RECORDS

of the

INDIAN MUSEUM

(A JOURNAL OF INDIAN ZOOLOGY)

Vol. XXIV, Part I.

MAY, 1922.

Calcutta:

PUBLISHED BY THE DIRECTOR, ZOOLOGICAL SURVEY OF INDIA.
PRINTED AT THE BAPTIST MISSION PRESS.

1922.

Price Two Rupees.

RECORDS

of the

INDIAN MUSEUM

(A JOURNAL OF INDIAN ZOOLOGY)

Vol. XXIV, 1922

EDITED BY
THE DIRECTOR,
ZOOLOGICAL SURVEY OF INDIA.

Calcutta:
PUBLISHED BY THE DIRECTOR, ZOOLOGICAL SURVEY OF INDIA

1922

CONTENTS.

PART I. *Published 6th May, 1922.*

PART II. *Published 29th June, 1922.*

PART III. *Published 31st August, 1922.*

PART IV. *Published 19th October, 1922.*

APPENDIX.

LIST OF PLATES.

LIST OF AUTHORS.

INDEX.

[*N.B.*—An asterisk (*) preceding a line denotes a new variety or subspecies; a dagger (†) indicates a new species; a double dagger (‡) a new genus or subgenus; synonyms are printed in italics.]

B

C

D

H

M

N

Z.

CALCUTTA : PRINTED BY SUPDT. GOVT. PRINTING, INDIA, 8, HASTINGS STREET.

LIST OF LITERATURE REFERRING TO INDIAN ZOOLOGY (EXCLUDING INSECTA) RECEIVED IN CALCUTTA DURING THE YEAR 1922.

Compiled by SUNDER LAL HORA, *D.Sc., Assistant Superintendent, Zoological Survey of India.*

ANNANDALE, N.—Ethics of Zoology. *Calcutta Review*, pp. 1-16 (1922)

ANNANDALE, N.—Museums and Taxonomic Zoology. *Mus. Journ.* XXI, pp. 141-146 (1922).

ANNANDALE, N.—Introduction to the study of an Island in the Chilka Lake. *Mem. As. Soc. Bengal* VII, pp. 257-287 (1922).

AYYANGAR, S. R.—Notes on the Fauna and Fishing Industries of the Laccadive Islands. *Madras Fish. Bull.* XV, pp. 45-69 (1922).

BABAULT, G.—*Recherches Zoologique* (Paris : 1922).

BAILEY, J.—Museum Publications (A review of Vol. VIII, part 13, Vol. XXI, part 1, Vol. XXIV, parts 1, 2, 3 of *Rec. Ind. Mus.*) *Mus. Journ. London* XXII, pp. 128, 129 (1922).

CAULLERY, M.—Le Parasitisme et la Symbiose. *Encyclopédie Scientifique* (Paris : 1922).

HORNELL, J.—The Madras Aquarium. *Journ. Bombay Nat. Hist. Soc.* XXVIII, pp. 621-629, one plate (1922).

HORNELL, J.—*The Madras Marine Aquarium* (Madras : 1922).

PEARSON, J.—Marine Biology. *Ceylon Administration Report for* 1920.

SEWELL, R. B. S. and ANNANDALE, N.—The Hydrography and Invertebrate Fauna of Rambha Bay in an abnormal year. *Mem. Ind. Mus.* V, pp. 677-710, pls. xxxii-xliii (1922).

SHERBORN, C. D.—*Index Animalium.* Part 1. 1801-1850 (London : 1922).

WOODLAND, W N. F.—On the Renal Portal System.(Renal Venous Meshwork) and Kidney Excretion in Vertebrata. *Journ. As. Soc. Bengal* (n. s.) XVIII, pp. 85-193 (1922).

Protozoa.

BHATIA, B. L.—Notes on Fresh-water Ciliate Protozoa of India.-II. *Journ. Roy. Microsc. Soc.* pp. 27-37 (1922).

CHATTERJEE, G. C.—A new flagellate parasitic in the human intestinal canal. *Ind. Journ. Med. Res.* X, pp. 523-525, pl. xxiv (1922).

CUSHMAN, J. A.—Foraminifera of the Philippines and Adjacent seas. *Bull. U. S. Nat. Mus.* No. 100, vol. 4 (1921).

FAUST, E. C.—A study of Trichomonas of Guinea-Pig from Peking. *Archiv. Protistenkunde Jena* XLIV, pp. 115-118, pt. v (1921).

KAMM, M. W.—A list of the New Gregarines described from 1911 to 1920. *Trans. Amer. Microsc. Soc. Menasha* (Wisconsin) XLI, pp. 122-152 (1922).

KOFOID, C. A. and SWEZY, O.—Mitosis and Fission in the active and encysted phases of Giardia enterica (Grassi) of man, with a discussion of the method of origin of Bilateral symmetry in the Polymastigote Flagellates. *University California Publications, Zoology* XX, pp. 199-234, pls. 23-26 (1922).

Porifera.

DENDY, A.—Report on the Sigmatotetraxonida collected by H. M. S. "Sealark" in the Indian Ocean. *Trans. Linn. Soc. London* (2) XVIII, pp. 1-164, pl. i-xviii (1922).

Coelentrata.

HORST, C. J. van der—Madreporaria: Agariciidae. *Trans. Linn. Soc. London* (2) XVIII, pp. 417-429, pls. xxxi, xxxii. (1922).

HORST, C. J. van der—The Madreporaria of the Siboga Expedition. II. *Siboga Exped.* XVIb, pp. 53-98, pls. i-vi (1921).

HORST, C. J. van der—The Madreporaria of the Siboga Expedition. Part III, Eupsammidae. *Siboga-Exped.* XVIc, pp. 47-75, pls. vii, viii (1922).

JARVIS, F. E.—The Hydroids from the Chagos, Seychelles and other islands and from the coasts of British East Africa and Zanzibar. *Trans. Linn. Soc. London* (2) XVIII, pp. 331-360, pls. xxiv-xxvi (1922).

LÜTTSCHWAGER, H.—Alcyonarien von den Philippinen. I. Die Gattung *Alcyonium* Linnaeus. *Philippine Journ. Sci. Manila* XX, pp. 519-540, pl. i (1922).

PAX, F.—Die Antipatharien der Deutschen Tiefsee Expedition. *Wissen. Ergebn. Deutsch. Tiefsee-Expedition*, pp. 1-16, pl. xxiii (1922).

ROSKIN, GR. VON.—Über den feineren Bau der Epithel-Muskelzellen von Hydra grisea und fusca. *Anat. Anz.* LVI, *pp.* 158-168 (1922).

SHERRIFFS, W R.—Evolution within the Genus *Dendronephthya* (*Spongodes*) (*Alcyonaria*), with descriptions of a number of species. *Proc. Zool. Soc. London*, pp. 33-77, pls. i-iii (1922).

STEPHENSON, T. A.—On the classification of Actiniaria. Part II. *Quart. Journ. Microsc. Sci.* LXV, pp. 493-576 (1921).

STIASNY, G.—Studien über Rhizostomeen mit besonderer berücksichtigung der Fauna des Malaiischen Archipels nebsteiner revision des system. *Cap. Zool. Hague* I, pp. 1-179, pls. i-v (1921).

Polyzoa.

ANNANDALE, N.—Polyzoa in the Colombo Waterworks. *Spolia Zeylanica* XII, pp. 207-209 (1922).

Crustacea.

BALSS, H.—Diagnosen neuer Japanischer Decapoden. *Zool. Anz.* LIV, pp. 1-6 (1922).

BALSS, H.—Crustacea VI : Decapoda Anomura (Paguridea) und Brachyura (Dromiacea bis Brachygnatha). In Michaelsen's *Beitr. Kennt. Mereesf. Westafrikas* III, pp. 39-67 (1921).

BOURNE, G. C.—The Raninidae : a study in Carcinology. *Journ. Linn. Soc. London* XXXV, pp. 25-79, pls. iv-vii (1922).

CHILTON, C.—Report on the Amphipoda obtained by the F. I. S. "Endeavour" in Australian Seas. *Fisheries Dep. Australia* V, pt. 2, pp. 33-92 (1921).

CHOPRA, B.—Preliminary note on Isopoda of the family Bopyridae parasitic on Indian Decapoda Macrura. *Journ. As. Soc. Bengal* (n. s.) XVIII, pp. 69-71 (1922).

COLOSI, G.—I Potamonidi del R. Museo Zoologico di Torino. *Boll. Mus. Zool. Anat. Comp. Torino* XXXV, pp. 1-39 (1920).

JACKSON, H. G.—A Revision of the Isopod Genus *Ligia* (Fabricius). *Proc. Zool. Soc. London*, part iii, pp. 683-704, pls. i-ii (1922).

KEMP, S.—Notes on Crustacea Decapoda in the Indian Museum, XV Pontoniinae. *Rec. Ind. Mus.* XXIV, pp. 113-288, pls. iii-ix (1922).

MAN, J. G. de.—The Decapoda of the Siboga Expedition. Part V On a collection of Macrurous Decapod Crustacea of the Siboga Expedition, chiefly Penaeidae and Alpheidae. *Siboga-Exped.* pp. 1-51, pls. i-iv (1922).

PARISI, B.—Elenco degli Stomatopodi del Museo Civico di Milano. *Atti Soc. Ital. Mus. Civ. Stor. Nat. Milano* LXI, pp. 91-114 (1922).

TATTERSALL, W. M.—Indian Mysidacea. *Rec. Ind. Mus.* XXIV, pp. 445-504 (1922).

TATTERSALL, W. M.—The Percy Sladen Trust Expedition to the Albrolhos Islands (Indian Ocean), under the Leadership of Prof. J. Dakin, F.L.S., F.Z.S.—Amphipoda and Isopoda. *Journ. Linn. Soc. London* XXXV, pp. 1-20, pl. i-iii (1922).

TATTERSALL, W. M.—Zoological Results of a Tour in the Far East. Amphipoda with notes on an Additional Species of Isopoda. *Mem. As. Soc. Bengal* VI, pp. 435-459, pls. xviii-xxi (1922).

WELTNER, W.—Cirripedia der Deutschen Tiefsee-Expedition. *Wissen. Ergebn. Deutsch. Tiefsee-Expedition*, pp. 61-112, pls. ii-iv (1922).

Echinodermata.

CLARK, A. H.—Sea-lilies and Feather-stars. *Smithson. Misc. Coll.* LXXII, No. 7, pp. 1-43, pls. 1-16 (1921).

CLARK, A. H.—A Monograph of the Existing Crinoids. I. The Comatulids. Part 2. *Bull. U. S. Nat. Mus.* LXXXII, pp. 1-795, pls. i-lvii (1921).

CLARK, H. L.—The Holothurians of the genus Stichopus. *Bull. Mus. Comp. Zool. Harvard* LXV, pp. 39-74, pl. i, ii (1922).

Döderlein, L.—Die Asteriden der Siboga-Expedition. 1. Porcellanasteridae, Astropectinidae, Benthopectinidae. *Siboga-Exped.* XLVI, pp. 1-47, pls. i-xiii (1921).

Fisher, W K.—A new Sea-star from Hongkong. *Ann. Mag. Nat. Hist.* (9) *X*, pp. 415-418, pl. x (1922).

Koehler, R.—*Echinoderma of the Indian Museum.* Part IX. Clypeastridés et Cassidulidés (Calcutta : 1922).

"Vermidea."

Anon.—Bibliography of Hookworm Diseases. Publication No. 11. The Rockfeller Foundation International Health Board (New York : 1922).

Bahl, Karm Narayan.—On the Development of the "Enteronephric" type of Nephridial system found in Indian Earthworms of the genus *Pheretima. Quart. Journ. Microsc. Sci.* (n. s.) LXVI, pp. 49-103, pls. v-vii (1922).

Baylis, H. A. and Daubney, R.—Report on the Parasitic Nematodes in the collection of the Zoological Survey of India. *Mem. Ind. Mus.* VII, pp. 263-347 (1922).

Brinkmann, A.—Die Pelagischen Nemertinen (Monographisch Dargestellt). *Bergens Mus. Skrift.* (n. s.) III, pp. 1-194, pls. i-xvi (1917).

Faust, E. C.—Notes on the Excretory System in Aspidogaster conchicola. *Trans. Amer. Mircosc. Soc. Menasha* (Wisconsin) XLI, pp. 113-117, pls. xiii, xiv (1922).

Fauvel, P.—Annélides Polychètes de l' Archipel Houtman Albrolhos (Australie Occidentale) recueillies par M. le. Prof. W. J. Dakin, F.L.S. *Journ. Linn. Soc. London* XXXIV, pp. 487-500 (1921).

Fischer, W.—Gephyreen der Deutschen Tiefsee-Expedition. *Wissen. Ergebn. Deutsch. Tiefsee-Expedition*, pp. 1-26, pls. i-ii (1922).

Giroud, A.—Notes sur le Tube Digestif d' Ascaris Holoptera (Rudolphi). *Archiv. Zool. Experiment. Paris* LXI, pp. 17-20 (1922).

Irwin-Smith, V.—Notes on Nematodes of the genus *Physaloptera* with special reference to those parasitic in Reptiles. Part ii. A review of the Physaloptera of Lizards. *Proc. Linn. Soc. N. S. Wales* XLVII, pp. 53-62 (1922).

Michaelsen, W.—Oligochäten von westlichen Vorderindien und ihre Beziehungen zur oligochäten fauna von Madagaskar und den Seychellen. *Mitt. Zool. Staatsinst. u. Zool. Mus. Hamburg* XXXVIII, pp. 27-68 (1920).

M'Intosh—Notes from the Gatty Marine Laboratory, St. Andrews.—No. XLIV 1. On new and rare *Polychaeta, Gephyrea*, etc., from various Regions. *Ann. Mag. Nat. Hist.* (9) IX, pp. 1-12 (1922).

Oka, A.—Hirudinea from the Inlé Lake, S. Shan States. *Rec. Ind. Mus.* XXIV, pp. 522-534 (1922).

Poche, F.—Zur Kenntnis der Amphilinidea. *Zool. Anz.* LIV, pp. 276-287 (1922).

RAO, C. R. N.—Some new Species of Earthworms belonging to the Genus *Glyphidrilus*. *Ann. Mag. Nat. Hist.* (9) IX, pp. 51-68 (1922).

SEWELL, R. B. S.—Cercarae Indicae. *Ind. Journ. Med. Research* X (suppl.), pp. 1-366 (1922).

SOUTHWELL, T.—Cestodes in the collection of the Indian Museum. *Ann. Trop. Med. Parasit.* XVI, pp. 127-152 (1922).

STEPHENSON, J.—On some Earthworms from India and Palestine belonging to the British Museum. *Ann. Mag. Nat. Hist.* (9) IX, pp. 129-136 (1922).

STEPHENSON, J.—A note on some supposed new species of Earthworms of the Genus *Glyphidrilus*. *Ann. Mag. Nat. Hist.* (9) IX, pp. 387-389 (1922).

STEPHENSON, J.—On the Septal and Pharyngeal Glands of the Mirodrili (Oligochaeta). *Trans. Roy. Soc. Edinburgh* LIII, pp. 231-264, pl. liii (1922).

STEPHENSON, J.—Some Earthworms from Kashmir, Bombay, and other parts of India. *Rec. Ind. Mus.* XXIV, pp. 427-443 (1922).

STEPHENSON, J.—Contributions to the Morphology, Classification, and Zoogeography of Indian Oligochaeta. *Proc. Zool. Soc. London*, pp. 109-148, pl. 1 (1922).

STILES, C. W. and HASSALL, A.—Index-Catalogue of Medical and Veterinary Zoology. Roundworms. *Bull. Hygienic Laboratory Washington*, No. 114, pp. 1-886 (1920).

Mollusca.

ANNANDALE, N.—Introduction to the Study of an Island in the Chilka Lake. *Mem. As. Soc. Bengal* VII, pp. 257-287 (1922).

ANNANDALE, N. and PRASHAD, B.—Description of a new species of Nudibranch Mollusc. *Mem. Ind. Mus.* V, pp. 700-702 (1922).

BAVAY, A.—Coquilles des cables marins de l' Indo-Pacifique. *Journ. Conchyliol. Paris*, LXVI, pp. 155-161, pl. vi (1922).

EHRMANN, P.—Land-und Süswasser-schnecken aus den südlichen Schan-Staaten, Hinterindien. *Sitzungsber. Naturf. Ges. Leipzig*, Jahrgg. 45-48, pp. 1-28, pl. 1 (1922).

GODWIN-AUSTEN, H. H.—*Land and Freshwater Mollusca of India* III, pp. 1-65, pls. CLIX-CLXV (London : 1920).

GODWIN-AUSTEN, H. H.—On a new *Alycaeus* from the Khasi Hills. *Rec. Ind. Mus.* XXIV, pp. 365 (1922).

HAAS, F.—Bemerkungen über Asiatische Najaden—*Abh. u. Ber. d. Mus. Natur. u. Heimatkunde Magdeburg*, III, pp. 287-316, pls. ix-xi (1922).

HAAS, F.—Eine nene indische Najade, *Trapezoideus prashadi*. *Senckenbergiana*, IV, pp. 101, 102 (1922).

HEDLEY, C.—A Revision of the Australian Turridae. *Rec. Austral. Mus.* XIII, pp. 213-359, pls. xlii-lvi (1922).

Hornell, J.—Pearl Formation in the Indian Pearl Oyster. *Journ. As. Soc. Bengal* (n. s.) XVIII, pp. 213-219 (1922).

Marshall, H.—List of Mollusca of Rangoon. *Journ. Bombay Nat. Hist. Soc.* XXVIII, pp. 773-776 (1922).

Prashad, B.—A Revision of the Burmese Unionidae. *Rec. Ind. Mus.* XXIV, pp. 91-111, pl. ii (1922).

Prashad, B.—Observations on the Invertebrate Fauna of the Kumaon Lakes. III. The Freshwater Mollusca. *Rec. Ind. Mus.* XXIV, pp. 11-17 (1922).

Simroth, H.—Über einige Nacktschnecken vom Malayischen Archipel von Lombok an ostwärts bis zu den Gesellschafts-Inseln. *Abh. Senckenb. Naturf. Ges.* XXXV, pp. 261-306, pls. xviii-xx (1920).

Sterki, V.—Some Notes on the Hinge of the Sphaeridae. *Nautilus* XXXV, pp. 104-117 (1922).

Arachnida and Myriapoda.

Borelli, A.—Di alcuni Dermatteri raccolti in Malesia dal Prof. C. F. Baker. *Boll. Mus. Zool. Anat. Comp. Torino* XXXV, pp. 1-9 (1921).

Brolemann, H. W.—Myriapods collected in Mesopotamia and N. W. Persia by W Edgar Evans, B.Sc., Late Capt. R.A.M.C. *Proc. Roy. Soc. Edinburgh* XLII, pp. 54-74 (1922).

Ewing, H. E.—The Phylogeny of the Gall Mites and a New Classification of the Suborder Prostigmata of the Order Acarina. *Ann. Ent. Soc. America* XV, pp. 213-222 (1922).

Heymons, R. von.—Beitrag zur Systematik und Morphologie der Zungenwürmer (Pentastomida). *Zool. Anz.* LV, pp. 154-167 (1922).

Hingston, R. W G.—The Snare of the Giant Wood Spider (*Nephila maculata*). *Journ. Bombay Nat. Hist. Soc.* XXVIII, pp. 642-649 (1922).

Hirst, S.—Mites injurious to domestic animals (with an appendix on the Acarine Disease of Hive Bees). *British Museum (Natural History) Economic Series* No. 13, pp. 1-107 (London : 1922).

Manavalaramanujam, S. G.—Occurrence of the Galeod Spider (*Rhagodes nigrocintus*) in the South Arcot District, Madras Presidency. *Journ. Bombay Nat. Hist. Soc.* XXVIII, p. 814 (1922).

Reimoser, E.—Katalog der Echten Spinnen (Araneae) des Paläarktischen Gebietes. *Abh. zool.- bot. Ges. Wien* X, pp. 1-280 (1919).

Remy, P.—Sur le Rejet de Sang par les Argasidae. *Archiv. Zool. Experiment. Paris* LXI, pp. 1-16 (1922).

Savory, T. H.—The Spider Liphistius : a Study in the Biology of a Primitive Animal. *Ann. Mag. Nat. Hist.* (9) X, pp. 444-449 (1922).

Waterston, J.—The Louse as a menace to Man. *British Museum (Natural History) Economic Series* No. 2, pp. 1-20 (London : 1921).

Pisces.

ANNANDALE, N. and HORA, S. L.—Parallel Evolution in the Fish and Tadpoles of Mountain Torrents. *Rec. Ind. Mus.* XXIV, pp. 505-509 (1922).

ARCHEY, G.—A New Species of Shark. *Trans. New Zealand Inst.* LIII, pp. 195, 196 (1921).

EISSELE, L.—Histologische Studien an der Schwimmblase einiger Süsswasserfische. *Biol. Zentralblatt* XLII, pp. 125-138 (1922).

GHOSH, A. C. and GHOSH, S. N.—Notes on carp-breeding and culture in confined waters of Bengal and Bihar. *Department of Fisheries, Bengal. Bull.* XVIII, pp. 1-9 (1922).

HORA, S. L.—Structural Modifications in the Fish of Mountain Torrents. *Rec. Ind. Mus.* XXIV, pp. 31-61 (1922).

HORA, S. L.—The Modification of the Swim-bladder in Hill-stream Fishes. *Journ. As. Soc. Bengal* (n.s.) XVIII, pp. 5-7 (1922).

HORA, S. L.—The Homology of the Weberian Ossicles. *Journ. As. Soc. Bengal* (n.s.) XVIII, pp. 1-4 (1922).

HORA, S. L.—Notes on Fishes in the Indian Museum. III. On Fishes belonging to the family Cobitidae from high altitudes in Central Asia. *Rec. Ind. Mus.* XXIV, pp. 63-83 (1922).

HORA, S. L.—Notes on Fishes in the Indian Museum, IV On Fishes belonging to the genus *Botia* (Cobitidae). *Rec. Ind. Mus.* XXIV, pp. 313-321 (1922).

HORN, A.—Der Schwimmblasenapparat bei Cobitis. *Biol. Zentralblatt* XLII, pp. 118-125 (1922).

MANFREDI, P.—Descrizione di una carpa mostruosa. *Natura* XIII, pp. 20-28 (1922).

MAXWELL, C. N.—Malayan Fishes. *Journ. Straits Branch Roy. Asiat. Soc.* No. 84, pp. 179-280, pls. i-lxxii (1921).

MILLS, J. P.—*The Lhota Nagas.* Fishing, pp. 70-74, pl. (London: 1922).

NICHOLS, J. T.—*Carangoides Jordani* from the Hawaiian Islands with notes on related species. *Amer. Mus. Novitates* No. 50, pp. 1-3 (1922).

NUSBAUM - HILAROWICZ, J.—Etudes d'anatomie comparée sur les Poissons provenant des campagnes scientifiques de S. A. S. le Prince de Monaco. *Res. Camp. Sci. Monaco* LVIII, pp. 1-115, pls. i-xii (1920).

ÔSHIMA, M.—A Review of the Fishes of the Family Mugilidae found in the Waters of Formosa. *Ann. Carnegie Mus.* XIII, pp. 240-259, pls. xi-xiii (1922).

OSHIMA, M.—A Review of the Fishes of the Family Centriscidae found in the Waters of Formosa. *Ann. Carnegie Mus.* XIII, pp. 260-264, pl. xiii, figs. 2-3 (1922).

REGAN, C. T.—Fishes of the Clupeid Genera *Clupeoides* and *Potamalosa*, and allied Genera. *Ann. Mag. Nat. Hist.* (9) X, pp. 587-590 (1922).

Waber, Max and Beaufort, L. F. De.—*The Fishes of the Indo-Australian Archipelago.* IV, pp. 1-410, text-figs. (Leiden : 1922).

Whitehouse, R. H.—The Grey Mullets of Tuticorin. *Madras Fish. Bull.* XV, pp. 71-98 (1922).

Batrachia and Reptilia.

Annandale, N. and Hora, S. L.—Parallel Evolution in the Fish and Tadpoles of Mountain Torrents. *Rec. Ind. Mus.* XXIV, pp. 505-509 (1922).

Barbour, T.—Sphaerodactylus. *Mem. Mus. Comp. Zool. Harvard* XLVII, pp. 217-278, pls. 1-26 (1921).

Bhattacharya, D. R.—Notes on the Venous System of *Varanus bengalensis*. *Journ. As. Soc. Bengal* (n.s.) XVII, pp. 257-261, pl. v (1922).

Boulenger, G. A.—Monograph of the Lacertidae II, pp. 1-449 (London : 1921).

Devanesen, D. W.—Notes on the Anatomy of *Cacopus systoma*, an Indian Toad of the Family Engystomatidae. *Proc. Zool. Soc. London*, pp. 527-556, part iii (1922).

Frere, A. G.—An aggressive Phoorsa (*Echis carinata*). *Journ. Bombay Nat. Hist. Soc.* XXVIII, pp. 291, 292 (1921).

Hora, S. L.—Some observations on the Oral Apparatus of the Tadpoles of *Megalophrys parva* Boulenger. *Journ. As. Soc. Bengal* (n.s.) XVIII, pp. 9-15 (1922).

Jeude, Th. W van Lidth de.—Snakes from Sumatra. *Zool. Meded. Leiden* VI, pp. 239-253 (1922).

Moulton, J. C.—The reported occurrence of Russell's Viper in Sumatra and the Malay Peninsula. *Journ. Straits Branch Roy. As. Soc.* No. 85, pp. 206, 207 (1922).

Noble, G. K.—Snakes That Inflate. *Natural History* XXI, pp. 166-171 (1921).

Noble, G. K.—The Phylogeny of the Salientia 1—The Osteology and the Thigh Musculature ; Their Bearing on Classification and Phylogeny. *Bull. American Mus. Nat. Hist.* XLVI, pp. 1-87, pls. i-xxiii (1922).

Procter, J. B.—On a new Toad, *Cophophryne alticola*, collected on the Mt. Everest Reconnaissance Expedition, 1921. *Ann. Mag. Nat. Hist.* (9) IX, pp. 583-587 (1922).

Procter, J. B.—Further Lizards and Snakes from Persia and Mesopotamia. *Journ. Bombay Nat. Hist. Soc.* XXVIII, No. 1, pp. 251-253 (1921).

Rao, C. R. N.—Notes on Batrachia. *Journ. Bombay Nat. Hist. Soc.* XXVIII, pp. 439-447 (1922).

Rooij, N. de.—Fauna Simalurensis. Reptilia. *Zool. Meded. Leiden* VI, pp. 217-238 (1922).

SMITH, M. A.—Notes on Reptiles and Batrachians from Siam and Indo-China. No. 1. *Journ. Nat. Hist. Soc. Siam* IV, pp. 203-214, pl. viii (1922).

SMITH, M. A.—The Frogs Allied to *Rana Doriae*. *Journ. Nat. Hist. Soc. Siam* IV, pp. 215-225, pl. IX (1922).

SMITH, M. A.—The Frogs Allied to *Rana Doriae*. Addendum. *Journ. Nat. Hist. Soc. Siam* IV, pp. 227-229 (1922).

SMITH, M. A.—On a collection of Reptiles and Batrachians from the mountains of Pahang, Malay Peninsula. *Journ. Fed. Malay States Mus.* X, pp. 263-282 (1922).

WALL, F.—A Review of the Indian Species of *Amblycephalus*. *Rec. Ind. Mus.* XXIV, pp. 19-27 (1922).

WALL, F.—A new Snake from the Northern Frontier of Assam. *Rec. Ind. Mus.* XXIV, pp. 29, 30 (1922).

WALL, F.—A New Snake of the family Uropeltidae. *Journ. Bombay Nat. Hist Soc.* XXVIII, pp. 41, 42, one pl. (1921).

WALL, F.—Notes on Some Notable additions to the Bombay Natural History Society's Snake collection. *Journ. Bombay Nat. Hist. Soc.* XXVIII, pp. 43, 44, one pl. (1921).

WALL, F.—Notes on some Lizards, Frogs and Human Beings in the Nilgiri Hills. *Journ. Bombay Nat. Hist. Soc.* XXVIII, pp. 493-499 (1922).

Aves.

ADOLPHI, H.—Über den Brustkorb und die Wirbelsäule der Vögel. *Zeitschr. Ges. Anat. München u. Berlin* LXV, pp. 1-149 (1922).

BAKER, E. C. S.—*The Game-Birds* of *India, Burma* and *Ceylon* II, pp. 1-328, pls. i-xix (London : 1921).

BAKER, E. C. S.—A note on some Oriental Zosteropidae, and descriptions of new Subspecies. *Ibis* (II) IV, pp. 142-147 (1922).

BAKER, E. C. S.—The Game Birds of India, Burma and Ceylon. Part XXX (Genus *Arboricola*). *Journ. Bombay Nat. Hist. Soc.* XXVIII, pp. 1-22, one pl. (1921).

BAKER, E. C. S.—Birds of the Indian Empire. Part IV (Hand-list of the "Birds of India"). *Journ. Bombay Nat. Hist. Soc.* XXVIII, pp. 85-106 (1921).

BAKER, E. C. S.—The Game Birds of India, Burma and Ceylon. Part XXXI. *Journ. Bombay Nat. Hist. Soc.* XXVIII. pp. 305-313, plate (1922).

BAKER, E. C. S.—Birds of the Indian Empire, Part V *Journ. Bombay Nat. Hist. Soc.* XXVIII, pp. 313-334 (1922).

BAKER, E. C. S.—The Game Birds of India, Burma and Ceylon. Part XXXII (Genus *Perdix*). *Journ. Bombay Nat. Hist. Soc.* XXVIII, pp. 571-575, one plate (1922).

BAKER, E. C. S.—Birds of the Indian Empire. Part VI. *Journ. Bombay Nat. Hist. Soc.* XXVIII, pp. 576-594 (1922).

Baker, H. R.—Occurrence of the Malay Bittern (*Gorsachius melanolophus*) at Ootacamund, S. India. *Journ. Bombay Nat. Hist. Soc.* XXVIII, p. 547 (1922).

Basil-Edwardes, S.—Behaviour of the White-cheeked Bulbul (*Molpastes bucogenys*) when its young is in danger; and the (?) parental instinct of love for the offspring displayed by the dark grey Bush-Chat (*Oveicola ferrea*). *Journ. Bombay Nat. Hist. Soc.* XXVIII, pp. 280, 281 (1921).

Bolster, R. C.—The Occurrence, Habits and Breeding of the spotted Sandgrouse (*Pteroclurus senegallus*) in the Bahawalpur State, Punjab. *Journ. Bombay Nat. Hist. Soc.* XXVIII, pp. 807-809 (1922).

Field, F.—Rough list and notes on the Birds found breeding in the Gonda District, Oudh. *Journ. Bombay Nat. Hist. Soc.* XXVIII, pp. 753-772 (1922).

Finn, F.—The Water Fowl of India and Asia. Review in *Journ. Bombay Nat. Hist. Soc.* XXVIII, p. 254 (1921).

Fletcher, T. B. and Inglis, C. M.—Some common Indian Birds, Nos. 13-18. *Agric. Journ. India* XVII, pp. 3-6, 113-118, 221-224, 343-346, 441-444, 543-545, pls. (1922).

Frere, A. G.—Roosting Habits of the Common Babbler (*Argya caudata*). *Journ. Bombay Nat. Hist. Soc.* XXVIII, p. 280 (1921).

Higgins, J. C.—Manipur names of certain Birds. *Journ. Bombay Nat. Hist. Soc.* XXVIII, pp. 288-290 (1921).

Kinloch, A. P.—The Avifauna of the Nelliampathy Hills. *Journ. Bombay Nat. Hist. Soc.* XXVIII, pp. 279, 280 (1921).

Kinnear, N. B.—On the Birds collected by Mr. A. F. R. Wollaston during the first Mt. Everest Expedition. *Ibis* (11) IV, pp. 495-525, pl. vii (1922).

Law, S. C.—An Albinoid *Otocompsa emeria*. *Journ. Bombay Nat. Hist. Soc.* XXVIII, pp. 281, 282 (1921).

Magrath, H. A. F.—Kashmir Bird Notes. *Journ. Bombay Nat. Hist. Soc.* XXVIII, pp. 276, 277 (1921).

Osmaston, A. E.—Note on the Nidification and habits of some Birds in British Garhwal. *Journ. Bombay Nat. Hist. Soc.* XXVIII, pp. 140-160, pls. (1921).

Osmaston, B. B.—The White-spotted Fantail Flycatcher (*Rhipidura pectoralis*). *Journ. Bombay Nat. Hist. Soc.* XXVIII, pp. 282, 283 (1921).

Osmaston, B. B.—The Crested Swift (*Macropteryx coronata*). *Journ. Bombay Nat. Hist. Soc.* XXVIII, pp. 283, 284 (1921).

Osmaston, B. B.—Occurrence of the Flamingo (*P. roseus*) in the Central Provinces. *Journ. Bombay Nat. Hist. Soc.* XXVIII, p. 549 (1922).

Osmaston, B. B.—Birds of Pachmarhi. *Journ. Bombay Nat. Hist. Soc.*, XXVIII, pp. 453-459, pls. i, ii (1922).

Osmaston, B. B.—The Occurrence of the Blue-bearded Bee-eater (*Nyctiornis athertoni*) in the C. P. *Journ. Bombay Nat. Hist. Soc.* XXVIII, p. 805 (1922).

ROBINSON, H. C. and KLOSS, C. B.—The Birds of South-West and Peninsular Siam. *Journ. Nat. Hist. Soc. Siam* V, pp. 1-87 (1921).

ROBINSON, H. C. and KLOSS, C. B.—Birds from the One Fathom Bank Lighthouse, Straits of Malacca. *Journ. Fed. Malay States Mus.* X, pp. 253-255 (1922).

ROBINSON, H. C. and KLOSS, C. B.—A list of Birds collected on Pulau Rumpia, Sembilan Islands. *Journ. Fed. Malay States Mus.* X, pp. 255-259 (1922).

ROBINSON, H. C. and KLOSS, C. B.—List of Birds collected on Pulau Jarak, Straits of Malacca. *Journ. Fed. Malay States Mus.* X, pp. 259-260 (1922).

ROBINSON, H. C. and KLOSS, C. B.—Three New Oriental Birds. *Journ. Fed. Malay States Mus.* X, pp. 261, 262 (1922).

SCHAUBURG, R. S. VAN.—On a collection of Birds from Acheen (Sumatra). *Ibis* (11), IV, pp. 662-675 (1922).

STOCKLEY, C. H.—Notes on Duck in the Rawalpindi District. *Journ. Bombay Nat. Hist. Soc.* XXVIII, p. 548 (1922).

STRESEMANN, E. von—Einige Bemerkungen Zur " Synopsis of the Accipitres " von H. Kirke Swann. Die indoaustralischen Tagraubvögel. *Journ. Ornithologie* LXX, pp. 487, 488 (1922).

SWANN, H. K.—A Synopsis of the Accipitres (Diurnal Birds of Prey) Parts II, III, IV (London : 1922).

TICEHURST, C. B.—Notes on some Indian Wheateaters. *Ibis* (11) IV, pp. 151-159 (1922).

TICEHURST, C. B.—The Birds of Sind (Parts i and ii). *Ibis* (11) IV, pp. 526-571, 605-662, pl. viii (1922).

TICEHURST, C. B.—The Birds of Mesopotamia. *Journ. Bombay Nat. Hist. Soc.* XXVIII, pp. 210-250, pls. i, ii (1921).

TICEHURST, C. B.—The Birds of Mesopotamia. Part II. *Journ. Bombay Nat. Hist. Soc.* XXVIII, pp. 381-427, pls. 3, 4 (1922).

TICEHURST, C. B. and BUXTON, P. A. and CHEESMAN, R. E.—The Birds of Mesopotamia. Part III. *Journ. Bombay Nat. Hist. Soc.* XXVIII, pp. 650-674, two plates (1922).

WAIT, W E.—The Passerine Birds of Ceylon. *Spolia Zeylanica* XII, pp. 22-194, pls. i, ii (1922).

WAITE, H. W.—The Marbled Duck (*Marmaronetta angustirostris*) in the Punjab. *Journ. Bombay Nat. Hist. Soc.* XXVIII, p. 807 (1922).

WHISTLER, H.—The Birds of Jhang District, S. W Punjab. Part I.—Passerine Birds. *Ibis* (11) IV, pp. 259-309 (1922).

WHISTLER, H.—The Birds of Jhang District, S. W Punjab. Part II. —Non-Passerine Birds. *Ibis* (11) IV, pp. 401-436 (1922).

WHISTLER, H.—An Addition to the list of Indian Birds. *Journ. Bombay Nat. Hist. Soc.* XXVIII, pp. 544, 545 (1922).

Mammalia.

Chatterjee, N. C.—The Indian Pangolin (*Manis pentadactyla*). *Journ. Bombay Nat. Hist. Soc.* XXVIII, pp. 273, 274 (1921).

Das, B. K.—On Truncated Umbilical Arteries in Some Indian Mammals. *Journ. Anat.* LVI, pp. 325-332 (1922).

Fischer, C. E. C.—The Habits of the Grey Mongoose. *Journ. Bombay Nat. Hist. Soc.* XXVIII, p. 274 (1921).

Hutton, J. H.—The occurrence of the Stripebacked Weasel (*Mustela strigidorsa*) in the Naga Hills. *Journ. Bombay Nat. Hist. Soc.* XXVIII, pp. 795, 796 (1922).

Lönnberg, E.—Some Remarks about Eastern Hedgehogs. *Ann. Mag. Nat. Hist.* (9), IX, pp. 620-629 (1922).

Milner, C. E.—Wild Dogs in Burma. *Journ. Bombay Nat. Hist. Soc.* XXVIII, pp. 266, 267 (1921).

Milner, C. E.—Distribution of Serow in Burma. *Journ. Bombay Nat. Hist. Soc.* XXVIII, pp. 267, 268 (1921).

Phillips, W W. A.—Notes on the Habits of Some Ceylon Bats. *Journ. Bombay Nat. Hist. Soc.* XXVIII, pp. 448-452 (1922).

Pitman, C. R. S.—Notes on Mesopotamian Mammals. *Journ. Bombay Nat. Hist. Soc.* XXVIII, pp. 474-480 (1922).

Pocock, R. I.—The External Characters of *Scarturus* and other Jerboas, compared with those of *Zapus* and *Pedetes*. *Proc. Zool. Soc. London*, part iii, pp. 659-682 (1922).

Powar, G. B.—A Good female Chinkara Head (*G. Bennetti*). *Journ. Bombay Nat. Hist. Soc.* XXVIII, p. 266 (1921).

Robinson, H. C. and Kloss, C. B.—New Mammals from French Indo-China and Siam. *Ann. Mag. Nat. Hist.* (9) IX, pp. 87-99 (1922).

Robinson, H. C. and Moulton, J. C.—The Bearded pig (*Sus barbatus*) in the Malay Peninsula. *Journ. Straits Branch Roy. As. Soc.*, No. 85, pp. 202-205 (1922).

Sonntag, C. F.—The Comparative Anatomy of the Tongues of the Mammalia. VII. Cetacea, Sirenia, and Ungulata. *Proc. Zool. Soc. London*, part iii, pp. 639-658 (1922).

Stockley, C. H.—Some notes on the Horns of the Thamin (*Cervus eldi*). *Journ. Bombay Nat. Hist. Soc.* XXVIII, pp. 268-271, plate (1921).

Suter, M.—Occurrence of the Tree Shrew (*Anathana wroughtoni*) at Khandalla, Poona District. *Journ. Bombay Nat. Hist. Soc.* XXVIII, p. 537 (1922).

Thomas, O.—On some interesting Hedgehogs from the Persian Gulf. *Ann. Mag. Nat. Hist.* (9) IX, pp. 142-144 (1922).

Thomas, O.—On some new Forms of *Ochotona*. *Ann. Mag. Nat. Hist.* (9) IX, pp. 187-193 (1922).

Thomas, O.—Some Notes on Ferret-Badgers. *Ann. Mag. Nat. Hist.* (9) IX, pp. 193-196 (1922).

Thomas, O.—The Generic Classification of the *Taphozous* Group. *Ann. Mag. Nat. Hist.* (9) IX, pp. 266, 267 (1922).

THOMAS, O.—On Mammals from the Yunnan Highlands collected by Mr. George Forrest and presented to the British Museum by Col. Stephenson R. Clarke, D.S.O. *Ann. Mag. Nat. Hist.* (9) X, pp. 391-406 (1922).

THOMAS, O.—Scientific results from the Mammal Survey, Nos. XXX and XXXI. *Journ. Bombay Nat. Hist. Soc.* XXVIII, pp. 26, 27 (1921).

THOMAS, O.—A New Arabian Hare. *Journ. Bombay Nat. Hist. Soc.* XXVIII, pp. 28, 29 (1921).

THOMAS, O. and HINTON, M. A. C.—The Mammals of the 1921 Mount Everest Expedition. *Ann. Mag. Nat. Hist.* (9) IX, pp. 178-186 (1922).

WARD, A. E.—Game Animals of Kashmir and Adjacent Hill Provinces. Part III. *Journ. Bombay Nat. Hist. Soc.* XXVIII, pp. 595-609, one plate (1922).

WINGE, H.—A review on the interrelationships of the Cetacea. *Smithson. Misc. Coll.*, LXXII No. 8, pp. 1-97 (1921). (Translated by G. S. Miller, Junior.)

WROUGHTON, R. C.—Scientific Results from the Mammal Survey. No. XXIX. *Journ. Bombay Nat. Hist. Soc.* XXVIII, pp. 23-26 (1921).

CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
8, HASTINGS STREET

RECORDS

of the

INDIAN MUSEUM

(A JOURNAL OF INDIAN ZOOLOGY)

Vol. XXIV.

Appendix A.

Calcutta:
PUBLISHED BY THE DIRECTOR, ZOOLOGICAL SURVEY OF INDIA

1923

Price One Rupee.

NEW AND RARE ODONATA FROM THE NILGIRI HILLS.

By MAJOR F. C. FRASER, *I.M.S.*

(Plate I.)

The Odonate fauna of the Nilgiris is of more than ordinary interest in that these hills have furnished some of the earliest known types of Dragonflies.

The Nilgiris were first explored by Europeans in 1822 and Rambur described several species of dragonflies in 1842 which had been collected from those hills during the two decades which had elapsed.

Unfortunately the descriptions given by this entomologist, although good, are often not too exact and lead to doubt as to what particular insect was described, especially in a case where there are several insects closely similar. Amongst these latter is the description of *Indoneura gomphoides* (*Argia gomphoides* Ramb.) which was obviously made from an immature insect and which does not give the exact measurements.

The Baron de Selys in his *Synopsis des Agrionines*, p. 20, 1842, redescribed *I. gomphoides* and gave the measurements of the abdomen and hindwing. It is evident that he knew the type and made his description from it, for in 1886, in his *Revision des Agrionines*, p. 171, he described under the same name, two specimens which he had received from Mr. McLachlan and, concerning them, noted that they differed from the type by being larger, by having the wings more rounded and Cu_1 rather longer. This implies a close, personal comparison of two types and leaves no doubt as to which was the original of *Indoneura gomphoides*, viz. the smaller of the two species.

Of the two other closely related species found in the Nilgiris *Disparoneura canningi* Fraser has no blue markings and *Disparoneura westermanni* Hagen is much larger than either of the two species described by Selys.

During the last decade I have had several opportunities of collecting and examining large numbers of specimens of *Indoneura* over a wide range of the Nilgiris, and I find that there are two very distinct types of *I gomphoides* as described by Selys, the smaller of which is undoubtedly Rambur's type, and the larger a new species for which I propose the name *Indoneura ramburi*.

Indoneura gomphoides (Ramb).

Argia gomphoides, Ramb., *Ins. Nevrop.*, p. 256 (1842); *Alloneura et Disparoneura gomphoides*, Selys, *Syn. des Agrionines*, p. 448 (1860)

id., *Rev. des Agrionines*, p. 171 (1886); *Indoneura gomphoides*, Laid., *Rec. Ind. Mus.* XIII, p. 347 (1917).

Male. Abdomen 36 mm. Hindwing 26 mm.

The markings in the adult stage are all turquoise blue, the thoracic ground colour is citron yellow only in teneral specimens and soon passes to pale blue whilst the humeral stripes take on a deeper shade.

The abdomen is moderately robust and short, and built more on the lines of *Calicnemis eximia*.

The wings are moderately sharply pointed at the apex; *ac* is situated midway between the two antenodal nervures and meets *ab* well away from the posterior margin of the wing; Cu_2 is 11 cells in length: the stigma is dark brown framed in black nervures; the postnodal nervures in the forewing number 19-22.

Female. The markings in this sex are a dirty grey, the humeral stripe often having an ochreous hue. The markings on the end segments of the abdomen are bluish.

Habits. This species frequents streams on the kundahs (open grassy country) around Ootacamund, where in restricted localities it may be seen swarming during the early months of the year before the onset of the monsoon. The break of the rains in June leads in a few days to its total disappearance although on fine days or during temporary breaks in the monsoon, a few stragglers may be seen.

Indoneura ramburi, sp. nov.

Disparoneura gomphoides, Selys, l.c. (1886).

Male. Abdomen 44 mm. Hindwing 30 mm.

The markings do not differ markedly from those of *Indoneura gomphoides* and are coloured turquoise blue in the adult, citron yellow in immature specimens.

The abdomen is very long and slim when compared to that of *I. gomphoides* and is built more on the lines of that of *Coeliccia renifera*.

The wings are more blunt at the apex; *ac* is situated much nearer the basal antenodal nervure and meets *ab* almost or just at the posterior margin of the wing; Cu_2 is 13 or more cells in length; the stigma is black; the postnodal nervures number in the forewing 22–32.

The anal appendages do not differ from those of *Indoneura gomphoides*.

Female. Abdomen 42 mm. Hindwing 30 mm.

Except for its greater length, not differing from the female of *I. gomphoides*. Stigma pale brown. Postnodal nervures in forewing 22–23.

Habits. This species is found at a lower level than the former and has a much more scattered and extended range between 3000 ft. to 6500 ft. It is never found in swarms as is *I gomphoides* and it often travels far from the neighbourhood of its native streams, extending deep into the jungle.

Unlike *I gomphoides* it does not appear much before the onset of the monsoon in June and from that time onwards during the rains, gradually increases in number. I have never found the two species in company and they are certainly quite distinct. The type described by Selys is presumably in the McLachlan collection but I cannot say for certain as I omitted to take the measurements when examining the collection in 1920.

In males taken at an elevation of 3000 ft., abdominal segments 8 and 9 show an almost constant invasion of the blue by the black ground colour from the base. This latter colour projects into the blue as a subdorsal streak on each side and limits it also laterally so that on each segment an inverted blue "T" is formed. In all other respects these specimens agree with *Indoneura ramburi* so that they are probably not more than a local variety of it.

Type in my own collection, paratypes in British and Indian Museums.

Phylloneura westermanni (Selys).

Alloneura westermanni, *Bull. Acad. Belg.* (2) X, p. 447 (1860); *Disparoneura westermanni*, Selys, *Mem. Cour.* XXXVIII, p. 171 (1886); Laidlaw, *Rec. Ind. Mus.* XIII, p. 347 (1917).

Male. Abdomen 51 mm. Hindwing 38 mm.

This insect has been lost sight of for many years and some doubt exists as to what genus the insect really belonged to. Recently I have secured twelve male specimens of a dragonfly from near Gudalur, Nilgiris, 4500 ft., 26·vi·1921, which fit the description and measurements given for *P. westermanni* so exactly that there can be no doubt but that they belong to that species.

The colouring is closely similar to that of *I. gomphoides* so that the two insects are apt to be mistaken for one another when resting or on the wing and I fell into this error when I took the first specimen of *P. westermanni* and imagined that I had taken a particularly fine and large specimen of *I. gomphoides*. The former insect is, however, very much larger and the blue on the abdominal segments more extensive, covering the apical half of the 7th segment as well as the whole of the 8th to 10th.

The venation of the wing is irregular and is of interest in that it shows well-marked traces of a transitional reduction from a complex to a simple form of venation. Rudiments of intercalated sectors are found in the wings of many specimens and the straightening out of a zig-zagged M_2 is well illustrated.

P. westermanni is even more primitive than *Indoneura* and is not congeneric with the latter as Dr. Laidlaw had surmised; I have therefore placed it in a genus of its own. On the contrary it is more closely allied to *Disparoneura*, as *ab* extends outwards as far as Cu_2a which it joins, as in all species of the latter genus. It thus differs markedly from *Indoneura* in which *ab* curves downward to meet the posterior margin of the wing so as to enclose a marginal cell. The primitive nature of the venation, however, separates it from *Disparoneura* as sharply as the same feature separates *Indoneura* from typical *Caconeura*.

Postnodal nervures to the forewing 27–29 ; stigma black; Cu_2 is 13 cells in length or less than half the wing length.

Female. Abdomen 46 mm. Hindwing 35 mm.

Very similar to the male but of stouter build, differing as follows:—

Wings uniformly enfumed. In the right hindwing *ab* is connected to the posterior border by 2 transverse nervures. In both forewings it is nearly confluent with the posterior border at its outer part and the space between the 2 nervures can only be detected with the aid of a strong magnifying glass. In 3 out of the four wings there are rudiments of intercalated sectors. No blue on segment 7.

Segments 8 and 9 have blue dorsal markings shaped like a German helmet with the top spike directed basalwards but not quite reaching the base on the 8th. Segment 10 has the whole of the dorsum blue.

Ovipositor of great size and much more conspicuous than in *Indoneura*.

Habits. This species haunts the neighbourhood of mountain streams but, unlike *Indoneura*, is rarely found on low herbage but keeps to the shelter of overhanging branches at a height of 8 to 10 feet from the ground.

The female is described from a single specimen taken at the same place as the males, near Gudalur, 14·viii·21. It was captured *in copula* whilst ovipositing in water trickling over the surface of a rock.

Genus **Protosticta** Selys.

In addition to *Protosticta gravelyi* Laid. described in these *Records* from Cochin and Kanara, I have to record three new species from the Nilgiris, all closely allied but differing in markings and in the case of one species, in morphology.

Two of these were found in company and all have the same characteristic habits. They are found in the beds of rocky, mountain streams, where they keep to the cover of the banks or rocky boulders.

In the dark shadows of the latter they may be detected sitting with the body and abdomen held horizontally out and almost invisible save for the chain of tiny white spots on the head, prothorax and abdomen.

When disturbed they hover continually with the abdomen held rigidly out in spite of its enormous length and move forward with a series of short, jerky flights. The females are found in almost nocturnal darkness, small caverns amongst the rocks being especially favoured by them for purposes of concealment. They appear to breed in the patchy morass bordering the streams they frequent.

Sufficient stress has not been laid on the extraordinary morphology of these dragonflies. The enormous size of the eyes and the length of the abdomen are outstanding features and with regard

to the latter, if compared to the length of the thorax, it is probably the longest abdomen found in any known dragonfly not excepting *Mecistogaster*.

Key to the Protosticta *from Southern India.*

1.	Abdominal segments 8 and 9 of nearly equal length; stigma blood red	*P. sanguinostigma.*
	Abdominal segment 8 more than twice the length of segment 9; stigma black	2.
2.	Prothorax white marked with a posterior, dorsal, triangular spot	3.
	Prothorax entirely bluish white	*P. hearseyi.*
3.	Abdominal segment 8 entirely black	*P. gravelyi.*
	Abdominal segment 8 with the basal third or half bluish white, the apical third or half black, the dorsal carina of this segment on its basal half finely black ...	*P. stevensi.*

Protosticta hearseyi, sp. nov.

(Plate I, figs. 3, 4.)

Two males and 15 females, 26·vi·21, Gudalur, Nilgiris, 4500 ft.

Male. Abdomen 35 mm. Hindwing 21 mm.

Head black, labium ashy white, labrum and genae palest blue, the former margined finely with black, the two basal joints of antennae pale blue. Eyes pale blue changing to olivaceous on the crown and paling beneath.

Prothorax pale blue, unmarked.

Thorax glossy black, almost metallic on the dorsum, pale blue at the sides. The mid-dorsal carina strongly defined in pale blue. Laterally a broad, black stripe on the 2nd suture and foreborder of metepimeron.

Beneath a black spot between the two hind legs and a pair of elongated spots posteriorly which converge on one another as they approach the first spot.

Legs bluish white, the two posterior pairs with a linear, black stripe on the femora.

Wings hyaline, the apices rather elongate; stigma black, its costal border shorter than the posterior, the inner border oblique; 14 postnodal nervures in the forewing.

Abdomen blackish brown marked with pale blue, this colour most marked on the end segments. The sides of segments 1 and 2 whitish, as is also a diffuse streak on the mid-dorsum, incomplete on the apical half of segment 2; pale basal annules on segments 3 to 7 which broaden laterally and obliquely; segment 8 turquoise blue marked narrowly and apically with black; segments 9 and 10 black, the former having a bluish marking on its side shaped like a crescent and star.

Relative size of the abdominal segments as for *P. gravelyi* Laid.

Anal appendages of subequal length, about as long as the two last abdominal segments. The superior stout at the base with a spine on the inner side of smaller size and nearer the base than that

found in *P. gravelyi*, somewhat bayonet-shaped in profile and chelate at the apices, one arm however expanded and roughly quadrate (figs. 3 and 4). Inferior appendages stout at the base, simple, tapering to a fine point and curving up slightly.

Female. Abdomen 32·5 mm. Hindwing 22 mm.

Very similar to the male and differing as follows:—

The labrum is more broadly bordered with black; the eyes are pale olivaceous green changing to pale brown on the crown; the mid-dorsal carina of the thorax is only obscurely whitish at its upper part.

The basal annule on segment 7 is much broader and its border crenate, segment 8 is brownish black with a lateral, quadrate spot of white, whilst 9 is paler brown and marked with a broad, lateral spot of dirty white connected to a smaller spot subdorsally. Segment 10 very small, black.

Habits. Found in marshy spots hiding in the shadow of rocks or amongst scrub at the sides of precipitous ravines. This species differs from all others by the two sexes being of nearly equal length, by the male having the mid-dorsal carina of the thorax strongly marked with white, and by the prothorax being quite unmarked.

Protosticta sanguinostigma, sp. nov.

(Plate I, figs. 5, 6.)

Two adult males, 2 teneral males, 3·vii·1921 and 23·vii·1921, Coonoor Rd., 10th mile, 1500 ft., Nilgiris.

Male. Abdomen 47 mm. Hindwing 25·5 mm.

Head. Eyes bottle green, pale greenish blue beneath and marked uniquely with a broad band of dark blackish brown which begins above and behind and passes obliquely forward and downward along the sides.

Labrum turquoise blue, narrowly bordered with black: lower part of epistome blue, the rest of head jet black save for an obscure, transverse fascia of pale brown at the back of head. Anterior surface of the two basal joints of antennae pale.

Prothorax black above with an oval spot of blue at each side in the middle, the sides whitish.

Thorax jet black with a coppery, metallic sheen above, the sides pale blue marked with a lateral stripe of black on the 2nd suture which is bordered diffusely behind with brown.

Legs white with a broad, diffuse, pale brown annule near the dorsal end of the femora which are striped in their length with black on the extensor surface.

Wings hyaline, the stigma blood red, its costal side much shorter than the posterior, its inner side much shorter than the outer, the latter strongly convex; postnodal nervures to forewing 16–18.

Abdomen very long and slender, black on the dorsum, paler brown on the sides, marked with pale turquoise blue. Segment

3 with a very narrow and obscure basal annule, segments 4 to 7 with broader annules, increasing in breadth from the 4th to the 7th; 8th segment turquoise blue with the apical border more or less narrowly bordered with black, this colour being continued very narrowly along the dorsal carina and tapering gradually towards the basal end of the segment; segments 9 and 10 all black. The relative size of the segments is much the same as in the former species but 8 is only very slightly longer than 9.

Anal appendages much the same as in the last species but the spine at the base is more on the outer side and much stouter, the chelate ends are broader and the broader arm bifid at its extremity.

Female. Abdomen 39 mm. Hindwing 26 mm.

Very similar to the male but of much stouter build and with a shorter abdomen.

Head. Eyes deep bottle-green above, paler green beneath, these two shades of green separated by a thick, equatorial line of black. Rest of head as for male but the blue on labrum and lower epistome is of a deeper shade.

Prothorax blackish above, dirty white at the sides; the posterior lobe with lateral prolongations shaped as two projecting points.

Thorax as for male but blue markings of a deeper shade.

Wings hyaline; postnodal nervures to forewing 16, in the hind 15, stigma a cherry red, arc distal to the 2nd antenodal nervure.

Abdomen black with white or blue markings as follows:— 1st segment with a blue lateral spot, segment 2 has a bluish lateral basal marking prolonged along the ventro-lateral border, segment 3 has the middle two-thirds or three-fifths of its ventro-lateral border a pale whitish brown, segment 4 has very obscure basal and ventro-lateral markings, segment 5 has a well-marked basal white annule, segment 6 obscure basal and ventro-lateral markings, segment 7 has a broad basal annule bluish in colour, occupying about one-third of its length, the remaining segments entirely black.

Habits. Found in similar situations to the last but more retiring and never coming out into the open. The four specimens taken were in the deepest jungle clinging to maiden-hair fern sprouting from crevices in the rocks The insect is readily distinguished from others by its red stigma and by the equality in size of segments 8 and 9.

Type in my own collection, paratypes in British and Indian Museums.

Protosticta stevensi, sp. nov.

(Plate I, figs. 1, 2, 7.)

Five females and a considerable number of males taken on the Coonoor-Metuppalayam Rd., 10th mile, 1500 ft., 3·vii 1921 and 24·vii·1921.

Male. Abdomen 49 mm. Hindwing 22 mm.

This species is very closely related to *P. gravelyi* from which it differs by the greater length of the abdomen and by the 8th abdominal segment having its basal third of half pale blue instead of all black as in *P. gravelyi*. The dorsal carina of this segment is narrowly black in its basal half.

Female. Abdomen 37 mm. Hindwing 23 mm.

Differing from *P. gravelyi*, which it much resembles, by the difference in the relative lengths of hindwing and abdomen and the markings of the abdomen. The basal annule on segment 7 occupies about the basal fourth and there is no basal annule to segment 8 but a lateral, irregular spot. There is also a large diffuse white spot on the outer side of the eye which is not present in *P. gravelyi*.

The ovipositor of this and other species has a large, prominent, stout, upward-turned spine on its dorsal apical surface.

Habits. As for the genus, but bolder and to be seen frequently flying in mid-stream. Large numbers of males were seen on the 3rd of July all with their heads facing up stream and travelling slowly in that direction. A few were seen paired, but the females as a rule kept to the shelter of the scrub lining the stream, where apparently the males sought them. By the 23rd of July the numbers had greatly diminished and few were seen.

Type in my own collection, paratypes in British and Indian Museums.

Pseudophaea fraseri Laidlaw.

Rec. Ind. Mus. XIX, p. 23 (1920).

Two females and a large number of males, Gudalur, 4000ft., Nilgiri Wynaad, 9·vii·1921.

Thanks to the kindness of Mr. Laidlaw I have been able to compare the above specimens taken by myself with a paratype of *P. fraseri* and I find that the differences are so marked as to constitute a very distinct race if not a new species. For the present and until I receive Mr Laidlaw's opinion I propose to call this race *wynaadensis*.

The differences are as tabulated :—

P. fraseri.	*P fraseri*, race *wynaadensis.*
Length of forewing 35 mm.	Length of forewing 38 mm.
Greatest breadth 6·5 mm.	Greatest breadth 7 mm.
Apical third of hindwing opaque, from 8·5 to 10 mm. long.	Considerably more than the apical third opaque, from 12 to 13 mm. long.
Length of abdomen 38 mm.	Length of abdomen 43 mm.

In addition to the above the anterior pair of femora are brownish black on the flexor surface, bright yellow on the extensor. The dorsal wedge-shaped line is bright turquoise blue and is so sharply contrasted with the black background as to give the impression

that it is phosphorescent and in fact it appears to glow like the lamp of a glowworm.

The second line on the thorax is ochreous in colour, and the first 6 segments of the abdomen are blood-red.

Female. Measurements of the two specimens :—

Abdomen 34 mm.	Forewing 35 mm.	Hindwing 32 mm.
,, 34·5 mm.	,, 36 mm.	,, 34 mm.

The wings are slightly enfumed throughout and the apices of both are tipped with brown, especially the hindwing where this colour extends in as far as the proximal end of the stigma. For the rest, the female does not differ from typical *P. fraseri* except that the antehumeral lines do not meet anteriorly on the thorax, but are parallel throughout.

Habits. This insect is found perched on plants and twigs overhanging the borders of the streams it frequents. Unlike most if not all other *Calopterygines* it is frequently seen settled with the wings outspread and the abdomen raised at an angle like many Libellulines.

The females are rarely found near water, but penetrate into the neighbouring jungle where they may be found paired with the males.

Type male and female in my own collection, paratypes in British and Indian Museums.

The distribution of this insect and *P. dispar* is extraordinarily local. The two never apparently occur together, but may be found on the same stream at different altitudes. At Gudalur *P. dispar* is found at an elevation of 4000 to 4500 ft., often in considerable numbers, whilst two miles further down the valley at an elevation of 3500 ft., *P. fraseri* is quite common. On the opposite side of the Nilgiris *P. dispar* is met with at elevations varying from 3500 to 6000 ft. at Coonoor, *P. fraseri* being entirely absent.

Phyllomacromia nilgiriensis Fraser.

Female. A single female, 24·vii·1921, near Kalar.

The type is in the British Museum and was taken in June, 1917, by myself at a stream not far above Kalar. I have now secured another specimen, also a female, taken on the same stream at about 100 yards from where the type was caught.

The wings of this specimen are enfumed throughout, the colouration forming a diffuse network corresponding to the nervures. The saffronation extends out nearly to the trigones; otherwise it does not differ from the type.

Taken whilst ovipositing in wet sand which formed the floor of a small, dark cavern amongst rocks bordering a mountain stream.

EXPLANATION OF PLATE I.

FIG. 1.—Terminal abdominal segments and anal appendages of *Protosticta stevensi*, dorsal view.

,, 2.—The same seen from the side.

,, 3.—Terminal abdominal segments and anal appendages of *Protosticta hearseyi*, dorsal view.

,, 4.—The same seen from the side.

,, 5.—Terminal abdominal segments and anal appendages of *Protosticta sanguinostigma*, dorsal view.

,, 6.—The same seen from the side.

,, 7.—Head and thorax of *Protosticta stevensi*.

ODONATA FROM THE NILGIRI HILLS

OBSERVATIONS ON THE INVERTEBRATE FAUNA OF THE KUMAON LAKES.

III. The Freshwater Mollusca.

By B. Prashad, *D.Sc., Assistant Superintendent, Zoological Survey of India.*

The present paper on the Mollusca of the Kumaon Lakes is a continuation of the two papers published by Dr. N. Annandale and Dr. S. W Kemp in 1912 [1] on the Invertebrate Fauna of the Kumaon Lakes. It is based on a small collection of molluscs made by Dr. Kemp in 1911, and the large series of specimens obtained by Mr. S. L. Hora and myself from the various lakes and streams in August, 1920. The lakes visited were: Naini Tal, Sariya Tal, Khurpa Tal, Sukha Tal, Bhim Tal, Naukuchia Tal, Sat Tal, Damianti Tal and Malwa Tal. Collections were also made in the hill-streams running in the vicinity of these lakes. Notes on the situation, etc., of most of these will be found in the paper cited already, and I only include here a few general observations on the physical conditions of the lakes during August, 1920, with more detailed notes on the areas not visited by Dr. Kemp in 1911.

The water-level in all the lakes was much higher at the time of our visit than at that of his, owing to large quantities of water that had been brought during the rains from the extensive catchment-areas around each of them; the area of the lakes also was much larger. The shallower regions of the lakes, which in May, 1911, had been found to harbour rich growths of sponges and Polyzoa, had five to six feet of water, and sponges and Polyzoa were practically non-existent. The water in most of the lakes was clear and held very little mud in suspension.

All the lakes with the exception of Malwa Tal had, along the margins and up to a depth of about ten feet, thick growths of aquatic plants such as *Chara*, *Potamogeton*, *Hydrilla* and *Nelumbium* and large quantities of algae, such as *Spirogyra*. Sponges and Polyzoa were in a few cases found growing on the stems and leaves of these aquatic plants.

The fauna as a whole was very poor. The Peridiniid, which was found to be very common in 1871 [2] and rather scarce in 1911, was only found in very small numbers in Bhim Tal and in still smaller numbers in Naini Tal. Leeches were plentiful under

---

[1] *Rec. Ind. Mus.* VII, p. 129 (1912).
[2] *Ann. Mag. Nat. Hist.* (4) VII, p. 229 (1871).

stones near the margins and a species of *Glossosiphonia* was found parasitic on *V bengalensis mandiensis*. Dragon-fly larvae, both Libellulids and Aeschnids, were fairly common, but the number of aquatic Hemiptera and Coleoptera was very small; in Malwa Tal the Hemiptera were a little more numerous. A special feature of Bhim Tal was the large numbers of Chironomid larvae which were living in tubes attached to submerged stones and tree-trunks. Molluscs of the genera *Limnaea, Gyraulus, Segmentina, Hippeutis* and *Sphaerium* were found in varying numbers in almost all the lakes, but *V bengalensis mandiensis* was only found in Naini Tal and Khurpa Tal. The conditions as to Crustacea were identical with what was found to be the case by Dr. Kemp in 1911. Fishes of the genera *Oreinus, Barilius, Barbus* and *Ophiocephalus* were common in all the lakes, and a species of the genus *Labeo* was also found in Malwa Tal.

SARIYA TAL.

This is a rather small lake, or rather a marsh in the course of a rapid hill-stream. It is situated at a distance of about three miles to the west of and at a slightly lower level than Naini Tal. It is a depression in the course of the hill-stream with about 3 to 8 feet of water; the area is not very large and the current in the lake is much slower than in the hill-stream. The entire area at the time of our visit supported a very thick vegetation consisting mainly of *Chara, Potamogeton* and large quantities of algae.

No Sponges or Polyzoa were seen. Dragon-fly larvae of *Sympetrum* sp.,[1] all too young to identify specifically, were fairly abundant. The Molluscan fauna was very poor; only a few *Limnaeae* and Planorbids were found after careful search.

KHURPA TAL.

Khurpa Tal is situated at a distance of about five miles from Naini Tal at an altitude of 5365 ft. It occupies a nearly circular depression surrounded on all sides by high hills. The area during the dry season is rather small, but the lake becomes much more extensive during the rains. The lake was stated to be over ten feet deep near the middle, though near the margins it is quite shallow. It is not fed by any streams and there is no regular outflow of water. At the time of our visit there was no real aquatic vegetation and the water was quite clear.

The fauna, which was very poor, consisted of the same species of fish as are found in the other lakes, a few dragon-fly larvae of the species *Anax parthenope* Selys, some *Limnaeae* and large numbers of *V bengalensis mandiensis* along the banks, feeding on algae growing on stones. No Planorbids were seen.

[1] I am indebted to Major F. C. Fraser, I.M.S., for the identifications of the dragon-fly larvae.

SUKHA TAL.

In May, 1911, this area was found to be quite dry, but a few Cladocera and Ostracoda were reared out of some earth brought back to Calcutta. In September, 1920, practically the whole of this area had 2 or 3 feet of water. The vegetation was very scanty, consisting only of a few stray plants of *Potamogeton*, but algae like *Hydrodictyon* and *Spirogyra* were very abundant.

A fair number of Cladocera and Ostracoda were collected and water-bugs were plentiful near the margins. Larvae of dragon-flies of the species *Anax parthenope* Selys, *Lestes cyanea* Selys and *Orthetrum triangulare* Selys were fairly abundant. No *Limnaea* was seen, but Planorbids of the genus *Gyraulus* were common amongst the algal filaments.

DAMIANTI TAL.

Situated at about the same level as the Sat Tal, but about a mile to the east of it, is a spring known as the Damianti Tal. A small stream, which has been greatly widened and deepened for irrigation purposes, leads down from the spring to the valley below. At the time of our visit both the spring and the mouth of the stream were full of cow-dung with many submerged grasses growing in them.

The only interesting animals collected here were a few *Limnaeae*, a few *Gyraulus* and some bivalves of the common Indian species, *Sphaerium indicum*.

The hill-streams were very uninteresting from the molluscan point of view. In the upper regions, where they are fairly rapid, no molluscs were found, but lower down they had a few Mollusca of the families Melaniidae, Planorbidae and Hydrobiidae. As these Molluscs were collected outside the limits of the Tal area and as they belong to common Gangetic species, I do not propose to include them in the present paper.

Family LIMNAEIDAE.

Genus **Limnaea** Lamarck.

Two species of this genus, *L. acuminata* and *L. luteola*, were collected in the Tal area. The former is the common species and is represented by a number of forms or phases, while the latter has a much restricted distribution and was found only once in a pond on the roadside near Naukuchia Tal.

Limnaea acuminata Lam.

1881. *Limnaea acuminata*, von Martens, *Conch. Mitth.* I, p. 75, pl. xiv.
1921. *Limnaea acuminata*, Annandale and Prashad, *Rec. Ind. Mus.* XXII, p. 568, pl. vii, figs. 1-3, text-fig. 12.

In the paper cited above Dr. Annandale and I have given reasons for considering most of the Indian species of the older

authors as being only forms, variations or phases of this highly plastic species. A few further remarks are necessary in view of the material now collected from the Tal Lakes.

Large series of specimens collected in Naini Tal, Sariya Tal, Khurpa Tal and Malwa Tal are like the typical *L. patula* Troschel figured by von Martens. Some of the shells from Naini Tal are referrable to the form *amygdalum* Troschel, while quite a large series of specimens are intermediate between the two forms. In view of these facts our conclusions as to the desirability of suppressing these names seem to be justified. We were, however, in doubt as to the form *chlamys* Benson. With a large series of specimens from a marshy area near Bhim Tal and from Naukuchia Tal, I believe this to be a well marked phase. Its elongate shape with a subcylindrical body-whorl, the comparatively short spire, rather narrow and elongate mouth with a nearly straight outer lip and the sulcate sculpture are quite characteristic of this phase.

The form referred to as Sowerby's *ventricularius* by Annandale[1] and *ventricularius* Kuster in the paper cited above was included on the authority of some Indian Museum specimens identified by Preston. The three shells, as I now find on comparison with the large series of shells from Naini Tal, are all young specimens of the form *amygdalum* Troschel and have nothing to do with the species *L. ventricularius* Parreiss, from " Ostindien."

Limnaea luteola Lam.

1920. *Limnaea luteola*, Annandale, *Ind. Journ. Med. Res.* VIII, p. 109.

This species, as was stated by Annandale in the paper cited above, is identical with Deshayes' *L. succinea*, but as Lamarck's name has priority, it should be known as *L. luteola*. It is not very abundant in the Gangetic Valley, but is the common species of Peninsular India. The occurrence of large numbers of specimens in a muddy pool near Naukuchia Tal at an altitude of over 4000 ft. is, therefore, of special interest. In this pool the specimens were found attached to the stems of *Potamogeton* and to a grass which were growing abundantly in the muddy waters of the pool.

All the specimens are quite typical and are fully grown.

Genus Gyraulus Agassiz.

1919. *Gyraulus*, Annandale and Prashad, *Rec. Ind. Mus.* XVIII, p. 52.
1921. *Gyraulus*. *id.*, *ib.*, XXII, p 582.

This genus is represented in the Tal Area by three species *G. convexiusculus* (Hutton), *G barrackporensis* (Clessin) and what appears to be an undescribed species. I do not, however, propose to describe it till the collection of the Indian Museum Planorbidae,

[1] *Ind. Journ. Med. Res.* VIII, p. 110 (1920).

now with Monsieur L. Germain of the Paris Museum, is returned to India.

Gyraulus convexiusculus (Hutton).

1921. *Gyraulus convexiusculus*, Annandale and Prashad, *op. cit.*, p. 582

Large numbers of specimens of this species were collected in Naini Tal, Sariya Tal and a hill-stream opening into the north-western corner of Bhim Tal, attached to the stems of *Potamogeton* and entangled in the filaments of algae like *Spirogyra*.

Gyraulus barrackporensis (Clessin).

1886. *Planorbis Barrackporensis*, Clessin, *Limnaeiden* in Mart. Chemn. *Conch. Cab.*, p. 125, pl. xviii, fig. 7.
1886. *Planorbis Huttoni, id., ib.*, p. 139, pl. xviii, fig. 4.
1909. *Planorbis barrackporensis*, Germain, *Rec. Ind. Mus.* III, p. 120.
1915. *Planorbis (G.) barrackporensis* and *P. (G.) huttoni*, Preston, *Faun. Brit. Ind. Freshw.-Moll.* pp. 121, 120.

I agree with Germain in considering *P. barrackporensis* and *P. huttoni* as being the same species. The species is known to occur in such widely separated localities as Barrackpore, Calcutta, Benares and Tibet.

In the Tal area we collected specimens of this species in Naukuchia Tal along with those of *Hippeutis caenosus* (Benson).

Genus Hippeutis Agassiz.

1921. ? *Hippeutis*, Annandale and Prashad, *op. cit.*, p. 584.

In the paper cited above Dr. Annandale and I recently suggested that Benson's *Planorbis caenosus*, which had hitherto been assigned to the genus or sub-genus *Segmentina*, agrees with his other species *P. umbilicalis* in shell-characters and is probably congeneric with it. We further questioned their being included in the genus *Segmentina* and suggested that they should probably be placed in the genus *Hippeutis*. An examination of the soft parts and radula of the European *H fontanus* confirms this opinion.

Hippeutis caenosus (Benson).

1850. *Planorbis caenosus*, Benson, *Ann. Mag. Nat. Hist.* (2) V, p. 349.
1876. *Planorbis caenosus*, Hanley and Theobald, *Conch. Ind.* pp. xviii and 18, pl. xxxix, figs. 7–9.
1878. *Planorbis caenosus*, Sowerby, *Conch, Icon.* XX, pl. x, figs. 78, *a, b.*
1878. *Planorbis caenosus*, Nevill, *Hand List Moll. Ind. Mus*, I, p. 246.
1886. *Planorbis caenosus*, Clessin, *op. cit.*, p. 165, pl. xxiv, fig. 4.
1915. *Planorbis (Segmentina) caenosus*, Preston, *op. cit.*, p. 127.
1918. *Planorbis caenosus*, Annandale, *Rec. Ind. Mus.* XIV, p. 113.

This species has been recorded from Jamalpur, Bengal; Manbhum, Orissa; Bhim Tal, United Provinces; and Yawnghwe Province, Burma. A fair series of specimens was collected by us in

Naukuchia Tal. Unfortunately most of them were dead shells and are not, therefore, available for anatomical study.

Genus **Segmentina** Fleming.

1921. *Segmentina*, Annandale and Prashad, *op. cit.*, p. 585.

In the Tal area we found specimens of *S. calathus* (Benson), the only Indian species which Dr. Annandale and I were able to assign definitely to this genus.

Segmentina calathus (Benson).

1821. *Segmentina calathus*, Annandale and Prashad, *op. cit.*, p. 585.

We found only a few specimens of this widely distributed species amongst the algae in Naini Tal. The specimens were found only near the shores.

Family HYDROBIIDAE.

In spite of careful search no representatives of this family were discovered by us in the Tal Lakes and I am very doubtful as to whether any of them are really endemic in the lakes. While making this rather bold statement I am aware of the record of some specimens of *Tricula montana* and *Bythinia pulchella* from Naini Tal by Nevill in his Hand-List,[1] but that does not necessarily mean that the specimens referred to were collected in the lake itself. Benson's type-series of the former species was collected in a small stream flowing into Bhim Tal and probably Stoliczka's specimens referred to by Nevill were also obtained from some stream around Naini Tal. The only specimen of *B. pulchella* (also from Stoliczka's collection, but not now to be traced in the Indian Museum) must also have been collected outside the lake, as the species is not known to inhabit large areas of clear water.

Genus **Tricula** Benson.

1921. *Tricula*, Prashad, *Rec. Ind. Mus.* XXII, p. 67.

I have nothing further to add to my recent account of the genus and of the species, *T. montana*, of the Tal area.

Genus **Digoniostoma** Annandale.

1920. *Digoniostoma*, Annandale, *Ind. Journ. Med. Res.* VIII, p. 104.
1921. *Digoniostoma*, Annandale, *Rec. Ind. Mus.* XXII, p. 4.

The only species which we actually found in the Tal area was Benson's *Paludina pulchella*. It has, on shell-characters alone, been recently assigned to the genus *Digoniostoma*, but the radula and soft parts are certainly different from those of *D. cerameopoma*, the type-species of the genus. I do not, however,

---

[1] *Hand-List Moll. Ind. Mus.* II, pp. 35 and 62 (1884).

discuss the generic position here, as, in view of Robson's [1] recent remarks, I propose revising all the Indian Hydrobiidae when more material is available.

Digoniostoma (?) **pulchella** (Benson).

1836. *Paludina pulchella*, Benson, *Journ. As. Soc. Bengal* V p. 476.

Large series of specimens of this species were collected by us in a pond along the roadside near Naukuchia Tal at an altitude of over 4000 ft., together with specimens of *L. luteola*.

Family VIVIPARIDAE.

Genus **Vivipara** Lam.

In the Tal area this genus is represented by a race of the common Indo-Gangetic species *V bengalensis*. Even this race was found to have a restricted distribution, as specimens were found only in Naini Tal and Khurpa Tal.

Vivipara bengalensis race **mandiensis** Kobelt.

1921. *Vivipara bengalensis* race *mandiensis*, Annandale, *Rec. Ind. Mus.* XXII, p. 271.

I have nothing to add to Annandale's detailed account of this and the allied races, beyond recording the occurrence of this race at such high altitudes as that of Naini Tal and Khurpa Tal.

Family CYRENIDAE.

Genus **Sphaerium** Scopoli.

1921. *Sphaerium*, Prashad, *Rec. Ind. Mus.* XXII, p. 614.

I have nothing to add to my recent account of this genus and of the widely distributed Indian species, *S. indicum* Desh., specimens of which were found by us in Damianti Tal.

---

[1] *Ann. Mag. Nat. Hist.* (9) VIII, pp. 401–413 (1921).

A REVIEW OF THE INDIAN SPECIES OF *AMBLYCEPHALUS*.

By Colonel F WALL, *C.M.G., I.M.S.*

I have recently had an opportunity of studying all the representative snakes of the genus *Amblycephalus* in the Indian Museum and in the Bombay Natural History Society's collections. I propose to add to this material the information derived from specimens I have collected myself, and to review the genus so far as it concerns Indian species. The Indian Museum contains types of what have been up to date accepted as three distinct species, viz. *modestus* (Theobald), *macularius* (Theobald) and *andersoni* (Boulenger), but which, I hope to show, should be regarded as a single species. It is to be noted that many of the head-shields in individuals of some of the species are subject to frequent variation owing to confluence. Further I notice that in many specimens the details of the periocular lepidosis are difficult to determine in spirit specimens. The praeocular, subocular, and postocular are difficult to differentiate owing to creases which simulate sutures, and it is sometimes impossible to be certain whether merely a crease is present or a genuine suture.

CHARACTERS OF THE GENUS.

General. Short snakes not exceeding about 610 mm. (2 feet) in length. Head bluntly rounded anteriorly, separated from the body by a much constricted neck. Snout short, feebly declivous, with no canthus rostralis. Nostril piercing about the middle of an entire shield. Eye large, with brilliant yellow iris, and a vertical pupil. Body strongly compressed. Tail short, about one-sixth to one-ninth the length of the body.

Lepidosis. Rostral rather broader than deep; the portion visible above less than the suture between the internasals. *Internasals*: a pair; broader than long; the suture between them less than half the internaso-praefrontal sutures. *Praefrontals*: a pair; the suture between them shorter than the internaso-praefrontal sutures. Touching the eye (except in *carinatus*). *Frontal* longer than the snout, longer than the supraoculars, shorter than the parietals. *Nasal* entire. *Loreal*: one; touching the internasal, touching the eye in some species. *Praeocular* variable, one usually present. Absent in some species. *Postocular* variable; usually one, sometimes none. *Suboculars* variable; one to four. *Temporals* variable; one to three anterior. *Supralabials*: 7 or 8; the 1st and 2nd touching the nasal, usually none touching the eye,

the last longer than the two preceding shields. *Mental* variable; sometimes touching the anterior sublinguals, sometimes not. *Sublinguals*: three large pairs, roughly symmetrical, with no groove between them. *Infralabials* very small. *Costals*: in 15 rows in the whole body-length; smooth, or some of the median rows feebly keeled. No apical pits. Vertebrals usually enlarged; arising by a gradual development, not a confluence of rows. *Ventrals* well developed, broad; the first the largest of the series. *Anal* entire. *Supracaudals* in even rows, vertebrals not enlarged. *Subcaudals* in pairs.

OSTEOLOGICAL CHARACTERS.

Praemaxilla about as broad as high. *Nasals* forming an osseous suture with the frontals. *Frontals* contributing to the rim of the orbit; not constricted at midorbit. *Praefrontal* suture extending beyond the middle of the frontal. *Postfrontal* not touching the frontal. *Parietal* contributing to the rim of the orbit. *Supratemporal* rudimentary; not projecting beyond the quadrate anteriorly. *Quadrate* well developed; oblique from above backwards. *Columella auris* extending from about the middle of the quadrate to the exoccipital. *Maxilla* about half the length of the dentary; expanded in depth anteriorly; expanded laterally posteriorly. Teeth 1 to 6; anododont, syncranterian, scaphiodont. An edentulous space anteriorly also posteriorly in some species. *Ectopterygoid* well developed; expanded anteriorly to overlie the posterior expansion of the maxilla. *Palatine* short; expanded laterally anteriorly. Teeth 1 to 3; anododont, kumatodont or scaphiodont. An edentulous space anteriorly, and in some species posteriorly. *Pterygoid* long. Teeth 7 to 20; anododont, scaphiodont. *Mandible.* Angular present. Splenial present. Coronoid absent. Dentary about twice its distance to the quadrate. Teeth 15 to 23; anododont, scaphiodont. *Occipitals.* The condyle is horseshoe-shaped, and formed by processes from the basioccipital and exoccipitals.

Vertebrae. Neural spines. Absent on the atlas. Well developed and as long as the body on the axis. Short and obliquely set backwards on the 3rd and 4th vertebrae, nearly as long as the body in the succeeding corporeal, and the caudal vertebrae. *Hypapophyses.* Well developed and vertical on the atlas. Bifid on the axis, the anterior vertical, the posterior obliquely set backwards. Disappearing in the vertebrae in the second-eighth of the body.[1] Absent on the first two caudal vertebrae. Two, laterally placed, on the 3rd and succeeding caudal vertebrae.

Costae. First as long as the second, articulated to the 3rd vertebra. Last bifid, the outer ramus about one-third as long as the inner. *Pseudocostal processes.* Bifid on the 1st, 2nd and 3rd caudal vertebrae, single on the succeeding vertebrae.

[1] As I find is the case in over twenty five species of Colubridae where the hypapophyses are not continued to the last vertebra. This site suggests some connection with the shoulder girdle of some ancestral form.

Amblycephalus monticola (Cantor).

A. monticola, Annandale, *J.A.S. Beng.* 1905, p. 176; *Rec. Ind. Mus.* 1912, pp. 37, 50 and 54; Boulenger, *Cat.* III, 1896, p. 443; Sclater, *List. Sn. Ind. Mus.* 1891, p. 66; Wall, *J. Bomb. N. H. S.* 1908, p. 354; *id., ibid.*, 1909, p. 356; *id., ibid.*, 1910, p. 843.

Colour. Uniform brown of various shades dorsally, lighter in the flanks. A series of narrow, blackish, vertical bars laterally, most distinct in the anterior part of the body, and tending to disappear at mid-body or posteriorly. Belly uniform paler brown to sordid yellow, with darker spots or dots. Head brown above. A more or less distinct narrow black bar on the neck, sending forwards a branch to the supercilium, and often another between the parietal shields. A narrow blackish streak from the eye to the gape.

Length. My largest specimen a female, measured 750 mm. (2 feet, 5½ inches).

Disposition. A live specimen that I acquired in Assam apparently unscathed proved to be a very quiet inoffensive creature, that allowed itself to be handled without betraying any malice. In spite of every provocation I could not induce it to assume an attitude of offence, or bite any object, but it emitted the tongue in a lazy fashion. Its movements were slow, which is not surprising in a snake that has so strongly compressed a body.

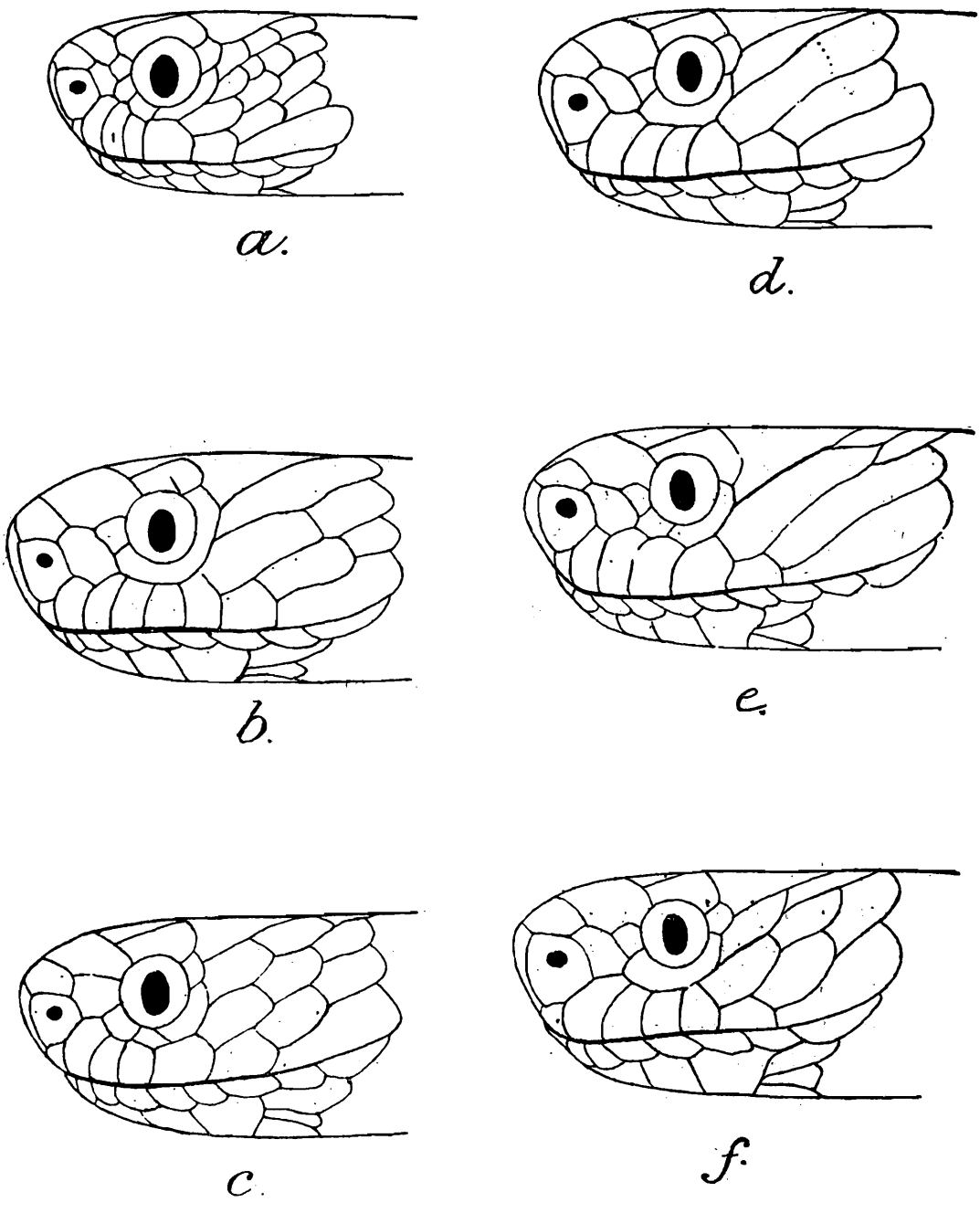
Food. The diet appears to consist exclusively of slugs and snails. I have on some occasions in Shillong removed one or two large black slugs from the stomach, which I was informed were a species of *Austenia*. Many other specimens contained small snails, some devoid of shell, others with broken shell attached, and once one with a perfect shell. I have known as many as five of these small snails in one specimen.

Breeding. I have examined three gravid females, and found eggs of such a size and character as to make it fairly certain that this species is oviparous. As many as six eggs were found in one example. The smallest specimens I have seen, apparently hatchlings, were 168 and 178 mm. (6⅝ and 7 inches) in length, but no dates of capture were available. The anal glands in both sexes furnish a custard-like secretion.

The genitalia are different from those of any other snake I have examined. They are slender cylindrical organs, which are bifurcate about half the length of their maximum extrusion. Each limb is cylindrical, and from base to apex there is no sign of any of those cartilaginous processes, which are seen in snakes of the families Colubridae and Viperidae.

Lepidosis. Praefrontal touching the eye. *Frontal* hexagonal in shape. Length much greater than the snout, greater than its breadth, two-thirds to four-fifths the parietals *Supraoculars* length subequal to, or rather greater than the praefrontals, half to three-fifths the frontal, two-fifths to half the parietals. *Loreal* touching the eye. *Praeocular* wanting; replaced by the contact of the loreal with the eye. *Postocular* one. I have seen this

confluent with the supraocular on one side in one specimen. *Suboculars* usually two, sometimes three. *Temporals* two anterior, the lower about half the length of the last supralabials Usually two lying along the parietals. *Supralabials* 7, sometime.



TEXT-FIG. 1.—Lepidosis of the Head in
a. *Amblycephalus carinatus*, Boie.
b. *A. moellendorffi* (Boettger).
c *A. monticola* (Cantor).
d. *A. andersoni*, Boulenger. Type.
e. *A. modestus*, Boulenger. Type.
f. *A. macularius* (Theobald). Co-type.

8 (rarely 6). In all my fresh specimens I found none touched the eye. In spirit specimens, however, it is not unusual to see the 4th, or the 4th and 5th touching the eye; 7th as long as, or longer than the 6th and 5th taken together. *Mental* usually touching the anterior sublinguals, rarely not. *Costals* in 15 rows in the

whole body length, obscurely keeled in the median rows of the posterior part of the body. Vertebral enlarged. *Ventrals* 181 to 198. *Subcaudals* 69 to 87.

Eye. Diameter subequal to the supraocular, three-seconds to four-thirds its distance to the edge of the lip.

Dentition. From three skulls in my collection. *Maxillary*: 5 to 7; syncranterian, anododont, kumatodont. An edentulous space anteriorly that would take two teeth. *Palatine*: 2 or 3; anododont, isodont. An edentulous space anteriorly that would take about two teeth, and another posteriorly that would take about three. *Pterygoid*: 11 to 13, anododont, very evenly scaphiodont. Mandibular: 20 to 24, anododont, very evenly scaphiodont.

Distribution. Eastern Himalayas. Sikkim. Assam: Abor Hills (*Ind. Mus.*), Naga Hills (Samaguting, *Ind Mus.*); Khasi Hills (*F W.*); Sibsagar (*Ind. Mus.*); near Jaipur (*F W.*); Dibrugarh (*F W.*).

Note.—I discredit the authenticity of the record from the Nicobars on the authority of de Roepstorff. The specimen (No. 8888) in the Indian Museum is indubitably this species. De Roepstorff's name is associated with two other records equally untrustworthy in my opinion, he being the only authority to record the Indian *Polyodontophis sagittarius*, and the Ceylon *Oligodon sublineatus* from the Nicobars.

Amblycephalus moellendorffi (Boettger).

A. moellendorffi, Boulenger, *Cat.* III, 1896, p. 443; Sclater, *List Sn. Ind. Mus.* 1891, p. 67.

Colour. Dirty white or greyish, heavily mottled with very fine purplish-brown specks on the dorsum. Many small round whitish spots outlined with purplish-brown, showing a decided tendency to form crossbars. A more or less conspicuous whitish collar. Belly irregularly spotted with blackish laterally. Beneath the tail densely mottled with fine blackish specks. Head uniform purplish-brown. Young marked exactly like adults.

Length. 350 mm. (1 foot, 1¾ inches). The smallest specimen I have seen was 162 mm. (6⅜ inches) in length.

Habits. The many specimens I acquired on Hong Kong Island were captured in the low scrub jungle on the slopes of the Peak.

Lepidosis. Praefrontal touching the eye. *Frontal* hexagonal in shape. Length subequal to or rather greater than the snout, subequal to its breadth, three-fifths to four-fifths the parietals. *Supraocular* shorter than the praefrontal, about half the length of the frontal, one-third to two-fifths the parietals. *Loreal* not touching the eye. *Praeocular* one. *Postocular* usually none (confluent with the subocular). *Subocular* a single crescentic shield from the supraocular to the praeocular (sometimes not united with the postocular). *Temporals* the upper usually as long as the parietals, sometimes divided into two. The lower

subequal to the last labial. *Supralabials* usually 7 (sometimes 8). None touching the eye; 7th as long as the three preceding shields. *Mental* not touching the anterior sublinguals. *Costals* in 15 rows in the whole body length, not keeled. Vertebrals not enlarged. *Ventrals* 136 to 159. *Subcaudals* 31 to 50.

Eye. Diameter subequal to the supraocular, equal to or rather less than distance to lip.

Distribution. Burma, Tenasserim (No. 4870, *Ind. Mus*). Siam, Cochin China, S. China and coastal Islands.

Amblycephalus macularius (Theobald).

A. macularius, Boulenger, *Cat.* III, p. 444; Sclater, *List. Sn. Ind. Mus.* 1891, p. 67; Wall, *Rec. Ind. Mus.* 1909, p. 149.
A. modestus, Boulenger, *Cat.* III, p. 444; Sclater, *List. Sn. Ind Mus.* 1891, p. 66.
A. andersoni, Boulenger, *Cat.* III, p. 444; *J. Bomb. N.H.S.* XVI, p. 235; Wall and Evans, *J. Bomb. N.H.S.* XIII, p. 611; Wall, *J. Bomb. N.H.S.* XVIII, p. 783.

Colour. Dorsally densely mottled with very fine specks of purplish-brown, with several small round whitish, or parti-coloured whitish and purplish spots interspersed. Ventrally beautifully dappled with purplish-black and white, especially laterally. Head uniform blackish-purple with speckling on the upper lip.

A female specimen sent to me from the Southern Shan States is very dark, and has no small round white or parti-coloured spots. Another from the same locality in the Bombay collection (ventrals 161, subcaudals 42) is uniform in colouration like the type of *A. modestus.*

Length. The largest I have seen measured 483 mm. (1 foot, 7 inches) in length.

Habits. Captain Venning wrote when sending me a specimen from Kalaw, that it was found at dusk clinging to the tops of some rank grass.

Food. As far as I am aware no observations have been made.

Breeding. Captain Venning's specimen, just alluded to, was a gravid female. It was killed on the 9th of June, 1913, and contained six large eggs.

Lepidosis. Praefrontal touching the eye. *Frontal* hexagonal in shape. Length much greater than the snout, three-seconds to four-thirds its breadth, rather shorter than the parietals. *Supraoculars* three-fourths, to equal to, the praefrontals, half to three-fifths the frontal, about two-fifths the parietals. *Loreal* not touching the eye. *Praeocular* usually one. (In specimen No. 8024 in the Indian Museum it is confluent with the praefrontal). *Postocular* usually one. (In the type of *modestus* it is confluent with the supraocular on the left side, normal on the right.) *Suboculars* usually one crescentic shield. (In the type of *modestus*, and in specimens Nos. 8025 and 8026 in the Indian Museum it is divided into two.) *Temporals* very variable. One or two anteriorly. (In the type of *modestus* the upper appears to be con-

fluent with the parietal.) There are usually two subequal shields lying along the parietals, but these may be confluent, as in the type of *andersoni*. (In the types of *andersoni* and *modestus* there is one long inferior temporal, apparently due to a confluence of the two normal shields.) *Supralabials* 7 (8 on one side in one example). None touching the eye. *Mental* sometimes touching the anterior sublinguals, sometimes not. *Costals* in 15 rows in the whole body length. Some of the median rows keeled. *Vertebrals* not enlarged. *Ventrals* 150 to 169. *Subcaudals* 37 to 51.

Eye. Diameter subequal to the length of the supraocular, subequal to or rather greater than its distance to edge of the lip.

Dentition. From one bad skull in my collection, nearly all the teeth being broken. *Maxillary*: 3 (4? in the type of *modestus*). An edentulous space anteriorly that would take three teeth, and one posteriorly that would take two. *Palatine*: 1? An edentulous space anteriorly that would take three teeth, and one posteriorly that would take two. *Pterygoid*: 7? left, 9? right, no edentulous space anteriorly. *Mandibular*: 23? on the right side, ? left; no edentulous space anteriorly or posteriorly.

Distribution. Eastern Himalayas: Sikkim (Gopaldhara, Darjeeling District, No. 18665, *Ind. Mus.*, type of *A. andersoni*). Burma: S. Shan States (Tounggyi, *Wall* and *Evans*, and *Bombay collection*; Kalaw, *F. W.*, Mogok, *Brit. Mus.*); Rangoon (No. 8028, *Ind. Mus.*, type of *A. modestus*); Tenasserim (Martaban, Nos. 8024, 8025 and 8026, *Ind. Mus.*, types of *A. macularius*); Sukli, Dawna Hills (No. 17034, *Ind. Mus.*) Indo-China (Mocquard, *Rept. l'Indo-Chine*, 1907, p 48).

Note.—I have examined most critically four times during the last sixteen years the monotypes of *A. modestus* and *A andersoni*, and the three types of *A macularius* in the Indian Museum, and can come to no other conclusion but that all represent a single species. *A. macularius* has page priority over *A. modestus*, and both antedate (1868) Boulenger's *A. andersoni* (1888).

I have now examined sixteen specimens.

Amblycephalus carinatus Boie.

A. carinatus, Boulenger, *Cat.* III, 1896, p. 445; Sclater, *List. Sn. Ind. Mus.* 1891, p. 67.

Colour. Dorsally brown of various shades, with numerous dark small spots arranged with a tendency to form cross bars. Ventrally yellowish or whitish with darker spots or mottling, which is often heaviest in the median line. An X-shaped dark mark on the nape, and a narrow dark streak behind the eye, sometimes connected with the X. A specimen in the Indian Museum (No. 8022) from Tenasserim is a uniform drab colour.

Length. The longest I have examined is 603 mm. (1 foot, 11¾ inches) long, the tail 120 mm. (4¾ inches). The smallest, apparently a hatchling, was 184 mm. (7¼ inches).

Lepidosis. *Praefrontal* not touching the eye. *Frontal* pentagonal in shape. Length much greater than the snout, three-seconds to four-thirds its breadth, subequal to the parietals. *Supraoculars* longer than the snout, subequal to the frontal, subequal to the parietals. *Loreal* not touching the eye. *Praeocular* one. *Postocular* usually one, sometimes absent being confluent with the subocular; rarely two. *Subocular* variable. Sometimes one crescentic shield, sometimes confluent with the postocular, sometimes divided into three or four. *Temporals* usually three anterior, the longest about three-fifths to two-thirds the last supralabial. Three or four lie along the parietals. *Supralabials* usually 7 or 8 (6 on the right side in specimen No. 8022 in the Indian Museum, 9 on the left side in specimen No. 11434 in the Indian Museum). None touching the eye. The last longer than the two preceding taken together. *Costals* in 15 rows in the whole body length; several of the median rows keeled. Vertebrals not enlarged. *Mental* not touching the anterior sublinguals. *Ventrals* 161 to 199. *Subcaudals* 53 to 92. Specimen No. 12781 in the Indian Museum from the Burma-Siam Hills has 92 (ventrals 193). Another, No. 11434 from Deli, Sumatra, has 87 (ventrals 187).

Eye. Diameter less than the supraocular, subequal to the length of the snout.

Dentition. From the figure in Boulenger's Catalogue. Vol. III, p. 438. *Maxillary*: 5; anododont, syncranterian, scaphiodont. An edentulous space anteriorly that would take two teeth. *Palatine*: 3; anododont, coryphodont. An edentulous space anteriorly that would take two teeth. *Pterygoid*: 15; anododont, scaphiodont. No edentulous space anteriorly. *Mandibular*: 18; anododont, strongly scaphiodont.

Distribution. Burma: Tenasserim (Mergui; Tavoy; Burma-Siam Hills; *Ind. Mus.*). Siam (*Malcolm Smith*). Cochin China: Lao Mountains (*Brit. Mus.*). Malay Archipelago: Sumatra (*Ind. Mus.*); Java (*Brit. Mus*).

Note. I have examined nine examples in the Indian Museum.

Amblycephalus hamptoni Boulenger.

A. hamptoni, Boulenger; *J. Bomb. N.H.S.* 1905, p. 236.

Colour. "Pale brown above with numerous blackish bars interrupted on the middle of the back, two black longitudinal streaks on the back of the head and nape, sides of head and lower parts yellow; a few black dots on the belly, and under the tail."

Length. 555 mm. (1 foot, 9¾ inches); tail 150 mm. (5⅞ inches).

Lepidosis. *Praefrontal* touching the eye. *Frontal of* hexagonal in shape. Length greater than the snout, equal to its breadth, three-fifths the parietals. *Supraoculars* length equals the praefrontals, three-fifths the frontal; two-fifths the parietals. *Loreal* not touching the eye. One on the right side, two (1/1) on the

left. *Praeocular* one. *Postocular* confluent with the subocular. *Temporals* one ; about as long as the last supralabial. *Supralabials* 8 on the right side, 7 on the left , none touching the eye. *Mental* touching the anterior sublinguals. *Costals* in 15 rows in the whole body length. Median rows feebly keeled. Vertebrals feebly enlarged. *Ventrals* 202 (Boulenger), I count them 197. *Subcaudals*: 96.

Eye. Diameter subequal to the supraocular, greater than its distance to the edge of the lip.

Distribution. Burma: Mogok, S. Shan States (*Brit. Mus.*).

Note.—Known from a single specimen in the British Museum.

A NEW SNAKE FROM THE NORTHERN FRONTIER OF ASSAM.

By Colonel F. WALL, *C.M.G., I.M.S.*

Oligodon melanozonatus, sp. nov.

O. erythrorhachis, Annandale, *Rec. Ind. Mus.* VIII, 1912, p. 48.

Type, No. 16799, co-type, No. 16798. Both in the Indian Museum.

Length 513 mm. (1 foot, 8¼ inches). Tail 83 mm. (3⅜ inches).

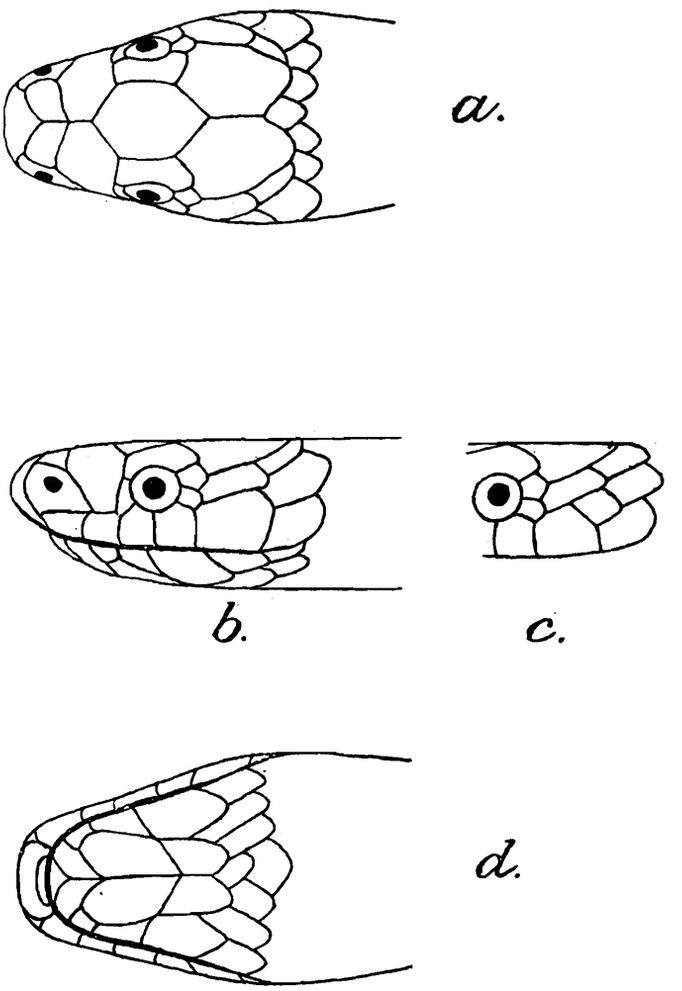
Lepidosis. Rostral touching six shields, the rostro-nasal shorter than the rostro-internasal sutures. Portion visible above three-fifths to three-fourths its distance from the frontal, one-third to two-fifths the length of the frontal. *Internasals*: a pair. The suture between them equal to that between the praefrontal fellows, about half the internaso-praefrontals. *Frontal*: length greater than the snout, equal to the parietals. *Supraoculars*: length about equal to its distance to mid-internasals, two-thirds the frontal, three-seconds the temporal; breadth two-fifths the frontal. *Nasal* entire. *Loreal* absent. *Praeocular*: one. *Postoculars*: two. *Temporal* 1+2. *Supralabials* 6.[1] The 1st and 2nd touching the nasal, the 2nd the praefrontal, the 3rd and 4th the eye, and the 5th the temporal. *Posterior sublinguals* shorter than the anterior pair, touching the 4th infralabial. *Infralabials* 4; the 4th largest, longer and broader than the posterior sublinguals, and touching two scales behind. *Costals* two heads-lengths behind the head 17, midbody 17, two heads-lengths before the vent 15. *Ventrals* 171 to 173. *Anal* divided. *Subcaudals* 42 to 45, divided.

Colour. Dorsally light brown, obscurely mottled with blackish. Twenty rather ill-defined black bars cross the body to end low in the flanks, and four such bars cross the tail. In the smaller and half-grown specimen these bars are as light centrally as the dorsal brown, and are edged anteriorly and posteriorly with black as in *albocinctus*. A whitish, black-edged sagitta on the nape, the point directed forwards. Just before this is a black-edged, light brown sagitta with the point on the middle of the frontal shield. An obscure, blackish, praefronto-frontal bar, reappearing below the eye. Belly white with transverse, black, irregularly-disposed cross-bars, many as broad as the ventral shields. Similar marks beneath the tail.

[1] These shields in the larger specimen are as shown in figure *b* on both sides, but in the smaller specimen as shown in figure *c* on the left side only, a 6th labial being wedged between the 5th and 7th.

Locality. Upper Rotung Valley, Abor Hills, Assam frontier, at about 2000 feet elevation.

Note. Dr. Annandale referred these specimens to *O. erythrorhachis* Wall, but a revision of the species of this genus from



TEXT-FIG. 1.—*Oligodon melanozonatus*, sp. nov.
Lepidosis of head: ×2.

the material available in the Indian Museum and Bombay collections, convinces me that they represent a species hitherto not described. In *O. erythrorhachis* the costals are 15 anteriorly, 13 two heads-lengths before the vent. The ventrals are 154 and subcaudals 64. The supralabials are 7.

STRUCTURAL MODIFICATIONS IN THE FISH OF MOUNTAIN TORRENTS.

By SUNDER LAL HORA, *M.Sc., Assistant Superintendent, Zoological Survey of India.*

CONTENTS.

INTRODUCTION.

Although in recent years considerable advance has been made in the study of animal adaptations to different types of environment, little attention seems to have been paid to the wonderful modifications exhibited by the fauna of mountain torrents. Except for a few casual remarks found in descriptions of hill-stream fishes, no detailed account, so far as I know, has been published of the subject. Nikolsky[1] in 1891 published a paper dealing with the correlation between the shape of the body of fishes and the strength of the current of streams and Annandale,[2] in two recent papers, has described some adaptive features in the fauna of hill-streams. Nikolsky's paper is unfortunately in Russian and is not available in Calcutta. From Annandale's papers I have received much help. Dr. Annandale has visited a large number of hill-streams in India and elsewhere, and was greatly impressed by the interesting adaptations exhibited by the various groups

[1] Nikolsky, *Rev. Soc. Nat. S. Petersb.*, pp. 137–139 (1891).

[2] Annandale, *Rec. Ind. Mus.* VIII, pp. 29–32 (1912), and *ibid.*, XVI, pp. 113–117 (1919).

of animals inhabiting these streams; it was at his suggestion that the work here published was undertaken.

Apart from their natural position in the animal kingdom, hill-stream fishes may be divided bionomically into two primary groups. The first group comprises those forms that migrate upstream at certain periods of their lives for spawning, etc.; these may be called the temporary inhabitants of these streams. Fishes of this group travel against the current by muscular effort and do not show, to any great extent, special modifications for life in rapid waters. The members of the second group are the permanent residents of the streams and of still smaller torrents and many exhibit extreme adaptations. It is with the latter group that the present paper is concerned.

The greatest handicap in dealing with the subject was the paucity of material available in the Museum or to be obtained from the streams. Species of many of the genera dealt with in this paper were not only poorly represented, but the specimens often consisted of old and badly preserved individuals quite unfit for detailed morphological investigation. In the hill-streams, on the other hand, there may be plenty of fish, but the readiness with which they seek shelter underneath stones or the swiftness with which they dart away makes it extremely difficult to obtain a good series of specimens. Most of the species are, therefore, known from very few individuals. Through the kindness of the Director, Zoological Survey of India, I was allowed to make tours in the Naga Hills, the Manipur Valley, the Khasi Hills, the Kumaon Hills, the Kharagpur Hills and the Darjiling Himalayas. Good collections were made at all these places. For histological investigation the material, wherever practicable, was fixed either in formol-alcohol or corrosive sublimate; haematoxylin and eosin have chiefly been used in staining sections of the adhesive apparatus.

The taxonomy of the Indian hill-stream genera has hitherto been involved in a state of great confusion and this factor greatly impeded the progress of my work. In a series of papers,[1] chiefly dealing with hill-stream forms, I have tried to elucidate the taxonomy of those genera of which sufficient material was present in the collection of the Indian Museum, and I have also worked out completely the collections made by myself in Manipur[2] in order to find out the correct names of the fishes with which this paper is concerned. Besides these I have published recently a paper on some rare and new forms kindly sent to us by Mr. G. E. Shaw from the base of the Darjiling Himalayas. In interpreting the generic position and specific limits of the various species assigned by Day to *Erethistes* and *Psilorhynchus*, I have derived great help from this collection.

---

[1] Hora, *Rec. Ind. Mus.* XXIX, pp. 195–215, pls. x, xi (1919); *ibid.* XXII pp. 13-19, *ibid.*, XXII, p. 633, pl. xxiv-xxvi (1921).

[2] Hora. *Rec. Ind. Mus.* XXII, pp. 165-214 (1921).

The figures illustrating this paper were drawn by me with the help of a camera lucida.

The types selected for the study of hill-stream adaptations belong to the two chief orders of Indian freshwater fishes, the Cyprinoidea and the Siluroidea. The genera on which observations have been made are the following:—

Cyprinoidea.	Siluroidea.
Balitora Gray.	*Erethistes* Mull. & Trosch.
Bhavania Hora.	*Glyptosternum*[1] McClelland.
Psilorhynchus McClelland.	*Pseudecheneis* Blyth.
Parapsilorhynchus Hora.	*Glyptothorax*[1] Blyth.
Garra Ham. Buch.	*Laguvia*[2] Hora.

All these genera are found only in small mountain torrents, with the exception of certain species of the genus *Garra* which descend into streams of fair size. All show special adaptations to this environment.

The Schizothoracinae and some of the species of *Nemachilus* which live in rapid-running rivers show similar but less well-marked adaptations. Some remarks on the nature of the adhesive apparatus of these forms are also included in this paper.

---

[1] While recently attempting to revise the species of the genus *Exostoma* Blyth, I have found that this generic name canot be employed for the forms to which it is usually assigned. I propose the following changes in view of the facts given below:—

Exostoma Blyth = *Glyptosternum* McClelland.
Glyptosternum McClelland = *Glyptothorax* Blyth.

McClelland (*Calcutta Journ. Nat. Hist.* II, pp. 584–585, and 587–588, 1842) described five species, *Glyptosternon reticulatus*, *G. sulcatus*, *G. striatus*, *G. pectinopterus* and *G. labiatus* under the new generic designation *Glyptosternon*. Blyth (*Journ. As. Soc. Bengal* XXIX, pp. 153–155, 1860) split up these five forms into four distinct genera, *Glyptosternon*, *Pseudecheneis*, *Glyptothorax* and *Exostoma*. He regarded *G. reticulatus* from Afghanistan as the type-species of McClelland's *Glyptosternon*. According to McClelland this species is stated to be "without spines; the first ray of the pectoral and ventral fins soft and pinnate, giving off soft pointed cartilaginous rays along the anterior margin; which are enveloped in the membrane of the fin. The under surface and anterior portion of the body form a flat corrugated surface." Of the several species of *Exostoma* in the collection of the Indian Museum, all except *E. berdmorei*, possess the outer ray of the pectoral and the ventral fins similar to that of McClelland's *Glyptosternon reticulatus*; they ought, therefore, to be included in the same genus. *Exostoma berdmorei*, Blyth, which is known from a single specimen from Tenasserim, now in a very bad condition, is the type-species of the genus *Exostoma*. The pectoral spine of this species is totally different from that of the others and corresponds to those forms which were included by Blyth under his genus *Glyptothorax*. The absence of a "pectoral disk," which led Blyth to separate the genus *Exostoma* from *Glyptothorax*, is not a valid generic distinction, because the thoracic adhesive apparatus of almost all the species included in the genus *Glyptothorax* may become indistinct in specimens which are old or have been badly preserved.

The generic name *Glyptosternon*, McClelland was latinised into *Glyptosternum* by Günther (*Cat. Fish. Brit. Mus.* V, p. 185, 1864).

[2] In a paper published recently (*Rec. Ind. Mus.* XXII, p. 739, 1921) I have given reasons for separating *Erethistes asperus* (McClelland) (*Calcutta Journ. Nat. Hist.* IV, p. 404, pl. xxiv, fig. 2) along with the two new species from the base of the Darjiling Himalayas from the genus *Erethistes* and have placed them all in a new genus *Laguvia*. This genus is intermediate in certain respects between *Erethistes* and *Glyptothorax*.

CONDITIONS AFFECTING FISH IN RAPID WATERS.

The conditions that influence the fauna of hill-streams are the following :—

(i) The chief factor is the strength of the current, and all the remaining conditions are due to it. The adaptations which are dealt with further on are all due primarily or secondarily to this one cause. The rate of flow of water varies considerably according to the season, but throughout the year its average flow is much higher than that of any stream in level country. This rapid flow of water would render life impossible to many animals if they did not possess special organs of adhesion or other appliances to counteract its influence. In places like Cherrapunji (Khasi Hills), where 458 inches of rain falls in a comparatively short time, the rate of flow of the water must at times be extremely rapid, and at such times some even of the most powerful fish cannot withstand it for more than a few minutes. It is unfortunate that I have not been able to collect any precise data to compare the rate of flow of water and the fauna inhabiting it. This is a case in which co-operation between a zoologist and a physicist is called for.

(ii) Next in importance are two factors on which the very existence of the animals depends—food and shelter. In a hill-stream there is always a sufficient quantity of food, but the only type usually available consists of algal slime covering stones and rocks. There is no opportunity for any other type of vegetation to grow, as it is liable to be uprooted and carried away by the strength of the current. In pools and ditches that are sometimes formed on the bank of the streams, there is generally a growth of water-weeds, but these cannot be referred to as rapid streams. Certain fishes such as the species of *Nemachilus* feed on May-fly and Dragon-fly larvae, but this type of food is usually scarce.

As regards shelter, there is plenty of it in a hill-stream for little fish. The species of *Nemachilus*, on the slightest provocation, hide themselves underneath stones. Those who have made collections in the hill-streams know how advantageous it is to run the net among small stones and sometimes to pick up stones in the net, because in this way all those forms which rest underneath stones are netted.

(iii) Hill-streams are never very deep, and their water is usually very clear. Consequently during the day-time the animals have to withstand intense light.

(iv) The water is well aerated as it is constantly in motion.

These conditions do not apply to pools that occur in the course of hill-streams, and the fish-fauna of these pools is very different from that of the rapid current. It is possible that those forms which live in rapid waters are sometimes carried into these pools, but I have never come across any instance in which the typical sluggish-water forms have been found in rapid waters. Species of *Danio*, *Lepidocephalichthys*, *Barbus*, *Barilius* are generally

met with in the pools. Of these genera only smaller forms like *Danio rerio* are usually found, for they alone are able to find during the flood season sufficient shelter underneath rocks and stones. The pools are, however, sometimes inhabited by large species of *Barbus* and *Barilius* which are sufficiently powerful to withstand floods.

MODIFICATIONS FOR LIFE IN HILL-STREAMS.

The modifications for life in hill-streams may be considered under the following heading :—

1. The external form of the fish and its size.
2. The scale-covering, etc.
3. The paired fins and the skeletal and muscular structures connected therewith.
4. The caudal fin and its peduncle.
5. The mouth, its position and shape; the jaws, the barbels, the lips and their muscles.
6. The eyes.
7. The gill-openings, branchiostegal rays and membranes.
8. The air-bladder.
9. Special modifications of the skin.

1. *The external form.*—Nikolsky (*op. cit.*) has dealt with this subject but as the text of his paper, which I have not seen is in Russian, I give my own observations in full. The fish with which this paper is concerned all live on the bottom, and the form is so modified as to offer the least resistance to the rapid current. The head and body are greatly flattened and in *Balitora, Glyptosternum* and in the most specialized hill-stream species of *Garra* and *Glyptothorax* the form is almost leaf-like. The ventral profile becomes straight and horizontal throughout and the dorsal profile is but slightly arched. The head is usually small and semicircular and the snout is trenchant. The Bornean genus *Gastromyzon* is in shape a typical hill-stream form.

The shape of the body depends upon the strength of the current and any deviation from the characteristic form of the fish is directly proportional to the rate of the flow of water. Thus the form of those fishes that live in places where the intensity of the flow is intermediate between that of a sluggish stream and of a hill-torrent is almost cylindrical, as in *Crossochilus latia*. Confining our attention to the members of the genus *Garra*, one can find all possible gradations in shape between such forms as *Crossochilus latia* and the most specialized hill-stream form such as *Balitora*. *Garra mullya*, one of the most widely distributed forms in the genus, lives in ponds, tanks and sometimes in rapid waters. The specimens collected from ponds and tanks are cylindrical, while those collected from rapid waters are sometimes flattened. Great modification in form is exhibited by *G. lissorhynchus, G. kempi* and *G. nasutus*, all of which are known from rapids

in the Eastern Himalayas. In dealing with the fishes of the Manipur Valley I have shown how the fauna of a stream changes within very short limits according to whether the bed is rocky or muddy. Small size is a distinct advantage in hill streams, firstly because the streams are small and secondly because small forms can find more shelter under pieces of rocks and stones during floods.

2. *The scale-covering, etc.*—In those Cyprinid fishes that take to hill-stream life, the lepidosis undergoes considerable modification. In the Schizothoracinae the scales are small and partly buried in the skin or are totally absent except in the anal and scapular regions. If in a normal Cyprinid genus in which the scales are large and imbricate, the hill-stream forms be compared with those from other types of environment, it will usually be found that the scales are greatly reduced on the under surface, and in some cases they disappear altogether. The region of the chest, which is to some extent employed in the process of adhesion, is the first to be modified, and then, with the increased rapidity of the flow of water, more and more of the under surface becomes naked. In two species of *Garra, G. abhoyai* and *G. rossicus*, the dorsal surface in front of the dorsal fin is also naked.

The reduction of scales on the lower parts is necessitated by the fact that a plain and smooth surface is necessary in order to allow adherence to rocks. I have not been able to understand why the scales should be reduced on the dorsal surface in *Garra abhoyai* and *G. rossicus*. Both possess a subcylindrical shape and are not among the most specialized hill-stream forms.

3. *The paired fins and the skeletal and muscular structures connected therewith.*—The fins are very plastic structures in the anatomy and they have been employed for various functions by diverse groups of fishes. The modifications of the pectoral fins in Flying-fishes, of the first dorsal fin in Sucking-fishes and of the ventral fins in Gobiidae and Gobiesocidae are a few instances among many. In hill-stream fishes the paired fins are used as organs of adhesion or of locomotion and for both these functions powerful muscles are required. In certain cases they are probably used also for respiration.

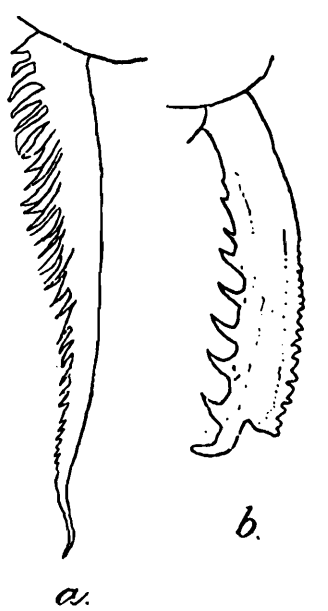
The outer rays of the paired fins are employed for the function of adhesion and the number of the inner rays is consequently increased. In *Gastromyzon borneensis* there are as many as 26–28 rays in the pectoral and 20–21 in the ventral fins. In an allied Indian genus, *Balitora*, there are 21 rays in the pectoral and 11 in the ventral fins. The outer rays of these fins are greatly thickened and much flattened.

Besides an increase in the number of fin-rays of the paired fins, their position and shape undergoes considerable change. The fins, instead of being situated on the under surface of the fish, are pushed outwards and ultimately are placed horizontally on the sides of the body. This change is brought about for two reasons, firstly to allow the ventral surface to be firmly applied to rocks, and secondly to enable the fins to act as organs of adhe-

sion. As regards the shape of the fins, some of the inner rays are directed upwards against the sides of the body, so that when the outer rays are used for the purpose of adhesion, the inner rays can be kept constantly in motion, probably for the purpose of respiration. I have embodied my observations on this point in an immature specimen of *Psilorhynchus* in a former paper.[1] In the genus *Glyptosternum* (fig. 8) only a few rays of the paired fins are visible from the under surface, while the remainder are reflected upwards. I have not observed these fishes in nature, but on a recent tour to the base of the Darjiling Himalayas, I was able to verify the observation that I had previously made on the immature specimens of *Psilorhynchus* from the Naga Hills, by keeping a half-grown specimen of *Garra annandalei* in an artificial pond of water in the course of the Mahanadi River. In *Parahomaloptera microstoma*[2] the shape of the fins is somewhat less modified than is the case in *Glyptosternum*.

The greatest specialization as regards fin-structure is found in *Gastromyzon borneensis*. The pectorals begin with a long base, vertically below the eyes: the ventrals possess long curved bases, which are united posteriorly. Between the bases of the ventral and the pectoral fins there is a lateral extension of the abdominal skin. "By this arrangement the whole flattened abdominal surface, together with the fins and the flattened lower surface of the head forms an enormous suctorial disc."[3]

I have already pointed out that the outer rays or the spines, as the case may be, of the paired fins are greatly flattened. Interesting modifications take place in the outer ray of these fins in the genus *Glyptosternum*, "soft pointed cartilaginous rays" are given off along the anterior margin (fig. 1*a*) to support the striated skin which forms the adhesive apparatus. This is described in detail below when dealing with the modification of the skin in the formation of the adhesive apparatus.



TEXT-FIG 1.—Pectoral spine of *Glyptothorax* and *Glyptosternum*.

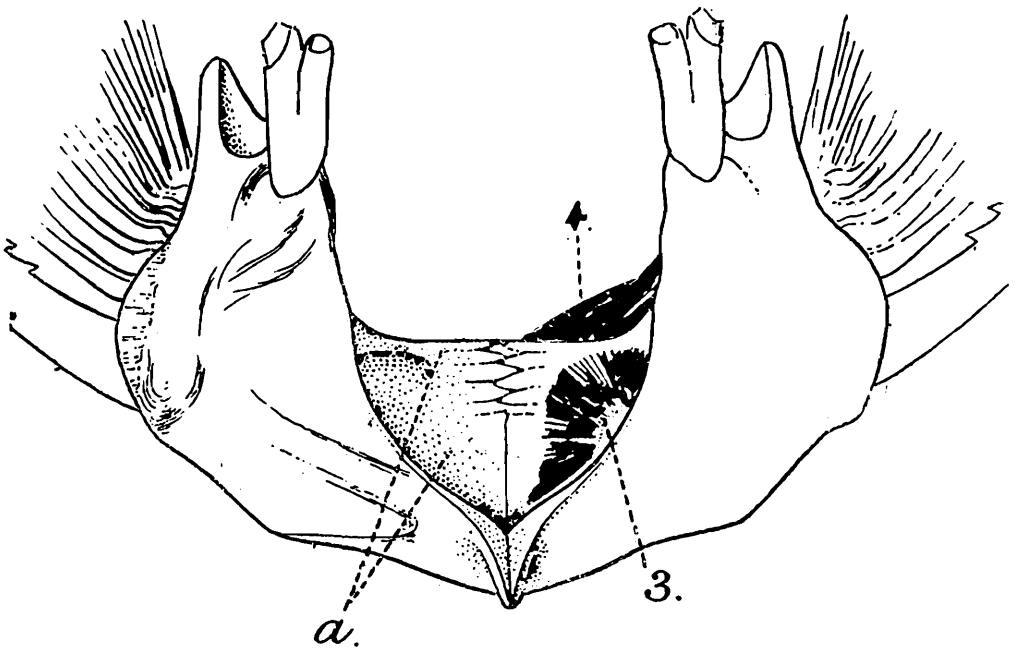
a. Outer pectoral ray of *Glyptosternum labiatum*.
b. Pectoral spine of *Glyptothorax berdmorei*.

The pectoral and the pelvic girdles are modified in certain hill-stream fishes, owing to the acquisition of new functions by the paired fins. It is unfortunate that I have not been able to study these structures in *Psilorhynchus*, *Bhavania*, *Balitora* and *Homaloptera*, on account of the paucity of

[1] Hora, *Rec. Ind. Mus.* XIX, p. 212 (1920).
[2] Weber and Beaufort, *Fishes Indo-Austr. Arch.* III, p. 20, fig. 5 (1916).
[3] Weber and Beaufort, *ibid.*, p. 2 (1916).

material; but even in those Cyprinid genera of which material was available in sufficient quantity, I am unable to find any striking modifications. In *Garra*, for instance, the whole structure is more or less similar to that found in *Labeo*, except that the adductor and abductor systems of muscles are better developed. At the same time it must be remembered that the fins do not form the chief organs of adhesion in this genus.

In the Siluroids, *Glyptothorax* and *Pseudechenais* in which the chief adhesive organ is situated on the chest, the only modifications consist in the fusion of the various bony elements for strengthening of the girdle. On account of the horizontal position of the fin, the shape of the girdle is considerably changed (fig. 2).



TEXT-FIG. 2.—Dorsal view of the pectoral girdle in *Glyptothorax madraspatanus*.

a = interclavicle; 3, 4 = muscles of the pectoral spine.

Great difficulty has been experienced in adopting suitable terms for the description of the various structures. I have followed Parker [1] in preference to McMurrich [2] in drawing up my descriptions.

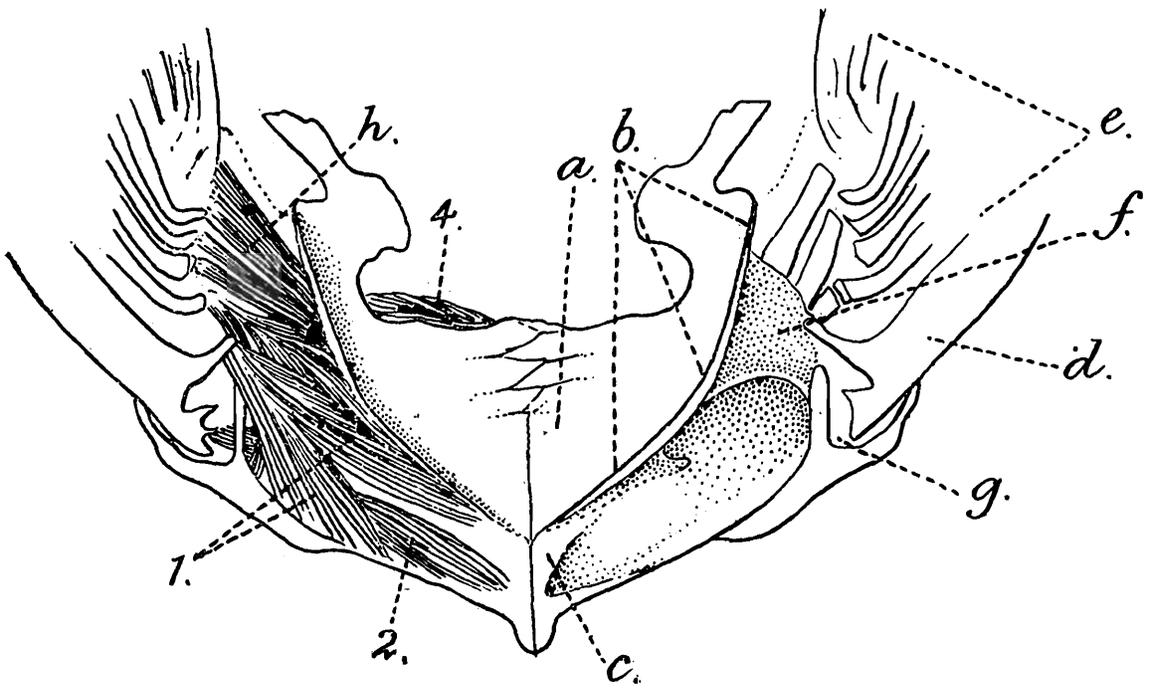
Besides the modifications enumerated above, other characteristic specializations are also found in *Glyptothorax* and *Pseudecheneis*. On the ventral aspect of the interclavicular bones (fig. 3) there are keel-like ridges (fig. 3*b*) for the attachment of the muscles. These ridges are greatly elevated posteriorly and end in spine-like processes; but they slope down anteriorly and meet each other in the mid-ventral line close to the union of the clavicles and the interclavicles.

---

[1] Parker, *A Monograph of the structure and development of the Shoulder girdle and Sternum in the Vertebrata* (1868)

[2] McMurrich, *Proc. Canadian Inst.* (n.s.) II, pp. 301–306 (1884).

The muscles controlling the movement of the pectoral fin (figs. 2, 3) in *Glyptothorax* are also interesting. Besides the abductor



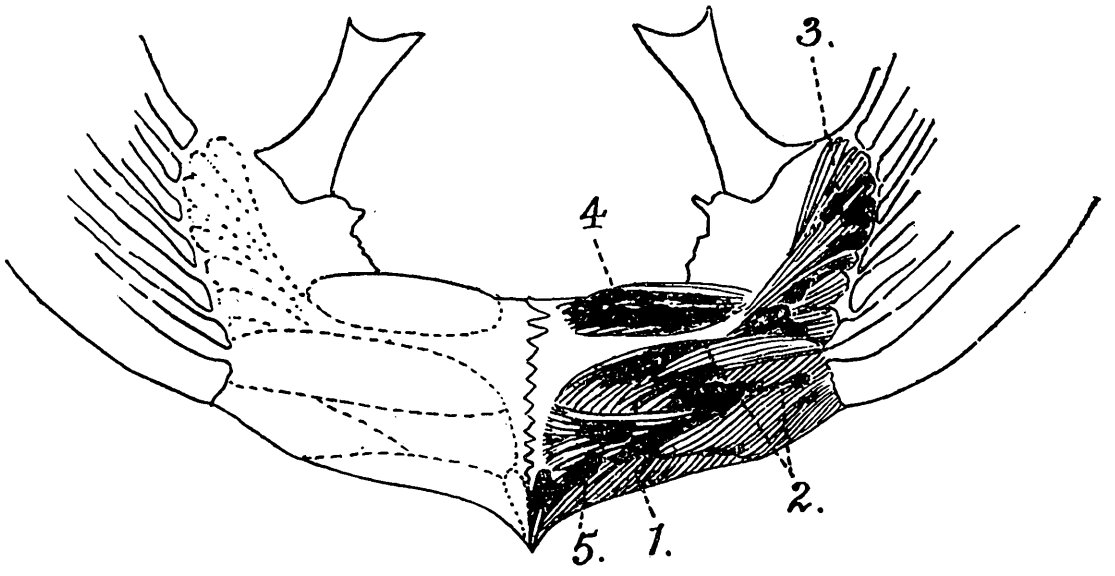
TEXT-FIG. 3.—Ventral view of the pectoral girdle in *Glyptothorax madraspatanus*.

a = interclavicle ; *b* = interclavicular ridge ; *c* = clavicle ; *d* = pectoral spine ; *e* = pectoral fin rays ; *f* = groove for the attachment of abductor muscles ; *g* = groove in the cubito-humeral process ; *h* = abductor muscles ; 1, 2 and 4 refer to the muscles of the pectoral spine.

and the adductor systems, there are four special muscles to move the spine. Muscle 1 arises from the anterior grooved and thickened border of the clavicle and also from along its posterior border near the base of the interclavicular ridge against the sides. Its action is to pull the spine towards the body and fold the rays. Muscle 2 takes its origin from the anterior border of the clavicle, further forward than muscle 1. In its course, it passes underneath muscle 1 and its function is that of expanding the fin. Muscle 3 is very extensive and fan-shaped. It arises along the whole of the surface of the clavicle and the interclavicle on the dorsal side and in its course passes through a bony canal. Its action is the same as that of muscle 2. Muscle 4 is very strong and passes through a passage in the bone. The muscle takes a curved course and its action is somewhat like that of a rope passing over a pully. Its function is that of folding the fin. It arises from the grooved and thickened posterior border of the clavicle.

The actions of the various muscles were studied by moving the muscles and by watching their effect upon the fin. It is clear that muscles 1 and 4 are stronger than 2 and 3, because it is in the action of folding of the fin that the adhesive function of the outer rays is involved. In those species of *Glyptothorax* in which the adhesive apparatus is present on the under surface of the pectoral spine, muscle 1 is the better developed.

In the genus *Glyptosternum*, where the fins act as organs of adhesion, the moidfications in the musculature are more marked (fig. 4) and the arrangement is different. The muscle labelled 2 in *Glyptothorax* correspond to 5 in *Glyptosternum*; muscle 4 is the same in both cases. Muscle 1 arises close to the mid-ventral suture of the clavicle and is inserted in the form of a glistening tendon on the anterior border of the pectoral spine. Its action is to expand the fin. Muscle 2 arises near the mid-ventral line and is inserted on the bases of the spine and the first few rays. Its function is, in all probability, to keep the spine and the few outer rays closely pressed against the substance on which the fish may be resting. This muscle is large and is not found in any other genus that I have studied; it has no other muscles to counteract its action.



TEXT-FIG. 4.—Muscles of the pectoral fin in *Glyptosternum labiatum*. Numbers 1, 2, 3, 4 and 5 indicate the muscles referred to in the text.

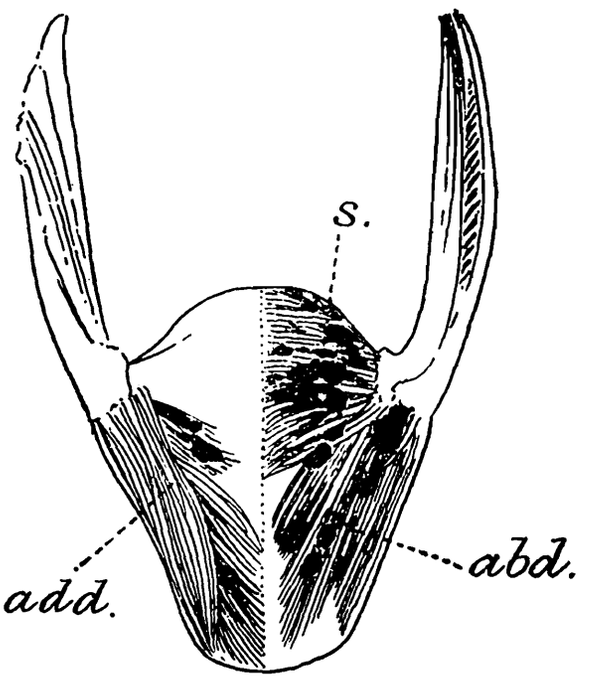
As regards the skeleton of the pectoral girdle in *Glyptosternum*, there are no bony ridges for the insertion of muscles. Otherwise it is very similar to that of *Glyptothorax*.

The pelvic fins also possess a special muscle (fig. 5) beside the abductor and abductor systems. This keeps the fins closely pressed against rocks, when the fish is resting, thus enabling it to adhere to rocks by means of striated skin on the under surface of some of the outer rays of the pelvic fin.

4. *The caudal fin and its peduncle.*—There is a general tendency amongst hill-stream fishes to possess a long, narrow, band-shaped caudal peduncle. For example in *Nemachilus tenuis* and *N lhasae* the caudal peduncle is more narrow and elongated than in any other species of the genus that I have seen. These two species resemble the Central Asiatic forms figured by Herzenstein[1] and it is possible that these features are correlated with high

[1] Herzenstein, *Wiss. Res. Przewalski Central. As. Reis.*, Theil III (2), pls. i-vii (1888).

altitudes and rapid running streams. Similarly in the genus *Glyptothorax*, two species, *G. striatus* and *G. saisii*, from the Khasi and the Parasnath Hills respectively, have a different form of caudal peduncle from the remaining species. It is long and narrow. In almost all species of *Homaloptera*, *Bhavania* and *Balitora* and in the most specialized species of the genus *Garra* the caudal peduncle is similarly modified.



TEXT-FIG. 5.—Muscles of the pelvic fins in *Glyptosternum labiatus*.

The right side of the figure shows the ventral view and the left side the dorsal view of the pelvic girdle. *add*= adductor muscles; *abd* = abductor muscles; *s* = special muscle.

As regards the fin, the chief modification consists in the inequality of its lobes. In most cases the lower lobe is somewhat longer than the upper, as in *Balitora brucei*, *Bhavania australis*, *Glyptothorax striatus*, *Glyptosternum labiatum* and *Garra nasutus*. In *Gastromyzon borneensis*, though the caudal fin is not deeply forked, the lower portion is longer and stronger than the upper.

I was not able to follow the true significance of these modifications, because the movements were too rapid for detailed analysis.

It may be pointed out in this connection that in Elasmobranch fishes, where the mouth is on the under surface considerably behind the tip of the snout, the lower lobe of the caudal fin is much shorter than the upper. I hope to make further observations on this point on another occasion.

5. *The mouth, its position and shape; the jaws; the barbels; the lips and their muscles.*—The mode of life and the nature of food in mountain-rapids necessitates a change in the position of the mouth and the structure of the jaws. The mouth, instead of being a transverse cleft at the anterior end of the fish, is situated on the under surface considerably behind the tip of the snout. It is usually crescentic or semicircular in outline. The jaws are greatly strengthened and their edges become sharp and cutting. In most cases, *Oreinus* for example, the jaws are covered with a strong horny covering. This is due to the fact that hill-stream fishes have to strip algal slime from stones for their food.

Barbels in rapid-waters would be a source of great encumbrance and, therefore, they are much reduced. In most of the hill-stream species they can only be made out after a careful examination.

In *Balitora* they are short and stumpy and liable to be overlooked. In the remaining hill-stream genera discussed in this paper they are short and thread-like. In *Parapsilorhynchus*, however, they are short and cylindrical.

In *Nemachilus* and the Homalopterid genera the lips are so modified as to form a sucker with the help of the mouth, and consequently they exhibit diverse modifications and specializations. In the genus *Nemachilus* the lips are divided in the middle and are greatly swollen, so that when they are pulled outwards away from the mouth, their divided parts form a continuous ring-like sucker. In most cases the skin of the swollen region is plicated, but I have not been able to find any trace of definite spines such as will be described later in the structure of the adhesive apparatus of other genera. I have already described in a previous paper [1] the way in which, by the action of certain muscles, the lips of *Bhavania annandalei* are converted into a sucker. In *Balitora* the thick lips are cut up into several tentaculate processes and when pulled apart they form an effective sucker. In most of the species of the genus *Glyptosternum* the lips are "reflected and spread continuously round the mouth, so as to form a broad flat sucker." Similar modifications occur in certain of the most specialized forms of the genus *Glyptothorax*.

6. *The eyes.*—With the flattening of the form in hill-stream fishes the eyes are more and more pushed towards the upper surface. In forms like *Balitora brucei*, *B. maculata* *Glyptothorax saisii*, *G. striatus.*, *Pseudecheneis sulcatus* and in almost all species of the genus *Glyptosternum* the eyes are situated on the dorsal surface and are placed close together. Besides this change in position, they are much reduced in size. To what cause this reduction is due, I do not know; but it is quite probable that the intensity of the light in the clear shallow waters of the hill-streams may have something to do with it.

7. *The gill-openings, branchiostegal rays and membranes.*—With the employment of the under surface for the purpose of adhesion to rocks and stones, the gill-openings are generally restricted to the sides. Except in the genera *Glyptothorax* and *Laguvia*, the gill-openings, in almost all the genera dealt with in this paper, do not extend beyond the base of the pectoral fin on the under surface. In certain species of *Garra* the openings are somewhat wider, but even in them they are separated from each other by a considerable distance. The greatest modification as regards this character has taken place in two species of *Glyptosternum*. In these the gill-openings are situated above the base of the pectoral fin and there is a short narrow passage from the interior of the gill-chamber to the exterior.

With the restriction of the gill-openings to the sides, it is natural to suppose that respiration will suffer to some extent. Moreover, when a fish is feeding on the algal slime, the under

[1] Hora, *Rec. Ind. Mus.* XIX, p. 203, pl. x, fig. 2.

surface of the head and body are firmly and closely applied to the rock to which it may be clinging at the time, and this also will make respiration difficult. In all probability the following factors help hill-stream fishes in respiration :—

(i) The water in the hill-stream is better oxygenated and is purer than that of a sluggish stream in a flat country.

(ii) By reducing the gill-openings, the fishes are enabled to retain water in their gill-chambers for a comparatively longer time.

(iii) The inner rays of the pectoral fins in fishes of rapid streams are held in constant motion when the fish rests against a piece of rock. The movements of these rays may help respiration in two ways :—

(*a*) The blood may be oxygenated in the rays themselves,
or (*b*) they may force water in and out of the gill-opening.

The following quotation from Mr. Chapin's notes given by Nichols and Griscom[1] on the mechanism of respiration in *Enchilichthys dybowskii* (Vaillant) when clinging to rocks is very interesting :—" Two examples were brought alive in a basin where they stuck fast to the smooth enamel surface. When thus attached, the water for respiration enters by the back of the mouth, and the movement of the gills often makes the whole fish quiver or move slightly back and forth. Natives say they cling to rocks and eat algae. They can swim rapidly. The mouth is here drawn as though slightly extended, while sucking, it of course contracts." The above observations were made on fishes in a state of captivity and require confirmation. The sucker by means of which the fish adheres appears from the figure to surround the mouth completely and it is probable that the fish uses both lips for adhesion as in the Indian hill-stream forms. The posterior jaw is in almost all cases more highly specialized for rasping the algal slime from the rocks than the anterior jaw and under the circumstances detailed above, it seems highly improbable that water can enter the gill cavities from the back of the mouth when the fish is either feeding on algal slime or clinging to a rock.

With the reduction of the gill-openings and the backward shifting of the mouth on the under surface considerably behind the tip of the snout, the branchiostegal rays and membranes are greatly reduced. Usually these structures on the two sides of a fish such as *Labeo rohita* meet and overlap on the under surface, but in hill-stream fishes, with the exception of those belonging to the genera *Glyptothorax* and *Laguvia*, they form an obtuse angle on the under surface, if they meet at all.

8. *The air-bladder.*—The bladder in the hill-stream forms shows considerable degeneration and in 1893 Bridge and Haddon[2]

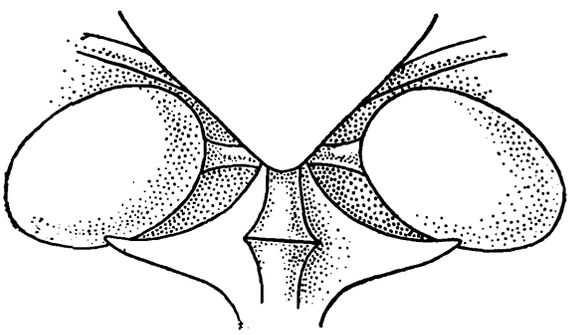
---

[1] Nichols and Griscom, *Bull. Amer. Mus. Nat. Hist.* XXXVII, p. 720, pl. lxxvi, fig. 3 (1917).

[2] Bridge and Haddon, *Trans. Phil. Soc. London*, vol. 184, part I (B), p. 305 (1893).

attributed the reduction to the following causes, which bear repetition even to-day. They say :—"The causes that have led to the degeneracy of the air-bladder in so many forms are in many instances not difficult to trace, and, as in so many Physoclist Teleostei, the assumption of a purely ground habit of life is probably the most important one. Not a few of the genera of Siluridae abnormales inhabit the comparatively shallow waters of rapidly flowing mountain streams and torrents often living at a considerable altitude, and in general habit are not unlike our common English Loaches. Many are provided with an adhesive apparatus on the ventral surface of the body between the pectoral fins for attachment to stones, so that they may be enabled to withstand the force of mountain torrents. Such fishes when not in motion by the exercise of their fins probably rest upon, or attach themselves to, the river bottom, and the utter uselessness and probable harmfulness of an air-bladder as a hydrostatic organ under such conditions is no doubt the cause of its degenerate and rudimentary conditions in such Siluroids as *Sisor, Pseudecheneis, Glyptosternum, Euclyptosternum, Exostoma, Amblyceps,* etc." I have dealt with this interesting organ at some length in my previous paper and have shown in the case of the genus *Garra* that the reduction in the organ is directly proportional to the strength of the current of the streams in which the fish live.

In almost all the highly specialized hill-stream forms such as certain species of Loaches, Homalopterid fishes and the forms included under the Silurid genera, *Glyptothorax*, *Glyptosternum* and *Pseudecheneis* the bladder is, divided into two lateral chambers (fig. 6) which are more or less connected with each other by a short, narrow transverse tube. Moreover the bladder is wholly or partially encapsuled by a bony case in almost all cases.

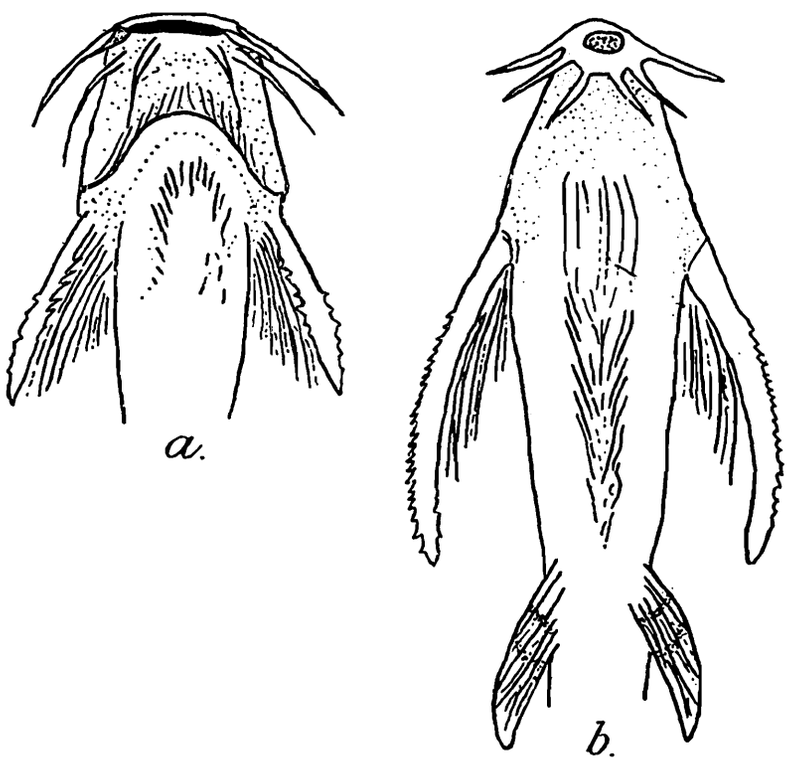


TEXT-FIG. 6.—Air-bladder of *Glyptothorax madraspatanus.*

9. *Special modifications of the skin.*—Under this heading I include the diverse forms of modifications exhibited by the skin in the formation of adhesive organs. The simplest form of specialization occurs in Cyprinid fishes, where the skin covering the under surface of the few outer rays of the paired fins is greatly thickened and becomes cushion-like in places. By these cushion-like pads the fishes are enabled to cling to rocks and hold their own against a rapid flow of water. In the Silurid genera the skin instead of being plain is thrown into grooves and ridges. Such striated portions of skin may occur anywhere on the under surface of the fish but are generally found in the anterior third of the body. I have found such striated surfaces on the barbels, on the sides of the mouth,

on the chest between the bases of the pectoral fins and lastly on the under surface of the pectoral and pelvic spines, and I have been able to make out a series showing the gradual specialization of the adhesive apparatus in the Silurid genera.

The genus *Erethistes* comprises small hill-stream forms in which the under surface of the body is smooth and greatly flattened. In one member of the genus, *E. elongata*, the structure is, however, somewhat different. The whole of the chest and the belly (fig. 7, *b*) is rugose and shows low, but well-marked striations. In the forms which I have assigned to my new genus *Laguvia*, these corrugations are restricted to the chest and the belly is quite smooth (fig. 7, *a*) This feature is still further marked in the



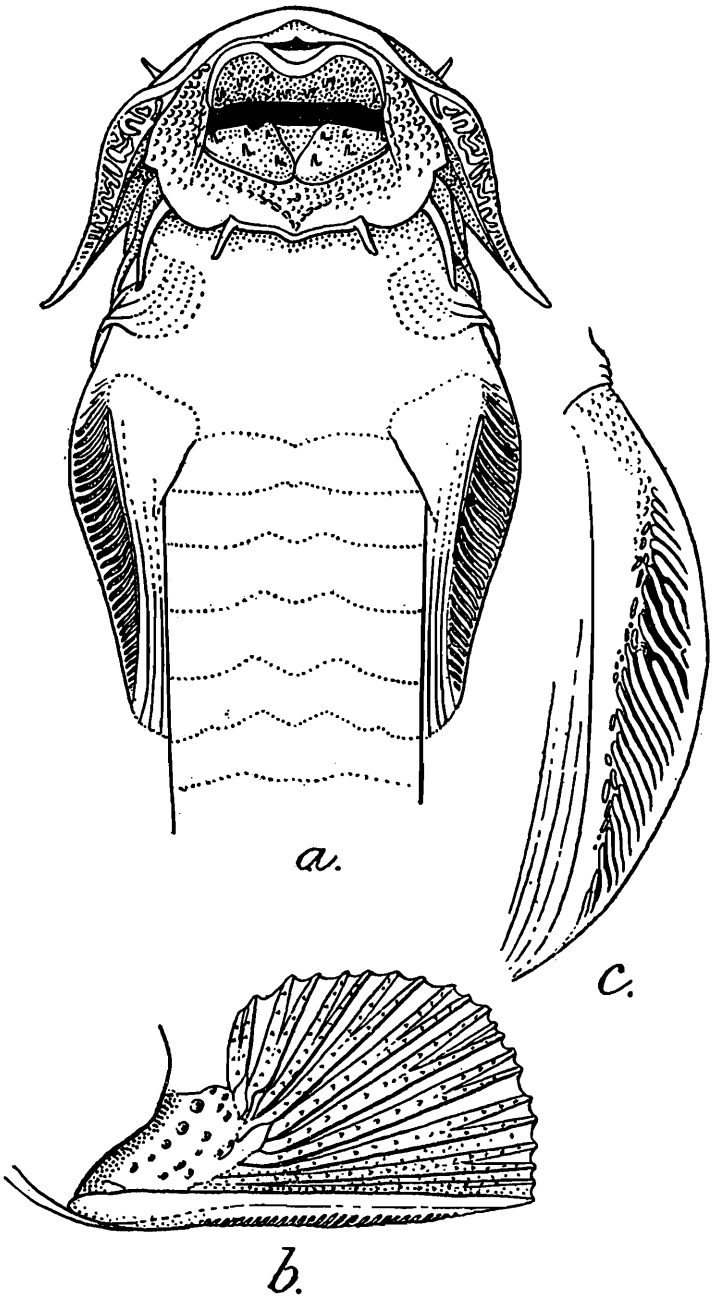
TEXT-FIG. 7.—Under surface of head and chest of *Laguvia* sp. and *Erethistes elongata*.

a. Laguvia sp. *b. Erethistes elongata.*

members of the genus *Glyptothorax*, where a definite U-shaped or V-shaped adhesive apparatus consisting of folds of skin is present on the chest between the bases of the pectoral fins. In certain species of the last genus, from very rapid waters an adhesive apparatus of a similar nature is also present on the under surface of the pectoral and pelvic spines. In *Pseudecheneis sulcatus* the skin is somewhat differently modified on the chest, but the striations on the spines of the paired fins are of a similar nature to those of the preceding genus.

Specialization has proceeded along another direction in the genus *Glyptosternum*. Here the skin on the under surface of the spines (figs. 8*a* and *c*) is striated and each ridge is supported by a short, pointed, cartilaginous ray given off from the outer side

of the first pectoral and pelvic rays (fig. 1, *a*). Besides this the striated region is supported by a definite, highly specialized tissue (fig. 16, *s.t.*). The chest is absolutely devoid of any adhesive apparatus. In certain species of the same genus the under surface of the barbels and the skin near their bases is striated (fig. 8*a*).



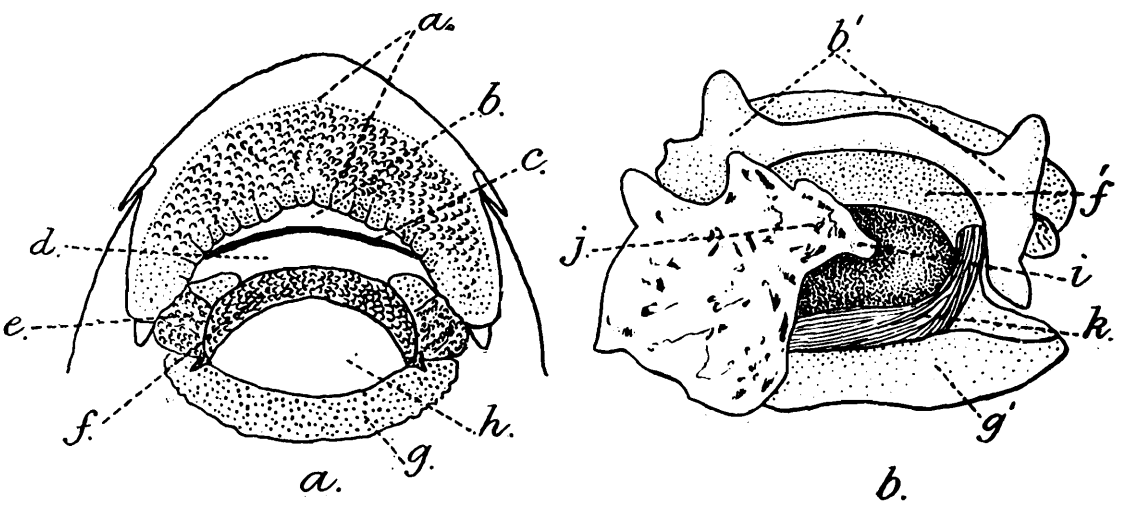
TEXT-FIG. 8.—Structure and form of the pectoral fins and the position of the adhesive apparatus in *Glyptosternum labiatum*.

a. Under surface of head and chest showing striated skin on pectoral spines and on maxillary barbels.
b. Pectoral fin showing reflected inner rays.
c. Under surface of pectoral spine highly magnified.

The disc of *Garra* (fig. 9*a*) with its associated structures is an efficient type of adhesive organ. The disc consists of a central callous portion (*h*) and of free tuberculated lateral and posterior borders (*g*). Its anterior border is formed by the posterior labial fold (*f*) which in its development has replaced the

posterior lip. The anterior labial fold (*a*) is fringed and tuberculated and helps the fish in adhering to rocks. A rudimentary form of disc has recently been described by me[1] in *Parapsilorhynchus discophorus*.

The disc of *Garra* works on the suction principle. In the middle of the under surface of the callous portion, a strong tendon (fig. 9*b*, *i*) is inserted and attached to the urohyal (*j*), so that when the urohyal is elevated, the callous portion of the disc is drawn in and thus a cavity is produced which is surrounded by fringed borders. These fringed and tuberculated borders are provided with efficient organs of adhesion as will be seen later when dealing with the minute structure of the adhesive organs.



TEXT-FIG. 9.—The disc of *Garra* and its associated structures.

a. Disc as seen from the under surface.

b. Dissection of disc from the dorsal surface to show the mechanism for suction.

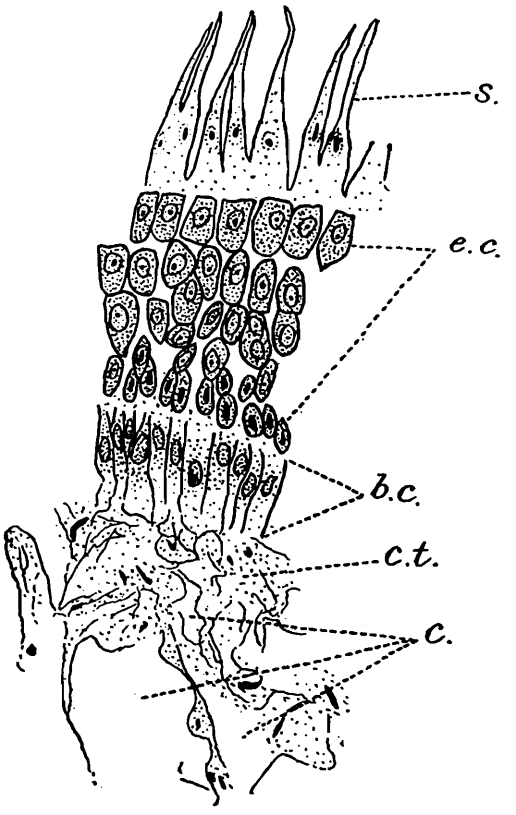
a = anterior labial fold ; *b*, *b'* = anterior jaw ; *c* = mouth opening ; *d* = posterior jaw ; *e* = connectives ; *f*, *f'* = posterior labial fold ; *g*, *g'* = free tuberculated border of the disc ; *h* = callous portion of the disc ; *i* = tendon joining the centre of the callous portion of disc with urohyal ; *j* = urohyal ; *k* = muscle joining the two sides of the anterior jaw.

THE MINUTE STRUCTURE OF THE ADHESIVE APPARATUS.

The simplest form of adhesive apparatus is found among hill-stream fishes of the order Cyprinoidea. It consists of the thickened skin covering the under surface of the few outer rays of the paired fins. In a transverse section of such a structure in *Bhavania annandalei* (fig. 10) the following arrangement may be seen:—The epidermis consists of several tiers of cells, varying in shape and size with their depth and resting on a loose connective tissue (*c.t.*), which constitutes the dermis. The outer epidermal layer is modified into stiff and strong spine-like processes (*s*), which are somewhat curved near their extremities. The inner limit of these processes is not well-defined and they appear to rest

[1] Hora, *Rec. Ind. Mus.* XXII, pp. 13–19, figs. (1921).

upon a homogeneous layer of protoplasm, they occupy as much as one-third of the total thickness of the epidermis and their inner ends are broad. The nuclei of the spines are somewhat oval in outline and are placed in the proximal half; each is surrounded by a whitish halo. The protoplasm of the spine and of the basal homogeneous layer stains lightly with hematoxylin, eosin and borax carmine. The deeper tissue takes up the stain readily. Below the homogeneous protoplasmic layer, the tissue consists of several layers of almost rectangular cells (*e. c.*) each with a distinct nucleus in the centre. The cells diminish in size with the depth of the tissue and become more and more irregular in form and arrangement. The interspaces between them become broader and in certain cells two nuclei are present. Below these and immediately above the basal epidermal layer (*b.c.*) there is a tier of small, more or less regularly arranged cells, the nuclei of which are solid, deeply staining ovoidal bodies. The basal layer of epidermal cells is made up of columnar tissue, the nuclei are oval and lie almost in the middle of the cell, or nearer its upper than its lower ends. The upper as well as the lower limits of the basal cells are hardly distinguishable and both these ends stain lightly. The nuclei appear to be in a state of mitotic division as the chromatin substance in them is greatly diffused.



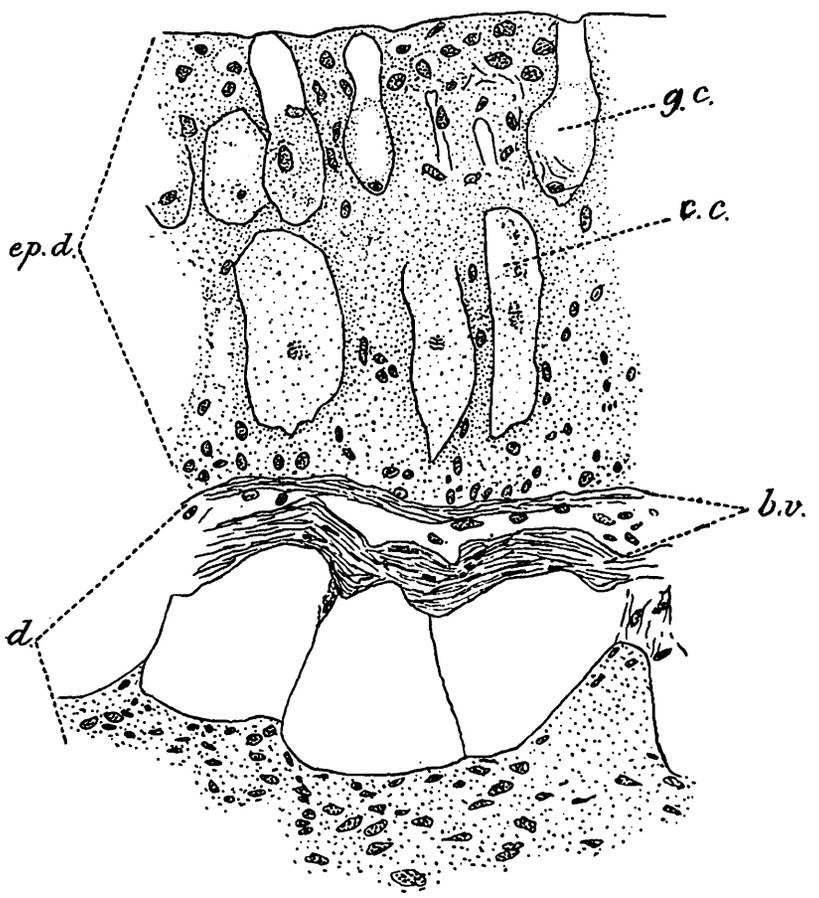
TEXT-FIG. 10.—Transverse section through a portion of the adhesive pad on the outer rays of the pectoral fin in *Bhavania annandalei*.

s = spine; *e.c.* = epithelial cells; *b.c.* = basal epithelial cell; *c.t.* = connective tissue; *c* = cavities for blood vessels.

The connective tissue (*c.t.*) below the basal layer of the epidermis is very loose and is richly interspersed with cavities (*c*) of the nature of blood-spaces. The nuclei are greatly elongated and stain deeply. The cell-limits in this tissue are not marked and the whole of the tissue is not so deeply stained as the middle layer of epidermal cells.

In the genus *Garra* this form of adhesive apparatus is supplemented by the presence of the characteristic disc behind the posterior jaw on the under surface. Before dealing with the structure of the adhesive disc, I propose to give a short account of that of the integument in this genus.

In a vertical section of the skin (fig. 11) covering the tip of the snout, where scales are of course absent, the epithelial region (*ep.d.*) is made up of a homogeneous mass of protoplasm with a large number of nuclei scattered in it. The nuclei are aggregated either near the base or near the apex of the epithelial region; some of them are surrounded by a white zone. Near the upper surface are present a number of large ampulliform gland-cells (*g.c.*). The protoplasm of the gland-cells is restricted to the periphery or to the base and the nucleus generally occupies the centre of the basal protoplasm. In the middle of the homogeneous epithelial mass

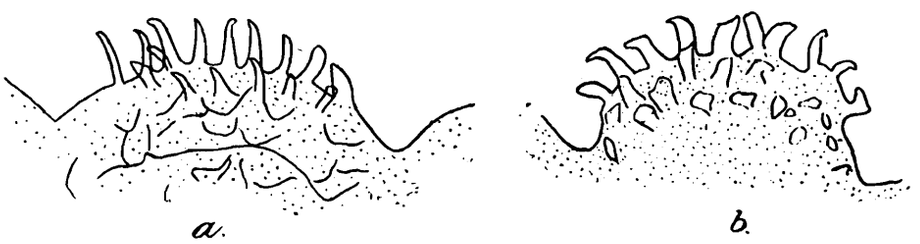


TEXT-FIG. 11.—Transverse section of the integument of *Garra annandalei* from the tip of the snout, x 435.

ep.d. = epidermis; *d* = dermis; *g.c.* = gland-cell; *c.c.* = clavate cell; *b.v.* = blood vessel.

are found big "clavate cells" (*c.c.*) forming as it were a distinct row by themselves. Below the epithelium are blood vessels (*b.v.*) whose walls stain rather deeply with eosin. Underneath the blood vessels are a number of big cavities, which probably represent the adipose tissue. The adipose tissue is said to be present below the skin of most of the fishes, but its presence in this position between the epithelial and dermal regions, is interesting. Below the fat-cells is the connective tissue, which is marked by a large number of nuclei which are not surrounded by a white zone. The cell-boundaries in this region are not distinguishable.

The structure of the mental disc in *Garra* may be treated under two headings, (i) the structure of the central callous portion of the disc and (ii) the structure of its tuberculated borders and of the fringed tuberculated anterior labial fold (fig. 12). The structure of the former is very similar to that of the integument



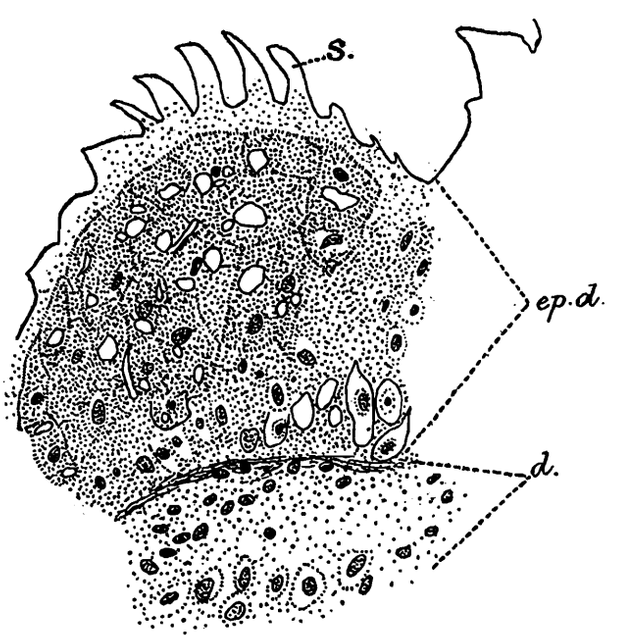
TEXT-FIG. 12.—Structure of tubercles on the disc and the anterior labial fold of *Garra annandalei*.

a. Tubercle on anterior labial fold.
b. Tubercle on lateral free borders of the disc.

described above. The following are, however, some salient points of difference:—

(i) The epithelial cells are better defined and in certain places the ampulliform gland-cells are more numerous.

(ii) The "clavate cells" are fewer in number and are situat-



TEXT-FIG. 13.—Transverse section through a portion of the tuberculated anterior labial fold of *Garra annandalei*, x 435.

s = spine; *ep.d.* = epidermis; *d* = dermis.

ed at great intervals. The protoplasm of these cells has receded inwards from near their upper cell-limits.

(iii) The dermis is chiefly composed of an adipose tissue, which is bounded both above and below by a thin layer of fibrous connective tissue.

The structure of the tuberculated region, on the other hand, is totally different. In a vertical section (fig. 13) of the fringed portion of the anterior labial fold, the superficial epidermal layer covering a tubercle is modified into spines (*s*). It is perhaps significant that I have not been able to find any nuclei in the spines; the spines are, otherwise, shorter, thicker and stouter than those described in *Bhavania annandalei*. On examining a large number of sections of this region and of the free tuberculated borders of the disc, I have observed that the spine is formed as a prolongation of the outer cell-wall of the superficial epidermal layer. Below the spinous layer, there are several tiers of polygonal cells (*ep.d.*) which are vacuolated. In the basal region the cell-limits are not well marked and the nuclei stand out prominently with haematoxylin stain. In some cells the nuclei are surrounded by a whitish halo. The dermis (*d*) consists of a compact connective tissue, with a large number of nuclei scattered just below the epidermis. The cell-boundaries in this region are not well-defined.

In the region of the posterior labial fold and also in that of the free border of the disc, the tubercles are provided with a dermal plug. The dermis consists of a large number of branched irregular cells, forming a primitive type of connective tissue.

The structure of the tuberculated region in *Garra* differs from that of the integument and of the central callous portion of the disc in the following points :—

(i) The gland-cells are absent.

(ii) The " clavate cells " are absent.

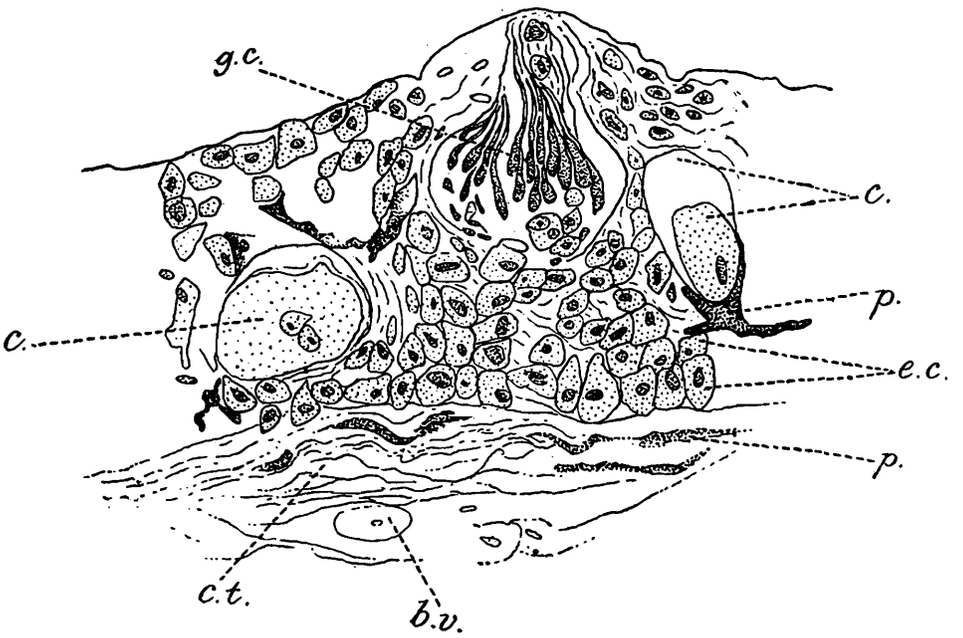
(iii) The superficial epithelial layer of cells is modified into spines which do not possess any nuclei.

(iv) The adipose tissue is totally absent, and the dermis, therefore, presents a compact, solid structure.

In the order Siluroidea the modification of the skin to form an adhesive apparatus is very different. It is thrown into folds and ridges, which are characterized by a special structure. Any portion of the skin may thus be modified to serve the purpose of adhesion. To illustrate the structure of the adhesive apparatus in Silurid fishes, I will first describe that found in *Glyptosternum labiatum*.

The structure of the integument found in this genus may in the first place be considered. In a vertical section (fig. 14) of the non-striated skin covering the dorso-lateral surface of the pectoral spine, the epithelium consists of several layers of small, more or less flattened and rectangular cells which possess well-marked cell-walls and relatively large oval nuclei. The cells near the surface are smaller than those immediately below them. Their outline varies considerably according to the extent to which they may be packed together in a particular place. Black pigment (*p*) is present at certain places in the tissue. Most of the central space of the epithelium is occupied by a number of big " clavate cells " (*c*), which are distributed at regular intervals and form a distinct layer of their own. They are fairly well developed and

sometimes their nuclei may be as big as an ordinary epithelial cell. The "clavate cell" possesses a distinct cell-wall and in most cases it contains more than one nucleus. The contents of the "clavate cell" are very different from those of the surrounding epithelial cells, as it is only lightly stained with haematoxylin and eosin. The nucleus is surrounded by a whitish area. The most interesting point is the degree of vacuolation that is generally met with in these cells. The process of vacuolation sets in from the outer wall and the protoplasm gradually recedes towards the inner side. In extreme cases more than half of the cell is emptied of protoplasm. I have not been able to make out the structure of the contents of a vacuole. The nucleus is generally vesicular with a distinct membrane and in those cells, which contain only



TEXT-FIG. 14.—Transverse section through the integument of *Glyptosternum labiatum* x 435.

e.c. = small epithelial cells; *p.* = pigment; *c.* = clavate cell; *g.c.* = gland-cell; *c.t.* = connective tissue; *b.v.* = blood vessel.

one nucleus, its chromatin matter is diffused as if preparing for a mitotic division. I have not been able to observe distinct nuclear figures in any of these cells. If more than one nucleus is present in a cell, the nucleolus can also be readily made out. Ramsay Wright[1] described these cells in the integument of *Amiuris catus*. He observed, "there can hardly be any doubt that the clavate cells have an important physiological role to play. What that is remains still obscure." I have found these cells in the integument covering the tip of the snout in *Garra* and in the position described above in *Glyptosternum labiatum;* but am unable to understand their exact significance. It may, however, be pointed out that they are always absent in an adhesive tissue in fishes.

The gland-cells in *Glyptosternum* are not scattered as has al-

[1] Ramsay Wright, *Proc. Canadian Inst.* (n. s.) II, pp. 254–255 (1884).

ready been described in the integument of *Garra*; but are aggregated to form definite structures. Each one of these structures is flask-shaped with the neck almost half as long as its total length. The mouth of the flask along with the adjoining tissue projects slightly above the surface of the integument. The body of the flask is occupied by a number of characteristic cells. The cells are elongated and are drawn out into long, fine processes which travel through the neck of the flask and open on the surface of the skin. The nuclei are very big and occupy almost the whole of the cell. The cells forming this characteristic structure do not begin at the same level and thus present an irregular bunch of cells hanging in the cavity of the flask by means of fine threads. Sometimes one or more epithelial cells make their way inside the flask and when seen they are usually found in the neck region.

It is after long hesitation that I have assigned to these cells the function of secretion. The following are the main reasons for holding this view :—

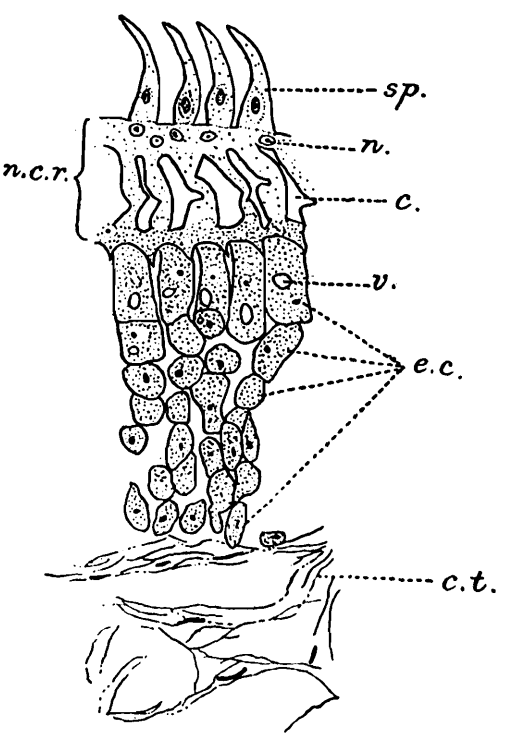
(i) The unicellular glands, usually present in the integument of fishes, are absent.

(ii) The mouth of the flask projects beyond the surface of the integument.

(iii) The cells have fine canals which open on the surface of the skin.

(iv) The cells are provided with big nuclei.

Such glandular structures are found at a considerable distance from each other, and I have not been able to find more than three in any one section.



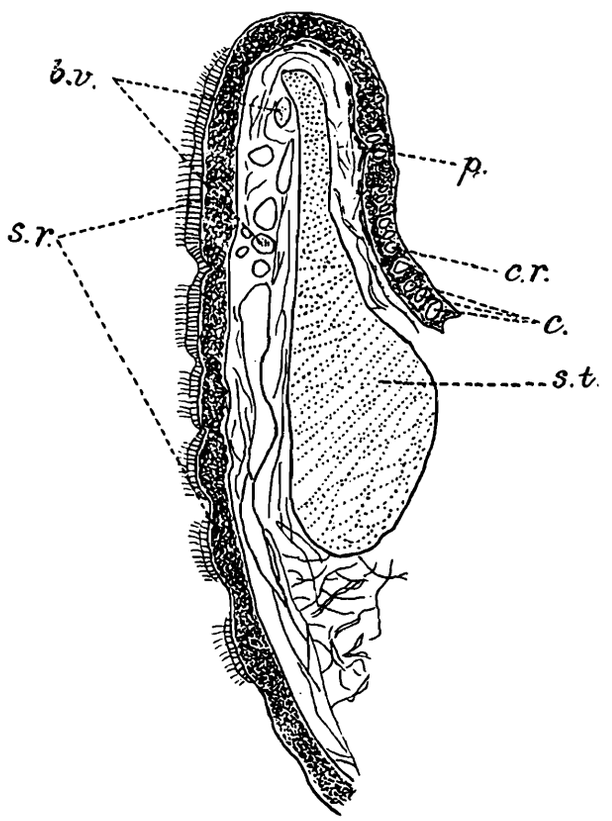
TEXT-FIG. 15.—Transverse section through the striated skin on the under surface of the outer ray of the pectoral fin in *Glyptosternum labiatum*, x 435.

s. p. = spine ; *n.* = nuclear bodies ; *n.c.r.* = non-cellular region ; *c.* = cavity ; *e.c.* = epithelial cells ; *v.* = vacuole ; *c.t.* = connective tissue.

In the structure of the adhesive apparatus (fig. 15) formed by the striation of the skin on the under surface of the pectoral and pelvic spines, a distinct advance is made upon that observed in *Bhavania* and *Garra*. The upper layer of epithelial cells is modified into curved spines (*sp.*), whose inner limits are not well defined. The spines are provided with definite nuclei, which are situated in their lower swollen portions. In the non-cellular region immediately below the spinous layer are a number of deeply staining bodies forming a definite row. What these bodies are, I have

not been able to determine definitely. Below the spines is a deep non-cellular layer (*n.c. r.*) in which are scattered a number of spaces (*c*) having a definite shape. They are almost crescentic in outline and possess a short spine-like process along their convex borders. The lower limit of the non-cellular region is formed by a regular wavy line. In the curves of this wavy line are situated a number of characteristic columnar cells. Each is provided with a nucleus, a distinct nucleolus and a small well-marked vacuole (*v*). Between two neighbouring cells there is generally a small chink-like cavity. Below these columnar cells, are a number of small epithelial cells which are irregularly arranged in four to five tiers. Usually they possess small, solid, deeply staining nuclei, but in certain cells the nuclei are altogether absent. Beneath the epithelial tissue is a loose connective tissue (*c.t.*) forming the dermis.

In the genus *Glyptosternum*, the adhesive apparatus is supported by a definite tissue as has already been remarked. The supporting tissue (fig. 16) consists of a mass of polyhedral cells (fig. 17) which are very turgid and are closely packed together. The nuclei of these cells are fairly large and in certain cases there may be more than one nucleus in a cell. The cells vary in form and size to a considerable extent and towards the base they are so much pressed together that the cell-limits become almost obliterated and the nuclei become spindle-shaped. The supporting tissue (*s.t.c.*) is surrounded by a loose connective tissue (*c.t.c.*).

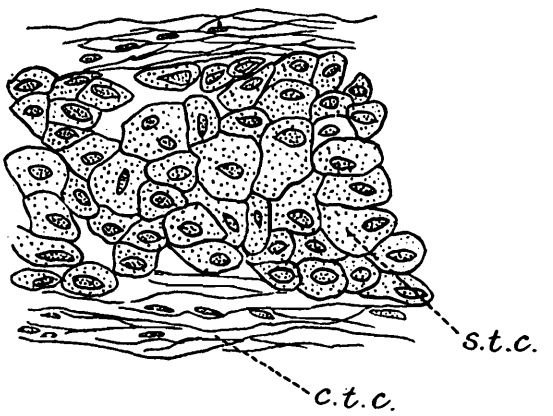


TEXT-FIG. 16.—Transverse section through the thickened skin covering the pectoral spine in *Glyptosternum labiatum*, x 42.

s.t. = supporting tissue ; *c.r.* = clavate cell region ; *p.* = pigment ; *s.r.* = striated region ; *b.v.* = blood vessel ; *c.* = clavate cells.

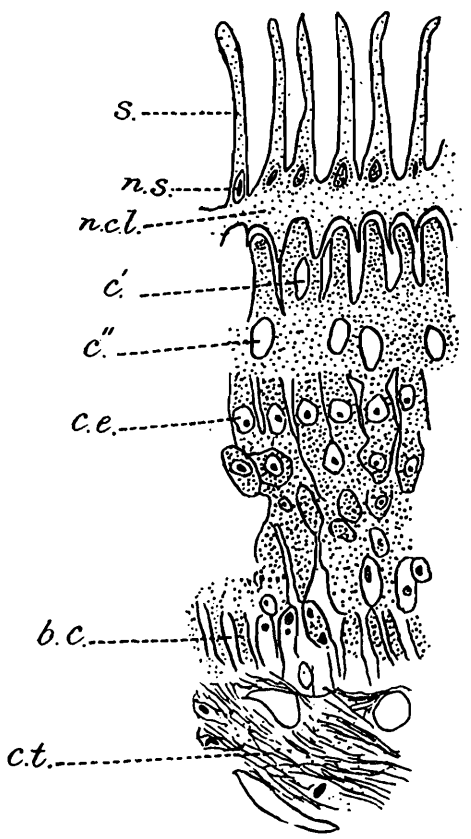
The structure of the thoracic adhesive apparatus of *Pseudecheneis sulcatus* is different from all the three types described above. The nuclei of the spines are situated in the non-cellular region and the cell-walls in the epithelial region are not well defined. In the cells of the first epithelial layer, immediately below the non-cellular region, there are ill defined vacuoles. The connective tissue is not so loose and is richly dotted with a large number of nuclei of various forms.

Within the genus *Glyptothorax*, the structure of the adhesive apparatus shows considerable variation. In *G. dorsalis*, a large number of specimens of which were collected in the sluggish and muddy streams of the Manipur Valley, the spines are small and the spinous layer as a whole is not well developed. The epithelium is composed of several tiers of small, squarish cells, of these the uppermost and the basal layers are highly vacuolated. The cell-walls are quite distinct and the basal layer is somewhat columnar. Below the epithelium is a dense sheet of connective tissue, in which are scattered big cavities full of blood corpuscles. Underneath the connective tissue are fat-cells with eccentric nuclei. In *G. madraspatanus* the structure (fig. 18) of the adhesive tissue is more advanced in so far as the cell-limits are not distinguishable. Immediately below the non-cellular region there are two layers of cavities (*c'.c''.*); the upper is in the form of elongated spaces with intervening columns of protoplasm, while the second layer consists of rounded cavities in the substance of the protoplasm. Below this the epithelium consists of a row of columnar cells which are followed by a number of small, rounded cells. In the basal epithelial layer I have not been able to find any nuclear structures. The greatest specialization in the structure of the adhesive tissue within the genus is reached in those forms that possess an adhesive surface on the chest as well as on the under surface of the pectoral and pelvic spines. I take *G. sp.* from Madras as an example of this kind of structure.



TEXT-FIG. 17.—Transverse section through the supporting tissue of the adhesive apparatus on the fins of *Glyptosternum labiatum*, x 435.

c.t.c. = connective tissue cells; *s.t.c.* = supporting tissue cells.



TEXT-FIG. 18.—Transverse section through a portion of the thoracic adhesive apparatus of *Glyptothorax madrasapatanus*, x 435.

s. = spine; *n.s.* = nucleus of the spine; *n.c.l.* = noncellular layer; *c.* = first row of cavities; *c''.* = second row of cavities; *c.e.* = columnar epithelium; *b.c.* = basal cells of epithelium; *c.t.* = connective tissue.

In a vertical section of the striated skin covering the under surface of the pectoral spine of *G.saisii* (fig. 19, *a*) the structure in all essential points corresponds to that of the previous examples. The spines (*s*) are hooked and more regular; their nuclei (*n.s.*) are situated near the base and each of them is surrounded by a whitish halo. The nuclei project into the non-cellular region (*n.c.r.*). Underneath the non-cellular region there are two rows of cavities or open spaces. The cavities of the first row (*c'*) are greatly elongated, they are broader near the upper than near the lower end. On focussing, a part of the cavity is found to contain a lightly stained protoplasmic substance. The second row of spaces (*c''*) is similar to the first, but here the lower portion of the cavity is filled with protoplasm; the upper margin of each cavity is deeply stained and in the section there appears an interrupted band. Then follow large columnar cells (*c.e.*) which are provided with big nuclei. The nuclei are oval and possess a well-defined nucleolus, they are surrounded by a whitish halo. Below these there are several rows of small, rounded epithelial cells, some of which are devoid of any nuclear substance. The basal layer (*b.c.*) is represented by finger-like processes of protoplasm which do not possess any nuclei. It may be pointed out for the sake of clear understanding that the whole of the structure is one continuous mass and that the cell-boundaries are nowhere marked but in drawing up the description it has been convenient to treat the structure as if it were composed of a number of distinct layers.

It is interesting to note the changes in the structure as we pass from the ridge to the grooved portion of the striated skin. Attention may be drawn to the following points of difference in the grooved area (fig. 19*b*):—

(i) The spines become smaller and smaller till they are represented by small knob-like projections on the surface. In the middle of the groove the surface becomes entirely smooth.

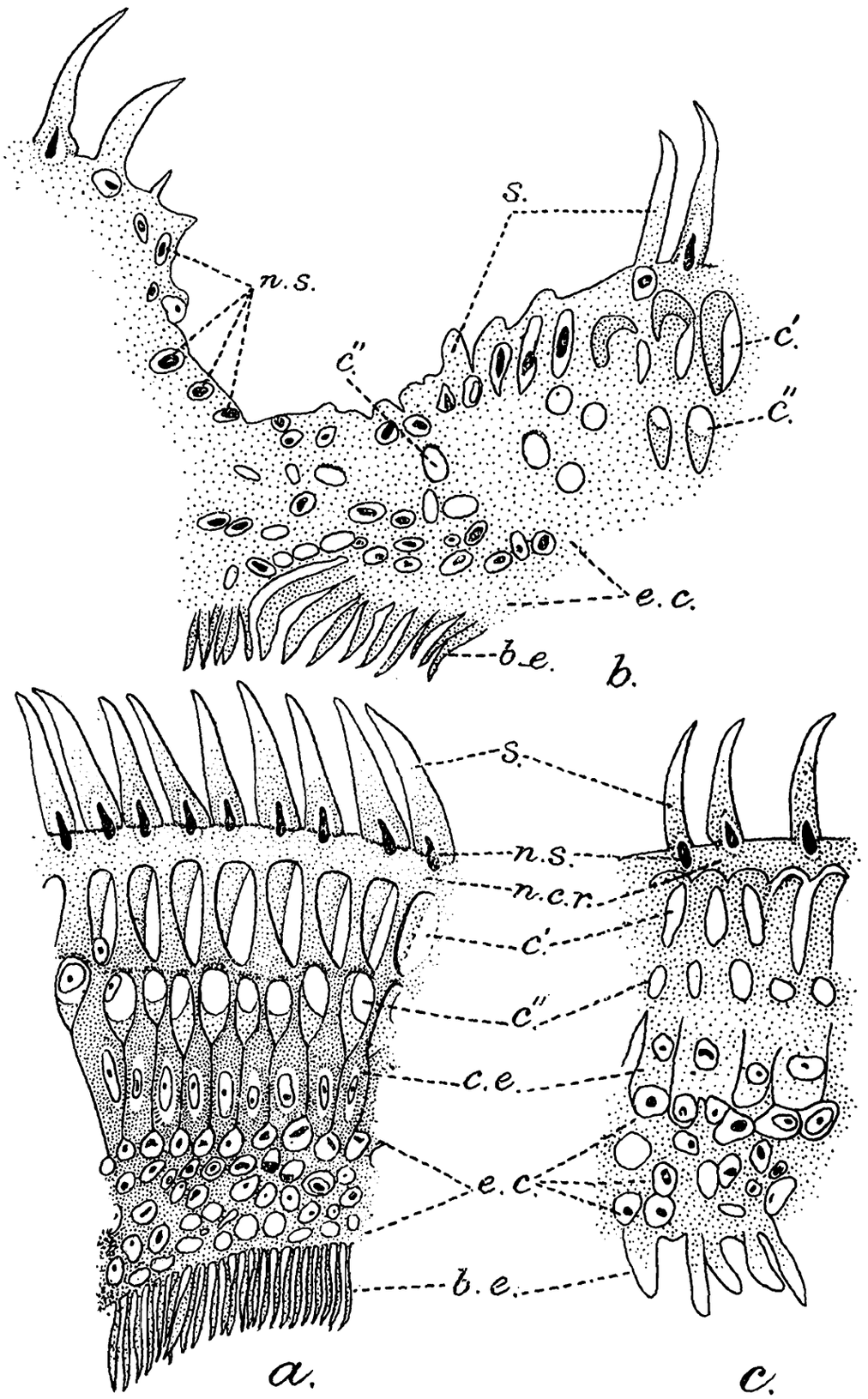
(ii) The nuclei of the spines recede inwards and ultimately form a continuous layer just below the surface of the skin.

(iii) The first layer of cavities is represented by small, oval or rounded spaces in the grooved region. In some cases this layer may be totally absent.

(iv) The second row of spaces is represented by small cavities; they are provided with a deeply staining upper margin.

The structure, on the whole, appears as a mass of protoplasm in which the nuclei are scattered either near the base or near the apex and a few cavities are present in the middle. The basal epithelium is represented by finger-like processes as described above.

In a horizontal section (fig. 19*c*) the structure of the adhesive tissue does not differ greatly from that seen in a vertical section. The chief difference lies in the form and extent of the various elements noted above. The non-cellular region is separated from the underlying tissue by a regular wavy line of demarcation. The



TEXT-FIG. 19.—Minute structure of the adhesive apparatus on the under surface of the pectoral spine of *Glyptothorax sp.*

a. Transverse section through a portion of the ridge, x 650.
b. Transverse section through a portion of the groove, x 650.
c. Horizontal section through a portion of the ridge, x 650.

s = spine; *n.s.* = nucleus of the spine; *n.c.r.* = non-cellular region; *c'*.= first row of cavities; *c''* = second row of cavities; *c.e.* = columnar epithelium *c.e.* = small, rounded epithelial cells; *b.e.* = basal epithelial cells.

cavities are considerably smaller and do not show any protoplasmic elements within their limits. The so-called columnar epithelium is not well-marked. The underlying structure corresponds to that described for the vertical section.

Having described the structure met with in the different forms selected above, it will be advantageous to consider the lines along which evolution has taken place from the simplest to the most complicated structure. In the simplest type of adhesive apparatus the skin is thickened and its outer epithelial layer of cells is modified into curved spines; the gland cells and the "clavate cells" of normal skin-tissue totally disappear. Specialization proceeds along two lines, firstly there is an increasing tendency at every step towards vacuolation of the superficial epithelial cells and this ultimately results in the formation of definite cavities, and secondly the cell-walls of epidermal cells become indistinguishable. The final stage is reached in *Glyptothorax sp.* where the whole of the epidermal tissue appears as a syncytium. The adhesive apparatus of the Silurid fishes is distinguished from that of the Cyprinid forms by the fact that in the former the skin is thickened and striated, whereas in the latter it is only thickened and forms a plain cushion-like pad. I have not been able to understand the true significance of increased vacuolation or of the syncytium formation in the tissue of the adhesive apparatus.

There is, however, no doubt as to the function of the epidermal spines. All of them are curved in the same direction and probably they point posteriorly. As the fish sticks to a stone with the head pointed up stream, and the current of water tends to move it backwards, the spines when closely applied to a stone, fix it securely by taking hold of the unevennesses of the rock. In Silurid fishes the ridges are pulled outwards and a sort of vacuum is produced in the grooves which helps the fishes in adhering to rocks.

So far as I know, the type of structure described above is not met with in tissues of adhesion in any other group of animals. Dahlgren and Kepner,[1] who have given a summary of the subject, have not anywhere referred to a spinous structure. Even in a longitudinal vertical section through a small region of the grasping organ on the head of *Remora*, the characteristic structure that I have described above apparently is not found.

CONCLUSION.

In conclusion I wish to refer briefly to the origin of the hill-stream fauna and to the means of dispersal and propagation adopted by it. In the following discussion I take up these points one by one.

Origin of the Hill-stream Fauna.—There are two possibilities, firstly, that the forms now living in the mountain-rapids were once

[1] Dahlgren and Kepner, *Principals of Animal Histology*, pp. 409–417 (1908).

accidentally carried into them, and secondly that there has been a step by step colonisation of the hill-torrents from the sluggish-streams that flow in level country. As regards the first possibility it may safely be inferred that forms which have not previously acquired adaptive characters, cannot live in rapid waters because at every move they are liable to be swept away down stream. The second view is more probable and the following are some of the main points in its favour:—

(1) As a hill-stream changes into a sluggish stream in almost level country its fauna changes accordingly and intermediate forms, like *Crossochilus latia*, between the typical hill-stream fishes and the fishes of the slow streams are always met with in the intermediate regions where the water is neither flowing very fast nor very slowly.

(2) The very fact that the members of certain genera such as *Glyptothorax* and *Garra* can be arranged in a series according to the degree of modification they exhibit in response to the strength of the current of stream, shows that there has been a gradual colonisation of rapid streams.

(3) The hill-stream fishes in the course of their development pass through many different stages which clearly show, at any rate in the case of *Garra*,[1] that the evolution of such forms is from those that live in sluggish streams. Not only is this shown by the form of the body but also in the modifications of such organs as the air-bladder, the position and form of the mouth and the eyes, and in the reduction of the branchiostegal membrane and rays. In short, the developmental series of *Garra* as given in a previous paper recapitulates the history of the evolution of the genus.

Having subscribed to the view that the hill-stream fauna has originated by the process of gradual colonisation from the slow streams, it will not be out of place to discuss the causes that might have led to the migration of these forms. There are two chief factors which might compel such a migration:—food and safety. In the hill-streams there is always plenty of food in the form of algal slime on the exposed surface of rocks, but only those animals can make use of it which have their jaws specially adapted for rasping it off the stones on which it grows. As regards safety, it may be said that there is very little competition in the hill-streams among the fishes themselves. Moreover, they are practically safe from the ravages wrought by birds and large predaceous fishes, crocodiles, etc. Certain fishes like *Nemachilus* can find shelter underneath stones and the readiness with which they hide themselves is marvellous. Probably the fishes inhabiting slow-running waters originally ascended the hill-streams step by step in search of food and gradually acquired certain characters which made them specially suitable for living in the newly chosen environment.

---

[1] Hora, *Rec. Ind. Mus.* XXII, p. 639 (1921).

Annandale,[1] when discussing the evolution of the adhesive apparatus in hill-stream fishes, made the following remark about the genus *Garra* :—" Whereas the chief factor in the case of *Psilorhynchus* was rapid-running water in a rocky stream-bed, in *Discognathus* the primary factor was a peculiar mode of feeding." Quite recently I[2] also subscribed to this view, but a more detailed study of the adhesive apparatus has led me to modify my previous ideas. I believe that the mental disc of *Garra* has not primarily been evolved for the " peculiar mode of feeding," which is practically similar in all the genera of hill-stream fishes, but for securing adhesion to rocks in rapid running waters. The adhesive apparatus on the under surface of the paired fins is an additional organ of adhesion in species that live in very rapid waters. In certain highly evolved species of *Garra*, which have secondarily taken to live in lakes and pools, the peculiar pad-like structure on the under surface of the paired fins have disppeared though the characteristic mental disc is still present, as it is probably of use to the fish in its " peculiar mode of feeding " which was acquired as a direct response to a life in hill-streams.

I am, therefore, led to conclude that none of the hill-stream forms are ancestral forms, but that all of them are descended from migrants from the slow-running streams. The modifications that some of these forms exhibit are due to the physical conditions prevailing in mountain-rapids, and it is to this cause that we must ascribe the similarity in form and structure exhibited by the more advanced members of the genera dealt with in this paper.

Means of dispersal.—When dealing with the fish of Manipur it was pointed out by me that most of the new species from the hill-streams had a localised distribution. This is the case with almost all the hill-stream fishes and naturally it is difficult to imagine a wide range of distribution of these forms. The most highly modified forms are not capable of living for a long time in muddy channels, on account of the form of their bodies and the structure of their jaws. In cases where a very wide range has been attributed to a hill-stream species, it has always been found on comparison of material from different localities that several allied forms had been grouped together under the same name and that most of them are capable of specific separation. For example *Glyptosternum labiatum* which was described from the Mishmi Hills in Upper Assam, was recorded by Vinciguerra[3] from the Kachin Hills, Upper Burma. Regan[4] in 1905 separated the Burmese specimens from those collected in the Mishmi Hills under the new name *G. vinciguerrae*. A remarkably wide range of distribution was attributed to *Garra lamta*, but as

---

[1] Annandale, *Rec. Ind. Mus.* XIV p. 117 (1919).
[2] Hora, *Rec. Ind. Mus.* XIX, p. 213 (1920).
[3] Vinciguerra, *Ann. Mus. Civ. Stor. Nat. Genova*, (2), IX, p. 252 (1889).
[4] Regan, *Ann. Mag. Nat. Hist.* (7) XV p. 184 (1905).

has been shown elsewhere,[1] the forms from various localities are not specifically identical.

Methods of propagation.—All the hill-stream fishes with which I am acquainted are oviparous. The rapid current in these streams makes it impossible for them to lay their eggs loose in the rocky beds, as they are liable to be carried down stream and destroyed. In my tours to the hill-streams I have always found that the pools in the courses of these streams were full of young specimens of the genera *Nemachilus* and *Barilius* and of a few other small fish that are usually found in pools. In no case was I able to find young of *Garra* or of any other highly modified hill-stream forms. Dr. Annandale and Major Sewell, however, found *Garra* and *Psilorhynchus* in pools of hill-torrents in the Western Ghats. There appear to be two possibilities, (i) that the hill-stream fishes migrate to slow running waters to lay their eggs and that every generation has later on to ascend up-stream to its natural habitat or, (ii) that the eggs are tightly fixed to stones. I am unable to say at present which hypothesis can be accepted as correct.

---

[1] Hora, *Rec. Ind. Mus.* XXII, pp. 633-687 (1921).

NOTES ON FISHES IN THE INDIAN MUSEUM.

III. On Fishes belonging to the Family Cobitidae from high altitudes in Central Asia.

By Sunder Lal Hora, *M.Sc.*, *Assistant Superintendent, Zoological Survey of India.*

The Cobitid fishes[1] from the high altitudes of Central Asia are generally characterized by the absence of a suborbital spine, by the elongate form of their body, especially of the caudal peduncle, and by the total absence of any scales. The belly is generally rounded and not depressed. The Indian Museum possesses a large number of specimens of this family from Tibet, Northern Kashmir, Western Turkestan and Seistan. When dealing with the fish of Seistan it was pointed out by Annandale and myself[2] that among those specimens which have been referred by several ichthyologists to *Nemachilus stoliczkae* Steind. there were several forms capable of specific separation. In this note an attempt is made to elucidate these points and to discuss the specific validity of the various species represented in our collection.

Here are also incorporated the results of an examination of the loaches recently collected in Kashmir by officers of the Zoological Survey of India.

At the end I have added a short note on the sexual dimorphism exhibited by some of these species.

The Central Asiatic forms belonging to the family Cobitidae dealt with in this note may be grouped into three distinct genera, which can be distinguished in the following manner:—

A. Two bladders; one lying free in abdominal cavity and second divided into two lateral chambers enclosed in bone ... ... *Diplophysa.*

B. One bladder, consisting of two lateral chambers enclosed in bone.

I. Soft dorsal fin between spiny dorsal and caudal fins present ... ... *Adiposia.*

II. Soft dorsal fin absent ... ... *Nemachilus.*

Genus Diplophysa Kessler.

1874. *Diplophysa*, Kessler, *Bull. Soc. Sci. Moscou* XI, pp. 1-63.
1888. *Lefua*, Herzenstein, *Wiss. Res. Prezewalski Central Asia. Reis., Zool.* III (2), p. 91,

Unfortunately the paper in which Kessler proposed the generic

---

[1] A large number of specimens of the Cobitid genus *Botia*, which possesses spines below the eye, have recently been collected in Kashmir. The genus extends to China as well, but I have not dealt with it here.

[2] Annandale and Hora, *Rec. Ind. Mus.* XVIII, p. 179 (1920).

name *Diplophysa*, is not available in Calcutta, so I take from Day [1] the characters on which this genus was erected. The genus *Diplophysa* comprises those fishes in which the body is greatly elongated and strongly compressed posteriorly; the eyes are surrounded with a fold of skin forming a lid; the lips are fleshy, the upper more or less denticulated, the inferior bilobed and more or less papillated and the air-vessel is divided into two parts, the anterior enclosed in a bony capsule and the posterior elongated and free in the abdominal cavity. I agree with Day (*op. cit.*) that the first three characters do not possess any generic value, but the last feature, that of the air-vessel, is quite sufficient to distinguish the genus *Diplophysa* from *Nemachilus*, to which it is closely allied. Day did not dispute the validity of the last character but suggested a re-examination of the Western Turkestan specimens and remarked that, "it would be very remarkable were the *Nemacheili* found in Europe, in fact throughout Asia, even in the Oxus, to have their air-vessel enclosed in bone, whereas in the river Ili going to Lake Balkash, and the river Urdjar falling into Lake Ala (Ala-Kul), to have the same organ partially free in the abdomen, as is seen in the genus *Botia*." Day did not think himself justified in recognising *Diplophysa* as a distinct genus from *Nemachilus* even on the character of the air-bladder, which is so remarkable.

Kessler [2] in 1879, when dealing with the Central Asiatic fishes, upheld his genus *Diplophysa* and described two new species under this generic designation. In reviewing Day's criticism of the genus he pointed out that in all probability Dr. Stoliczka's collection was made in the area south west of the Tarim river-system, while Przewalski's collection, which contained several representatives of the genus, was made much further to the east. Moreover he considered the air-bladder to be as important for taxonomic purposes as the pharyngeal teeth, on which the two families Cobitidae and Cyprinidae are distinguished.

Herzenstein [3] in his valuable monograph of Central Asiatic fishes agreed with Day and considered *Diplophysa* synonymous with *Nemachilus*. But at the same time he instituted a new genus *Lefua* to accommodate *Diplophysa costata* Kessler and *Octonema pleskei* Herz. He characterized the genus *Lefua* as follows:— "Caput valde depressum. Os fere terminale. Spina suborbitalis nulla. Nares anteriores cirro sat longo instructae. Cirri rostrales 4, supra-maxillares 2. Vesicae natatoriae pars posterior in cavitate abdominali libere suspensa." No notice seems to have been taken of this genus till 1907 when Berg [4] recognised it and considered the Japanese genus *Elixis* Jordan and Fowler [5] as a synonym of

---

[1] Day, *Proc. Zool. Soc. London*, p. 793 (1876); *Sci. Res. 2nd. Yarkand Mission, Ichthyol.*, p. 12 (1878).

[2] Kessler, *Bull. Acad. Sci. St. Pétersbourg* XXV, p. 302 (1879).

[3] Herzenstein, *Wiss. Res. Przewalski Central As. Reis., Zool.* III (2), p. 1 (1888).

[4] Berg, *Proc. U.S. Nat. Mus.* XXXII, p. 437 (1907).

[5] Jordan and Fowler, *Proc U.S. Nat. Mus.* XXVI, p. 768 (1903).

Lefua, the definition of which he modified as follows:—"Cirri 8, four rostral, two maxillary and two at the anterior nostrils. Scales present. No erectile spine below the eye. Dorsal fin about over the ventral, with few rays; caudal rounded. Air-bladder with a posterior part free in the abdominal cavity." The genus *Elixis* was established to comprise those species of *Nemachilus* which possessed a pair of nasal barbels in addition to six others that surround the mouth. In *E. nikkonis*, the genotype of the genus, and in *E. coreanus* subsequently described by Jordan and Starks [1] no mention is made as to the nature of the air-bladder in them. I have examined some Indian species of the genus *Nemachilus*, such as *N evezardi* Day [2] which possess a pair of well-developed nasal barbels but have not found in them a free bladder in the abdominal cavity. It is quite probable that the Japanese species with eight barbels may not possess a free bladder as is said to be present in the Chinese species with eight barbels assigned to the genus *Lefua* by Herzenstein. I am led, therefore, to believe that Berg united the two genera merely on the consideration of the nasal barbels and paid little attention to the character of the air-bladder. He, moreover, considered *Nemachilus dixoni* Fowler,[3] *Elixis coreanus* Jordan and Starks and the two forms included by Herzenstein under his genus *Lefua* as representing only one species, having examined a large number of specimens from widely different localities in China and Korea. I doubt the validity of this statement and suggest a re-examination of these specimens. There seems to me nothing at present in the definition of *Lefua* and *Elixis*, except the presence of nasal barbels, which could justify their separation from *Diplophysa* and *Nemachilus* respectively, but Annandale and I (*op. cit.*, p. 185) have already pointed out that we do not consider it a character of generic value. I conclude, therefore, that *Lefua* is a synonym of *Diplophysa* and *Elixis* of *Nemachilus*.

Quite recently Weber and Beaufort [4] have recognised the genus *Elixis* and have referred *Nemachilus obesus* Vaill,[5] to it only on the character of the nasal barbels.

In a recent contribution to the ichthyology of Central Asia, Zugmayer [6] has recognised the genus *Diplophysa* as distinct from *Nemachilus*, though closely allied to it. The chief distinction between the two genera lies in the fact that according to Zugmayer a part of the air-vessel lies free in the abdominal cavity in *Diplophysa*, whereas in *Nemachilus* it is wholly enclosed in a bony capsule. Having examined the air-bladder in *Diplophysa papilloso-labiata* Kessler, Zugmayer states that the two parts are distinct from each other.

---

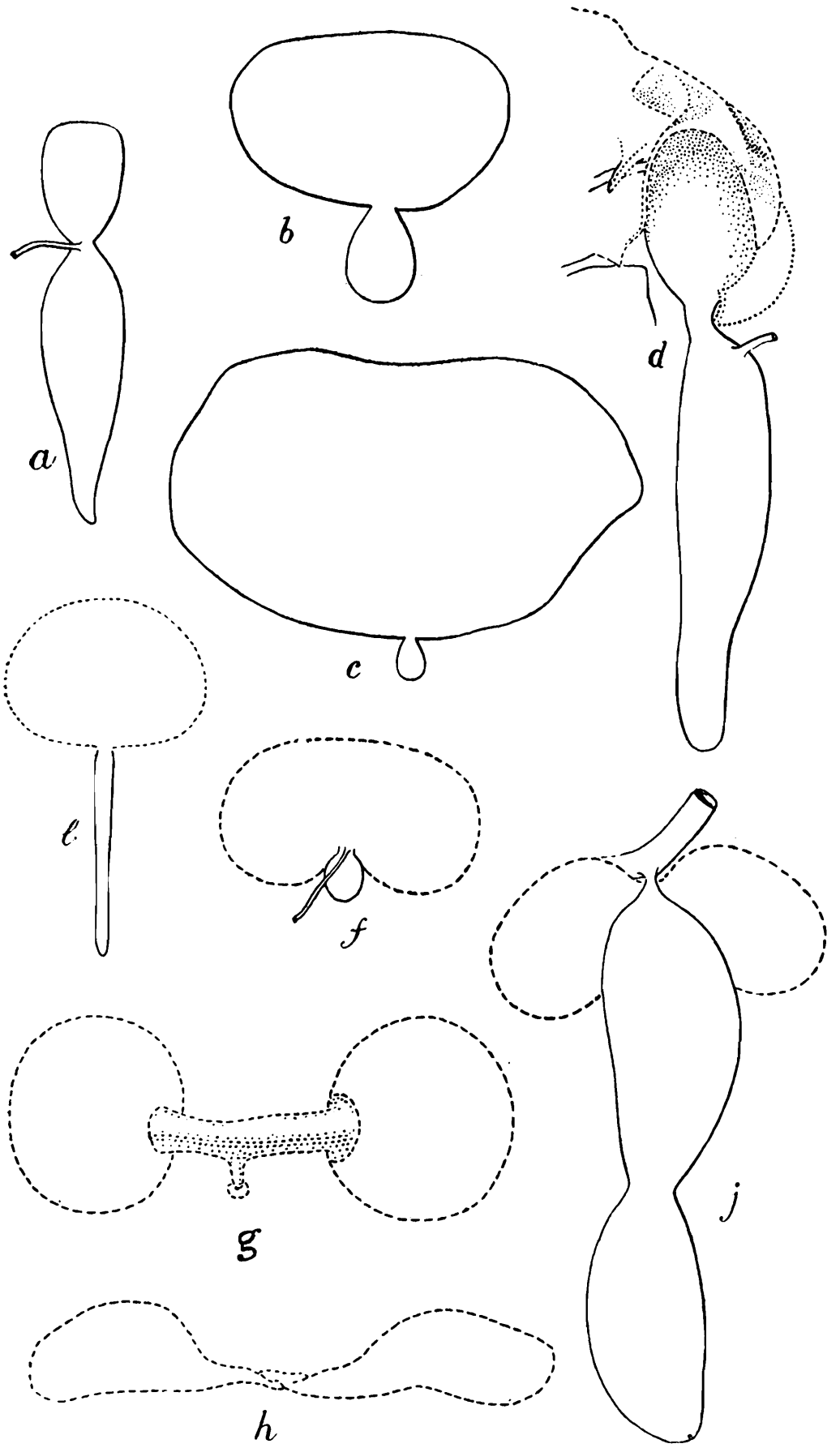
[1] Jordan and Starks, *Proc. U.S. Nat. Mus.* XXVIII, p. 201, fig. 7 (1905).
[2] Day, *Fish. India* II, p. 613, pl. cliii, fig. 11 (1878).
[3] Fowler, *Proc. Acad. Nat. Sci. Philadelphia*, p. 181 (1899, 1900).
[4] *Weber and Beaufort, Fishes Indo-Austral. Archipel.* III, p. 35, fig. 16 (1916).
[5] Vaillant, *Notes Leyden Mus.* XXIV, p. 134 (1902).
[6] Zugmayer, *Zool. Jahrb. Syst.* XXIX, p. 294 (1910).

I have myself examined specimens of the same species in our collection and agree with Zugmayer's statement. Both Kessler and Zugmayer believe that there is only one bladder in *Diplophysa* and that the anterior part is enclosed in bone while the posterior lies free in the abdominal cavity. Zugmayer found the two bladders to be quite distinct from each other but regarded them as parts of the same bladder. On examining the bladder in young specimens of a new species from Eastern Tibet (Rham-tso) I find that the two bladders are totally distinct from each other and that they are not the two parts of a single structure. The posterior bladder, that lies free in the abdominal cavity, is connected with the oesophagus by a short pneumatic duct given off from its anterior end. This duct is only distinct in young specimens and atrophies in the adult. In order to understand the true significance of the posterior bladder and its relation to the anterior, it is necessary to examine the various types of bladder commonly met with among the different genera of Cyprinoidea.

The swim-bladder of a typical Cyprinid fish such as *Labeo rohita* is large and lies free in the abdominal cavity. It is constricted in the middle to form an anterior and a posterior chamber (fig. 1*a*). The pneumatic duct from the oesophagus opens into the constricted region. In those genera that live in rapid running waters the bladder undergoes considerable degeneration; this consists firstly in the gradual reduction of the two chambers and the ultimate disappearance of the posterior, and secondly, in the thickening of their walls. In extreme cases the bladder becomes completely enclosed in a bony capsule derived from the transverse processes of the adjacent vertebrae.

In the genus *Psilorhynchus* the posterior chamber is greatly reduced and the anterior is covered by a thick fibrous coat (figs. 1*b*, 1*c*). In *Nemachilus vittatus* from the Kashmir Valley the anterior chamber is laterally flattened and covered by a bony capsule while the posterior chamber is small and thick walled (fig. 1*f*). The pneumatic duct still opens into the constricted region between the two chambers. In other species of this genus the anterior part is divided into two lateral chambers which are enclosed in a bony capsule and all remains of the posterior chamber are wanting. In *Adiposia rhadinaea* there is still a short bulb-like structure representing the posterior chamber (fig. 1*g*) otherwise it is very similar to that found in most species of *Nemachilus*. In extreme cases such as *Balitora brucei* the two lateral halves of the anterior chamber are much reduced and are somewhat separated from each other (fig. 1*h*).

Among the members of the genus *Diplophysa* the anterior bladder (fig. 1*j*), which is enclosed in a bony capsule, is in all probability similar to that found in the genus *Nemachilus* and, thus, it may represent the primary or the true original bladder of the fish. The posterior bladder, that lies free in the abdominal cavity, is a secondary structure and in its origin and position is



TEXT-FIG. 1.—Types of air-bladder found in Cyprinoid fishes.

a, *Labeo rohita*. *b*, *c*, *Psilorhynchus balitora*.
d, *Botia hymenophysa*. *e*, *Botia almorhae*.
f, *Nemachilus vittatus*. *g*, *Adiposia rhadinaea*.
h, *Balitora brucei*. *j*, *Diplophysa stewarti*.

The dotted line in the figure indicates that the portion thus outlined is enclosed in bone.

quite different from the normal Cyprinoid bladder. The following are the chief points of difference:—

(i) There is a short pneumatic duct from the anterior end of the bladder to the oesophagus, while in the normal Cyprinoid type the pneumatic duct is long and opens into the middle of the bladder in the constricted region.

(ii) The bladder may or may not be constricted in the middle.

(iii) The pneumatic duct is present only in young specimens, while it is lost in the adult.

In the genus *Botia*, the structure of the air-bladder differs considerably. Though in many respects of a typical Cyprinoid form, the anterior chamber is partially (fig. 1*d*) or wholly (fig. 1*e*) enclosed in a bony capsule formed by the transverse processes of the neighbouring vertebrae. On comparing drawings *d* and *j* in figure 1, it will be seen that Day was in error in suggesting that the bladder of *Diplophysa* would have to be similar in structure to that in *Botia*.

The reduction of the swim-bladder in fishes that live in rapid-running waters is in all probability due to the fact that they live on the bottom and do not require to make vertical movements. The enclosure of the bladder in a bony capsule presumably has some special biological significance, but of this nothing is yet known. Zugmayer believed that the free bladder in *Diplophysa* is to be explained by the assumption that the members of the genus have not yet acquired a true ground habit and that consequently the posterior half has not yet been affected. This, however, does not appear to be a correct interpretation of the fact as there are two distinct air-bladders in *Diplophysa*, the one enclosed in a bony capsule being possibly the original Cyprinoid bladder, while the other that lies free in the abdominal cavity is either a secondary acquisition or, as Dr. Annandale suggests to me, represents the modified posterior chamber of the normal Cyprinoid bladder. In the latter case the anterior chamber has become enclosed in bone, as in *Nemachilus vittatus*, and the posterior chamber was nipped off, retaining its connection with the oesophagus through the primary pneumatic duct. The members of the genus *Diplophysa* have in all probability come to live secondarily in the deep muddy waters of the lake-basins of Central Asia in which situation they require a hydrostatic organ for vertical movements; I believe that they have originated from forms like *Nemachilus* in which the air-bladder is reduced and enclosed in a bony capsule. When the primary air-bladder became enclosed in bone it probably could not again be modified for the performance of a hydrostatic function to suit the new environment. I thus believe that *Diplophysa* is a more specialized genus than *Nemachilus*, whereas Zugmayer regards it as more primitive. Of the species of *Diplophysa* at present known, all described by Kessler, the following have been recorded either from lakes or from deep muddy waters at great altitudes in Central Asia:—

Diplophysa strauchii,		Ili river flowing into Lake Balkash.
,,	*labiatus*,	Urdjar river flowing into Ala-kul.
,,	*intermedius*,	Lake Dalai-nor.
,,	*nasalis*,	,,
,,	*costata*,	,,
,,	*dalaicus*,	,,
,,	*kungessana*,	Kinges River.
,,	*papilloso-labiata*,	Juldus.
,,	*microphthalmus*,	Chami.

Of the nine species enumerated above the first two are from Eastern Turkestan, the next four from Lake Dalai-nor, which is situated in the lake basin of Mongolia, and the remaining three from the Tarim river-system which ultimately drains into lake Lob-nor. It is significant that all the Cobitid fishes known from Lake Dalai-nor belong to the genus *Diplophysa*. A new species of this genus described here was obtained by Capt. Kennedy and Capt. Stewart in a small stream flowing into Rham-tso, a lake of considerable dimensions at an altitude of 14,700 ft. in Eastern Tibet.

It will thus be seen that the genus is known from Eastern Turkestan and Mongolia on the one hand and from Rham-tso in Eastern Tibet on the other. This apparently discontinuous distribution may be accounted for by the fact that very little is at present known of the ichthyology of the intermediate region.

There is yet another possibility which may explain the distribution of this genus. It is possible that the genus is polyphyletic in origin, because the character of the bladder on which it is solely based, may have originated on more than one occasion in response to life in deep waters which necessitated some hydrostatic mechanism.

The genus *Diplophysa* is represented by two species in the collection of the Indian Museum, one of which is new to science.

Diplophysa papilloso-labiata Kessler.

1878. *Diplophysa papilloso-labiata*, Kessler, *Bull. Acad. St. Pétersbourg* XXV p. 299.
1878. *Diplophysa papilloso-labiata*, Kessler, *Mél. biol.* X, p. 257.
1888. *Nemachilus strauchii* var. *papilloso-labiatus*, Herzenstein, *Wiss. Res. Przewalski Central As. Reis., Zool.* III (2), p. 50, pl. vi, fig. 5.
1910. *Diplophysa* (*Nemachilus*) *strauchii papilloso-labiata*, Zugmayer, *Zool. Zahrb. Syst.* XXIX, p. 297.

This is the only species of the genus *Diplophysa* collected by Dr. Stoliczka. There are seven specimens in our collection and they are labelled as having come from Yarkand, probably from the Yarkand river which forms a part of the Tarim river-system. Of the seven specimens four are males and the rest females. The species exhibits a well-marked sexual dimorphism.

The free air-bladder is not constricted in the middle and lies almost in the middle of the abdominal cavity. In my dissections I have not been able to find any pneumatic duct.

The eggs of this species are very small and almost fill the whole of the abdominal cavity.

Diplophysa papilloso-labiata is known only from the Tarim river-system (Eastern Turkestan). The longest specimen in our collection is 105 mm. in length without including the length of the caudal fin.

Diplophysa stewarti, sp. nov.

(Text-figs. 2*c*, 2*d*.)

1908. *Nemachilus stoliczkae*, Lloyd (in part), *Rec. Ind. Mus.* II, p. 341.

1911. *Nemachilus stoliczkae*, Stewart (in part), *Rec. Ind. Mus.* VI, p. 70.

1920. *Nemachilus lhasae*, Annandale and Hora (in part), *Rec. Ind. Mus.* XVIII, p. 179.

This species is represented in our collection by several young and half-grown specimens. It closely resembles *Nemachilus lhasae* Regan with which Annandale and myself [1] confused it when dealing with the fish of Seistan. Both Lloyd and Stewart referred these specimens along with *Nemachilus lhasae* to *N stoliczkae*. *Diplophysa stewarti* is, however, readily distinguished by the presence of a second air-bladder and also by the nature of its skin, which is tuberculate all over.

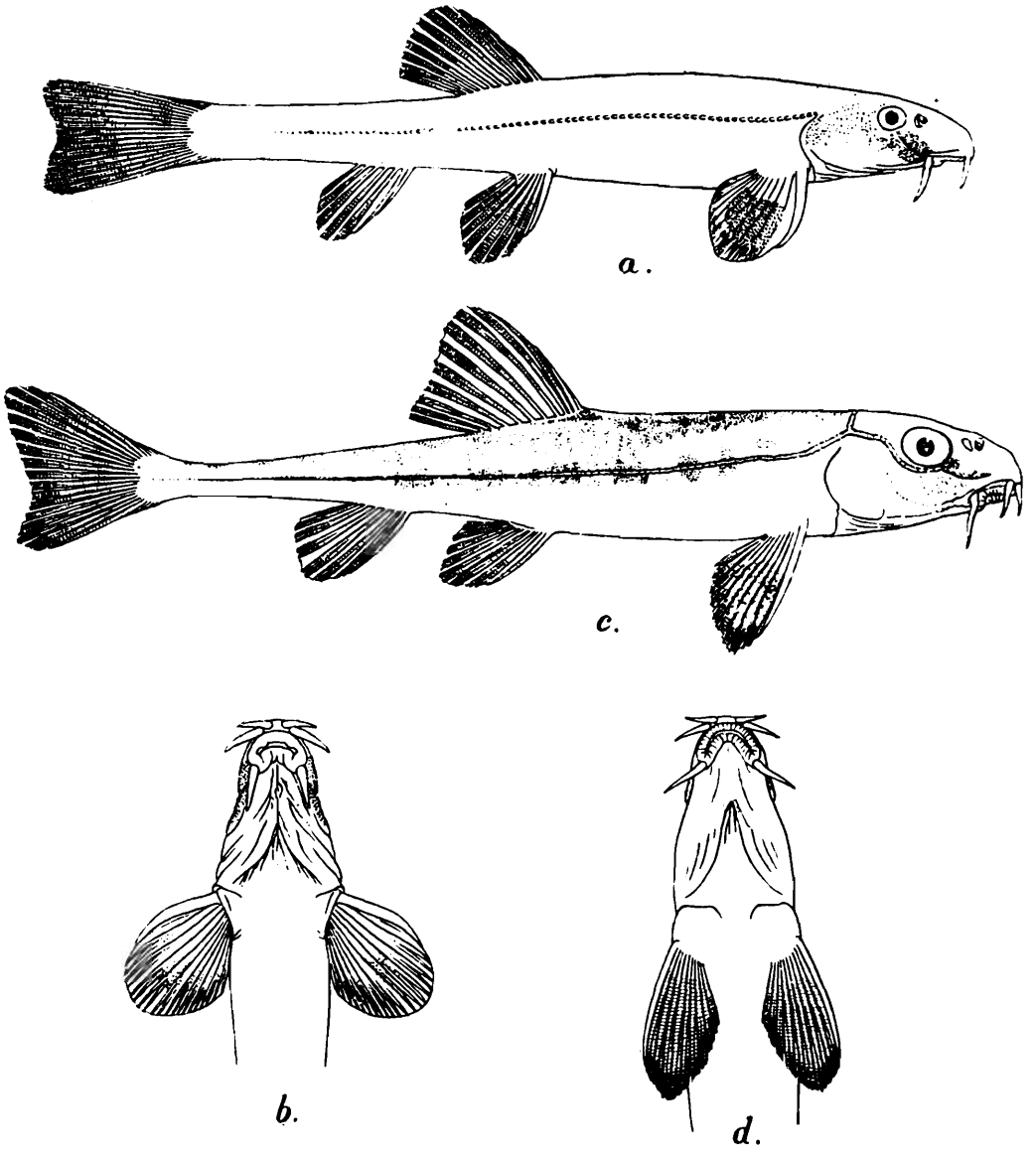
The dorsal profile is highest near the nape, in front of which it slopes considerably to the tip of the snout. The body is thickest anteriorly and gradually and regularly slopes to the base of the caudal fin. The head is round, narrow and pointed; its length is contained 4·2 times in the length of the fish without the caudal fin. The body is deepest at its commencement and the greatest depth of the body is contained 1·6 times in the length of the head. The eyes are placed in the middle of the head and are scarcely visible from below; the diameter is contained 3·4 to 3·7 times in the length of the head. There are six barbels, 4 rostral and 2 maxillary. The maxillary barbels are the longest; they are slightly longer than the diameter of the eye. The upper lip is fringed and the lower is interrupted in the middle and is strongly papillated. The lateral line is complete; anteriorly it is continued as a series of open pores below the eyes. There are a few open pores on the dorsal surface of the head near its posterior border extending downwards on each side to join the lateral line. The dorsal fin commences considerably in advance of the ventrals and its origin is equidistant from the tip of the snout and the base of the caudal fin. It is higher than the depth of the body immediately below it. The ventrals extend beyond the anal opening and almost reach the base of the anal fin. The caudal peduncle is long and narrow; its least height is contained 6·1 to 6·6 times in its length. The caudal fin is deeply concave with the upper lobe considerably longer than the lower.

---

[1] Annandale and Hora, *Rec. Ind. Mus.* XVIII, p. 179 (1920).

This species exhibits sexual dimorphism and the males can readily be distinguished by a tuberculate pad below the eye.

The secondary bladder is large and constricted in the middle. It differs from the normal Cyprinoid type in the fact that the pneumatic duct here opens at the anterior end instead of in the constricted region.



TEXT-FIG. 2.—Cobitid fishes from Eastern Tibet.

a. Lateral view of *Nemachilus tibetanus* Regan.
b. Under surface of head and chest of same.
c. Lateral view of *Diplophysa stewarti*, sp. nov.
d. Under surface of head and chest of same.

The colour in spirit is characteristic of the species. There are short black bars along the lateral line and on the back. The belly and under surface of the head and also the general colour of the body is pale olivaceous. The dorsal and the caudal fins are marked with black.

Type-specimen.—F. 2894/1, *Zoological Survey of India* (*Ind. Mus.*).

Locality :—The specimens were collected by Capt. R. S. Kennedy, I.M.S., and Capt. F H. Stewart, I.M.S.. in a small

stream flowing into Rham-tso (Eastern Tibet). There are two young specimens from Se-Chen in Tibet, which I also refer to this species.

Genus **Adiposia**, Annandale & Hora.

1920. *Adiposia*, Annandale and Hora, *Rec. Ind. Mus.* XVIII, p. 182.

The genus was recently proposed by Annandale and myself for two species of Cobitid fishes from Seistan with a long soft dorsal fin between the bases of the dorsal and the caudal fins. We also referred a species from Turkestan, *Adiposia longicauda* (Kessler),[1] to this new genus.

Genus **Nemachilus** v. Hass.

The thirteen species of the genus *Nemachilus* from Central Asia in the collection differ from the numerous forms known from the Indian Empire in their large size and almost subcylindrical form. None of them, moreover, possesses the vertical bands of pigment which characterize those from lower altitudes.

The following is an artificial key to the Central Asiatic species of *Nemachilus* in the collection of the Indian Museum :—

I. Ventrals terminating a considerable distance in front of anal opening.
  A. Eyes wholly in anterior half of head, dorsal commencing in advance of ventrals. ... ... *N. yarkandensis.*
  B. Eyes in middle of head; ventrals commencing in advance of dorsal ... ... *N. gracilis.*

II. Ventrals just reaching or extending beyond anal opening.
  A. Anterior origin of dorsal almost equidistant between tip of snout and base of caudal.
    1. Lateral line incomplete, ending shortly after its commencement ... ... *N. vittatus.*
    2. Lateral line complete or becoming somewhat obscure behind anal fin.
      a. Eye almost in middle of head.
        i. Pectorals as long as head ... ... *N. yasinensis* ♂.
        ii. Pectorals shorter than head.
          α. Least height of caudal peduncle almost equal to diameter of eye ... ... *N. lhasae.*
          β. Least height of caudal peduncle considerably greater than diameter of eye. ... ... *N. kashmirensis.*
      b. Snout longer than postorbital part of head ... *N. tenuis.*
  B. Anterior origin of dorsal not equidistant between tip of snout and base of caudal.
    1. Anterior origin of dorsal nearer tip of snout than base of caudal ... ... *N. ladacensis.*
    2. Anterior origin of dorsal nearer base of caudal than tip of snout.
      a. Eye in middle of head.
        i. Ventrals distinctly extending beyond anal opening.
          α. Least height of caudal peduncle 4 times in its length, lower lip almost continuous ... ... *N. stoliczkae.*
          β. Least height of caudal peduncle 5 times in its length, lower lip widely interrupted ... *N. tenuicauda.*
        ii. Ventrals just reaching anal opening ... ... *N. marmoratus.*

[1] Kessler "Pisces" in Fedtschenko's "*Reise in Turkestan*," p. 38, pl. vi, figs. 22, 23 (1874).

b. Eye not in middle of head.
  i. Snout shorter than postorbital part of head.
    a. Anal fin separated from caudal by a distance almost equal to its own length ... ... *N. microps.*
    β. Anal fin separated from caudal by a distance considerably less than its own length ... *N. yasinensis* ♀
  ii. Snout longer than postorbital part of head. ... *N. tibetanus.*

Nemachilus yarkandensis Day.

1876. *Nemachilus yarkandensis*, Day, *Proc. Zool. Soc. London*, p. 79.
1878. *Nemachilus yarkandensis*, Day, *Sci. Res. 2nd Yarkand Mission, Ichthyol.*, p. 14, pl. v, fig. 3.
1889. *Nemachilus yarkandensis*, Herzenstein (in part), *Wiss. Res. Przewalski Central As. Reis., Zool.* III (2), p. 74.
1910. *Nemachilus yarkandensis*, Zugmayer, *Zool. Jahrb. Syst.* XXIX, p. 295.

The Indian Museum possesses a large number of specimens of this species from Yarkand, Pas Robat, Yankihissar and Kashgar. Besides these there is one specimen about 132 mm. in length labelled as having come from Kashmir which I am convinced also belongs to this species. So far *N yarkandensis* has been recorded only from the Tarim River system and its extension into Kashmir is very doubtful and requires confirmation. My specimens correspond in every detail to the typical form. The various varieties described and figured by Herzenstein are not represented in our collection ; probably they are all far Eastern or Chinese forms.

Nemachilus tarimensis Kessler[1] has been considered to be synonymous with *N yarkandensis* by Herzenstein, who figures Kessler's original specimen of *N tarimensis* as *N yarkandensis* (*s. st.*). After a careful comparison I am lead to believe that the two species are different and that *N tarimensis* as figured by Herzenstein differs from *N yarkandensis* in the following points:—

N tarimensis.	*N yarkandensis.*
The commencement of the dorsal fin is almost equidistant from the tip of the snout and the base of the caudal fin.	The commencement of the dorsal fin is distinctly nearer to the base of the caudal fin than to the tip of the snout.
The eyes are large and are not situated entirely in the anterior half of the head.	The eyes are small and are situated in the anterior half of the head.

As regards the three varieties of this species, it is difficult to discuss their true relationships without examining Herzenstein's specimens. *N yarkandensis longibarbus* differs from the typical form in the commencement of the dorsal fin, which is situated in the middle of the body, the longer barbels and the curve of its dorsal profile. Probably it represents a new species. The other two varieties, *brevibarbus* and *macropterus* somewhat resemble our specimens.

---

[1] Kessler, *Bull. Acad. St. Petersbourg* XXV p. 300 (1878).

Nemachilus gracilis Day.

1876. *Nemachilus gracilis*, Day, *Proc. Zool. Soc. London*, p. 798.
1878. *Nemachilus gracilis*, Day, *Sci. Res. 2nd Yarkand Mission, Ichthyol.*, p. 16, pl. iv. fig. 5.
1878. *Nemachilus gracilis*, Day, *Fish. India* II, p. 621.
1889. *Nemachilus gracilis*, Day, *Faun. Brit. Ind. Fish.* I, p. 237.
1898. *Nemachilus stoliczkae*, Alcock, *Rep. Nat. Hist. Res. Pamir Bound. Comm.*, p. 38.

This species is readily distinguished by the nature of its lower lip which is widely interrupted in the middle and is thrown into a longitudinal fold on either side. I have examined Day's type-specimen "from Basgo, on the head waters of Indus."

I also refer to this species a specimen from Lukong River and several others from the affluents of the Yasin River near Darkot. The latter were collected by Col. Alcock. The waters of both these streams flow directly or indirectly into the Indus River. These specimens were previously recorded as *N. stoliczkae.*

Several young, half-grown and adult specimens have recently been collected in the Kashmir Valley. The specimens were obtained from a lake about four miles from Sonmarg. The species exhibits marked sexual dimorphism. The eggs are minute.

The adult individuals possess 6 to 7 broad black bands across the back. In young specimens there is a series of black dots along the lateral line and the dorsal surface is mottled with black and brown.

Nemachilus vittatus (Heckel).

1838. *Cobitis vittata*, Heckel, *Fische Kaschm.*, p. 80, pl. xii, figs. 3 and 4.
1844. *Cobitis vittata*, Heckel, in Hügel's *Kaschmir* IV p. 382, fig.

Günther [1] combined Heckel's two species of this genus from Kashmir and adopted for them the specific name *marmoratus.* Day [2] followed Günther and recognised only one form from the Kashmir lakes. Zugmayer [3] perhaps doubted Günther's identification and in recording *Nemachilus marmoratus* from "Wular Lake" gave Günther as the author of the species. On examining the old collection of the Indian Museum, I find that out of 17 specimens from the Kashmir lakes, 16 belong to *N vittatus* and one to another species. *N vittatus* can be readily recognised by the nature of its lateral line which ends shortly after its commencement.

I have not included references by Günther, Day and Zugmayer under the title of this species as it is impossible to be sure of the identity of the species they recorded. They do not make any

---

[1] Günther, *Cat. Brit. Mus. Fish.* VII, p. 356 (1868).
[2] Day, *Proc. Zool. Soc. London*, p. 798 (1876); *Fish. India* II, p. 620 (1878).
[3] Zugmayer, *Zool. Jahrb. Syst.* XXIX, p. 296 (1910).

mention of the lateral line in which, as explained above, the specific character is to be found.

Quite a number of specimens have recently been brought back from several places in the Kashmir Valley by the members of the Zoological Survey of India.

Nemachilus yasinensi Alcock.

1898. *Nemachilus yasinensis*, Alcock, *Rep. Nat. Hist. Res. Pamir Bound. Comm.*, p. 38, pl. ii, figs. 2, 2*a*.

This species has hitherto been known from a single male specimen procured by Col. Alcock in the Yasin River. The specimen is now preserved in our collection. A large number of specimens have recently been obtained from a small stream flowing into the Sind River, a tributary of the Jhelum River. Among these there are three female specimens which differ considerably from the males. The following are some of the chief points of difference :—

Male.	*Female.*
The dorsal fin commences midway between the tip of the snout and the base of the caudal fin.	The dorsal fin commences somewhat nearer to the base of the caudal than to the tip of the snout.
The snout is slightly longer than the postorbital part of the head.	The snout is shorter than the postorbital part of head.
The lateral line is continued to the base of the caudal fin.	The lateral line ends in front of the base of the ventral fins.
The caudal fin is forked.	The caudal fin is either rounded or truncate.

Besides these the female specimens possess short paired fins, small eyes and a deep caudal peduncle as compared with the males. The males possess well-marked secondary sexual characters such as are described towards the end of this paper.

The eggs are small.

The species is now known from the head-waters of the Indus and Jhelum Rivers.

Nemachilus lhasae Regan

(Text-figs. 3*a*–*c*.)

1905. *Nemachilus lhasae*, Regan, *Ann. Mag. Nat. Hist.* (7) XV p. 301.
1908. *Nemachilus stoliczkae*, Lloyd (in part), *Rec. Ind. Mus.*, II, p. 341.
1911. *Nemachilus stoliczkae*, Stewart (in part), *Rec. Ind. Mus.* VI, p. 70
1920. *Nemachilus lhasae*, Annandale and Hora (in part), *Rec. Ind. Mus.* XVIII, p. 179.

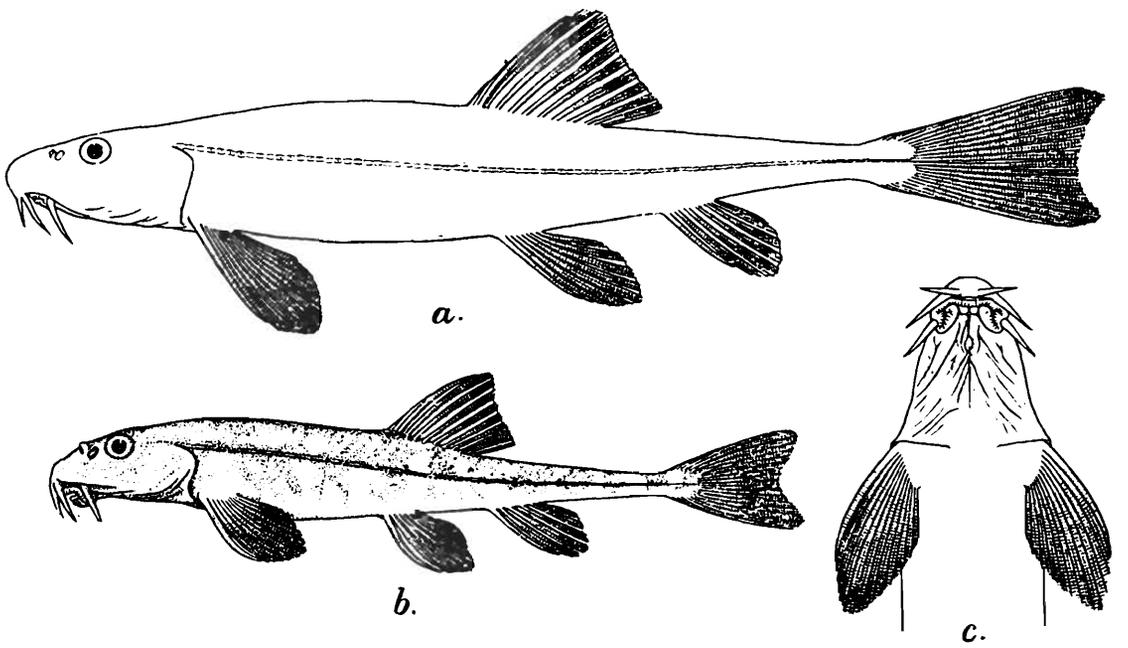
There are several young and half-grown specimens of this species before me, which have been referred to *Nemachilus stoliczkae* by Lloyd. They were collected by Capt. Kennedy and Capt. Stewart in Rhamtso, Nyang-chu, Langma-thang-chu, Phari and to the S.W of Dochen, all in Eastern Tibet. My specimens agree with Regan's description of the species. The young individuals, however, possess black blotches along the lateral line besides short cross-bars on the back.

The species exhibits well-marked sexual dimorphism.

Nemachilus kashmirensis, sp. nov.

1876. *Nemachilus rupicola*, Day, *Proc. Zool. Soc. London*, p. 799.
1878. *Nemachilus rupicola*, Day, *Sci. Res. 2nd Yarkand Mission-Ichthyol.*, p. 17.

To this new species I assign several specimens recently collected in Verinag, Kukarnag and in a small stream flowing from the Kashmir waterworks reservoir to the trout farm at Harwan. The species is characterized by an emarginate caudal fin and by the presence of broad, black bands across the back. Probably these characters led Day to refer some of his Kashmir examples to *Nemachilus rupicola* (McClell.)[1] I have recently visited the



TEXT-FIG. 3.—*Nemachilus lhasae*, Regan.

a. Lateral view of adult specimen.
b. Same of young specimen
c. Under surface of head and chest of adult specimen.

Simla Hills and have obtained some specimens of *N rupicola*, which differ from *N kashmirensis* in the following points:—

N kashmirensis.	*N rupicola.*
The ventrals extend beyond the anal opening and almost reach to the base of the anal fin.	The ventrals do not reach the anal opening and are separated from the anal fin by a considerable distance.
The pectorals are shorter than the head.	The pectorals are longer than the head.
There are no definite black bands on the sides of the body.	There are several black bands on the sides of the body.
The body is absolutely devoid of a scaly covering.	There are minute scales covering at least the posterior three-fourths of the body.

I propose to give a detailed description with figures of this species in my paper on the Indian species of the genus to be published in this journal at some future date.

[1] McClelland, *Journ. As. Soc. Bengal* VII, p. 948, pl. 55, fig. 3.

Nemachilus tenuis Day.

1876. *Nemachilus tenuis*, Day, *Proc. Zool. Soc. London*, p. 796.
1878. *Nemachilus tenuis*, Day, *Sci. Res. 2nd Yarkand Mission, Ichthyol.*, p. 15, pl. v, fig. 4.
1898. *Nemachilus tenuis*, Alcock, *Rep. Nat. Hist. Res. Pamir Bound. Comm.*, p. 14.
1906. *Nemachilus stenurus*, editorial note to Regan, *Journ. As. Soc. Bengal*, II,. p. 8.
1920. *Nemachilus stoliczkae*, Annandale and Hora (in part), *Rec. Ind. Mus.* XVIII, p. 178.

The specimens from which Day drew up his description of *Nemachilus tenuis*, came from two sources, from "Aktash, where the waters of the Ak-su Pass to the Oxus" and from "Yaukihissar where the rivers go to the Yarkand River." Day's specimens from the latter locality are not to be found in our collection, though there are several specimens of other species of the genus from the same place. The record, therefore, requires confirmation as I think it improbable that the species really extends to the Tarim river-system. Several specimens from the Great Pamir, whence the waters pass to the Oxus system, were correctly referred to this species by Alcock.

Quite recently Annandale and I (*op. cit.*) identified the Seistan examples as *N stoliczkae*, but I now believe that they represent *N. tenuis*. The Seistan specimens were collected in the Helmand River which may once have formed a part of the once-extensive Oxus system. Regan (*op. cit.*) referred these specimens to *N. stenurus* on account of their long and narrow caudal peduncle, but this is also a character of *N tenuis*. The two species differ in the following points:—

N stenurus Herz.	*N tenuis* Day.
The commencement of the dorsal fin is nearer to the tip of the snout than to the base of the caudal fin.	The commencement of dorsal fin is either equidistant from the base of the caudal fin and the tip of the snout or it is slightly nearer to the former than to the latter.
The lower lip is continuous and entire.	The lower lip is widely interrupted in the middle and is greatly pliated.

N stenurus was described from Dy-tschu, the sources of the Yang-tse-kiang River; while *N tenuis* is known from the Oxus system.

Vinciguerra[1] on the authority of Regan referred his examples from Skardu in the Indus System to *N. stenurus* for he writes, "nel riferire questi individui al *N. stenurus* sono confortato dall' avviso di Tate Regan, al quale li ho comunicati." The specimens require re-examination.

It is evident from the above discussion that the character of a long and narrow caudal peduncle is shared by a number of species. Such species are *N stenurus* from the sources of the Yang-tse-kiang, *N tenuis* from the Oxus system and *N lhasae*

[1] Vinciguera, *Ann. Mus. Stor. Nat. Genova* XLVII, p. 148 (1916).

from Eastern Tibet. The Skardu specimens probably represent another form in the same series.

Nemachilus ladacensis Günther.

1868. *Nemachilus ladacensis*, Günther, *Cat. Brit. Mus. Fish.* VII, p. 356.

The Indian Museum possesses only one specimen of this species six and a half inches in length, from Kashmir; it agrees closely with Günther's description but had been referred to *N stoliczkae* by Day. Day's[1] *N. ladacensis* differs from Günther's account in several respects and probably represents a different species. The descriptions differ in the following points:—

N. ladacensis Günther.	*N. ladacensis* Day.
"The origin of the dorsal fin is nearer to end of snout than to the root of the caudal."	"Dorsal commences midway between the front edge of the eye and the base of the caudal fin."
"The free portion of tail is very low, its depth being nearly one fourth of its length."	"Free portion of the tail twice as high as long at its base."
The caudal fin is rounded?	The caudal fin is emarginate.

The proportions are also different in the two species.

Unfortunately the specimen from which Day drew up his description and which he "deposited in the Indian Museum" is not now to be found.

Day's specimen was said to have been collected by von Schlagintweit at Gnari Khorsum, Tibet. *N ladacensis* is known from Ladak and Kashmir.

Nemachilus stoliczkae (Steind.).

1866. *Cobitis stoliczkae*, Steindachner, *Verh. Zool-bot. Ges. Wien*, p. 793, pl. xiv, fig. 2.

1868. *Nemachilus stoliczkae*, Günther, *Cat. Brit. Mus. Fish.* VII, p. 360.

A very wide interpretation has been given to this species by Day,[2] Herzenstein,[3] Günther,[4] and several other ichthyologists. I have examined a large number of specimens in our collection from Lukong stream, Chagra, Yarkand, Sirikol and Aktash which were referred to this species by Day but find that several distinct forms are represented among them. There are only six specimens which I can definitely refer to this species, one from Rupshu, the type-locality, three from Lukong Stream, one from Chagra and one from Kashmir. The waters from these places pass to the Indus River.

---

[1] Day, *Proc. Zool. Soc. London*, p. 797 (1876); *Sci. Res. 2nd Yarkand Mission, Ichthyol.*, p. 15, pl. iv, fig. 4.

[2] Day, *Proc. Zool Soc. London*, p. 795 (1876); *Sci. Res 2nd Yarkand Mission, Ichthyol.*, p. 14, pl. v, fig. 2 (1878).

[3] Herzenstein, *Wiss. Res. Przewalski Central As. Reis., Zool.* III (2), p. 14 (1888).

[4] Günther, in Pratt's "*Snows of Tibet*" p. 249 (1892).

Herzenstein (*op. cit.*) has recognised several varieties of this species, most of which so far as I can judge from the figures represent different species. My specimens agree with the typical form, of which I have examined one specimen from Rupshu.

Vinciguerra[1] has recorded the species from Skardu, but it appears from his description that he has grouped several distinct forms under one name. In identifying his specimens as *N stoliczkae* he has followed Day and Herzenstein for he observes that, "questa determinazione é basata non tanto sulla descrizione e figura originale, quanto su quelle di Day, di Günther e specialmente di Herzenstein."

Lloyd[2] referred some specimens from Eastern Tibet to this species. I have been able to recognize at least three different forms among the material he examined, two of them belonging to the genus *Nemachilus*, viz. *N. lhasae* Regan and *N tibetanus* Regan,[3] while the third belongs to the genus *Diplophysa* and is described here as new.

Day[4] in his later works regarded *Nemachilus griffithii*, Günther,[5] as synonymous with this species. I have not examined any specimen of Günther's species, but it appears from the description that the two are different. In *N griffithii* "the origin of the dorsal fin is midway between the root of the caudal and the end of the snout," while in *N stoliczkae* "the origin of the dorsal fin is conspicuously nearer to the root of the caudal than to the end of the snout."

Nemachilus tenuicauda (Steind.).

1866. *Cobitis tenuicauda*, Steindachner, *Verh. Zool.-bot. Ges. Wien* XVI, p. 792, pl. 17, fig. 3.
1868. *Nemachilus tenuicauda*, Günther, *Cat. Brit. Mus. Fish.* VII, p. 357.

This species closely resembles *N stoliczkae*, from which it is distinguished by its elongate and narrow caudal peduncle and by its colouration.

Nemachilus tenuicauda is represented in our collection by two specimens from Leh.

Nemachilus marmoratus (Heckel).

1838. *Cobitis marmorata*, Heckel, *Fish. Kaschm.*, p. 76, pl. xii, figs. 1 and 2.
1844. *Cobitis marmorata*, Heckel, in Hügel's *Kaschmir* IV p. 380, fig.

This is apparently a rare species and is represented in our collection by a few specimens recently obtained in Kashmir. The specimens were obtained from Kukarnag Spring and from ponds on the road between Martand and Ichabal.

---

[1] Vinciguerra, *Ann. Mus. Stor. Nat. Genova* XLVII, p. 146 (1916).
[2] Lloyd, *Rec. Ind. Mus.* II, p. 341 (1908).
[3] Regan, *Ann. Mag. Nat. Hist.* (7) XV pp. 187 and 301 (1905)
[4] Day, *Fish. India* II, p. 620 (1878).
[5] Günther, *Cat. Brit. Mus. Fish.* VII, p. 360 (1868).

I am unable to say whether Zugmayer's (*op. cit.*) specimens represent this species or *N vittatus*, but the latter is undoubtedly more common in the Kashmir lakes.

For the reasons already given under *N vittatus* I have not included references by Günther and Day under the title of this species.

Nemachilus microps (Steind.).

1866. *Cobitis microps*, Steindachner, *Verh. Zool.-bot. Ges. Wien* XVI, p. 794, pl. 13, fig. 3.
1868. *Nemachilus microps*, Günther, *Cat. Brit. Mus. Fish.* VII, p. 357.

This species is readily distinguished by its small eyes. We have two specimens in our collection from Mecma [1] (Yarkand Mission, Dr. Stoliczka's collection) which agree with Steindachner's description of the species. These specimens had previously been referred to *Nemachilus stoliczkae*. The male possesses well-marked secondary sexual characters below the eyes.

The species was originally described from Leh and in all probability the waters from Mecma pass to the Indus River.

Nemachilus tibetanus Regan.

(Text-figs. 2*a*, 2*b*.)

1905. *Nemachilus tibetanus*, Regan, *Ann. Mag. Nat. Hist.* (7) XV, p. 187.
1908. *Nemachilus stoliczkae*, Lloyd (in part), *Rec. Ind. Mus.* II, p. 341.
1911. *Nemachilus stoliczkae*, Stewart (in part), *Rec. Ind. Mus.* VI, p. 70.

The specimens before me of this species were collected by Capt. Kennedy in Nyang-chu at Kangmar and by Capt. Stewart in Gyang-tse. These had been referred to *Nemachilus stoliczkae* by Lloyd and Stewart. The species differs from *N lhasae*, which is known from the adjacent region, by the greater depth of its caudal peduncle, by the position of the dorsal fin, whose commencement is situated nearer to the root of the caudal than to the tip of the snout, and by the position of the eye, which is nearer to the tip of the snout than to the posterior margin of the head.

Nemachilus tibetanus exhibits a well-marked sexual dimorphism.

Nemachilus sp.

There are several specimens in our collection from Sirikol, which have been referred to *Nemachilus stoliczkae* by Day with the following remark, "in specimens from Sirikol the snout is rather more pointed." I am unable to refer these specimens to any of the known species of the genus, but on account of their bad state of preservation I do not propose to describe them as a new species.

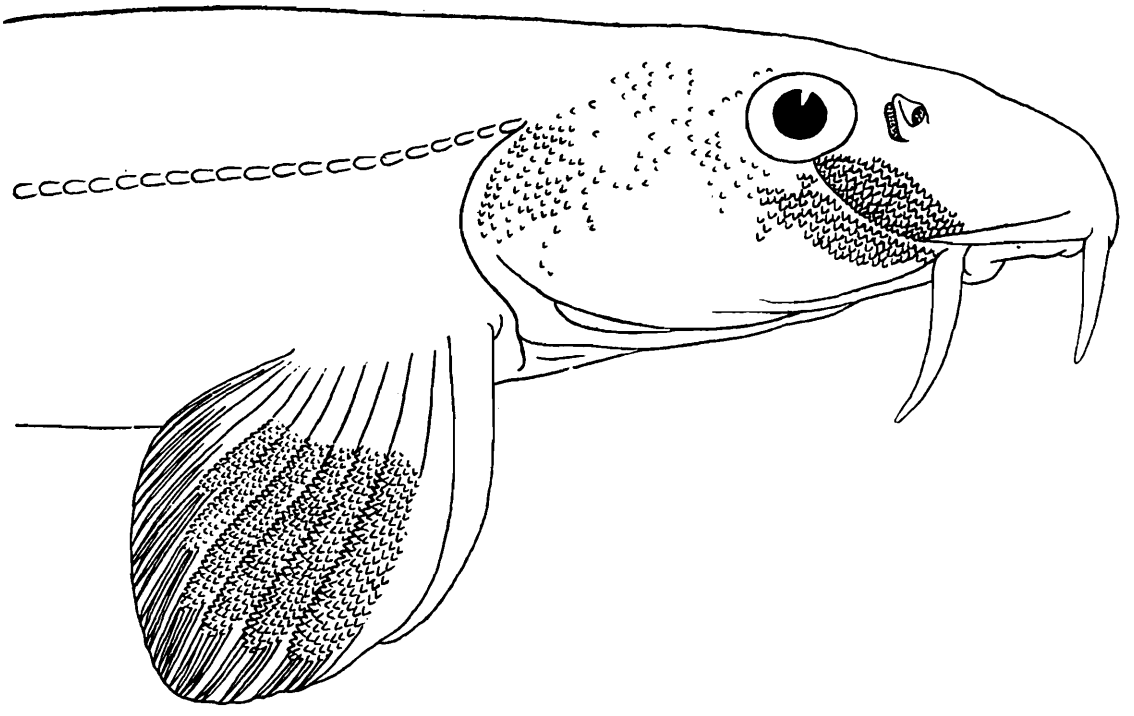
---

[1] The Yarkand Mission made collections in several places outside Yarkand. I have not been able to determine the exact locality of Mecma, but I suppose waters from this place flow into the Indus river-system.

Among the specimens from this locality two forms are represented, one in which the caudal peduncle is very low and the commencement of the dorsal fin is situated at an equal distance from the tip of the snout and the base of the caudal fin; while in the other the caudal peduncle is fairly deep and the origin of the dorsal fin is distinctly nearer to the base of the caudal than to the tip of the snout. Most of the females, which are about 54 mm. in length, are full of eggs. The snout is long and pointed and the eyes are situated in the middle of the head.

NOTE ON THE SECONDARY SEXUAL CHARACTERS OF CERTAIN SPECIES OF COBITID FISHES FROM HIGH ALTITUDES IN CENTRAL ASIA.

In the Indian species of the genus *Nemachilus* which exhibit sexual dimorphism the male is provided with "a slit-like



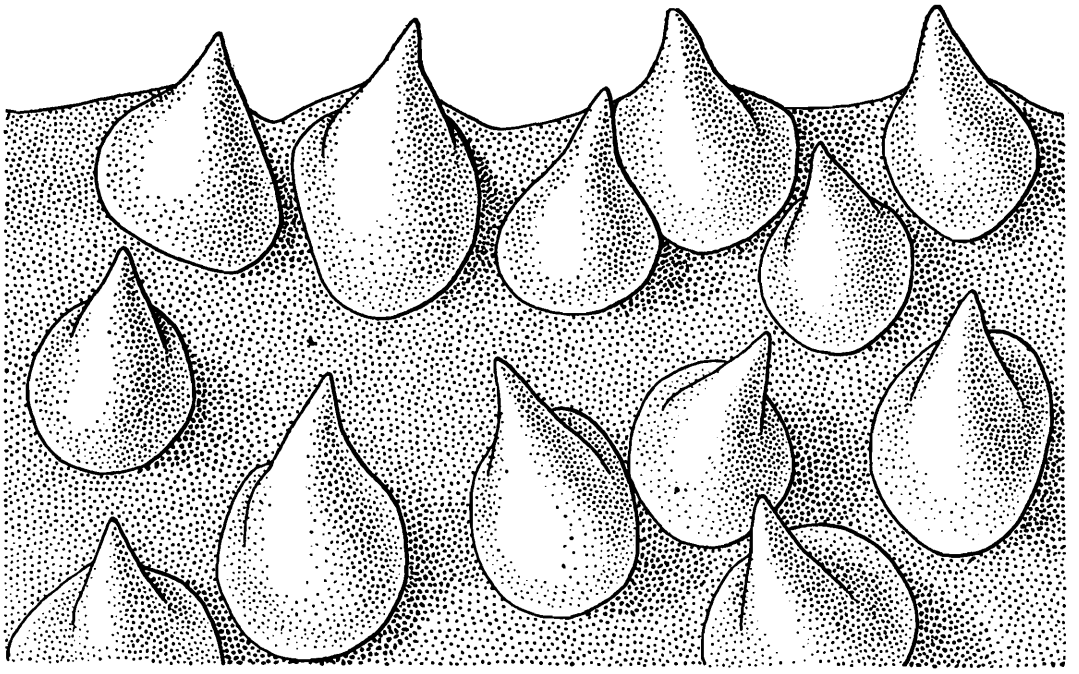
TEXT-FIG. 4.—Lateral view of head and upper surface of pectoral fin in a male specimen of *Nemachilus tibetanus* Regan, showing secondary sexual characters.

deep groove in front of the eye which bends round a small knob-like rounded flap of skin protruding below the anterior one-third of the orbit, the ridge above the groove appearing slightly swollen and cushion-like." The pectoral fins are also modified where "there is a kind of padding and thickening on the upper surface" and "on the padding, minute hooked denticular outgrowths are noticed." These secondary sexual characters were described by Chaudhuri in *Nemachilus mackenziei*[1] and *N manipurensis*[2] and

[1] Chaudhuri, *Rec. Ind. Mus.* V, p. 183.

[2] Chaudhuri, *Rec. Ind. Mus.* VII, p. 443, pl. xl, figs. 4, 4*a*, 4*b*; pl. xli, figs. 1, 1*a*, 1*b*.

I have noticed similar modifications in mature males of several other Indian species of the genus. In the Central Asiatic forms, however, the secondary characters of the male are more marked and somewhat complicated. Of the thirteen species of the genus *Nemachilus* referred to in this paper, seven show marked sexual dimorphism. The male in these is usually provided with a raised tuberculate area below the nares, separated ventrally by a groove from the adjacent parts of the skin. The area is almost rectangular, commencing at the corner of the lips and extending posteriorly below the anterior third of the orbit. In certain species such as *N. tenuis*, *N yasinensis* and *N tibetanus* (fig. 4), there is another tuberculate area immediately behind the first one. Sometimes the tubercles are irregularly scattered on the operculum and the sides of the head behind the eyes. In all species that exhibit



TEXT-FIG. 5.—Tubercles covering secondary sexual pads of male of *N. tibetanus* (highly magnified).

sexual dimorphism, the pectoral fin-rays are provided with thickened tuberculate pads on their dorsal aspect. These tubercles on the fin-rays are not to be confused with encysted glochidia, which are sometimes found in this position, though they resemble them closely. A few scattered tubercles are sometimes found on the under surface of the pectoral fin-rays.

In both the species of the genus *Diplophysa* in our collection, the male is modified on exactly the same lines as has already been described for the genus *Nemachilus*.

The structure of the tuberculate areas is somewhat interesting. Each of the tubercles is provided with a short, stout spine-like outgrowth (fig. 5) which is sharp and slightly curved towards the end. The spine rests on a broad cushion-like rounded base.

Recently I have collected an interesting specimen of *Nemachilus* from the Simla Hills. It possesses a groove and a small

knob-like rounded flap of skin below the eye, but on dissection was found to be full of eggs. There is no padding on the dorsal aspect of the pectoral fin-rays and even the sexual character below the eye is not so well marked. I have examined a large number of specimens of the species to which I think this example probably belongs, *N. rupicola* (McClelland), and have not been able to find any other specimen with secondary sexual characters.

A NOTE ON BEES OF THE GENERA *XYLOCOPA* AND *BOMBUS* IN THE INDIAN MUSEUM.

By CEDRIC DOVER, *F.E.S.*

The accumulation of a large amount of unnamed carpenter- and bumble-bees in the collection of the Zoological Survey of India has led me to attempt their identification; and, as, though no novelties were among them, my results are not quite without interest, I have drawn up the following short note in the hope that it will prove useful.

Subfamily *XYLOCOPINAE*.[1]

Xylocopa tenuiscapa Westw.

1921. *Xylocopa tenuiscapa*, Dover, *Rec. Ind. Mus.* XXII, p. 389.

In the paper quoted I have given references to works which give characters by which the female of *X. latipes* and *X. tenuiscapa* may be readily separated, and I have also quoted Maidl, who regards Sichel's *albofasciata* as the female of this species. "In Bingham's description of the male for tibiae read basitarsi" (*Cockerell*).

The Indian Museum possesses a specimen from Tenasserim which is probably a *latipes* ♀ but differs from it in being much larger (about 37 mm.) and there are two deep dents on either side of the disc of the mesonotum, which is smooth and brightly polished.

Xylocopa acutipennis Smith.

The Indian Museum has examples from the following localities unnoticed by Bingham: Darjiling District, above Tura in the Garo Hills of Assam, 3500 ft., and the Dawna Hills in Lower Burma 2000–3000 ft.

Xylocopa attenuata Perez.

1852. *Xylocopa pictifrons*. Smith, *Trans. Ent. Soc.* (2) XI, p. 42, ♀ *nec* ♂
1897. *Xylocopa pictifrons*, Bingham, *Faun. Brit. Ind. Hym.* I, p. 538, ♂
1901. *Xylocopa attenuata*, Perez, *Act. Soc. Linn. Bordeaux* LXXV (6) VI, p. 46, ♀
1912. *Xylocopa attenuata*, Maidl, *Ann. Nat. Hofmus. Wien* XXVI, p. 287.
1921. *Xylocopa attenuata*, Dover, *Journ. Bomb. Nat. Hist. Soc.* XXVII, p. 961,

The species is found sparingly in the Indian plains, and commonly in Sikkim and Kumaon. It is found also in China,

[1] I have thought it best in this note not to recognise the genus *Mesotrichia*.

Java, Formosa and the Malay Peninsula. Some confusion has existed as to the sexes of the species described by Smith and Bingham as *pictifrons*, but this has been admirably cleared up by Maidl in his paper. He regards the male described by Smith as typical *pictifrons*, while Bingham's male and Smith's female are a separate species for which he has adopted the name *attenuata* of Perez.

Xylocopa auripennis Lepel.

In addition to the localities noticed by Bingham, the Indian Museum also possesses specimens from the Darjiling District, the Naga Hills and Sibsagar in Assam, South India and Nepal. The species is supposed to be mimicked by a Sphingid moth (*Sataspes hauxwelli*), which according to De Niceville (*Journ. Bomb. Nat. Hist. Soc.* XIII, p. 174) was "a beautiful mimic of the very common large blue carpenter-bee *Xylocopa auripennis*, Lepeletier." The wings of the moth are a deep indigo-blue with bronze markings, which scarcely resembles the wings of the bee, and in the cabinet the whole insect seems entirely different.

De Niceville does not say that the bee and the moth were taken together, and in the absence of definite field-observations, the moth has little claims to being a mimic of the *Xylocopa*.

Xylocopa dissimilis Lepel.

The Museum has specimens from Bangalore, Bandra in the Bombay Presidency, Mong-Wan in Yunnan (W China) and Southern China.

Xylocopa fenestrata Fabr

? *Xylocopa bombayensis*, Cam. ? *M. S.*
1921. *Xylocopa fenestrata*, Dover, *Rec. Ind. Mus.* XXII, p. 390.

In the paper cited, I have noticed what appears to be an aberration of *X. fenestrata* from Barkuda Island in the Chilka Lake, with a comparatively large, and a small, almost reniform, hyaline marking on each of the hindwings. The Indian Museum possesses another specimen from Hamirpur Road in the United Provinces (*Caunter*, X'11), which has the lower halves of the wings semi-hyaline. The fact that Kling described an example with semi-lunate, hyaline markings on the hindwings under the name *lunata*, makes me now think that aberrations of this species, with hyaline markings of some sort on the wings are perhaps not uncommon. It might be of interest to note here that I remember to have seen a specimen of the closely allied African *X. carinata* with an irregular hyaline patch on the right forewing. Can it be that these markings are caused by injuries sustained in the early stages? *X. fenestrata* is a common Indian species, extending as far Celebes on the south-east and probably into Australia, and Madagascar on the south-west. It does not penetrate into South Africa, but is replaced there by

X. carinata. Meade-Waldo has shown [1] that Cameron's *X. bombayensis* is a synonym of this species.

Xylocopa amethystina Fabr.

Bengal, Chota Nagpur, Bihar and Sind are not recorded by Bingham. This is an apparently widely distributed species in India.

Xlyocopa bryorum Fabr.

The Museum has specimens from Assam and the Andamans.

Xylocopa collaris Lepel.

This species is found in most parts of India, Burma and Ceylon and is known from Borneo, Sumatra, Java, the Philippines, Celebes and Malacca and from the Palaearctic Region.

Xylocopa tranquebarica Fabr.

1804. *Bombus tranquebaricus*, Fabr., *Syst. Piez.*, p. 343.
1917. *Xylocopa tranquebarica*, Cockerell, *Philipp. Journ. Sci.* XII, p. 346.
1921. *Xylocopa rufescens*, Dover, *Rec. Ind. Mus.* XXII, p. 390.

Found in Sikkim, Bengal, South India, Burma, Andamans, Java, Sumatra, Borneo and the Philippines. There are three examples in the Indian Museum under the name *ferruginea* which I think really belong to this species. Prof. Cockerell has shown that the more generally used name *rufescens* will have to be sunk in favour of *tranquebarica*. He has also noted its crepuscular habits.

Xylocopa caerulea Fabr.

This beautiful species has been found in Sikkim, Burma, Ceylon, Annam, Sumatra, Borneo, Java and New Caledonia.

Xylocopa flavonigrescens Smith.

1918. *Xylocopa flavonigrescens*, Cockerell, *Entomologist*, LI, p. 104.

The Zoological Survey possesses examples from Sikkim, Sylhet, Tenasserim, Ton-Kin and Malacca. Meade-Waldo, basing his opinion on the male, thought Cameron's *malayana* (*Proc. Zool. Soc. Lond.* 1901, p. 32) to be the same as this species, but Prof. Cockerell notes that a female from the island of Penang is the same as *X. malayana*.

Xylocopa nitidiventris, X. dubiosa and X. convexa Smith.

1878. Smith, *Scient. Res. 2nd. Yark. Miss.* (*Hym.*) pp. 7 and 8.

The types of these species, described from the neighbourhood of Yangihissar in Yarkand, are in the collection of the Indian

[1] *Ann. Mag. Nat. Hist.* XIV, p. 404, 1914.

Museum. The U.S. National Museum has specimens of *X nitidiventris* from Kukier, Eastern Turkestan.

Subfamily *BOMBINAE*.[1]

Bombus montivagus Smith.

The Indian Museum has examples from Upper Tenasserim and Take-pum Mt. on the Chinese Frontier in N E. Burma.

A form has also been taken in Onari in British Garwhal, 11,000 ft., which has the colour of the pubescence on the apical three segments of the abdomen almost snow-white and not fulvous red.

Bombus lapidarius var. tunicatus Smith.

1897. *Bombus tunicatus*, Bingham, *Faun. Brit. Ind. Hym.* I, p. 549.
1910. *Bombus tunicatus*, Cockerell, *Ann. Mag. Nat. Hist.* V, p. 417.
1916. *Bombus lapidarius* var. *tunicatus*, Meade-Waldo, *Ann. Mag. Nat. Hist.* XVII, p. 467.

Following Meade-Waldo I consider *tunicatus* and Cockerell's *gilgitensis* to be varieties of the European *B. lapidarius* Linn. The Museum possesses specimens of the former variety from Garwhal, Simla Hills, Mussoorie, Nepal, and two examples from Calcutta. In *Nature* for May 19th, 1921, I recorded the capture of the two Calcutta examples and mentioned having seen what was probably a species of *Bombus* at the base of the Eastern Himalayas, as "bumble bees" are supposed never to descend below 3,000 ft. Burkill (*Journ. As. Soc. Beng.* (*n. s.*) II, p. 521, 1906) found *B. haemorrhoidalis* common in the N W Himalayas at 1,600 ft., but the capture of *Bombus* actually in the plains is astonishing, and it is probable that such an incident may never occur again, though I originally mentioned that these bees probably occur, very rarely, in the plains. There is an old record of *B. orientalis* in Calcutta which I think must be authentic, but as to how these strictly hill-species have been found here I can offer no explanation other than that these species of *Bombus* probably nest in the ground and have been conveyed here through the agency of man.

A fly, *Criorhina imitator* of the family Syrphidae, closely resembles this species and the case appears to be one of real mimicry. Brunetti in his original description (*Rec. Ind. Mus.* XI, p. 237, 1915) stated that it was a mimic of the bee *Bombus trifasciatus* (as understood by Bingham), but I think it will be admitted that it resembles *tunicatus* more closely in the light pubescence on the anterior parts of the thorax, on the scutellum, on the basal abdominal segments, and in the colour of its wings and legs. The pubescence on the apical abdominal segments is also reddish, but unfortunately, it is not quite so dense as in the bee it resembles. Hingston in *A Naturalist in Himalaya* (Witherby: 1920, p. 184) notices the resemblance of *Bombylius* to *Bombus* and of a species

[1] As the use of the term *Bremus* for *Bombus* is dependent on the validity of the "Erlangen" list, and this is still a debatable point I have preferred to use the more generally known name.

of *Bombylius* to *B. lapidarius* var. *tunicatus*. I have never noticed this myself and judging from his description I think it just probable that his *Bombylius* is really a *Criorhina*.

Bombus eximius Smith.

The Darjiling District, Khasi Hills, Shillong, and Mong-wan in W China may be added to the localities given by Bingham.

Bombus flavescens Smith.

The Darjiling District, Nepal and Kumaon may be added to the localities given by Bingham.

Bombus funerarius Smith.

There are specimens in the Indian Museum from the Western Himalayas. Col. Bingham remarks that individuals with the pubescence on the apical three segments bright orange-red instead of greyish have only been found in Sikkim, but I have seen an example from the W Himalayas.

Bombus alienus Smith.

1897. *Bombus? vallestris*, Bingham, *Faun. Brit. Ind. Hym.* I, p. 553.
1916. *Bombus alienus*, Meade-Waldo, *Ann. Mag. Nat. Hist.* XVII, p. 467.

This species (omitted from the "Fauna") was taken in October, 1903, by Mr. R. E. Turner in Shillong. *B. vallestris* agrees fairly well with the description of *alienus*, but as Smith's type of the latter species is not available in Calcutta, and his type and? cotypes of *vallestris* in the Indian Museum are almost unrecognisable, I can offer no definite opinion. Meade-Waldo says that it is probable that *vallestris* is synonymous with *alienus*.

Bombus Bhaemorrhoidalis Smith.

The Museum possesses specimens from several localities in the Eastern and Western Himalayas.

Bombus orientalis Smith.

To Mr. Paiva's list of the specimens in the Indian Museum (*Rec. Ind. Mus.* VIII, p. 80, 1912) I may add Yokohama and? Calcutta.

Bombus longiceps Smith.

1910. *Bombus longiceps*, Cockerell, *Ann. Mag. Nat. Hist.* V, p. 505.
1916. *Bombus longiceps*, Meade-Waldo, *Ann. Mag. Nat. Hist.* XVII, p. 468.

The Museum possesses a worn specimen which is, I think, the type of this species from Leh in Ladak. It has also been taken by Captain Hingston in Kashmir. I agree with the authors cited that *longiceps* cannot be a variety of *hortorum*.

A REVISION OF THE BURMESE UNIONIDAE.

By B. PRASHAD, *D.Sc., Assistant Superintendent, Zoological Survey of India.*

(Plate II.)

In spite of various eminent malacologists having paid considerable attention to the Burmese Unionidae from early times, our knowledge of these forms was hitherto in a very confused state. Of the earlier authors, references to whose works are embodied in this paper, Benson Gould, Blanford, Theobald and Nevill deserve special mention, all of them with the exception of Blanford, who in 1866[1] tried to summarize all that was known to date, described numbers of species at various times from collections made in various parts of Burma. The most comprehensive collection of Burmese Unionidae was made by Leonardo Fea in the years 1885–1887 for the Genoa Museum and a detailed paper[2] on these collections was published by Tapparone-Canefri. In the part dealing with the Unionidae thirteen new species and varieties were described and notes were included on twenty-two of the already known species and varieties. A small part of the collection, however, which was probably received after the report was written, was not included in it. Apparently Tapparone-Canefri had to base his work to a very great extent, if not entirely, on the incomplete published descriptions of the earlier authors and on the illustrations in the *Conchologia Indica* of Hanley and Theobald, for most of his identifications are incorrect, this would not have happened if he had had authentically named material for comparison. He referred all his new species to the composite genus *Unio*, and gave elaborate descriptions but did not publish any figures, his work, therefore, has been a great stumbling block in the way of all later work. Simpson[3] tried to remedy this by an examination of the named duplicates of some of these species which the United States National Museum had received by exchange, but did not succeed in many cases owing probably to the small amount of material available. Haas[4] also has tried to deal with some of the species, but the results of his work on the predominent Indo-Burmese genera have not been published as yet.

---

[1] Blanford, *Journ. As. Soc. Bengal*, XXXV, pt. i, pp. 134–155 (1866).

[2] Tapparone-Canefri, *Ann. Mus. Civ. Stor. Nat. Genova*, XXVII, pp. 339–355 (1889).

[3] Simpson, *Desc. Cat. Naiades* (Detroit, 1914).

[4] Haas, in Martini and Chemn. *Conch.-Cab. Unio* (in the course of publication).

The author whose work is most open to criticism, however, is Preston, who in two of his works [1] dealt with the Indo-Burmese Unionidae. He had for the basis of these works the entire collection belonging to the Indian Museum, which besides being very rich in specimens of various species, is specially valuable because of the many type-specimens or of specimens from type-localities, in many cases named or seen by the authors of the species. Another feature of the collection is the existence of labels in the hand-writings of the various specialists, of whom Blanford, Theobald and Nevill deserve special mention. Nevill in particular had rearranged the whole collection and given provisional names to species and varieties which he considered as new. Preston without any further work accepted Nevill's identifications and under his manuscript names described these species or varieties as new. He did not even attempt to sort out the specimens of different species where Nevill had left large series mixed up, but labelled all the specimens in one lot according to Nevill's label which he found with it. In attempting to revise Preston's work I found that it was quite impossible adequately to work out the Burmese forms without an examination of Tapparone-Canefri's type-specimens, and I applied to Dr. R Gestro of the Genoa Museum. He was not only kind enough sent me the whole of Fea's Burmese collection on loan, but also generously presented to the Indian Museum specimens of a number of the species, duplicates of which were still available. This kindness on Dr. Gestro's part, for which I am greatly indebted to him, has made it possible for me to assign T.-Canefri's species to their proper generic and specific position. I have besides carefully gone through the large collections of Indo-Burmese Unionidae already in the Indian Museum.

The results of the work may be briefly summarized here. Most of the forms described by T.-Canefri and Preston were found to be referrable to already known species and I have not come across any new forms. Notes are given on the generic position, relationships, structure and geographical distribution of the twenty-six species and varieties (excluding *M. woodthorpi*, Godwin-Austen) which I am now able to recognize as being endemic in Burma. They belong to the following genera, *Margaritanopsis*, Haas; *Indonaia*, Prashad; *Oxynaia*, Haas; *Physunio*, Simpson; *Pseudodon*, Gould; *Trigonodon*, Conrad; *Indopseudodon*, Prashad; *Parreyssia*, Conrad; *Lamellidens*, Simpson and *Trapezoideus*, Simpson.

Genus **Margaritanopsis** Haas.

1913. *Margaritanopsis*, Haas, *Nachr. Deutsch. Malakozool. Ges.* LXV p. 33.
1913. *Margaritanopsis*, Haas, in Martini and Chemnitz *Conch. Cab. Unio*, p. 121.
1914. *Margaritana* (in part) Simpson, *Descr. Cat. Naiades*, p. 511.

---

[1] Preston, *Rec. Ind. Mus.* VII, pp. 279–308, pl. viii (1912) and *Faun. Brit. Ind. Freshw.-Moll.* pp. 134-195 (1915).

Haas erected this genus for *Unio laosensis* Lea in 1913, but Simpson considers that the species is an undoubted *Margaritana* and that the new genus is not justified. The genus, however, appears to be well characterized and I agree with Haas in separating *M laosensis*, with its peculiar distribution in Cambodia, Siam and Burma, from the other species of the genus *Margaritana*. Godwin-Austen has recently described another species from the Shan States under the name *M woodthorpi* [1], but of this I have seen no specimens.

Margaritanopsis laosensis (Lea).

Pl. II, figs. 1–4.

1863. *Unio laosenis*, Lea, *Proc. Acad. Nat. Sci. Philadelphia* VII, p. 190.
1913. *Margaritanopsis laosensis*, Haas, *op. cit.*, p. 33.
1913. *Margaritanopsis laosensis*, Haas, *op. cit.*, pp. 122, 123, pl. vii, figs. 1, 2.
1914. *Margaritanopsis laosensis*, Simpson, *op. cit.*, pp. 520, 521.

My reasons for agreeing with Haas in keeping this species in his new genus *Margaritanopsis* are based on an examination of four specimens collected by Fea in the Karin Hills, Burma, at an altitude of 1000–1200 feet and labelled *Unio sella* T Canefri, a manuscript name only as the species was never described as such. These specimens, as was rightly considered by Haas, are referrable to this species and are of special interest because they beautifully illustrate the changes that take place in the structure of the hinge during the growth of the young into the adult shell, changes which appear to be characteristic of the genus.

The young shells are somewhat rhomboidal and only show a beginning of the arcuate outline of the ventral margin of the adult shells. They are thin and not at all solid. The pseudocardinals in the right valves of the young shells are lamellar, thin, and lie one above the other; in the adult shell the upper or anterior becomes very thick, somewhat knob-like and lies just next to the scar of the anterior adductor muscle, the lower (or now the posterior) comes to be more or less in line with the anterior and is separated from it by a fairly deep groove, it now takes the form of an elongated ridge with its anterior edge raised into a trigonal tooth-like structure. In the left valve there is a single lamellar pseudocardinal in the young shells, but in the adult it becomes very thick and divided into two parts—an anterior smaller and somewhat trigonal and a posterior much larger and conical, for interlocking with the teeth of the other valve. I have nothing further to add to Lea's original description of the species and to Haas' elaborate notes on it.

The species described as *Unio rectangularis* by Tapparone, Canefri (*loc. cit.*, pp. 354, 355) is based on a single very young-shell. It is undoubtedly to be referred to the genus *Margaritanop-*

[1] Godwin-Austen, *Rec. Ind. Mus.* XVI, pp. 202–204, pl. xv. (1919).

sis and probably represents another species of the genus. Owing, however, to a single young shell being available I do not feel disposed to consider it as a distinct species but a figure of the unique specimen (pl. II, fig. 5) is published for future reference.

Genus **Indonaia** Prashad.

1918. *Indonaia*, Prashad, *Rec. Ind. Mus.* XV, pp. 148–148, fig. 2.
1921. *Indonaia, id., ib.*, XXII, p. 602.

Six species of this genus are known to occur in Burma. Of these *I caerulea* has a wide distribution throughout India and Burma, *I. bonneaudi* and *I pachysoma* occur in Assam and Burma, *I. crispisulcata* and *I chaudhurii* are only known from Burma, while *I. crispata* has a wide range in Burma, Siam and Cambodia.

Indonaia caerulea (Lea).

1889. *Unio leioma*, Tapparone-Canefri, *op. cit.*, p. 344.
1914. *Nodularia caerulea*, Simpson, *op. cit.*, pp. 978–980.
1915. *Nodularia caeruleus*, Preston, *op. cit.*, pp. 136, 137.

As a result of my examination of the large series of specimens of this species in the Indian Museum, I am able to confirm Simpson's conclusion that *Unio gerbidoni* Eydoux, *Unio humilis* Lea, *Unio corrianus* Küster, *Unio leioma* Benson, *Unio pilatus* Lea, *Unio evitatus* Lea, *Unio trirostris* Sowerby and *Unio andersonianus* Nevill (part only) are synonyms of this species.

This is the commonest species of the genus throughout India and Burma and it is represented by a large series of specimens in the Indian Museum.

Indonaia bonneaudi (Eydoux).

1889. *Unio Bonneaudi*, Tapparone-Canefri, *op. cit.*, p. 343.
1914. *Nodularia bonneaudi*, Simpson, *op. cit.*, pp. 988, 989.
1915. *Nodularia bonneaudi*, Preston, *op. cit.*, pp. 140, 141.

I have not seen the specimens referred to this species by Tapparone-Canefri, but have no doubt as to his identification.

The species is widely distributed in Assam and Burma and is represented by a large series of shells in the Indian Museum. The specimens show great variation both as regards shape and colour. Normally they are oval or ovate but some are distinctly rostrate posteriorly, in colour they vary from yellowish green to dull brown or even black.

Indonaia chaudhurii (Preston).

1912. *Nodularia chaudhurii*, Preston, *Rec. Ind. Mus.* VII, p. 290.
1914. *Nodularia chaudhurii*, Simpson, *op. cit.*, p. 988.
1915. *Nodularia chaudhurii*, Preston, *op. cit.*, p. 140, fig. 7 (1, 2).

I am not quite certain as to the validity of this species. The only specimens I have seen are the type-series of Preston. They come very near *I. bonneaudi*, but the shells are shorter, more

ovate, less inflated and have the sculpture more pronounced. For the present I propose considering this species as distinct, but believe that it will only turn out to be a form of *I bonneaudi* when more material is collected.

Indonaia pachysoma (Benson).

1914 *Nodularia pachysoma*, Simpson, *op. cit.*, p. 987.
1915. *Nodularia pachysoma*, Preston, *op. cit.*, pp. 139, 140.

I pachysoma is nearly related to *I. bonneaudi* and *I. caerulea*. From the former it is distinguished by its more elongate, more inflated, but less deep shells, more pronounced umbones and much stronger hinge, while from the latter it differs in having much brighter and more inflated shells and in the entire absence of the radial sculpture on the sides.

The species has practically the same distribution as *I. bonneaudi* and is represented in the Indian Museum by a large series of specimens from the Brahmaputra River, Assam, and the Irrawadi River, Burma.

Indonaia crispata (Gould).

1914. *Nodularia crispata*, Simpson, *op. cit.*, pp. 994, 995.
1915. *Nodularia crispata*, Preston, *op. cit.*, p. 142.

Gould's original description is very short but Simpson has recently given an elaborate description. It is a very characteristic form and is easily distinguished from all other Burmese species of the genus by its sculpture, which consists of green zigzag radial lines interspersed here and there with thicker nodules on a yellowish to brownish ground; the ridges run transversely in the anterior region and vertically in the posterior part of the shell.

In the Indian Museum collection the species is represented by specimens from Bhamo (Burma), Siam and Cambodia.

Indonaia crispisulcata (Benson).

1914. *Nodularia crispisulcata*, Simpson, *op. cit.*, p. 1017.
1915. *Nodularia (Radiatula) crispisulcata*, Preston, *op. cit.*, pp. 146, 147.

Simpson in 1900 separated this species along with his *N lima* to form a new section, *Radiatula*, of the genus *Nodularia*; but as I have recently [1] shown there is no justification for separating *I. lima* from species like *I caerulea* and *I. bonneaudi*. Nothing is known about the anatomy of *I crispisulcata* and I do not consider the shell characters alone as being sufficient for the separation of this species into a distinct section.

The species, as represented by a large series of shells from Bongong River, Burma, in the Indian Museum, is remarkably constant in the sculpture of the shell.

---

[1] Prashad, *Rec. Ind. Mus.* XXII, p. 604 (1921).

Genus **Oxynaia** Haas.

1913. *Oxynaia*, Haas, *op. cit.*, p. 34.
1913. *Oxynaia*, Haas, *op. cit.*, p. 152.
1914. *Nodularia* (in part), Simpson, *op. cit.*, p. 115.

Haas established this genus for the species *N jourdyi*, *N diespiter*, *N micheloti* and *N pugio* of Simpson's composite genus *Nodularia*. Of these I have only seen specimens of *Oxynaia pugio*, but the descriptions of the other species and my examination of the specimens of *O. pugio* justifies Haas' separation of these species into a distinct genus.

Oxynaia pugio (Benson).

1862. *Unio pugio*, Benson, *Ann. Mag. Nat. Hist.* (3) X, p. 193.
1889. *Unio pugio*, Tapparone-Canefri, *op. cit.* p. 344.
1913. *Oxynaia pugio*, Haas, *op. cit.*, pp. 158, 159, pl. xiv, figs. 6, 7.
1914. *Nodularia pugio*, Simpson, *op. cit.*, p. 990.
1915. *Nodularia pugio*, Preston, *op. cit.*, p. 141.

This species has a strongly marked and angled posterior ridge running to the cuneate posterior margin, the shell region lying internal to the ridge between the two valves is nearly flat, but is divided in some specimens by the line of union of the two valves rising in the middle; both the anterior and posterior margins are very short, the posterior being much the shorter of the two and distinctly cuneate owing to the ventral margin sharply rising up to meet the point of union of the posterior ridge; the beaks are elevated but not very full. The hinge is characteristic in that the pseudocardinals in the right valve are double, but the anterior is reduced to a thin, lamellar structure only, while the posterior is thickened into a triangular, conical and more or less canine-shaped tooth; in the left valve also there are two pseudocardinals placed in line with one another, the anterior is small and somewhat conical, the posterior is elongate, ridge-like or triangular and the two are separated from one another by a fairly deep concavity in which the tooth of the corresponding valve fits. Nothing is known about the anatomy of any of the species of the genus *Oxynaia*.

In the Indian Museum the species is represented by a large series of shells from Tenasserim, Pegu, Sawaddy River and from Myadong in Burma.

A single specimen from Arrakan appears to belong to a distinct variety, but with this scanty material I do not feel justified in describing it as such.

Genus **Physunio** Simpson.

1918. *Physunio*, Annandale, *Rec. Ind. Mus.* XIV, p. 138.

In the paper cited above Annandale described two interesting species of this genus from the Inlé Basin. The soft-parts of these were described by Ghosh [1] and further notes on the anatomy were

[1] Ghosh, *Rec. Ind. Mus.* XV, pp. 109–122, pl. xvi (1918).

added by me[1] later. I have nothing further to add regarding these two species (*P. micropteroides* Annandale and *P. ferrugineus* Annandale).

Genus **Pseudodon** Gould.

1844. *Pseudodon*, Gould, *Proc. Boston Soc. Nat. Hist.* I, p. 161.
1853. *Monodontina*, Conrad, *Proc. Acad. Nat. Sci. Philadelphia*, VI, p. 269.
1914. *Pseudodon* (in part), Simpson, *op. cit.*, p. 1079.
1915. *Pseudodon s. s.* (in part), Preston, *op. cit.*, p. 152.
1919. *Monodontina*, Prashad, *Rec. Ind. Mus.* XVI, pp. 403–408.
1920. *Pseudodon* (subgen. *Monodontina*), Haas, *op cit.*, p. 318.

I am afraid I am responsible for introducing some confusion in the already confused state of affairs regarding this genus. In the paper cited above I revived the generic name *Monodontina* for species like *P. vondembuschiana*, since the animal of *P. chaperi*, which I consider as one of the varieties of this species, was very different from that of *P. salwenianus* (wrongly spelt *salvenianus*) described by me in a previous paper.[2] In the genus *Monodontina* I also included the species *P. inoscularis* as a variety of *P. vondembuschianus*, having through oversight considered *P. salwenianus*, instead of *P. inoscularis*, as the type of the genus *Pseudodon*. Since the genus *Monodontina*, with *P. vondembuschiana* as its type-species, is synonymous with *Pseudodon* with *P. inoscularis* as its type, the former name must give way to the latter, it having been described about nine years after *Pseudodon*. The genus *Pseudodon* as now restricted will include the species or varieties *orbicularis*, *cambodjensis*, *ovalis*, *ellipticus*, *zollingeri*, *vondembuschianus*, *chaperi*, *ponderosus* and *inoscularis*. The specimen which I doubtfully assigned to *cumingii* (*loc. cit.*, p. 408) is not the true *cumingii* and cannot be included here.

Pseudodon vondembuschiana var. **inoscularis** (Gould).

1919. *Monodontina vondembuschiana* var. *inoscularis*, Prashad, *op. cit.*, p. 408.
1921. *Pseudodon* (*Pseudodon*) *inoscularis*, Haas, *op. cit.*, p. 341, pl. xlii, fig. 7.

In the paper cited above I have given reasons for considering this species as a variety of Lea's *vondembuschiana*, but as I have stated above I made a mistake in adopting the generic name *Monodontina*.

In the Indian Museum collection this variety is represented by two specimens from Tenasserim.

Genus **Trigonodon** Conrad.

1865. *Trigonodon*, Conrad, *Amer. Journ. Conch.* I, p. 233

In view of the differences in hinge and other shell characters of the species that now have to be assigned to the genus *Pseudodon*,

[1] Prashad, *Rec. Ind. Mus.* XIV pp. 183–185, pl. xxii (1918) and XVI, p. 294, fig. 5 (1919). [2] Prashad, *Rec. Ind. Mus* XVI, p. 295, fig. 6 (1919).

the species *peguensis* with its two varieties must now be separated from it. The arrangement, however, is only provisional till the soft parts of these forms are investigated.

Trigonodon peguensis (Anthony).

1900. *Pseudodon crebristriatus* var. *peguensis*, Simpson, *op. cit.* p., 835.
1914. *Pseudodon peguensis*, Simpson, *op. cit.*, pp. 1083, 1084.
1915. *Pseudodon peguensis*, Preston, *op. cit.*, p. 150.

As stated in the notes on the genus above, I have been obliged to revive Conrad's generic name *Trigonodon* for this species and its varieties. The type-species of the genus is *Monocondylaea crebristriatus* Anthony, which I think is no more than a variety of *T peguensis*.

Simpson in his first work treated this species as a variety of *M crebristriatus*, but in his Descriptive Catalogue he was doubtful whether the two were distinct. His first course was not correct since, if the two forms are varieties of the same species, the name of the species should be *T peguensis*, this being the first of the two species described by Anthony.

As a result of my examination of a fair series of specimens of this species and of the form *crebristriatus* from Pegu I am unable to consider the two as distinct species. The latter, however, owing to the shells being more compressed and the sculpture more strongly marked, with the umbones a little more inflated, may be regarded as a distinct variety.

var. crebristriatus (Anthony).

1914. *Pseudodon crebristriatus*, Simpson, *op. cit.*, pp, 1082, 1083.
1915. *Pseudodon crebristriatus*, Preston, *op. cit.*, pp. 150, 151.

There are only two specimens of this form in the Indian Museum collection, from Pegu, the type-locality. They resemble the original description very closely and only differ from typical *T. peguensis* in the points already noted.

var. curvata (Preston).

1915. *Pseudodon peguensis* var. *curvata*, Preston, *op. cit.*, p. 152, fig. 9 (1, 2, 3).

This form, of which I have seen a large series from Pegu, differs from the *forma typica* and the var. *crebristriatus* in having a less ovate shape, distinctly curved ventral margin, hardly projecting umbones and in having only very faint sculpture on the posterior wing.

Genus Indopseudodon, nov.

I have very reluctantly adopted the course of introducing a new generic name for the species *P. salwenianus* and *P. ava*, as the anatomy of the related forms is not known and as so many new

subgeneric names have recently been introduced by Haas. Probably my new name may have to be dropped when the exact generic positions of the various subgenera of Haas can be decided by examination of the animals of these species.

The soft parts of this genus were described by me in 1919 [1] as those of *Pseudodon*, *s.s.*, based on an examination of the animal of *P. salwenianus*.

Indopseudodon salwenianus (Gould).

1844. *Anodon salwenianus*, Gould, *op cit.*, p. 160.
1914. *Pseudodon salwenianus*, Simpson, *op. cit.*, pp. 1093, 1094.
1915. *Pseudodon salwenianus*, Preston, *op. cit.*, p. 152.
1919. *Pseudodon salwenianus*, Prashad, *op. cit.*, pp. 295, 296, fig. 6 (animal).
1920. *Pseudodon salwenianus*, Haas, *op. cit.*, pp. 341, 342, pl. xliii, fig. 4.

I. salwenianus, as Simpson pointed out in his description of the species, is distinguished from the allied species by its considerable length and by the strong plicated sculpture on the posterior wing.

In the Indian Museum collection it is represented by a fair series of specimens from the Tenasserim River and a shell with the label "Burma," exact locality not stated. No specimens of this species were obtained by Fea.

Indopseudodon ava (Theobald).

1873. *Monocondylaea avae*, Theobald, *Journ. As. Soc. Bengal*, XLII. pt. ii, p. 209, pl. xvii, fig. 15.
1900. *Pseudodon ava*, Simpson, *op. cit.*, p. 839.
1914. *Pseudodon ava*, Simpson, *op. cit.*, p. 1098.
1915. *Pseudodon ava*, Preston, *op. cit.* pp. 153, 154.
1920. *Pseudodon avae*, Haas, *op. cit.*, p. 343, pl. xliii, figs. 5, 6.

Simpson in his first work included this species in his section *Binereus* of the genus *Pseudodon*, but in his recent 'Catalogue' was doubtful as to its exact position though he still retained it in this section. Haas, however, from an examination of an authentic Burmese specimen was able to assign the species to its exact position near *I. salwenianus*. I have before me one of Theobald's specimens from Mandalay and can confirm Haas' conclusions. Theobald's comparison of this species with *cumingi* and *inoscularis* in the remarks at the end of his description is rather unfortunate as the species is not related to either of them.

Genus **Parreyssia** Conrad.

1914. *Parreysia*, Simpson, *op. cit.*, pp. 1103, 1104.
1919. *Parreysia*, Prashad, *op. cit.*, p. 292, fig. 3.

Eight species of this genus are now known from Burma. Of these only *P. smaragdites* occurs in Assam as well, all the others

[1] Prashad, *Rec. Ind. Mus.* XVI, pp. 295, 296, fig. 6 (1919).

being confined to Burma. Most of these Burmese species, though they show near relationships with the other Indian species of the genus, form a definite group among themselves.

Parreyssia bhamoensis (Theobald).

1873. *Unio bhamoensis*, Theobald, *Journ. As. Soc. Bengal* XLII, pp. 207, 208, pl. xvii, fig. 1.
1876. *Unio bhamoensis*, Hanley and Theobald, *Conch. Ind.* p. 62, pl. clv, fig. 2.
1878. *Unio bhamoensis* (in part), Nevill, in Anderson's *Zool. Res. Yunnan Exped.* p. 900.
1890. *Unio bhamoensis*, Paetel, *Conch Sam.* III, p. 146.
1899. *Unio bhamoensis*, von Martens, *Arch. Naturgesch.* LXV, pp. 38, 39, pl. v, figs. 2, 4.
1900. *Parreysia bhamoensis* (in part), Simpson, *Proc. U.S. Nat. Mus.* XXII, p. 483.
1914. *Parreysia bhamoensis*, Simpson, *Descr. Cat. Naiades*, pp. 1111, 1112.
1915. *Parreysia* (*Parreysia*) *bhamoensis*, Preston, *Faun. Brit. Ind. Freshw. Moll.* p 163.

The type-specimen of this species from Bhamo, with the label "*U Bhamoensis* n. sp." written in Theobald's hand, is preserved in the Indian Museum collection. The species was stated to be a rare one, and Theobald considered it and *U mandelayensis*, the species described next to it, to form "a natural little subgroup of osculent species," which, however, he did not feel "justified in separating from the great Indian *corrugatus* group." Nevill, while working out the Yunnan collections, did not agree with Theobald's conclusions and united the two species *U bhamoensis* and *U mandelayensis* under the former name. Tapparone-Canefri,[1] in his paper on the Burmese molluscs collected by Fea, agreed with Nevill in his interpretation of Theobald's two forms, but wrongly selected the name *U mandelayensis* for the species. I have examined one of Tapparone-Canefri's specimens and find that it is a true *mandelayensis*. Von Martens, who published good figures of this species, considered the species *U bhamoensis* as distinct from *U mandelayensis*. Simpson in his first work united the two species under the name *P. bhamoensis*, and in this was followed by Preston; in his later work, however, having examined more specimens, he rightly regarded the two species as distinct.

I have examined the types of the two species besides a large series of specimens in the Indian Museum and find the following differences between the two species:—(i) The shell of *P. bhamoensis* is only sub-triangular as opposed to the distinctly triangular shell of *P. mandelayensis*, (ii) the beaks in *P. bhamoensis* are high but not placed well forwards, (iii) in young shells of *P. bhamoensis* the beaks and the umbonal region have only a faintly marked zigzag radial sculpture which extends over the posterior wing and a little on the anterior side, but no tubercles

[1] Tapparone-Canefri, *Ann. Mus. Civ. Stor. Nat. Genova*, XXVII, p. 342 (1889).

are ever developed, in *P. mandelayensis* on the other hand the tubercles are always distinctly developed and the sculpture is much coarser, and (iv) the hinge of *P. bhamoensis* has lamellar pseudocardinals which are not very thick, not at like tooth-like and only slightly ragged.

In the Indian Museum collection the species is represented by the type-specimen from Bhamo and a fair series of specimens of all ages from Sagaing, Zayleyman and Tavoy in Burma.

Parreyssia mandelayensis (Theobald).

1873. *Unio mandelayensis*, Theobald, *op. cit.*, p. 208, pl. xvii, fig. 2.
1876. *Unio mandelayanus*, Hanley and Theobald, *op. cit.*, p. 62, pl. cliv, fig. 4.
1878. *Unio bhamoensis* (in part), Nevill, *op. cit.*, p. 900.
1889. *Unio mandelayensis*, Tapparone-Canefri, *op. cit.*, p. 342.
1890. *Unio mandelayensis*, Paetel, *op cit.*, p. 158.
1899. *Unio mandelayensis*, von Martens, *op. cit.*, p. 38.
1900. *Parreysia bhamoensis* (in part), Simpson, *op. cit.*, p. 843.
1914. *Parreysia mandelayensis*, Simpson, *op. cit.*, pp. 1112, 1113.
1915. *Parreysia* (*Parreysia*) *bhamoensis* (in part), Preston, *op. cit.*, pp. 163, 164.

The question of the validity of this species as distinct from *P. bhamoensis* has been discussed already in the account of the latter species, and I would only note here the distinguishing features of the species.

The shell is triangular with a very high and forwardly placed beak, the beak and the umbonal region are both very strongly sculptured and often have distinct tubercles or even spines developed in this region. The hinge is very strong, with compact, thick and distinctly tooth-like pseudocardinals.

I have examined a specimen from Theobald's collection, which is the one figured by him in the paper cited above and is probably the type of the species. Besides I have examined one of the specimens named by Tapparone-Canefri, and other specimens in the Indian Museum collection from Bhamo, Sheinmagah, Maydong and Pegu in Burma.

Parreyssia houngdaranicus (Tapparone-Canefri).

Pl. II, fig. 6.

1889. *Unio houngdaranicus*, Tapparone-Canefri, *op. cit.*, p. 341.
1900. *Parreysia tavoyensis* var. *triembolus* (in part), Simpson, *op. cit.*, p. 844.
1914. *Parreysia tavoyensis* var. *triembolus* (in part), Simpson, *op. cit.*, pp. 1115, 1116.
1915. *Parreysia tavoyensis* var. *triembolus* (in part), Preston, *op. cit.*, p. 167.

Simpson, on the basis of a specimen labelled *U. houngdaranicus* from Fea's collection in the U.S. National Museum, placed *U. houngdaranicus* in the synonymy of what he called *Parreysia tavoyensis* var. *triembolus*, but from his remarks it appears that he was not quite certain as to the correctness of his conclusions.

As a result of a careful examination of Tapperone-Canefri's type-specimen of the species and the forms with which Simpson included it, I am of opinion that Simpson's conclusions are quite untenable. Not only is the species quite distinct from Benson's *Unio triembolus*, but it also has no relationship whatsoever with Gould's *Unio tavoyensis*. It is on the other hand to be grouped with species like *U bhamoensis* and *U mandelayensis*, forms in which the anterior margin is greatly shortened, the beak placed far forwards and the posterior side drawn out into a cuneate or elliptical lobe. The species may be redescribed as follows:—

Shell subrhomboidal to subovate, moderately inflated, subsolid, inequilateral; beaks high and full, very forwardly placed and recurved outwards and downwards, with a fairly deep cavity, sculptured irregularly with low zigzag transverse bars extending over a little more than the depth of the shell; posterior ridge only feebly marked, dorsal margin slightly arched, somewhat truncate; anterior margin very short, rapidly curving inwards between the umbones in the lunule region and regularly curving below over the podium to meet the nearly straight or slightly arcuate ventral margin; posterior margin longer than the anterior, sharply truncate and rather slanting; epidermis dark brown to black, somewhat shining, ligament prominent, of an amber to chocolate brown colour, hinge-teeth moderately strong; pseudocardinals slightly ragged, three in the right valve, of which the middle is the largest, and three in the left valve, of which the posteriormost is the best developed; laterals slightly arched, single in the right and two in the left valve, anterior muscle scar deeply impressed, posterior quite shallow; nacre shining white in the umbonal region but with a light bluish tinge below.

The type-series was collected by Fea in the Houngdaran River, Meetan, Tenasserim, Lower Burma.

Parreyssia smaragdites (Benson).

1862. *Unio smaragdites*, Benson, *Ann. Mag. Nat. Hist.*, (3) X, p. 190.
1866. *Unio smaragdites*, Blanford, *Journ. As. Soc. Bengal* XXXV, p. 147.
1876. *Unio smaragdites*, Hanley and Theobald, *op. cit.*, p. 5, pl. x, fig. 5.
1877. *Unio andersoniana* (in part), Nevill, *Journ. As. Soc. Bengal*, XLVI, p. 40.
1878. *Unio andersoniana* (in part), Nevill, *op. cit.*, pp. 901, 902, pl. lxxx, figs. 9, 9*a*, 9*b*.
1889. *Unio smaragdites*, Tapparone-Canefri, *op. cit.*, p. 343.
1890. *Unio smaragdites*, Paetel, *op. cit.*, p. 167.
1899. *Unio smaragdites*, von Martens, *op. cit.*, p. 39.
1900. *Parreysia smaragdites*, Simpson, *op. cit.*, p. 843.
1914. *Parreysia favidens* (in part), Simpson, *op. cit.*, pp. 1109, 1110.
1915. *Parreysia* (*Parreysia*) *smaragdites*, Preston, *op. cit.*, p. 163.

Simpson recently regarded *P. smaragdites* as only a synonym of *P. favidens*, but the former species, as is clear from the large series of specimens in the Indian Museum, is quite distinct from the latter. Nevill's large series of *Unio andersoniana* from Burma

mostly consists of this species, the remainder being young shells of *Indonaia caerulea.*

P. smaragdites, as was noted by Benson, is characterized by the shells being of a beautiful green colour interspersed with lemon-yellow in the middle, the beaks being submedian and greatly deflected forwards, with deep cavities and a well-marked lunule.

Benson's specimens were taken in the Berhampooter (Brahmaputra) River, Assam, but the species is now known to have a wide range in Burma and Assam.

Parreyssia burmanus (Blanford).

1869. *Unio burmanus*, Blanford, *Proc. Zool. Soc. London*, p. 449.
1875. *Unio vulcanus*, Hanley, *Proc. Zool. Soc. London*, p. 606.
1876. *Unio burmanus* and *Unio vulcanus*, Hanley and Theobald, *op. cit.*, p. 19, pl. xlii, fig. 7 and p. 62, pl. clv, fig. 3.
1878. *Unio burmanus*, Nevill, *op. cit.*, p. 900.
1879. *Unio burmanus*, Tapparone-Canefri, *op. cit.*, p. 343.
1890. *Unio burmanus* and *Unio vulcanus*, Paetel, *op. cit.*, pp. 146 and 172.
? 1899. *Unio burmanus*, von Martens, *op. cit.*, p. 38, pl. v, fig. 5.
1900. *Parreysia burmanus* and *P. vulcanus*, Simpson, *op. cit.*, p. 845 and p. 844.
1912. *Parreysia pernodulosa*, Preston, *Rec. Ind. Mus.* VII, p. 300.
1914. *Parreysia burmanus*, Simpson, *op. cit.*, p. 1120.
1915. *Parreysia burmanus*, *P. pernodulosa*, and *P. vulcanus*, Preston, *op. cit.*, pp. 170, 164, 168.

The only specimen of this species which I have seen from Fea's collection is a half-grown individual. It is decidedly longer in proportion to the height and is abnormal so far as the sculpture is concerned. The nodular sculpture which is a characteristic of the umbones of the young and half-grown shells of this species is quite obsolete and the radial sculpture over the rest of the beak is also feebly developed.

The specimens figured by von Martens (*loc. cit.*) are, in my opinion, not referrable to this species and I have therefore included a reference to his notes on this species with a reservation only. Hanley's *Unio vulcanus*, which was described from a single specimen and later figured by Hanley and Theobald in the *Conchologia Indica*, is undoubtedly based on a young specimen of this species. Some of the half-grown shells from Bhamo in the Indian Museum collection answer to Hanley's description and are quite like the figure of the type-shell in the *Conchologia Indica*. According to von Martens (*loc. cit.*, p. 38), however, the young shells of *Unio tavoyensis* resemble the figure of the type of *U. vulcanus*. Preston's *P. pernodulosa* is based on very young shells of this species.

The types of this species along with a large series of specimens from the type-locality, the Irrawadi River near Bhamo, are preserved in the Indian Museum. The types of Preston's *P. pernodulosa* were collected by Dr. Anderson at Zaleyman in Upper Burma; Fea's specimens were taken at Teinzo in the Mule Stream, north-east of Bhamo.

Parreyssia tavoyensis (Gould).

1843. *Unio tavoyensis*, Gould, *Proc. Boston Soc. Nat. Hist.* I, pp. 140, 141.
1856. *Unio tavoyensis*, Küster, in Martini and Chemnitz, *Conch.-Cab., Unio*, p. 166, pl. xlviii, fig. 2.
1862. *Unio tavoyensis*, Gould, *Otia Conch.* p. 190.
1864. *Unio tavoyensis*, Reeve, *Conch. Icon.* XVI, pl. xiii, fig. 49.
1866. *Unio tavoyensis*, Blanford, *Journ. As. Soc. Bengal* XXXV, p. 148.
1868. *Unio parma*, Benson, Sowerby in *Conch. Icon.* XVI, pl. xclviii, fig. 514.
1870. *Margaron (Unio) tavoyensis*, Lea, *Synonyms*, p. 31.
1876. *Unio parma* and *U. tavoyensis*, Hanley and Theobald, *op. cit.*, p. 61, pl. cliv, fig. 1 and p. 62, pl. cliv, figs. 6, 7.
1889. *Unio parma*, Tapparone-Canefri, *op. cit.*, p. 239.
1890. *Unio parma, U. savoyensis* and *U. tavoyensis*, Paetel, *op. cit.*, pp.164, 166, 169.
1899. *Unio tavoyensis*, von Martens, *op. cit.*, pp. 37, 38.
1900. *Parreysia tavoyensis*, Simpson, *op. cit.*, p. 843.
1914. *Parreysia tavoyensis*, Simpson, *op. cit.*, pp. 1114, 1115.
1915. *Parreysia tavoyensis*, Preston, *op. cit.*, pp. 167, 168.

Unio parma Benson, was doubtfully included by Simpson and Preston in the synonymy of this species; having before me, however, one of Benson's original specimens, probably a cotype of the species, I am now able to confirm Simpson's conclusions. Tapparone-Canefri's specimen from Bhamo, referred to in his paper cited above as *U parma* and another from Tenasserim labelled *Unio sp.* also belong to this species. Simpson considered Benson's *Unio triembolus* as a variety of *P. tavoyensis*, but an examination of one of Benson's type-series of specimens shows that *U triembolus* is quite a distinct species.

The umbones and a considerable part of the valves in the young shells are covered with a beautiful zigzag sculpture; this however, becomes obsolete with age and hardly a trace of it is left in full-grown individuals.

P. tavoyensis is represented in the collection of the Indian Museum by a large series of shells from Pegu, Tenasserim, Tavoy and Arrakan.

Parreyssia feddeni (Theobald).

1874. *Unio feddeni*, Theobald, *Journ. As. Soc. Bengal* XLII, pt. ii, p. 208, pl. xvii, fig. 3.
1877. *Unio feddeni*, Nevill, *Journ. As. Soc. Bengal* XLVI, pt. ii, p. 38.
1878. *Unio feddeni*, Nevill, *op. cit.*, p. 900.
1900. *Parreysia feddeni*, Simpson, *p. cit.*, p. 165.
1914. *Parreysia feddeni*, Simpson, *p. cit.*, pp. 1113, 1114.
1915. *Parreysia (Parreysia) feddeni*, Preston, *op. cit.*, p. 165.

This species was described by Theobald from shells collected by Mr. F. Fedden and said to have been obtained from the Peemgunga River in Central India. Later Nevill, when reporting on Dr. Anderson's Yunnan collections, stated that the species is tolerably abundant in the rice-fields at Pegu and also at Yaylaymaw in Burma. He also doubted Central India as the provenance of this species from the fact that in the "carefully kept

collections of Mr. H. F Blanford" specimens of *U. feddeni* obtained from Fedden were labelled as from Burma. Since Fedden had collected in both localities the probabilities were that Theobald had mixed up the labels of his specimens. The only specimen of this species now in the Indian Museum collection is from Burma and none of the Central Indian specimens in the collection are referrable to this species. It is probable, therefore, that Nevill was correct in considering this species as a true Burmese form.

Theobald's description of the shell of this species, except for the inaccuracy in his description of the hinge pointed out by me in a recent paper [1], is quite complete and needs no amplification.

The species is not represented in Fea's Burmese collections.

Parreyssia feae (Tapparone-Canefri).

Pl. II, figs. 7, 8.

1889. *Unio feae*, Tapparone-Canefri, *op. cit.*, p. 340.
1900. *Parreysia feae*, Simpson, *op. cit.*, p. 844.
1914. *Parreysia feae*, Simpson, *op. cit.*, pp. 1116, 1117.
1915. *Parreysia (Parreysia) feae*, Preston, *op. cit.*, p. 168.

This species, which was described from specimens collected at Meetan in the Houngdaran River, Burma, has never been figured and was hitherto known only from the author's original description and the short notes added recently by Simpson from an examination of some of Fea's specimens. The following additional notes are based on three specimens one labelled "Type" and the other two "Co-types," which have been presented to the Indian Museum by Dr. R. Gestro of the Genoa Museum.

The shells of this species vary in outline. In the young they are subrhomboidal but become more elongate as growth proceeds. The zigzag radial sculpture of the young shells becomes obsolete with age and in fully grown shells is just faintly indicated. The umbones are high, recurved forwards and inwards but not meeting in the middle line; they are often weathered even in half-grown individuals. The young shells are dirty yellow interspersed with green in the region with raised zigzag sculpture, older shells are yellowish-brown, while the full-grown type is dark chocolate-brown. The nacre is bluish white.

Genus **Lammellidens** Simpson.

1914. *Lamellidens*, Simpson, *op. cit.*, p. 1165.
1919. *Lamellidens*, Prashad, *op. cit.*, p. 293, fig. 4.

A large number of specific and varietal names have been given by previous authors to ordinary variations of the commoner Indo-Burmese forms of this genus, and it has been found necessary on examination of the large collections of Unionids now available, to drop most of these names. I am now able to recognize only six definite species and varieties as occurring within the

[1] Prashad, *Rec. Ind. Mus.* XIX, p. 713 (1920).

limits of Burma. Three of these *L. generosus, L. lamellatus* and *L. scutum* are confined to Burma, while the other three have a much wider distribution.

Lamellidens marginalis (Lamarck).

1876. ? *Unio marginalis* var. *zonata*, Hanley and Theobald, *op. cit.*, p. 20, pl. xliv, fig. 2.
1889. *Unio marginalis* with vars. *subflabellatta, cylindrica* (*nec* Hanley and Theobald) and *obesa* (*nec* Hanley and Theobald), *U. protensus* var. *obtusatus*, Tapparone-Canefri, *op. cit.*, pp. 345, 346, 350.
1914. *Lamellidens marginalis*, Simpson, *op. cit.*, pp. 1166–1168.
1915. *Lamellidens marginalis*, Preston, *op. cit.*, pp. 175, 176.
1921. *Lamellidens marginalis*, Prashad, *Rec. Ind. Mus.* XXII, p. 606, fig 6A.

In the paper cited above I have recently given the distinctive characters of the species and have figured the hinge of a typical specimen.

Tapparone-Canefri was apparently unaware of the great variation in the shape and form of this species and gave specific and varietal names to shells which are quite typical. As a result of my examination of Tapparone-Canefri's named specimens I find that five of his names, including his true *marginalis*, must be treated as synonyms. Simpson doubtfully included *Unio dolichorhynchus* and *U. gianelli* in the synonymy of *L. marginalis*, but the former on examination of the type was found to be an elongate specimen of *L. corrianus* and the latter a half-grown *L. scutum*. The various Burmese forms included by Preston as varieties and subspecies of this species, are discussed in the notes on the several species.

L. marginalis has a very wide range of distribution, throughout India, Burma and Ceylon.

Lamellidens corrianus (Lea).

Pl. II, figs. 9-11.

1889. *Unio corrianus, U. dolichorhynchus, U. protensus* and var. *ellipticus*, Tapparone-Canefri, *op. cit.*, pp. 347–350.
1900. *Lamellidens canefrinus*, Simpson, *op. cit.*, p. 857.
1914. *Lamellidens canefrinus*, Simpson, *op. cit.*, p. 1176.
1915. *Lamellidens canefrinus*, Preston, *op. cit.*, p. 187.
1921. *Lamellidens corrianus*, Prashad, *op. cit.*, p. 609, fig. 29C.

In the paper cited above I have given reasons for considering *L. corrianus* as a species distinct from *L. marginalis*. As a result of my examination of Tapparone-Canefri's types of *U protensus* and its var. *ellipticus* I find, that both of them should be referred to this species, Simpson's new name *canefricus* must, therefore, be sunk in the synonymy of *L. corrianus*. The type specimen of *L. dolichorhynchus* differs from typical shells of *L. corrianus* in being a little more elongate and the cuneation of the posterior margin is therefore more pronounced, but these differences in the shape of the shell in the case of a variable species

such as *L. corrianus* are not enough to warrant the erection of a distinct variety, much less a separate species.

L. corrianus like *L. marginalis*, is widely distributed throughout India and Burma.

Lamellidens jenkinsianus subsp. obesa (Hanley and Theobald).

1920. *Lamellidens jenkinsianus* subsp. *obesa*, Prashad, *Rec. Ind. Mus.* XIX, pp. 170–172, pl. ix, figs. 1, 2.

In the paper cited above I have recently discussed the question of the various forms of *L. jenkinsianus*. In Fea's collection from Burma there is a young specimen of the form *obesa* from Tonghoo. This specimen is one of the few unnamed specimens of Fea's collection and only had the name '*Unio*' on the label. The specimen is from the same locality from which Theobald's specimens, now in the Indian Museum, were collected.

It may also be noted here that the specimens referred to as *Unio marginalis* var. *obesus* by Tapparone-Canefri (*loc. cit.*, p. 346) are, as has been pointed out already, only typical specimens of *L. marginalis*.

Lamellidens generosus (Gould).

Pl. II, figs. 12-17.

1847. *Unio generosus*, Gould, *op. cit.*, p. 220.
1870. *Margaron* (*Unio*) *generosus*, Lea, *Synonyms*, p. 20.
1876. *Unio generosus* and var. *angustior*, *id.*, *ib.*, p. 22, pl. xlvi, figs. 4, 7.
1876. *Unio lamellatus*, var. (*nec* Lea), Hanley and Theobald, *op. cit.*, p. 5, pl. ix, fig. 6.
1889. *Unio marginalis* var. *zonata* (*nec* Hanley and Theobald),[1] var. *tricolor* (*nec* Küster), *U. pulcher* and var. *lamellatiformis*, *U. generosus* and var. *delapsus*, Tapparone-Canefri, *op. cit.*, pp. 346, 347, 350, 351, 352.
1899. *Unio generosus*, von Martens, *op. cit.*, p. 46.
1900. *Lamellidens generosus*, Simpson, *op. cit.*, p. 857.
1912. *Lamellidens marginalis* subsp. *sawaddyensis*, Preston, *Rec. Ind. Mus.* VII, p. 305.
1914. *Lamellidens marginalis* var. *tricolor* and subsp. *sawaddyensis*, *L. Burmanus*[2] and *L. generosus*, Simpson, *op. cit.*, pp. 1168, 1169. 1170, 1175.
1915. *Lamellidens marginalis* var. *tricolor* and subsp. *sawaddyensis*, and *L. pulcher* with var. *lamellatiformis*, Preston, *op. cit.*, pp. 176, 177, 185.

The above elaborate synonymy is based on a careful examination of the type-specimens of Tapparone-Canefri's and Preston's new species and also of authentic specimens of others in the Indian Museum collection.

The specimens identified by both Tapparone-Canefri and Preston as belonging to the var. *tricolor* Küster are undoubtedly

[1] Hanley and Theobald, *Conch. Ind.* p. 20, pl. xliv, fig. 2. The shell figured is apparently a young specimen of *L. marginalis*.

[2] The second name, *Lamellidens Burmanus*, on the same page (1170) certainly a *lapsus calami* for *I thwaitesi*.

the young of this species and I have little doubt that Küster's types also belonged to it.

Simpson has recently described this species very fully and I have nothing more to add to his description beyond noting the changes that take place in the colour of the shell during growth. The young shells are fulvous or chocolate-brown in the umbonal region and the greater part of the shell is bordered by a broad band of deep yellow on the inner side, while the dorsal slope together with the posterior wing and the rest of the shell are shining green. As the shell grows the green and yellow gradually disappear and the shells as a whole become dark chestnut to black; the umbonal region, however, is always much lighter. A certain amount of variation is also exhibited by the posterior wing and the posterior margin; in young shells the wing is usually much broader proportionately and more marked, but as the shells increase in size it becomes much narrower, the posterior margin shows much greater variation, it may be only somewhat narrowed or may even take on a distinct cuneate appearance.

In the Indian Museum collection this species is represented by a large series of specimens of all ages from various localities in Burma.

Lamellidens lamellatus (Lea).

1838. *Unio lamellatus*, Lea, *Trans. Amer. Phil. Soc.* VI, p. 19, pl. vi, fig. 16.
1889. *Unio pulcher* var. *ponderosulus*, Tapparone-Canefri, *op. cit.*, pp. 351, 352.
1914. *Lamellidens lamellatus*, Simpson, *op. cit.*, pp. 1172, 1173.

Both Simpson and Preston have wrongly included Lea's *Unio layardi* in the synonymy of *L. lamellatus*. *Lamellidens layardi* has no relationship whatsoever with such Burmese species as *L. generosus*, *L. lamellatus* and *L. scutum*, but is closely allied to *L. marginalis*.

L. lamellatus, as has been noted above, is allied to *L. generosus*, but is distinguished by its general shape, thinner shell, less well developed post-dorsal wing and more delicate hinge-teeth.

I have examined a large series of this species from various localities in Burma, in the Indian Museum collection.

Lamellidens scutum (Sowerby).

1868. *Unio scutum*, Sowerby, *Conch. Icon.* XVI, pl. xciv, fig. 510.
1876. *Unio scutum*, Hanley and Theobald, *Conch. Ind.* p. 22, pl. xlvi, fig. 1.
1889. *Unio gianelli* with var. *degener*, Tapparone-Canefri, *op. cit.*, pp. 353, 354.
1899. *Unio scutum*, with var. *humilior*, von Martens, *op. cit.*, pp. 45, 46.
1912. *Lamellidens marginalis* var. *sublamellata*, Preston, *op. cit.*, p. 305.
1914. *Lamellidens scutum*, Simpson, *op. cit.*, pp. 1173, 1174.
1915. *Lamellidens marginalis* vars. *zonata* (*nec* Hanley and Theobald), *sublamellata*, *scutum* and *humilior*, Preston, *op. cit.*, pp. 177, 181, fig. 19 (1–3).

An examination of the types of *Unio giannelli*, its var. *degener*, *L. marginalis* var. *sublamellata* and shells identified as var. *zonata*, has shown that they are all referrable to this species. The shells of var. *humilior* von Martens also gradually fade into those of the typical form and it is impossible, therefore, to distinguish this variety.

L. scutum has a comparatively less broad, less tumid, but more elongate type of shell than that of either *L. generosus* or *L. lamellatus*—the other two species of this interesting group. The group, so far as is known at present, is confined to Burma.

Genus **Trapezoideus** Simpson.

1921. *Trapezoideus*, Prashad, *Rec. Ind. Mus.* XXII, p. 609.

In the paper cited above I have described the anatomy of this interesting genus. In Burma it is represented by five species, all of which, with the exception of *T foliaceus*, are endemic in Burma.

Trapezoideus exolescens (Gould).

1843. *Unio exolescens*, Gould, *op. cit.*, p. 141.
1852. *Margaron* (*Unio*) *exolescens*, Lea, *Synoyms*, p. 32.
1862. *Unio exolescens*, Gould, *Otia Conch.*, p. 191.
1866. *Unio exolescens*, Blanford, *Journ. As. Soc. Bengal*, XXXV pt. i, p. 149.
1876. *Unio exolescens*, Hanley and Theobald, *op. cit.*, p. 43, pl. cvii, fig. 5.
1877. *Unio fragilis*, Nevill, *Journ. As. Soc. Bengal*, XLVI, p. 39.
1878. *Unio foliaceus* var. *fragilis*, Nevill, *op. cit.*, p. 400, pl. lxxx, fig. 8.
1889. *Unio exolescens*, Tapparone-Canefri, *op, cit.*, p. 349.
1899. *Unio exolescens*, von Martens, *op. cit.*, p. 42.
1900. *Trapezoideus exolescens*, Simpson, *op. cit.*, p. 859.
1914. *Trapezoideus exolescens*, Simpson, *op. cit.*, p. 1185.
1915. *Trapezoideus exolescens*, Preston, *op. cit*, p. 195.
1920. *Trapezoideus exolescens*, Haas, *op. cit.*, p. 272.

An examination of Nevill's type of *Unio fragilis* has shown that the species should be referred to *T exolescens* rather than to var. *comptus* of *T foliaceus* as Simpson thought (*loc. cit.*, p. 1182) or to *T misellus* as Haas has done. One of the specimens in Fea's collection is labelled *Unio microsomus*, T. Canefri, n. sp.,' but this is not referred to in his paper; the specimen is only a young example of *T exolescens*; the other shells referred by T. Canefri to *T exolescens* are correctly identified.

The locality of the type-specimens was not certain, but von Martens' specimens were obtained at Mandalay and the Indian Museum specimens are from Bhamo.

Trapezoideus foliaceus (Gould).

1843. *Unio foliacea*, Gould, *op. cit.*, p. 141.
1852. *Margaron* (*Unio*) *foliacea*, Lea, *op. cit.*, p. 39.
1862. *Unio foliacea*, Gould, *op. cit.*, p. 191.
1865. *Unio Peguensis*, Anthony, *Amer. Journ. Conch.* I, p. 351, pl xxv, fig. 2.

1866. *Unio foliaceus* and *Unio peguensis*, *op. cit.*, pp. 148, 154.
1868. *Unio peguensis*, Reeve, *Conch. Icon.* XVI, pl. xcv, fig. 519.
1876. *Unio foliaceus*, Hanley and Theobald, *op. cit.*. p. 19, pl. xlii, fig. 3.
1889. *Unio foliaceus*, Tapparone-Canefri, *op. cit.*, p. 345.
1900. *Trapezoideus foliaceus*, Simpson, *op. cit.*, p. 858.
1912. *Trapezoideus foliaceus*, Preston, *op. cit.*, p. 307.
1914. *Trapezoideus foliaceus*, Simpson, *op. cit.*, pp. 1181, 1182.
1915. *Trapezoideus foliaceus*, Preston, *op. cit.*, p. 193.
1919. *Trapezoideus foliaceus*, Haas, *op. cit.*, pp. 261, 262, pl. xxxii, fig. 3.

Anthony's *Unio peguensis* is synonymous with this species and is not referrable to the genus *Pseudodon* as Simpson believed. Deshayes and Julien's *Unio comptus* is *T misellus*, and the type of *Unio fragilis*, Nevill, is a specimen of *T exolescens* (*vide* p. 109). Preston's new variety *zaleymanensis* is not a variety of this species, but is based on young and half-grown shells of *T misellus*.

T foliaceus is represented in the Indian Musuem collection by specimens from Bhamo and Zaleyman, Burma.

Trapezoideus dallianus (Frierson).

1899. *Unio foliaceus*, von Martens, *op. cit.*, p. 42.
1913. *Parreysia dalliana*, Frierson, *Nautilus*, XXVI, p. 142.
1919. *Trapezoideus dallianus*, Haas, *op. cit.*, p. 263, pl. xxxii, fig. 4.

Frierson's species, as Haas has pointed out, is a *Trapezoideus* and not a *Parreyssia* as the author of it thought. Haas has also, I think, rightly referred von Martens' specimens of *T foliaceus* to this species.

In the Indian Museum there is a single right valve from Burma, exact locality not stated, which belongs to this species.

Trapezoideus misellus (Morelet).

1912. *Trapezoideus foliaceus* var. *zaleymanensis*, Preston, *op. cit.*, p. 307.
1915. *Trapezoideus foliaceus* var. *zaleymanensis*, Preston, *op. cit.*, p. 194.
1919. *Trapezoideus misellus*, Haas, *op. cit.*, pp. 266–270, pl. xxxii, figs, 6–9, pl. xxxiii, figs. 1–5.

Haas has given the complete synonymy of this species quite recently. However, he wrongly included in it Nevill's *Unio fragilis*, the type of which, as I have stated already, is *T misellus*, and he did not include in the synonymy Preston's var. *Zaleymanensis* of *T foliaceus*, which was described from young and half-grown shells of this species.

The species is represented in the Indian Museum collection by a fair series of specimens of all ages from Tenasserim, the Irrawadi River, Zaleyman and Bhamo.

Trapezoideus subclathratus (v. Martens).

1919. *Trapezoideus subclathratus*, Haas, *op. cit.*, pp. 270–272, pl. xxiii, fig. 6.

Careful examination of a single specimen of this form taken at Sheinpagali, Burma, leaves no doubt in my mind that, as Haas correctly states, this species is distinct from *T misellus*, of which von Martens considered it to be a variety.

EXPLANATION OF PLATE II.

All figures are direct photographs of dry shells.

Margaritanopsis laosensis (Lea).

FIGS. 1–4.—Shells of various ages, forming the type-series of *Unio sella*, Tapparone-Canefri: ×½.

Margaritanopsis sp.

FIG. 5.—Type-shell of *Unio rectangularis*, Tapparone-Canefri: ×½.

Parreyssia houngdaranicus (Tapparone-Canefri).

FIG. 6.—Type-shell from Houngdaran River, Burma: natural size.

Parreyssia feae (Tapparone-Canefri).

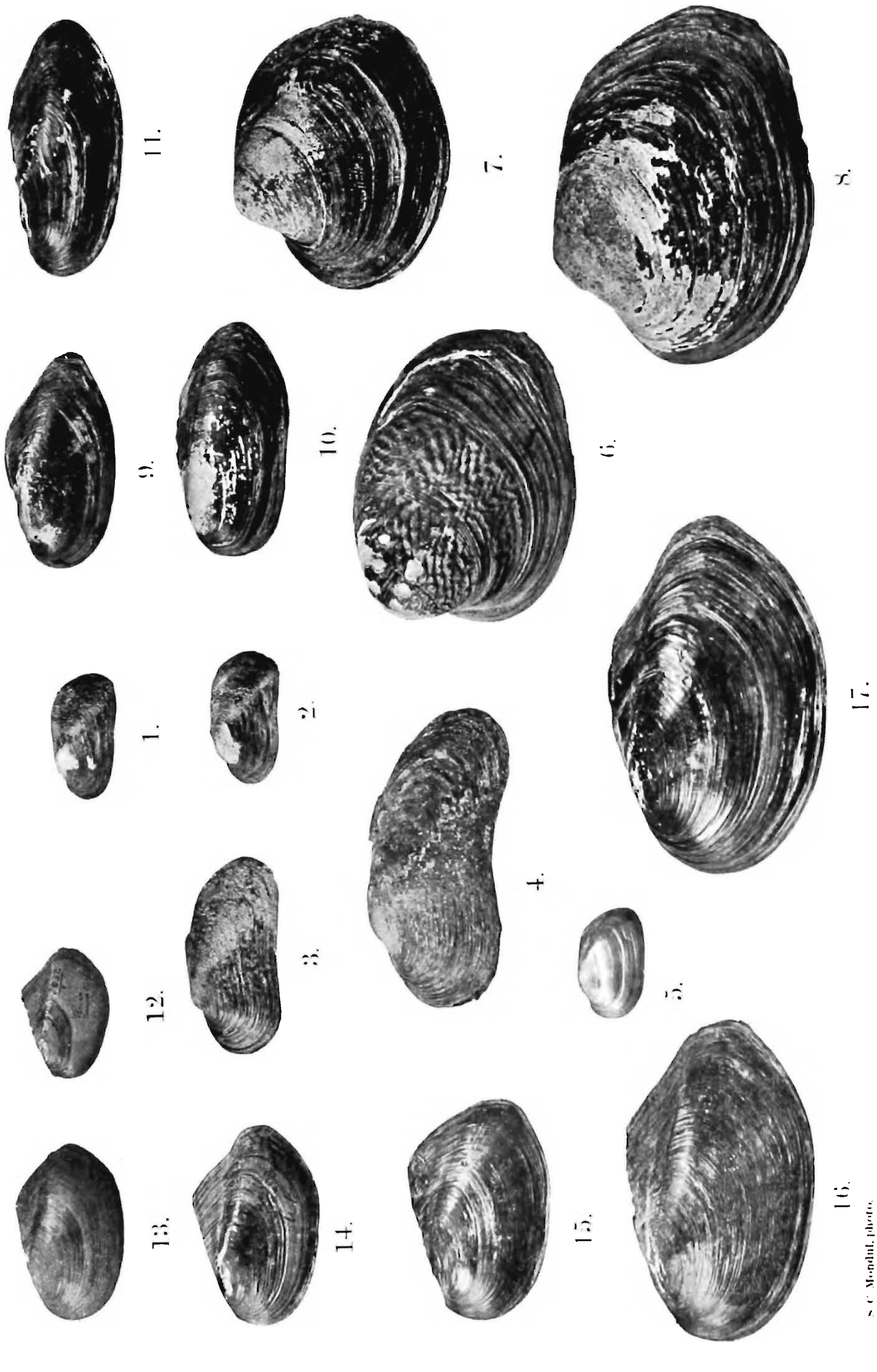
FIG. 7.—Adult shell from Meetan, Burma: natural size.
,, 8.—Type shell from the same locality: natural size.

Lamellidens corrianus (Lea).

FIG. 9.—Type-shell of *Unio protensus*, Tapparone-Canefri: ×½.
,, 10.—Type-shell of *Unio protensus* var. *ellipticus*, Tapparone-Canefri: ×½.
,, 11.—Type-shell of *Unio dolichorhynchus*, Tapparone-Canefri: ×½.

Lamellidens generosus (Gould).

FIG. 12.—Young shell of *L. marginalis* subsp. *sawaddyensis*, Preston: ×½.
,, 13.—Specimen identified as *Unio marginalis* var. *tricolor* by Tapparone-Canefri: ×½.
,, 14.—Half-grown specimen of *L. marginalis* subsp. *sawaddyensis*, Preston: ×½.
,, 15.—Type-shell of *Unio pulcher*, Tapparone-Canefri: ×½.
,, 16.—A shell identified by Preston as *L. marginalis* var. *sublamellata*: ×½.
,, 17.—Type-shell of *L. marginalis* subsp. *sawaddayensis*, Preston: ×½.



BURMESE UNIONIDÆ.

S. C. Mondul, photo.