of the median cord are narrow and columnar (Text-fig. 1, B, MC).

It has been observed that the neural swellings arise from 3 to 4 neuroblasts which become differentiated on either side of the neural groove. The neuroblasts now divide repeatedly to form a mass of daughter cells known as the ganglion cells (Text-fig. 1, B, GNC). The neuroblasts stop dividing further and the ganglion cells become

compact, and condense to form the ganglia. The ultimate fate of the parent neuroblasts is not known.

The median cord, as described before, is placed like a wedge between the two lateral cords (Text-fig. 1, B, MC). The neurogenic cells of the median cord are distinguished from the other nerve cells by their larger size and paler cytoplasm. The cells of the median cord take part in the formation of the nerve ganglion in combination with the segmental swellings of the two lateral cords.

The cells of the median cord give off fine fibres which form the transverse commissures. These fibres unite with the ganglionic fibres from the ganglion cells and thus establish a connection between the two members of the same segmental ganglionic pair.

As growth progresses the two lateral cords unite medially, leaving a temporary notch on the ventral side (Text-fig. 2, B, VN), which soon disappears, with the growth of the nervous tissue. During the subsequent development, the nerve cords become separated from the underlying ectoderm. The ganglia of the same segment fuse together to give rise to the segmental ganglion. In the intersegmental regions the two ventrally running lateral cords come in close approximation to one another, but can be easily distinguished from each other. These form the paired longitudinal connectives between the succeeding and the preceding ganglion. The transverse commissures between the ganglia of each pair become obliterated due to the consolidation of the two ganglionic halves but the line of fusion can still be observed. The paired lateral nerves arise from the lateral portion of the ganglia. At the side of the developing nerves, the ganglion cells produce fine fibres which become continuous with the fibre region of the ganglia on the one side and form the lateral nerve on the other (Text-fig. 5, B, LN).

In an 88 hour old embryo the nervous system of *D. cingulatus* consists of the supra-oesophageal ganglion, three gnathal, three thoracic and ten abdominal ganglia (Text-fig. 3, C SOGN, MDGN, MXGN, LBGN, 1THGN, 2THGN, 3THGN, 1ABGN, 10ABGN). It is interesting to note that in the adult *D. cingulatus*, the nervous system consists of a cerebral ganglia (supra-oesophageal ganglion), a suboesophageal ganglion and two thoracic ganglionic masses and the ventral nerve cord devoid of any abdominal ganglia. The presence of 10 abdominal ganglia and three thoracic ganglia during early embryonic stages, as mentioned above, gives an indication of the massive consolidation of the ganglia that has resulted in the adult condition. The triganglionic origin of the sub-oesophageal ganglionic mass (three gnathal ganglia) representing the mandibular, maxillary and labial ganglia, can be observed even at the 100th hour of development (Text-fig. 3, F, MDGN, MXGN, LBGN). The three gnathal ganglia later fuse to form the sub-oesophageal ganglionic mass. (Text-fig. 4, C, SBOGN).

At a slightly later stage of development, signs of fusion become evident. The first abdominal ganglion fuses with the third thoracic ganglion which is followed by the establishment of continuity of the neuropiles of the first three abdominal ganglia, which marks the first step towards the consolidation of abdominal ganglia (Text-fig. 2, G, 3THGN, 1, ABGN). At the 100th hour of development the neuropiles of all the abdominal ganglia become continuous (Text-fig. 3,

F, ABGN, NP), which gives the indication of fusion of all the abdominal ganglia.

Concentration of abdominal and thoracic ganglia occurs between 100 and 108 hours of development (Text-fig. 4, A). The abdominal part of the ventral nerve cord is pulled up into the thorax, which results in the complete absence of abdominal ganglia in the adult. In an 108 hour old embryo the nervous system consists of the supra-oesophageal ganglion, sub-oesophageal ganglion (Text-fig. 4, A, SOGN, SBOGN) and two thoracic ganglia (Text-fig. 4, A, 1THGN, 2THGN). Of the two thoracic ganglionic masses, the first belongs to the prothorax while the second represents the complex of meso, and metathoracic ganglionic masses with which have become fused the embryonic abdominal ganglia (Text-fig. 4, A).

Thus, at the time of hatching, the nervous system consists of a supra-oesophageal ganglion, a sub-oesophageal ganglion, two thoracic ganglionic masses and a ventral nerve cord which extends up to the posterior end of the abdomen.

(B) *The Brain :*

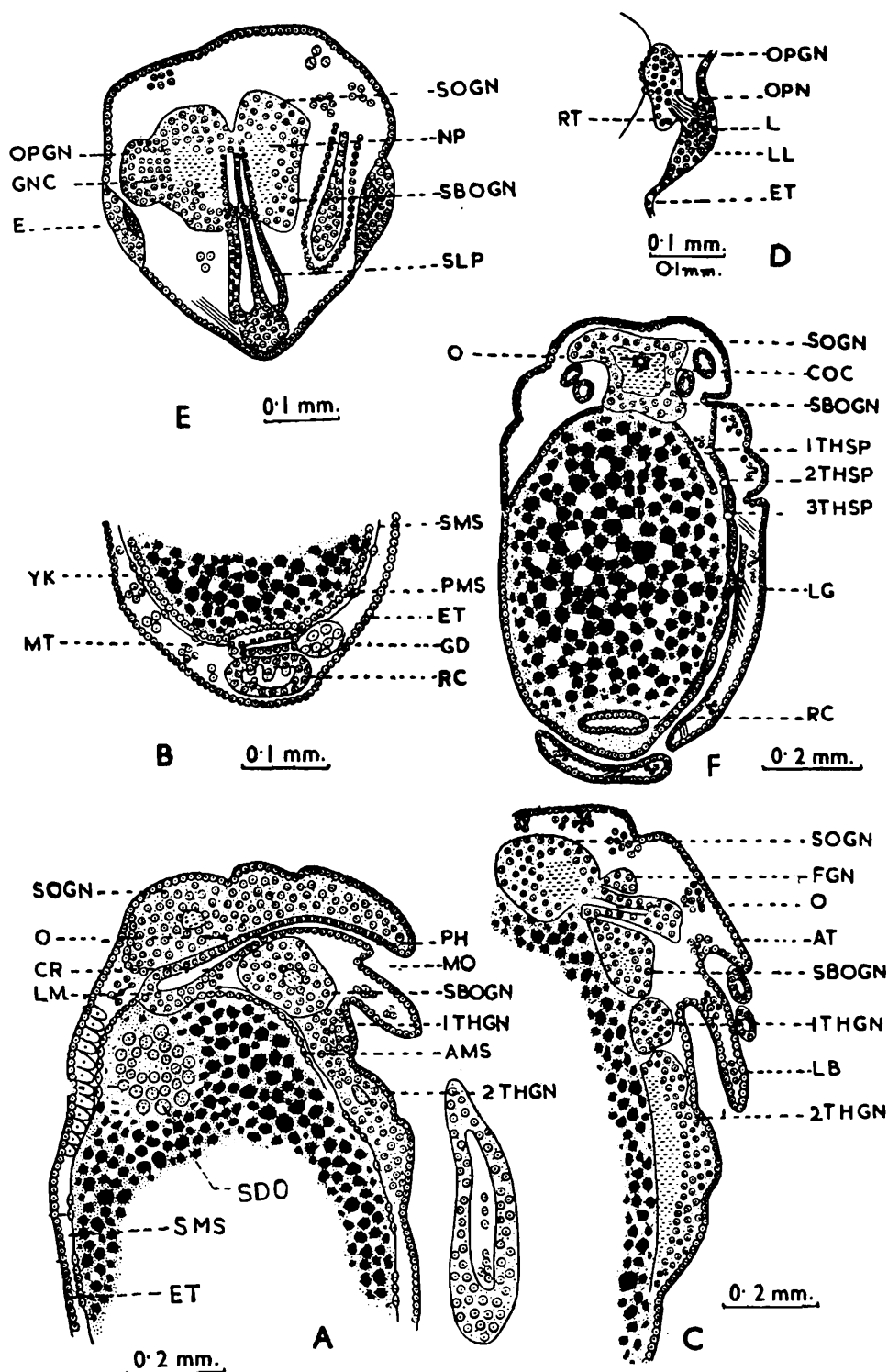
The brain of *Dysdercus cingulatus* is formed by the fusion of three pairs of ganglia, viz. protocerebrum, deutocerebrum and tritocerebrum (Text-fig. 3, A, P., D., T.). These three component ganglia of the brain, become defined on either side of the anterior end of the germ band at the same time, as the ventral ganglia make their appearance. The protocerebrum develops from the neuroblasts of the protocerebral segment. The deutocerebrum and the tritocerebrum develop from the neuroblasts in the antennary and premandibular segment respectively.

(i) *The Protocerebrum and the Optic Ganglion :* The protocerebral lobe of the brain is the largest of the three components and occupies a greater part of the head lobe (Text-fig. 3, A, P). The two lobes of the protocerebrum are connected medially by a narrow bridge through which a transverse band of nerve fibres traverse, giving rise to the supra-oesophageal commissure (Text-fig. 2, A & 5, E, SOC). The commissure arises partly from the cells of the protocerebral lobes and partly from a median thickening of the epidermis which retains its intimate relation with the protocerebral lobes till the commissure is completely formed (Text-fig. 2, A).

The protocerebral lobes can be distinguished into its three constituent lobes. The first, the second and the third lobes are separated from each other by a slight depression.

The ganglia of the brain retain their connection with the ectodermal wall till the end of the third day of development. Partial separation takes place at the 72nd hour of development, while complete separation takes place after 76 hours of development.

Optic Ganglion : At about the 68th hour of development the ectoderm opposite to the protocerebral lobe 3 becomes thickened to form a more or less round mass of cells. The peripheral cells of this mass arrange themselves in a single row, while in the rest of the mass they exhibit an irregular arrangement. This mass will give rise both to the optic ganglion and the optic plate (Text-figs. 2, A, OPL,



TEXT-FIG. 4. Organogeny of *Dysdercus cingulatus* (Fabr.)

Fig. A. L. S. of an egg of 108 hours through the anterior end.

Fig. B. L. S. of an egg of 108 hours through the posterior end.

Fig. C. L. S. of an egg of 108 hours showing the frontal ganglion above the stomodaeum.

Fig. D. T. S. of an egg of 108 hours showing the optic ganglion.

Fig. E. T. S. of an egg of 108 hours through the anterior end.

Fig. F. F. S. of an egg of 112 hours showing the thoracic ganglion.

OPP). After another four hours of development, the inner irregular mass (optic ganglion) begins to separate from the outer unilayered optic plate (Text-fig. 2, D, OPL, EPL), and later on the dermatogen loses its connection with the optic ganglion and becomes continuous with the optic plate. After 80 hours of incubation the separation of

the optic ganglion from the optic plate is complete (Text-fig. 3, A, EPL, OPL). The optic ganglion now fuses with the protocerebral lobe and loses its entity in the later stages.

In *Dysdercus cingulatus*, it has been observed that the cells of the peripheral thickened ectoderm divide and give rise to a large number of ganglionic cells, which are destined to form the optic ganglion. These ganglion cells in their turn form nerve fibres which become continuous with the fibre region of the protocerebral lobes (Text-fig. 4, E, GNC, OPGN).

(ii) *Deutocerebrum and Tritocerebrum*: The deutocerebral lobes of *D. cingulatus* are fairly large and occupy a position at the base of the antenna (Text-fig. 3, A, D). They do not extend so far laterally as the protocerebral lobes. The proto and deutocerebral lobes of the brain are at first widely separated from each other, but with the subsequent development, the deuto—cerebral lobes fuse with the protocerebrum. There is no transverse commissure in the deutocerebrum.

The tritocerebral ganglia (Text-fig. 3, A, T) are the smallest of the three lobes and lie in front of the mandibles and belong to the premandibular segment. They are in continuation with the deutocerebrum in front and with the mandibular ganglion behind. The tritocerebrum merges completely in the hinder margin of the deutocerebrum. The tritocerebral lobes are connected to each other by a transverse commissure known as the sub-oesophageal commissure (Text-figs. 5, E, SBOC).

The tritocerebrum also gives rise to the circumoesophageal connectives which unite it to the sub-oesophageal ganglionic mass (Text-figs. 5, E, COC).

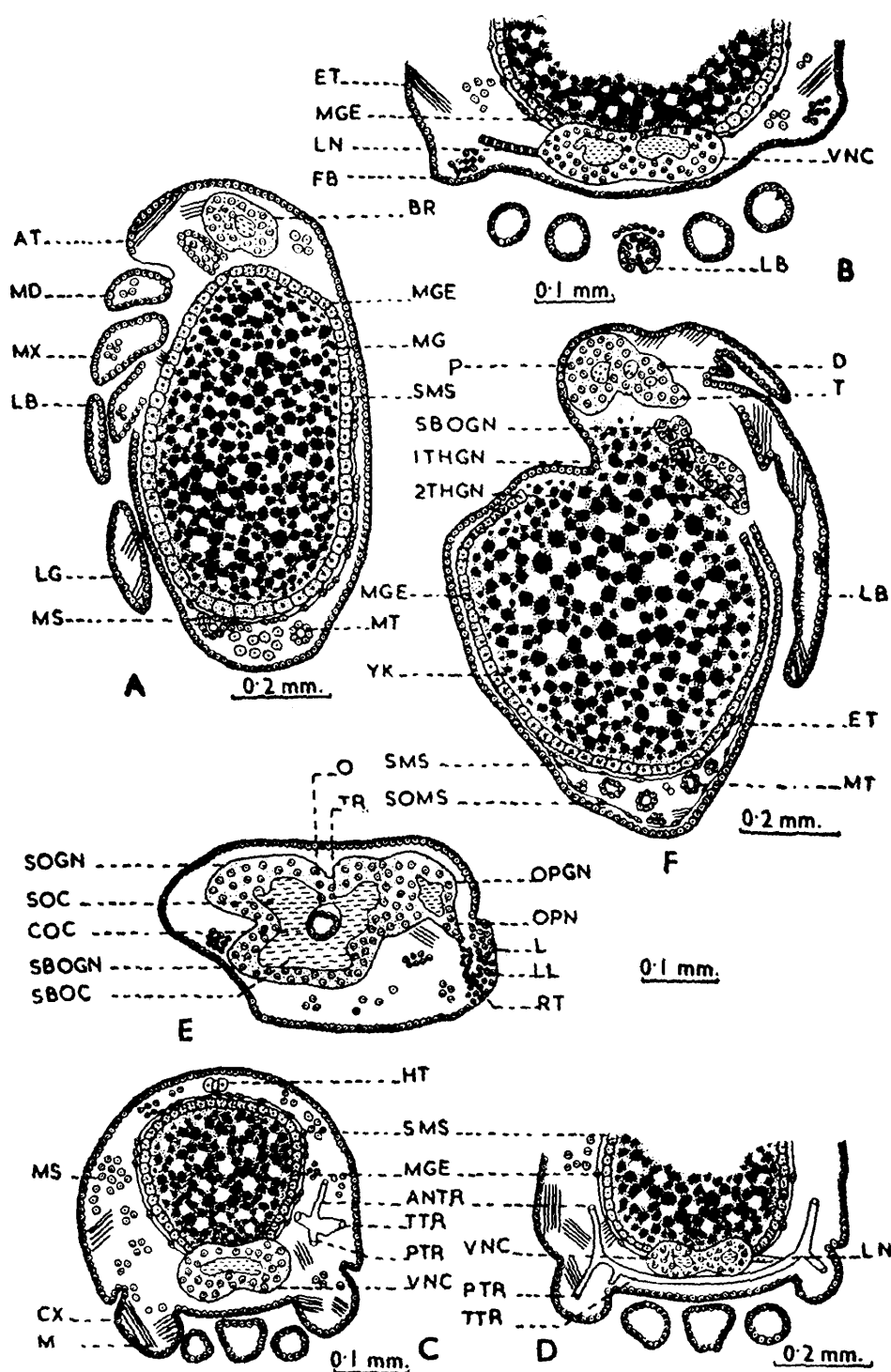
(C) *Sympathetic Nervous System*:

The sympathetic nervous system of *Dysdercus cingulatus* originates from a median thickening in the dorsal wall of the stomodaeum after 72 hours of development (Text-fig. 2, C, FGN). At this stage a large mass of cells is seen above the dorsal wall of the stomodaeum (Text-fig. 2, D, FGN). This mass of cells has not as yet assumed the form of true nerve cells. At the 108th hour of development these cells consolidate to form the frontal ganglion lying on the dorsal wall of the stomodaeum. It is soon constricted off from the stomodaeal wall and can be seen closely adhering to it (Text-figs. 3, A & 4, C, FGN).

After another 8 hours of development *i.e.*, at the 116th hour, the frontal ganglion gets completely severed off from the dorsal wall of the stomodaeum (Text-fig. 2, D, FGN). This mass of cells has not as yet assumed the form of true nerve cells. At the 108th hour of development these cells consolidate to form the frontal ganglion lying on the dorsal wall of the stomodaeum. It is soon constricted off from the stomodaeal wall and can be seen closely adhering to it (Text-figs. 3, A & 4, C, FGN).

After another 8 hours of development *i.e.*, at the 116th hour, the frontal ganglion gets completely severed off from the dorsal wall of the stomodaeum and is separated from it by the mesodermal layer that penetrates in between the two. The origin of the recurrent nerve,

the paired pharyngeal ganglia and the occipital ganglion could not be traced.



TEXT-FIG. 5. Organogeny of *Dysdercus cingulatus* (Fabr.)

- Fig. A. L. S. of an egg of 116 hours showing the completely formed mid gut epithelium.
 Fig. B. T. S. of an egg of 116 hours showing the origin of lateral nerve.
 Fig. C. T. S. of an egg of 116 hours showing the anterior, posterior and transverse tracheal branches.
 Fig. D. T. S. of an egg of 116 hours showing the anterior, posterior and transverse tracheal trunks.
 Fig. E. T. S. of an egg of 116 hours through the anterior end.
 Fig. F. L. S. of an egg of 124 hours L. S. showing the proto-, deuto and tritocereberum, the sub-oesophageal ganglion and two thoracic ganglia.

In *Rhodnius prolixus*, Mellanby (1936) states that the sympathetic nervous system develops from a mass of cells lying in the mid dorsal part of the stomodaeum. The anterior part of this mass of cells gives rise to the frontal ganglion, while the posterior part forms the sympathetic ganglion. The two ganglia are connected by a recurrent nerve.

(D) *Development of the Eye*: At the 44th hour of development, the dorso-lateral areas of the ectoderm on either side of the brain, become thickened to form the common rudiment of the optic ganglion and the optic plate (Text-fig. 2, A, OPL, OPP). The outermost cells of this ectodermal thickening are arranged neatly in a single row, while the rest of the cells show an irregular arrangement.

After 72 hours of incubation the inner cell mass, destined to form the optic ganglion, separates from the outer layer (optic plate), which in its turn becomes continuous with the rest of the dermatogen (Text-figs. 2, A, D, & 3, A, EPL, OPL, OPP). The outer layer of the optic plate now thickens (Text-figs. 2, A, D & 3, A, EPL, OPP), and after 108 hours of development becomes transparent to form the convex lens of the eyes (Text-fig. 5, E, L). The cells underlying the lens arrange themselves neatly and constitute the lenticular layer (Text-fig. 4, D, 5, E, LL). The layer below the lenticular layer forms the retina, the cells of which are closely packed (Text-figs. 4, D & 5, E, L, LL, RT). The so formed structure of the eye remains unaltered during the entire embryonic development. While the structural differentiation of the cells of the eye is taking place, the peripheral cells of the optic ganglion send out long nerve fibres to the eye which together constitute the optic nerve (Text-figs. 4, D & 5, E, OPN).

VI—SYNOPTIC TABLE OF DEVELOPMENT AT DIFFERENT HOURS OF INCUBATION

<i>State of development</i>	<i>Incubation period</i>
The stomodaeal invagination appears on the outer surface of the germ band. The anterior and posterior cells of the mesodermal layer give rise to the anterior and posterior mid-gut rudiments.	40 hours
Neuroblasts appear. Two continuous rows of nerve swellings are formed.	44 hours
The proctodaeal invagination makes its appearance and the posterior mid-gut rudiment becomes distinguishable.	46-48 hours
The anterior and posterior mid-gut ribbons start growing posteriorly and anteriorly respectively.	50 hours
Eleven pairs of spiracular invaginations are formed.	56 hours
Malpighian tubules appear. Fusion of the two lateral nerve swellings takes place and the segmental ganglia are formed in all the segments. Brain enlarges. The common rudiment of the optic ganglion and the optic plate is differentiated.	68 hours
The optic ganglion becomes well differentiated. The rudiment of the sympathetic nervous system appears.	72 hours

State of development

The abdominal ganglia show signs of fusion. The mandibular, maxillary and labial ganglion become distinct. The spiracular invaginations deepen and form a blind tube.	76 hours
The optic lobe becomes associated with the protocerebrum. Frontal ganglion is formed.	80 hours
Abdominal ganglia consolidate.	88 hours
Pharynx and oesophagus are formed.	100 hours
The oesophagus dilates to form the crop. The abdominal ganglia and the third thoracic ganglion fuse with the meso-thoracic ganglion. The lens, the retina of the eye are formed.	108 hours
Complete mid-gut is formed. An anterior, posterior and transverse tracheal branch arise from the blind end of the spiracular invagination.	116 hours
The fore,- mid,- and hind gut become continuous. The eyes appear as dark brown spots.	128 hours

VII—SUMMARY

1. The stomodaeal and proctodaeal invaginations arise as ectodermal invaginations of the germ band and grow towards the outer surface of the embryonic rudiment *i.e.* towards the side of the serosa.
2. The proctodaeal invagination is in direct continuation with the amniotic cavity in the early stages of development and hence it is known as the amnio-proctodaeal cavity.
3. The anterior and posterior mid-gut rudiments are derived from the anterior and posterior cell masses of the mesodermal layer.
4. The Malpighian tubules arise from the blind end of the proctodaeum and hence are ectodermal in origin. There are two pairs of Malpighian tubules, and each one of them opens by a separate opening into the lumen of the proctodaeum.
5. The tracheal system makes its appearance as eleven pairs of ectodermal invaginations, which represent the spiracles.
6. The first three pairs of spiracles belong to the three thoracic segments and the rest eight to the first eight abdominal segments respectively.
7. The pro-thoracic spiracle closes a little before the hatching of the egg and an anterior shifting of the meso- and metathoracic spiracles occurs.
8. The nervous system develops from the neuroblasts which are specialized ectodermal cells. The neuroblasts divide to give rise to two rows of neural swellings, which form the segmental ganglia of the nerve cord in each segment of the body.
9. The nervous system in the embryonic stages consists of a brain, a sub-oesophageal ganglion, three thoracic and ten abdominal ganglia.

10. At a later stage of development all the abdominal ganglia along with the third thoracic fuse with the second thoracic ganglion. Thus in the adult bug, the nervous system consists of the brain the sub-oesophageal ganglion and two thoracic ganglia only.

VIII—ACKNOWLEDGEMENTS

I take this opportunity of thanking Dr. T. Singh, Professor of Zoology and Entomology, School of Entomology, St. John's College, Agra, for guidance and for facilities for work during the course of this work. I owe my thanks to Dr. Santokh Singh of the School of Entomology, for constant encouragement and for his very able advice in the preparation of this paper. I have also to thank Dr. M. S. Mani, and Dr. Shah M. Alam, Prof. and Head of the Zoology Department, Aligarh Muslim University, for useful suggestions.

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ABBREVIATIONS

A.—Amnion; AC.—Amniotic cavity; IABGN.—First abdominal ganglion; 10ABGN.—10th abdominal ganglion; AER.—Anterior endoderm rudiment; AMS.—Anterior mid-gut strand; APC.—Amnio-proctodaeal cavity; AT.—Antenna; ATMS.—Antennary mesoderm; BMDST.—Base of the mandibular stylet; BMXST.—Base of the maxillary stylet; BR.—Brain; CH.—Chorion; CR.—Crop; CX.—Coxa; D.—Deutocerebrum; DB.—Dermatoblasts; E.—Eye; EPL.—Eye plate; ET.—Ectoderm; FB.—Fat body; FGN.—Frontal ganglion; GC.—Germ cells; GD.—Gonad; GNC.—Ganglion cells; HT.—Heart; L.—Lens; LB.—Labium; LBG.N.—Labial ganglion; LG.—Leg; LL.—Lenticular layer; LM.—Limiting membrane; LN.—Lateral nerve; LR.—Labrum; M.—Muscle; MC.—Median cord; MD.—Mandible; MDGN.—Mandibular ganglion; MG.—Mid-gut; MGE.—Mid-gut epithelium; MO.—Mouth; MS.—Mesoderm; MT.—Malpighian tubule; MTE.—Median thickening of the ectoderm; MX.—Maxilla; MXGN.—Maxillary ganglion; MXST.—Maxillary stylet; NB.—Neuroblasts; NG.—Neural groove; NP.—Neuropile; NS.—Neural swelling; O.—Oesophagus; OE.—Oenocytes; OM.—Oblique muscles; OPGN.—Optic ganglion; OPL.—Optic lobe; OPN.—Optic nerve; OPP.—Optic plate; PER.—Posterior endoderm rudiment; PH.—Pharynx; PMD.—Pcemandibular rudiment; PMS.—Posterior mid-gut strand; POM.—Pre-oral mesoderm; PT.—Proctodaeum; PTOM.—Post-oral mesoderm; PTR.—Posterior trachea; RC.—Rectum; RT.—Retina; S.—Stomodaeum; SBOC.—Sub-oesophageal commissure; SBOGN.—Sub-oesophageal ganglion; SDO.—Secondary dorsal organ; SE.—Serosa; SI.—Stomodaeal invagination; SLP.—Salivary piston; SMS.—Splanchnic mesoderm; SOC.—Supra-oesophageal commissure; SOGN.—Supra-oesophageal ganglion; SP.—Spiracle; SP₁, SP₂, SP₃.—Spiracle 1, 2 & 3; T.—Tritocerebrum; 1, 2 & 3 THGN.—First, Second and third thoracic ganglion; 1, 2 & 3 THSP.—First, second and third thoracic spiracle; TR.—Trachea; TTR.—Transverse trachea; VN.—Ventral notch; VNC.—Ventral nerve cord; YK.—Yolk.

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