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Dr. A. K. Ghosh
Director
Zoological Survey of India

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Dr. A. K. Ghosh
Director
Zoological Survey of India

RECORDS
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ZOOLOGICAL SURVEY OF INDIA

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TERMITES FROM ARID AREAS OF PUNJAB AND HARYANA, INDIA.

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INTRODUCTION

The arid region of Thar Desert (1,67,750 sq. kms). is contained in the states of Rajasthan (62%), Gujarat (20%), Punjab (5%) and Haryana (4%) in India and some parts of Punjab and Sind in Pakistan. Termites from Rajasthan portion of Thar Desert have been studied extensively by many workers (as reviewed by Roonwal, 1976, 1982) and of Gujarat portion by Thakur (1984, 1989,). However, as there is no published record of termites occurring in arid areas of Pnnjab and Haryana (Roonwal, 1975), the present contribution is an effort to make available information on termites of this part of the country.

The author made extensive survey of termites from Thar Desert portion of Punjab (Bhatinda, Ferozepur and Sangrur) and Haryana (Hissar and Mahendragarh) in November-December, 1982 and collected 187 vials of termites. The present paper is based on the study of this collection. A total of 19 species of termites under 10 genera belonging to two families (Rhinotermitidae) are reported.

All measurements are in mm.

Abbreviations used : Coll., collected by ; Dist., District ; ex., extracted from ; exs., examples ; Im., Imago ; k., King ; Ny., Nymph ; P.S.E.B., Panjab State Electricity Board ; Q. Queen ; S., Soldier ; sev., several ; Type-loc., Type locality ; W., Worker ; Z. S. I., Zoological Survey of India.

SYSTEMATIC ACCOUNT

Family I. RHINOTERMITIDAE

Subfamily (i) HETEROTERMITINAE

1. **Heterotermes indicola** (Wasmann)

1902. *Leucotermes indicola* Wasmann, *Zool. Jahrab. Abt. Syst.*, Jena, 17 (i) : 118-119. S. & W. Type-loc. : INDIA : Bombay (Maharashtra).

1949. *Heterotermes indicola* : Snyder, *Smiths. misc. Coll.*, 112 : 68.

1979. *Heterotermes indicola* : Thakur and Sen-Sarma, *Indian For. Rec.*, 13 (2) : 10-15.

Present address : Forest Research Institute, P. O. New Forest, Dehra Dun.

Material : (i) One vial with 3 S. and 22 W. from an open land behind D.A.V. College, Bhatinda, 30. xi. 82 (ii) One vial with 2 S. and 10 W from P.W.D. Rest house, Mahendragarh, 16. xii. 82, *ex.* wooden almirah.

Measurements (three S. from Bhatinda) : Total body length with mandibles 4.95-5.20, head length to lateral base of mandibles 1.54-1.61, max. width of head 0.84-0.91, max. length of mandibles 0.81-0.84, min. (median) length of postmentum 1.19-1.23, max. width of postmentum 0.42-0.46, max length of pronotum 0.56, max. width of pronotum 0.74-0.77. No. of Antennal segments 16.

Distribution : *Previous record* : Widely distributed in Pakistan and northern and western India, upto an altitude of 1800 m. and above 20° N lat. *Present record* : Punjab : Bhatinda. Haryana : Mahendragarh.

Subfamily (ii) COPTOTERMITINAE

2. **Coptotermes heimi** (Wasmann)

1902. *Arrhinotermes heimi* Wasmann, *Zool. Jahrab. Abt. Syst.*, Jena, 17 (1) : 104. Im. Type-loc. : INDIA : Wallon, Ahmadnagar (Maharashtra).

1962. *Coptotermes heimi* : Roonwal and Chhotani, *Indian spec. Termite Genus Coptotermes*, New Delhi (*Indian Council. Res., Entomol. Monggr. No. 2*) : 38-57.

Material : (i) One vial with 7 S. and sev. W from Saina vill., *ca.* 7 km from Bhatinda, 29.xi.82, *ex. Ficus* sp. (ii) One vial with 3 S. and 10 W from Banasar garden Sangrur, 7.xii.82, *ex. Eucalyptus* sp. (iii) One vial with 3 S. and sev. W. from Dhuri gate, Sangrur, 8.xii.82, *ex.* Rotten tree-trunk.

Measurements (five S. from Bhatinda) : Total body-length with mandibles 3.89-4.10, head-length to lateral base of mandibles 1.23-1.26, max. width of head 1.05, length of left mandible 0.81, max. length of pronotum 0.42-0.46, max. width of pronotum 0.63-0.70. Antennal segments 14.

Distribution : *Previous record* : Very widely distributed almost all over India, Pakistan and Bangladesh. *Present record* : Punjab : Bhatinda and Sangrur.

Family II. TERMITIDAE

Subfamily (i) APICOTERMITINAE

3. **Speculitermes cyclops** Wasmann

1902. Speculitermes cyclops Wasmann, *Zool. Jahrab. Abt. Syst.*, Jena, 17 (1) : 160-162. Im., W. Type-loc. : INDIA : Khandala, Bombay (Maharashtra).

Material : One vial with sev. W. from Saina vill., *ca.* 7 km from Bhatinda, 29.xi.82 *ex.* cow-dung.

Measurements (four W. from Bhatinda) : Total body-length with mandibles 4.55-4.76, head-length to lateral base of mandibles 0.98-1.05, max. width of head 1.33, max. diameter of mid-dorsal spot on head 0.11-0.14, max. length of pronotum 0.42-0.46, max. width of pronotum 0.73-0.77. Antennal segments 14.

Distribution : *Previous record* : Recorded from the moist open and scrubby areas in northern and western India. (Gujarat, Jammu and Kashmir, Rajasthan, Madhya Pradesh, Maharashtra and Uttar Pradesh) and Pakistan. Present record : Punjab : Bhatinda.

Subfamily (ii) TERMITINAE

4. **Amitermes belli** (Desneux)

1906. *Termes belli* Desneux, *Ann. Soc. entomol. Belg.*, Brussels, 49 (12) : 352-354. Im., S. & W. *Type-loc* : PAKISTAN : Karachi (Sind).

Material : (i) One vial with sev. S. and W. from tree plantations along canal side, Gobindpur vill., *ca.* 14 km from Bhatinda, 1.xii.82. (ii) One vial with 6 S. and sev, W. from Dhuri gate, Sangrur, 7.xii.82.

Measurements (five S. from Bhatinda) : Total body-length with mandibles 4.62-4.73, head-length to lateral base of mandibles 1.23-1.30, max. width of head 1.02-1.05, length of left mandible 0.81-0.84, max. length of pronotum 0,28-0.32, max. width of pronotum 0.71. Antennal segments 14.

Distribution : *Previous records* ; INDIA : Western India (Gujarat and Rajasthan) and PAKISTAN : Baluchistan, N.W.F.P., Sind and Punjab. *Present record* : Punjab : Bhatinda and Sangrur.

5. **Microcerotermes tenuignathus** Holmgren

1913. *Microcerotermes tenuignathus* Holmgren, *J. Bombay nat. Hist. Soc.*, Bombay, 22 (1) : 116-117. S. and W. Type-loc : INDIA ; Vadtal (Gujarat).

Material : One vial with 7 S. and sev. W. from Banasar garden. Sangrur, 7.xii.82, *ex.* soil.

Measurements (five S. from Sangrur) : Total body-length 4.38-4.52, head-length to lateral base of mandibles 0.77-0.81, max. length of pronotum 0.32, max. width of pronotum 0.56. Antennal segments 13.

Distribution : *Previous records* : INDIA : Gujarat, Rajasthan. PAKISTAN : Baluchistan, N.W.F.P., Punjab and Sind. *Present record* : Panjab : Sangrur.

Subfamily (iii) MACROTERMITINAE

6. **Odontotermes assmuthi** Holmgren

1913. *Odontotermes* (*Odontotermes*) *assmuthi* Holmgren, *J. Bombay nat. Hist. Soc.*, Bombay, 22 (1) : 112-113. S. and W. Type-loc. : INDIA : Bombay : Borivli Jungles (Maharasthtra).

1981. *Odontotermes assmuthi* : Thakur, *Indian For. Rec.*, 14 (2) : 16-21.

Material : Two vials with sev. S. & W. from agr. field near P.S.E.B. office, *ca.* 5 km from Ferozepur, 24.xi.83, *ex.* soil.

Measurements (six S. from Ferozepur) : Total body-length 4.90-5.15, head-length

to lateral base of mandibles 1.68-1.72, max. width of head 1.19-1.23, length of left mandible 0.91, distance of tooth in left mandible from tip 0.32, max. width of pronotum 0.84-0.88. Antennal segments 16.

Distribution : *Previous records* : INDIA : Assam, Bihar, Gujarat, Jammu and Kashmir, Karnataka, Maharashtra, Madhya Pradesh, Punjab, Tamil Nadu and Uttar Pradesh. PAKISTAN : Hangu (Kohat district). BANGLADESH : Dinajpur and Rajashahi. *Present record* : Punjab : Ferozepur.

7. **Odontotermes bellahunisensis** Holmgren & Holmgren

1917. *Odontotermes (Cyclotermes) bellahunisensis* Holmgren and Holmgren, *Mem. Dept. Agric. India* (Ent.), 5. (3) : 150-151. Im., S., W. Type-loc : INDIA : Bellahunsi, Bellary district (Karnataka).

1981. *Odontotermes bellahunisensis* : Thakur, *Indian For. Rec.* 14 (2) : 21-25.

Material : (i) One vial with 3 S. and sev. W. from vegetation along canalside, *ca.* 7 km from Bhatinda, 27.xi.82. (ii) One vial with 5 S. and 10 W. from vegetation near Thermal Power, Bhatinda, 28.xi.826 (iii) Two vials with sev. S. and W. from Saina uill., *ca.* 7 km from Bhatinda, 29.xi.82 (iv) One vial with 3 S. and 8 W from open land behind D.A.V. College, Bhatinda, 30.xi.82, *ex.* cow-dung. (v) One vial with 4 S. and sev. W. on Barnala road, *ca.* 4 km from Bhatinda, 2.xii. 82 *ex.* understone (vi) Two vials with sev. S. and W from Ranbir club area, Sangrur, 5.xii.82 (vii) One vial with 3 S. and 10 W. from Dhuri gate, Sangrur, 8.xii.82, *ex.* cow-dung (viii) One vial with 5 S. and sev. W. from experimental agriculture farms, Haryana Agric. Univ., Hissar. 10.xii.82. *ex.* soil (ix) One vial with sev. S and W. from Juliflora vegetation behind Fort, Mahendragarh, 17.xii.82, *cx.* understone.

Measurements (seven S. from Mahendragarh) : Total body-length 4.55 4.73, length of head to lateral base mandibles 1.12-1.16, max. width of head 1.09-1.12 length of left mandible 0.67, distance of tooth in left mandible from tip 0.21, max. width of pronotum 0.84. Antennal segments 16.

Distribution : Previous recores : INDIA : Assam, Bihar, Gujarat, Karnataka, Orissa, Rajasthan, Tamil Nadu and West Bengal. *Present rocord* : Bunjab : Bhatinpa and Singrur. Haryana : Hissar and Mahendragarth.

8. **Odontotermes brunneus** (Hagen)

1858. *Termes brunneus* Hagen, *Linn. Entomol.*, London, 12 : 133. Im., S. Type-loc : INDIA : Bengal.

198I. *Odontotermes brunneus* : Thakur, *Indian For. Rec.*, 14 (2) : 33-37.

Material : (i) One vial with 5 S. & sev. W. from experimental agr. farms, Haryana Agric. Univ., Hissar, 10.xii 82, *ex.* termite mound. (ii) One vial with 3 S. and sev. W. from H. A. U. campus, Hissar, 12.xii.82, *ex.* termite mound.

Measurements (five S. from Hissar) : Total body-length 5·81-6·16, length of head to lateral base of mandibles 1·61-1·65, max. width of head 1·40, length of left mandible

0·95-1·02, distance of tooth in left mandible from tip 0·35, max width of pronotum 1·02. Antennal segments 16.

Distribution ; Previous records INDIA : Gujarat, Karnataka, Maharashtra, Rajasthan and Tamil Nadu. *Present record* : Haryana : Hissar.

9. **Odontotermes giriensis** Roonwal and Chhotani

1962. *Odontotermes giriensis* Roonwal and Chhotani, *Proc. Nat. Inst. Sci. India*, (B) 28 (4) : 341-345. S and W. *Type-loc.* : INDIA : Rogrengiri, Garo Hills district (Meghalaya).
1981. *Odontotermes giriensis* : Thakur, *Indian For. Rec.*, 14 (2) : 55-59.

Material : (i) Two vials with sev. S. and W. from open land near Army store, Ferozepur cantt., 23.xi.82 *ex.* soil (ii) Four vials with sev. S. and W. from vegetation near Thermal Power, Bhatinda, 28.xi.82 (iii) One vial with 5 S. and sev. W. from Saina vill., *ca.* 7 km from .Bhatinda, 29.xi.82 (vi) Four vials with sev. S. and W. from open land behind D.A.V. Colleges, Bhatinda, 30.xi.02 (v) One vial with 3 S. & sev. W. from Gobindpur vill., Bhatinda, 7.xii.82. (vi) Threee vials with sev. S. & W. from experimental Agri. farms, H.A.U., Hissar, 10.xii.82. (vill) Two vials with sev. S. & W. from Dadri road, *ca.* 4 km from Mahendragarh, 16.xii.82, *ex.* soil. (viii) One vial with 5 S. and sev. W. from Juliflora vegetation behind Fort, Mahendragarh, 17.xii.82, *ex.* cow-dung.

Measurements (ten S. from Ferozepur) : Total body length 4.27-4.41, length of head to lateral base of mandibles 1.26-1.33, max. width of head 1.12-1.16 length of left mandible 0.67-0.70, distance of tooth in left mandible from tip 0.18-0.21, max. width of pronotum 0.81-0.84. Antennal segments 16.

Distribution : *Previous records* : INDIA : Arunachal Pradesh, Assam, Gujarat, Meghalaya, Rajasthan, Tripura adn *Uttar Pradesh*. *Present record* : Punjab : Bhatinda and Ferozepur. Haryana : Hissar and Mahendragarh.

10. **Odontotermes gurdaspurensis** Holmgren & Holmgren

1917. *Odontotermes (Odontotermes) obesus f. gurdaspurensis* Holmgren and Holmgren, *Mem. Dept.* Agric. (Ent.), 5 (3) : 149-150. Im., S. and W. *Type-loc.* : INDIA : Gurdaspur.
1981. *Odontotermes gurdaspurensis* : Thakur, *Indian For. Rec.*, 14 (2) : 59-63.

Material : (i) One vial with 6 S. and sev. W. from agric. field on Zeera road, *ca.* 12 km from Ferozepur, 22.xi.82. (ii) Four vials with sev. S. and W. from agr. field near P.S.E.B., Office, Ferozepur, 24.xi.82. (iii) Five vials with sev. S. & W. from roadside towards kotkapura, *ca.* 12 km from Ferozepur, 25.xi.82, *ex.* soil. (iv) One vial with 7 S. and sev. W, from vegetation near Thermal Power, Bhatinda, 28.xi.82, *ex.* understone. (v) Three vials with sev. S. and W. collected near Ranbir club, Sangrur, 5.xii.82, *ex.* understone. (vi) Two vials with sev. S. & W. from roadside on Malerkotla road, *ca.* 4 km from Sangrur, 6.xii.82. (vii) Three vials with sev. S. & W. from Hissar—Balsamand road, *ca.* 5 km from H.A.U., Hissar, 21.xii.82. (viii) One vial with 3 S. and sev. W. from Narnaul

road, *ca.* 6 km from Mahendragarh, 15.xii.82, *ex.* understone (ix) One vial with 4 S and sev. W from Dadri road, *ca.* 5 km from Mahendragrah, 16.xii.82, *ex.* understone.

Measurements : (One S. from Hissar) : Total body—length 6.06, length of head to lateral base of mandibles 1.58, max. width of head 1.33, length or left mandible 1.05, distance of tooth in left mandible from tip 0.42, max. width of pronotum 0.95. Antennal segments 16.

Distribution : *Previous records* : INDIA : Jammu ann Kashmir, Gujarat, Haryana, Himachal Pradesh, Madhya Pradesh, Punjab, Rajasthan and Uttar Pradesh. PAKISTAN : Baluchistan, Islamabad, Jhelum, Kohat, Kohore, Loralai, N.W.F.P., Peshawar, Rawalpindi. *Present record* : Punjab : Bhatinda, Ferozepur and Sangrur. Haryana : Hissar and Mahendragarh.

11. **Odontotermes indicus** Thakur

1981. *Odontotermes indicus* Thakur, *Indian For. Rec.*, 14 (2) : 70-75. Im., S. and W. *Type-loc* : INDIA : Bombay (Maharashtra).

Material : One vial with 4 S. and sev. W. from Banasar garden, Sangrur, 7.xii.82, *ex.* cow-dung.

Measurements (Five S. from Sangrur) : Total body-length 8·40-8·61, length of head to lateral base of mandibles 2·69-2·76, max. width of head 2·24-2·28, length of left mandible 1·47-1·51, distance of tooth in left mandible from tip 0·63, max. width of pronotum 1·61-1·65. Antennal segments 17.

Distribution : *Previous records* : This species is widely distributed throughout India, except the eastern zone. *Present record* : Punjab : Sangrur.

12. **Odontotermes latiguloides** Roonwal and Verma

1973. *Odontotermes latiguloides* Roonwal and Verma, *J. Indian Acad. Wood. Sci.*, 4 (2) : 81-91. S. and W. *Type*-loc. : INDIA : Mandalgarh (Bhilwara district), *ca.* 48 km SW of Bhilwara (Rajasthan).

1981. *Odontotermes latiguloides* : Thakur, *Indian For. Rec.*, 14 (2) : 81-83.

Material : One vial with 3 S. and sev. W. from vegetation near Thermal Power, Bhatinda, 28.xi. 82, *ex.* understone. (ii) One vial with 2 S. and sev. W. from Saina vill., *ca.* km from Bhatinda, 29.xi.82, *ex.* cow-dung. (iii) Two vials with sev. S. and W. from open land behind D. A. V. College, Bhatinda, 30.xi. 82, *ex.* cow-dung. (iv) Three vials with sev. S. and W. from Gobindpur vill., *ca.* 14 km from Bhatinda, 1.xii. 82, *ex.* understone. (v) Gne vial with 2 S. and sev. W from Banasar garden, Sangrur, 7.xii.82 *ex.* understone. (vi) Two vials with sev. S. and W. from Narnaul road, *ca.* 6 km from Mahendragarh, 15.xii.82, *ex.* cow-dung.

Measurements (two S. from Sangrur) : Total body-length with mandibles 4.27-4.34, length of head to lateral base of mandibles 1.05-1.09, max. Width of head 1.12, length of

left mandible 0·84, distance of tooth in left mandible from tip 0·28, max. width of pronotum 0·49-0·53. Antennal segments 16.

Distribution : *Previous records* : INDIA : Gujarat and Rajasthan. *Present record* : Punjab : Bhatinda and Sangrur. Haryana : Mahendragarh.

13. **Odontotermes lokanandi** Chatterjee and Thakur

1967. *Odontotermes lokanandi* Chatterjee and Thakur, *Indian For. Rec.*, **11** (1) : 38-41. S. and W. Type-loc. : INDIA : Residence plot area No. 6, near River Tawi, Jammu (Jammu and Kashmir.

1981. *Odontotermes lokanandi* : Thakur, *Indian For. Rec.*, 14 (2) : 84-86 ; 132-134.

Material : (i) One vial with 7 S. and 10 W. from agr. field, *ca.* 7 km from B & R Rest House, Ferozepur cantt., 21.xi.82 *ex.* soil. (ii) Two vials with sev. S. & W. from open land near Army store, Ferozepur cantt., 23.xi.82, *ex.* understone. (iii) Two vials with sev. S. and W. from vegetation near Thermal Power, Bhatinda, 28.xi.12, *ex.* understone. (iv) Two vials with sev. S. & W. from open land behind D. A. V. College, Bhatinda, 30.xi.82, *ex.* soil. (v) One vial with 2 S. and sev. W. from Gobindpur vill., Bhatinda, 1.xi.82, *ex.* understone. (vi) One vial with 5 S. & 10 W. from Narnual road, *ca.* 6 km from Mahendragarh, 15.xii.82 *ex.* soil.

Measurements (six S. from Mahendragarh) : Total body-length 3·92-4·06, length of head to lateral base of mandibles 1·05-1·12 max. width of head 1·02-1·05, length of left mandible 0·67. distance of tooth in left mandible from tip 0·14, max. width of pronotum 0·77 Antennal segments 16.

Distribution : *Previous records* : INDIA : Gujarat, Himachal Pradesh, Jammu and Kashmir and Uttar Pradesh. Very widely distributed in Pakistan and Bangladesh. *Present record* : Punjab : Bhatinda and Ferozepur. Haryana : Mahendragarh.

14. **Odontotermes microdentatus** Roonwal and Sen-Sarma

1960. *Odontotermes microdentatus* Roonwal and Sen-Sarma, *Indian Counc. Agric. Res.* (*Ent. Monogr. No. I*) : 33-39. Im., S. Tyoe-loc. : INDIA : Dehra Dun (Uttar Pradesh).

1981. *Odontotermes microdentatus* : Thakur, *Indian For. Rec.* 14 (2) : 92-97.

Material : One vial with 6 S. and sev. W. from Haryana Agr. Univ. farm, Hissar, 10.xii.82. *ex.* Termite mound.

Measurements : (five S. from Hissar) : Total body-length 4·90-5·04, length of head to lateral base of mandibles 1·40-1·54, max. width of head 1.12-1·19. length of left mandible 0·84, distance of tooth in left mandible from tip 0·21-0·25, max. width of pronotum 0·77. Antennal segments 16.

Distribution : *Previous records* : INDIA : Bihar, Gujarat, Himachal Pradesh, Madhya Pradesh and Uttar Pradesh. *Present record* : Haryana : Hissar.

15. **Odontotermes obesus** (Rambur)

1842. *Termes obesus* Rambur, *Hist. natur. Insects Neuroptera*, Paris : 304. Im. *Type-loc.* : INDIA : Bombay (Maharashtra).

1981. *Odontotermes obesus* : Thakur, *Indian For. Rec.*, 14 (2) : 100-107.

Material : (i) A vial with 5 S. & 13 W. from Muktsar road, *ca.* 6 km from B & R Rest House, Ferozepur cantt., 20.xi.82, *ex.* understone. (ii) Three vials with sev. S. & W. from agr. field, *ca.* 7 km from B & R Rest House, Ferozepur cantt., 21.xi.82, *ex.* soil- (iii) One vial with 3 S, & sev. W. from agr. field, *ca.* 12 km towards Zeera, Ferozepur, 22.xi.82, *ex.* soil. (iv) Two vials with sev. S. & W. from agr. field near P. S. E. B. Office, Ferozepur, 24.xi.82, *ex.* soil. (v) Two vials with sev. S. & W from roadside towards Kotkapura, *ca.* 12 ·km from Ferozepur, 25.xi.82, *ex.* understone. (vi) Three vials with sev. S. & W from vegetation near Thermal Power, Bhatinda, 28.xi.82. (vii) One vial with 6 S. ansd ev. W. from Govindpur vill., Bhatinda, 1.xii.80, *ex.* soil. (viii) One vial with 2 S. & Sev. W. from Barnala road, 1.xii.82, *ex.* understone. (ix) Two vials with sev. S & W. collected near Ranbir club, Sangrur, 5.xii.82. (x) Two vials with sev. S. & W. from Dhuri gate, Sangrur, 8 xii.82 (xi) Seven vials with sev. S. & W from experimental agr. farms, H. A. U. Hissar, 10.xii.82. *ex.* soil. (xii) Two vials with sev. S. & W. from Hissar-Balsamand road, *ca.* 5 km from H. A. U., Hissar, 11.xii82. (xiii) Four vials with sev. S. & W. from H. A. U. Campus, Hissar, 12.xii.82, *ex.* understone. (xiv) Two vials with sev. S. & W. from Nehru Stadium, Hissar, 13.xii.82, *ex.* ground. (xv) Two vials with sev. S. & W. from roadside on Mahendragarh-Narnaul road, *ca.* 6 km from P. W.D. Rest House, Mahendragarh, 15.xii.82. (xvi) Two vials with sev. S. & W. from Mahendragarh-Dadri road, *ca.* 5 km from Mahendragarh, 16.xii 82. (xvii) Seventeen vials with sev. S. & W. from juliflora vegetation behind Fort. Mahendragarh, 17.xii.82, *ex.* understone.

Measurements (One S. from Sangrur) : Total body-length 5·25, length of head to lateral base of mandibles 1·40, max. width of head 1·26 length of left mandible 0·98. distance of tooth *in* left mandible from tip 0·32. max. width of pronotum 0·98. Antennal segments 16.

Distribution : *Previous records* : This is the most common and widely distributed termite species, occurring all over India, Pakistan, Bangladesh and Burma. *Present records* : Punjab : Bhatinda, Ferozepur and Sangrur. Haryana : Hissar and Mahendragarh.

16. **Microtermes mycophagus** (Desneux)

1906. *Termes mycophagus* Desneux, *Ann. Soc. Ent. Belg.*, 49 (12) : 348-352. Im. S. & W. Type-loc. : PAKISTAN : Karachi (Sind).

Material : (i) One vial with 5 S. & sev. W. from agr. field near P, S. E. B. Office, Ferozepur, 24.xi.83, *ex.* soil. (ii) Two vials with sev. S. &. W. from vegetation near Thermal Power, Bhatinda, 28.xi.82. (iii) One vial with 2 S. & sev. W. from Saina vill. *ca.* 7 km from Bhatinda, 29,xi.82. (iv) One vial with 3 S. & sev. W. from open land

behind D. A. V. College, Bhatinda, 30.xi.82, *ex.* soil. (v) Two vials with sev. W. & S. from roadside towards Malerkotla, *ca.* 4 km from Sangrur, 6.xii.82. (vi) One vial with 2 S. & sev. W. from experimental agr. farms, H. A. U., Hissar, 10.xii.82. *cx.* soil. (vii) One vial with 1 S. & sev. W. from Satnali road, *ca.* 7 km from Mahendragarh, 17.xii.82.

Measurements (five S. from Ferozepur) : Total body-length 4·20-4·55, length of head to lateral base of mandibles 0·91-0·98, max. width of head 0·88-0·92, length of left mandible 0·56-0·61, max, width of pronotum 0·63-0·67. Antennal segments 15.

Distribution : Previous records : INDIA : Delhi, Gujarat, Rajasthan and Punjab. PAKISTAN : Sind, Punjab, N. W. F. P. and Baluchistan. *Present record* : Punjab : Bhatinda, Ferozepur and Sangrur. Haryana : Hissar and Mahendragarh.

17. **Microtermes obesi** Holmgren

1912. *Microtermes obesi* Holmgren, *J. Bombay nat. Hist. Sec.*, Bombay, 21 (3) : 787-788. Im. *Type-loc.* : INDIA : Khandala near Bombay (Maharashtra).

Material : (i) One vial with 3 S. & sev. W from agr. field, *ca.* 7 km from B & R Rest House, Ferozepur cantt., 21.xi.82. (ii) Two vials with sev. S. & W from open land near Army Store, Ferozepur cantt., 23 xi.82, *ex.* understone. (iii) Three vials with sev. S. & W. from vegetation near Thermal Power, Bhatinda, 22.xi.82. (iv) Five vials with sev. S. & W. from Saina will. *ca.* 7 km from Bhatinda, 29.xi.82. (v) Three vials with sev. S. & W. from open land behind D. A, V College, Bhatinda, 30.xi.82. (vi) One vial with 4 S. & sev. W. from Govindpur vill., Bhatinda, 1.xii.82. (vii) One vial with 2 S. & W. collected near Railway Station, Sangrur, 5.xii.82. (viii) One vial with 2 S. & 5 W. from roadside towards Malerkotla, *ca.* 4 km from Sangrur, 6.xii.82. (iv) Five vials with sev. S. & W. from roadside on Mahendragarh—Narnaul road, *ca.* 6 km from Mahendragarh., 15.xii.82. (x) Six vials with sev. S. & W. from Dadri road, *ca.* 5 km from Mahenpragarh, 16.xii.82. (xi) Three vials with sev. S. & W. from Satnali road, *ca.* 3 km from Mahendragarh, 17.xii.82, *ex.* soil.

Measurements (ten S. from Sangrur) : Total body-length 4·48-4·83, length of head to lateral base of mandibles 0·8I-0·91, max. width of head 0·77-0·84, length of left mandible 0·49-0·53, max. midth of pronotum 0·46-0·49. Antennal segments 14.

Distribution : *Previous records* : Widely distributed species recorded from all over India, Pakistan, Bangladesh, Sri Lanka, Bhutan, Burma and Thailand. *Present record* : Punjab : Bhatinda, Ferozepur and Sangrur. Haryana : Mahendragarh.

18. **Microtermes unicolor** Snyder

1933. *Microtermes unicolor* Snyder, *Proc. Biol. Soc.*, 46 : 92-93. Im. (dealated K & Q). *Type-loc.* : INDIA : Dehra Dun (Uttar Pradesh).

Material : (i) One vial with 5 S. & sev. W. from vegetation Near Thermal Power, Bhatinda, 28.xi.82. (ii) One vial with 3 S. & sev. W. from Banasar garden, Sangrur,

7.xii.82. (iii) One vial with 6 S. & sev. W. from vegetation along Satnali road, *ca.* 3 km from Mahendragarh, 17·xii.82.

Measurements (three S. from Mahendragarh) : Total body-length 3·92-4·41, length of head to lateral base of mandibles 0·88-0·91, max. width of head 0·81, length of left mandible 0·49, max. width of pronotum 0·49-0·53. Antennal segments 14.

Distribution : *Previous records* : INDIA : Gujarat, Himachal Pradesh, Jammu & Kashmir, Punjab, Rajasthan and Uttar Pradesh. Also recorded from Pakistan (Punjab, N. W. F. P. and Sind) and Bangladesh. *Present record* : Punjab : Bhatinda and Sangrur. Haryana : Mahendragarh

Subfamily (iv) NASUTITERMITINAE

19. **Trinervitermes biformis** (Wasmann)

1902. *Eutermes biformis* Wasmann, *Zool. Jahrab. Abt. Syst.*, Jena, 17 (1) : 133-135. Im., S. & W. *Type-loc.* : SRI LANKA : Bandarawalla and INDIA : Khandala, Bombay (Maharashtra).

Material : (i) One vial with sev. S & W. (major and minor from open land near P. S. E. B. Office, *ca.* 5 km from Ferozepur 24.xi.82, *ex.* soil. (ii) One vial with sev. S. & W. (major and minor) from roadside on Barnala road, *ca.* 4 km from Bhatinda, 2.xii.82, *ex.* soil. (iii) One vial with 4 S. & sev. W (major & minor) from Banasar garden. Sangrur, 7.xii.82, ex. soil. (iv) One vial with sev. S & W. (major & minor) from H. A. U. Campus, Hissar, 12.xii.82, *ex.* soil.

Measurements (five S. major from Hissar) : Total body-length 4·76-4·90, length of head without rostrum 1·40-1·47, max. width of head 1·33 1·37, max. posterior buldge of head 0·56-0·60, max width of pronotum 0·49-0·53. Antennal segments 13.

Distribution : *Previous records* : INDIA : Andhra Pradesh, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Rajasthan, Tamil Nadu and West Bengal. Also known from Pakistan and Sri Laaka. *Present record* : Bhatinda, Ferozepur and Sangrur. Haryana : Hissar.

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SUMMARY

Nineteen species of termites (Insecta : Isoptera) belonging to families Rhinotermitidae (2 species) and Termitidae (17 species) are reported from the arid areas of Punjab and Haryana. All are new records from this portion of the Thar Desert.

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GRYLLIDAE (INSECTA : ORTHOPTERA) FROM JAVADI HILLS, TAMIL NADU, INDIA

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Javadi Hills in the North Arcot District of Tamil Nadu remained unsurveyed for unknown reasons until the Zoological Survey of India began surveying it in October, 1982. No species of the Family Gryllidae has so far been recorded from the Javadi Hills. The present paper deals with collections made largely during the February-March, 1983 survey in which the present author participated. One species is recorded here for the first time from India, in addition to 12 other species belonging to 10 genera.

Javadi Hills lie in the rain-shadow area of the Eastern Ghats complex. The hills are mainly undulating, with a few peaks. They enjoy a moderate to cool climate almost throughout the year, and winters tend to be very cold. Day temperature in summer ranges around 32°-35°C, while that in winter may be about 20°C or less. Winter nights are quite chill, with the temperature touching 15°C or less. Rainfall in Javadi Hills, which is contributed by both SW and NE monsoons, ranges between 850 and 900 mm, and is equally distributed.

The kinds of soil met with in the Javadi Hills are sandy, red loam and Kalleri soil. Tropical dry evergreen forest and dry deciduous forest are met with, especially in the Veerappanur and Pattaraikkadu Reserved Forest areas, from where most of the Gryllid collections were made.

I. Subfamily : GRYLLINAE

1. **Gryllus bimaculatus** De Geer

1773. *Gryllus bimaculatus* De Geer, *Mem. Ins.*, 3 : 521.
1961. *Gryllus bimaculatus*, Chopard, *Eos*, 37 : 269.
1967. *Gryllus bimaculatus*, Chopard, *Orth. Cat.*, 10 : 49.
1969. *Gryllus bimaculatus*, Chopard, *Fauna Ind. Grylloidea*, 2 : 35.

Material examined : Tamil Nadu : N. Arcot Dist. : 1 ♀, Pudur (Pattaraikkadu)—alt. 580 m, 5.iii.1983 (*M. Vasanth* coll.).

Distribution : INDIA : Arunachal Pradesh, Meghalaya, Sikkim, W Bengal, Bihar, Uttar Pradesh, Himachal Pradesh, Punjab, Jammu & Kashmir, Rajasthan, Gujarat, Maharashtra, Madhya Pradesh, Karnataka, Andhra Pradesh, Tamil Nadu, Pondicherry,

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S. Andaman and Nicobar Islands ; PAKISTAN ; SRI LANKA ; BURMA ; MALAYSIA ; SINGAPORE ; NEPAL ; Tropical Africa.

Remarks : This widely distributed species has been recorded earlier from other localities in Tamil Nadu (Palni and Nilgiri Hills, Tiruchirapalli, Coimbatore). It does not appear to be very abundant in Javadi Hills. The lone female specimen collected was found below a large rock where the soil was very wet.

2. **Gryllodes sigillatus** (Walker)

1869. *Gryllus sigillatus* Walker, *Cat. Derm. Salt. Br. M.*, 1 : 46.
1877. *Gryllodes sigillatus*, Saussure, *Mem. Soc. Geneve*, 25 : 210.
1967. *Gryllodes sigillatus*, Chopard, *Orth. Cat.*, 10 : 108.
1969. *Gryllodes sigillatus*, Chopard, *Fauna Ind. Grylloidea*, 2 : 85.

Material examined : Tamil Nadu : N. Arcot Dist. : 1♂, 2♀, Kanaru stream-alt. *c* 510 m, 26.ii.1983 ; 1♂, 1♀, Vannanthurai-alt. 590 m, 27.ii.1983 (*M. Vasanth* coll.).

Distribution INDIA : Assam, Meghalaya, Manipur, W Bengal, Bihar, Orissa, Uttar Pradesh, Himachal Pradesh, Jammu & Kashmir, Punjab, Rajasthan, Maharashtra, Madhya Pradesh, Karnataka, Kerala, Andhra Pradesh, Tamil Nadu, Andaman and Nicobar Islands ; SRI LANKA ; MALAYSIA ; PAKISTAN.

Remarks : Vasanth (in press) has recorded this speeies for the first time from Meghalaya and Manipur. In Tamil Nadu this species has so far been recorded from Madurai, Nilgiri and Palni Hills.

3. **Platygryllus brunneri** (Saussure)

1877. *Gryllus brunneri* Saussure, *Mem. Soc. Geneve*, 25 : 170.
1961. *Platygryllus brunneri*, Chopard, *Eos*, 37 : 276.
1964. *Platygryllus brunneri*, Randell, *Canad. Ent.*, 96 : 1598.

Material examined : Tamil Nadu : N. Arcot Dist. : 1♂, 1♀, Theerthakanaru Odugathur-alt. 410 m, 21.iv.1984 (*K. R. Rao & pty.* coll.) ; 2♂, 3♀, Kanaru stream-alt. *c* 510 m, 26.ii.1983 ; 8♂, 11♀, Vannanthurai-alt. 590 m, 27.ii.1983 ; 4♂, 3♀, Motlapattu-600 m, 26.ii.1983 ; 8 ♂, 11♀, Vannanthuria alt. 590m, 22.ii.1983 ; 4♂, Kondikalluru-alt. 580 m, 6.iii.1983 ; 8♂, 3♀, Bheemamaduvu-alt. 500 m, 24.ii.1983 & 1.iii.1983 (*M. Vasanth* coll.).

Distribution : INDIA : Bihar, Orissa, Uttar Pradesh, Himachal Pradesh, Rajasthan, Madhya Pradesh, Tamil Nadu ; BANGLADESH ; MOROCCO.

Remarks : This is, by far, the most abundantly represented species in the Javadi Hills collections, and is recorded for the first time from Eastern ghats. South of Madhya Pradesh, it has been recorded only from Coimbatore in Tamil Nadu. A large population of this species was existant at Vannanthurai during the end of February, 1983, under dry leaf litter, and in cracks in the caking mud. At this spot no other Gryllid species was available in the leaf litter.

4. **Modicogryllus confirmatus** (Walker)

1859. *Acheta confirmata* Walker, *Ann. Mag. nat. Hist.*, (3) 4 : 221.
1869. *Gryllus confirmatus*, Walker, *Cat. Derm. Salt. Br. M.*, 1 : 371.
1961. *Modicogryllus confirmatus*, Chopard, *Eos*, 37 : 272.
1967. *Modicogryllus confirmatus*, Chopard, *Orth. Cat.*, 10 : 80.

Material examined : Tamil Nadu : N. Arcot Dist. : 3♂, Bheemamaduvu-alt. 500 m, 1.iii.1983 ; 3♂, 2♀, Kanaru stream-alt. 510 m, 26.ii.1983 & 9.iii.1983 ; 2♂, 2♀, Vannanthurai-alt. 590 m, 27.ii.1983 ; 4♂, 1♀, Motlapattu-alt. 600 m, 25.ii.1983 ; 1♂, Madikkaru-alt.600 m, 28.ii.1983 (*M. Vasanth* coll.).

Distribution : INDIA : Assam, Arunachal Pradesh, Meghalaya, Manipur, W Bengal, Bihar, Orissa, Uttar Pradesh, Haryana, Rajasthan, Maharashtra, Madhya Pradesh, Karnataka, Tamil Nadu, Andaman and Nicobar Islands ; NEPAL ; BANGLADESH ; BURMA ; SRI LANKA ; PAKISTAN ; MALAYSIA ; THAILAND ; CHINA ; IRAN.

Remarks : Earlier, this species was known only from Madurai in Tamil Nadu.

5 **Teleogryllus mitratus** (Burmeister)

1838. *Gryllus mitratus* Burmeister, *Handb. Ent.* 2 : 34.
1869. *Gryllus testaceus*, Walker, *Cat. Derm. Salt. Br. M.*, 1 : 38 (Primary homonym of *Gryllus testaceus* De Geer, 1773).
1961. *Teleogryllus testaceus*, Chopard, *Eos*, 37 : 277.
1980. *Teleogryllus mitratus*, Townsend, *J. nat. Hist.*, 14 : 158.

Material examined : Tamil Nadu : N. Arcot Dist. : 3 ♂, 2 ♂, 4 nymphs, Pudur (Pattaraikkadu) -alt. 580 m, 5.iiii.1983 ; 7 ♂, 2 nymphs, Vannanthurai -alt. 590 m, 27. ii. 1983 ; 2 ♀, Kanaru stream-alt. *c* 510 m, 26.ii.1983 ; 1 ♂ 4 nymphs, Kondikalluru alt. 580 m, 6.iii.1983 ; 2 ♂, 1 ♀, Motlapattu - alt. 600 m, 25.ii.1983 (*M. Vasanth* coll.).

Distribntion : INDIA : Meghalaya, Assam, W. Bengal, Bihar, Orissa, Uttar Pradesh, Madhya Pradesh, Karnataka, Tamil Nadu, Kerala, Andaman and Nicobar Islands ; SRI LANKA ; NEPAL ; BURMA ; MALAYSIA ; SINGAPORE ; INDONESIA ; THAILAND ; BORNEO ; INDO-CHINA ; PHILIPPINES ; TENASSERIM ; CHINA ; VIETNAM.

Remarks : Practically all the specimens were collected from the wet soil under large rocks embedded in dry stream beds.

The present species is actually what was earlier known as *Teleogryllus testaceus* (Walker) (*vide* Townsend, 1980).

In Tamil Nadu, the present species has so far been recorded from Tiruchirapalli and Coimbatore. Its present record from Javadi Hills is, perhaps, the first from the eastern ghats.

6. **Velarifictorus asperus** (Walker)

1869. *Gryllus aspersus* Walker, *Cat. Derm. Salt. Br. M.*, 1 : 39.
1931. *Scapsipedus aspersus*, Chopard, *Bull. Raffles Mus.*, 6 : 130.
1964. *Velarifictorus aspersus*, Randell, *Canad. Ent.*, 96 : 1587.

Material examined : Tamil Nadu : N. Arcot Dist. : 2 ♂, Pattaraikkadu, 8.iii.1983 (*M. Vasanth* coll.).

Distribution : INDIA : Arunachal Pradesh, Meghalaya, W. Bengal, Uttar Pradesh, Jammu, Andhra Pradesh, Maharashtra, Karnataka, Tamil Nadu ; SRI LANKA ; BURMA ; MALAYSIA : SINGAPORE ; INDONESIA (Java) ; BORNEO ; ANNAM ; HONG KONG ; CHINA.

Remarks : The two specimens were collected from a crack in caking mud made moist by water trickling from a water pump nearby. They were located by their calling sound. Interestingly, neither of the specimens has excavated mandibles as is usually seen in the males of the species.

Vasanth (in press) has recorded it for the first time from Tamil Nadu.

II. Subfamily : NEMOBIINAE

7. **Pteronemobius fascipes** (Walker)

1869. *Eneoptera fascipes* Walker, *Cat. Derm. Salt. Br. M.*, 1 : 67.
1931. *Pteronemobius fascipes*, Chopard, *Bull. Raffles Mus.*, 6 : 134.
1967. *Pteronemobius fascipes*, Chopard, *Orth. Cat.*, 10 : 169.

Material examined : Tamil Nadu : N. Arcot Dist : 2 ♂, 1 ♀, Kondikalluru -alt. 580 m, 6.iii.1983 ; 2 ♂, 1 ♀, Kanaru stream -alt. *c* 510 m, 26.ii.1983 ; 1 ♂ (head missing), 3 ♀, Bheemamaduvu -alt. 500 m, 1.iii.1983 (*M. Vasanth* coll.).

Distribution : INDIA : Assam, Manipur, Arunachal Pradesh, Meghalaya, W. Bengal, Sikkim, Bihar, Orissa, Uttar Pradesh, Himachal Pradesh, Haryana, Jammu & Kashmir, Maharashtra, Goa, Madhya Pradesh, Karnataka, Kerala, Tamil Nadu ; SRI LANKA ; SINGAPORE ; BURMA ; INDONESIA (Java).

Remarks : The present species is distributed virtually throughout the Indian Union. The earlier records of this species from Tamil Nadu are from Tindivanam and Tiruchirapalli.

8. **Pteronemobius taprobanensis** (Walker)

1869. *Trigonidium taprobanense* Walker, *Cat. Derm. Salt. Br. M.*, 1 : 102.
1924. *Pteronemobius javanus*, Chopard, *Rec. Ind. Mus.*, 26 : 182.
1925. *Pteronemobius taprobanensis*, Chopard, *Ann. Mag. nat. Hist.*, (9) 15 : 507.
1969. *Pteronemobius taprobanensis*, Chopard, *Fauna Ind. Gryllodea*, 2 : 163,

Material examined : Tamil Nadu : N. Arcot Dist. : 1 ♀, Kondikalluru -alt. 580 m, 6.iii.1983 (*M Vasanth* coll.).

Distribution : INDIA : Arunachal Pradesh, Assam, Manipur, Meghalaya, W. Bengal, Bihar, Orissa, Madhya Pradesh, Rajasthan, Maharashtra, Tamil Nadu, Andaman and Nicobar Islands ; BANGLADESH ; SRI LANKA ; BURMA ; MALAYSIA ; INDONESIA.

Remarks : This is the first record from the Eastern ghats. It was earlier recorded

from the Western ghats (Nilgiris in Tamil Nadu). Vasanth (in press) recorded it first from Manipur and Meghalaya.

9. **Paranemobius pictus** (Saussure)

1877. *Pseudonemobius pictus* Saussure, *Mem. Soc. Geneve.* 25 : 67.
1925. *Paranemobius pictus*, Chopard, *Ann. Mag. nat. Hist.*, (9) 15 : 506.
1969. *Paranemobius pictus*, Chopard, *Fauna Ind. Grylloidea*, 2 : 174.

Material examined : Tamil Nadu : N. Arcot Dist. : 3 ♂, 3 ♀, 4 nymphs, Bheemamaduvu -alt. 500 m, 24.ii.1983 ; 1 ♀, Vannanthurai -alt. 590 m, 27.ii.1983 ; 2 ♂, 5 ♀, 3 nymphs, Kanaru stream -alt. *c* 510 m, 26.ii.1983 & 9.iii.1983 (*M Vasanth* coll.).

Distribution : INDIA : Bihar, Madhya Pradesh, Maharashtra, Kashmir, Karnataka, Kerala, Tamil Nadu ; SRI LANKA.

Remarks : This agile, moisture-loving Nemobiine was collected from boulders in streams, where large populations of several age-groups were found accumulated on the face of the boulder near stagnant water. In one locality, i.e. Bheemamaduvu, a good number of them was found on the walls of a pit containing stagnant water. The species was so far unknown from the Eastern ghats, although there are records from Western ghats.

III. Subfamily : OECANTHINAE

10. **Oecanthus indicus** (Saussure)

1878. *Oecanthus indicus* Saussure, *Mem. Soc. Geneve*, 25 : 454.
1966. *Oecanthus indicus*, T. J. Walker, *Florida Ent.*, 49 (4) : 268.
1968. *Oecanthus indicus*, Chopard, *Orth. Cat.*, 12 : 432.

Material examined : Tamil Nadu : N. Arcot Dist. : 1 ♀, Vannanthurai -alt. 590 m, 27.ii.1983 (*M. Vasanth* coll.).

Distribution : INDIA : Arunachal Pradesh, Assam, Meghalaya, W. Bengal, Bihar, Orissa, Madhya Pradesh, Maharashtra, Karnataka, Tamil Nadu, Andaman Islands ; SRI LANKA ; MALAY ARCHIPELAGO ; PHILIPPINES.

Remarks : The single female specimen of the present species was collected from an *Ipomea* plant (Fam : Convolvulaceae).

This species, and the subfamily to which it belongs, were first recorded from Assam and Meghalaya by Vasanth (in press), The previous records of this species from Tamil Nadu are from the Nilgiris, Kodaikanal and Coimbatore.

IV. Subfamily : TRIGONIDIINAE

11. **Anaxipha rufonotata** Chopard

1931. *Anaxipha rufonotata* Chopard, *Ark. Zool.*, (A) 23, No. 9 : 12.
1969. *Anaxipha rufonotata*, Chopard, *Fauna Ind. Grylloidea*, 2 : 279.

Material examined : Tamil Nadu : N. Arcot Dist. : 1 ♂, Bheemamaduvu -alt. 500 m, 24.ii.1983 (*M. Vasanth* coll.).

Distribution : INDIA : Tamil Nadu ; MALAYSIA ; MDONESIA (Sumatra).

Remarks : The present species is recorded for the first time from India. Its earlier records are from Sumatra, from where it was originally described, and Malaysia.

Although the genitalia of the specimen studied is identical with that figured by Chopard (1969), the four reddish lines on the head, and the row of reddish spots on the posterior margin of the pronotum which, apparently, have given the species its name, are absent. The present specimen is quite akin to *A. longipennis* (Serville) in its external characteristics. It is micropterous.

12. **Trigonidium cicindeloides** Rambur

1839. *Trigonidium cicindeloides cicindeloides* Rambur, *Faune Andal*, 2 : 39.
1968. *Trigonidium cicindeloides*, Chopard, *Orth. Cat.*, 12 : 340.

Material examined : Tamil Nadu : N. Arcot Dist. : 2 ♀, Odugathur, Utharakaveri Aru-alt. 300 m, 23.iv.1984 (*K. R. Rao* and *G. Thirumalai* coll.) ; 1 ♂, 1 ♀, Kondikalluru alt. 580 m, 6.iii.1983 (*M. Vasanth* coll.).

Distribution : INDIA : Assam, Arunachal Pradesh, Meghalaya, Manipur, Mizoram, W. Bengal, Bihar, Orissa, Himachal Pradesh, Maharashtra, Goa, Karnataka, Tamil Nadu, Andaman Islands ; SRI LANKA ; NEPAL ; BURMA ; MALAYSIA ; widely distributed from S. Europe to S. Asia and all ovcr Africa.

Remarks : There is a view among a section of modern Gryllid-taxonomists that the present species and the following one, *viz.*, *T. humbertianum* (Saussure) should be regarded merely as two subspecies of *T. cicindeloides* Rambur. The present author also subscribes to this view as it is felt that the differences between the two species are not only too insignificant, but also limited to a few external characters, the genitalia being identical.

13. **Trigonidium humbertianum** (Saussure)

1878. *Homoeoxiphus humbertianum* Saussure, *Mem. Soc. Geneve*, 25 : 468.
1925. *Trigonidium humbertianum*, Chopard, *Ann. Mag. nat. Hist.*, (9) 15 : 525.
1968. *Trigonidium cicindeloides humbertianum*, Chopard, *Orth. Cat.* 12 : 342.

Material examined : Tamil Nadu : N. Arcot Dist. : 1 ♀, Odugathur, Utharakaveri Aru-alt. 300 m, 23.iv.1984 (*K. R. Rao* and *G. Thirumalai* coll.) ; 1 ♂, 1 ♀, Vannanthurai alt. 590 m, 27.ii.1983 (*M. Vasanth* coll.).

Distribution : INDIA : Arunachal Pradesh, Assam, Manipur, Meghalaya, W. Bengal, Bihar, Orissa, Madhya Pradesh, Gujarat, Maharashtra, Kerala, Tamil Nadu ; SRI LANKA ; MALAYSIA ; widely distributed in the Oriental Region.

Remarks : This species has been hitherto recorded from only one locality in Tamil Nadu, *viz.*, Coimbatore. It was first recorded from Arunachal Pradesh, Manipur and Meghalaya by Vasanth (in press).

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RECORDS OF MOSQUITOES (DIPTERA : CULICIDAE) FROM MANIPUR GENUS—CULEX

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INTRODUCTION

The genus *Culex* is of immense medical importance because it includes certain proved vectors i.e. *Culex quinquefasciatus* for bancroftian filariasis and *C. tritaeniorhynchus* for Japanese encephalitis. In addition to it, some members *viz.*, *C. gelidus*, *C. fuscocephala*, *C. vishnui*, and *C. pseudovishnui* have been proved to be probable or potential vectors of Japanese encephalitis.

The mosquito-borne diseases are on increase in India, and the state of Manipur remained no exception to it. The state faced an epidemic of Japanese encephalitis during 1982 (Chakraborty *et al.*, 1984). Inspite of continuance of the fatal cause of these diseases in the state, the genus *Culex* was not studied earlier with due precision. The recorded number of species under the genus stands at 11 (Malhotra *et al.*, 1983).

In view of the above, periodic surveys were made during 1983 to 1985 from far and wide localities of the state. The present communication deals with the distribution records of the genus *Culex* in the state. The methods used for collection, rearing procedure, and topographic description & climate of the study area have been presented earlier (Rajput and Singh, 1986). The identification was made mainly on the basis of adult characters, but the genital characters and characters of immatures were also taken into consideration whenever those forms were available. The present work follows Barraud (1934), Bram (1967), Reuben (1969) and Sirivanakarn (1276, 1977a & b) for identification ; Knight and Stone (1977) for classification & nomenclature.

Collection Recards :

1. **Culex bitaeniorhynchus** Giles

Culex bitaeniorhynchus Giles, 1901, *J. Bomb. Nat, Hist. Soc.* 13 : 607 ; Barraud, 1934 : 391-394 ; Knight and Stone, 1977 : 203.

The species has its wide range of distribution in Oriental, Palearctic, Ethiopian and Australian region. Recorded from all over India.

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Present records : Manipur : *Canchipur* (785 m.)—24 —♂. 33 ♀ ♀, (2 Oct. '84) larvae were reared from a paddy-field. *Chandel* (1,500 m.)—1 ♂ 1 ♀ (22 Oct. '85) from forest-vegetation. *Chingmeirong* (785 m.)—2 ♂♂ (11 Sept. '83-29 Nov. '83), 29 ♂♂, 17 ♀ ♀ (27 Jun. '84—14 Oct. '84) were collected from shrubby vegetation ; 1 ♀ (15 Mar. '84) larva was reared from a pond. *Geljang* (850 m.)—1 — (27 Nov. '84) from shrubby vegetation. *Khongampat* (785 m.)—2 ♂♂, 1 ♀ (27 Nov. '83), 18 ♂♂, 16 ♀ ♀ (12 Aug. '84) from herb vegetation ; 1 ♂, 2 ♀ ♀ (12 Aug. '84) larvae were reared from a paddy fields. *Khurkhul* (830 m.)—1 ♂, 1 ♀ (29 Jan. '84) from herb vegetation. *Langol-hill* (785 m.)—1 ♂ (29 Jul. '84) from pit-shelter in a drain. *Mantripukhri* (785 m.)—2 ♀ ♀ (7 Nov. '83—19 Nov. '83), 5 ♂♂ (27 Jul '84—14 Oct. '84) attracted over bulb-light ; 3 ♀ ♀ (9 Jul '84—26 Jul. '84) from bovine-bait ; 2 ♀ ♀ (10 Jul. '84—22 Aug. '84) from cattle-shed ; 1 ♀ (27 Jul. '84) from human-bait. *Moreh* (150 m.)—2 ♂♂, 1 ♀ (18 Aug. '84) from shrubby vegetation ; 3 ♂♂ (18 Aug. '84) from human-bait ; 1 ♂ (19 Aug. '84) from nala margin-groove in forest ; 1 ♂, 3 ♀ ♀ (19 Aug. '84) from herb vegetation. *Pheidinga* (900 m.)—1 ♀ (12 Aug. '84) from shrubby vegetation. *Tamenglong* (1,200 m.)—1 ♀ (8 Sept. '84) from shrubby vegetation. Associative breeders were *Anopheles nigerrimus*, *A. annularis* and *Culex pseudovishnui*.

2. **Culex edwardsi** Barraud

Culex edwardsi Barraud, 1923, *Indian. J. Med. Res.* 11 : 507 ; Barraud, 1934 : 397-398 ; Knight and Stone, 1977 : 207.

The species has its range of distribution in Oriental and Australian region. From India, it has been reported from Madhya Pradesh, Manipur, Meghalaya and Tamil Nadu.

Present records : Manipur : *Langol-hill* (850 m.)—1 ♂ and 1 ♀ (26 Jan. '84) from herb vegetation and pit-shelter respectively ; 1 ♂, 1 ♀ (19 Feb. '84) from shrubby vegetation. *Mantripukhri* (785 m.)—1 ♂, 1 ♀ (13 Feb. '84) from herb vegetation. *Pheidinga* (900 m.)—3 ♂♂ (29 Jan. '84) from herb vegetation.

3. **Culex epidesmus** (Theobald)

Taeniorhynchus epidesmus Theobald, 1910, *Rec. Indian Mus.* 4 ; 22 : Barraud, 1934 : 389-391 ; Knight and Stone, 1977 : 207.

This is an Oriental species recorded from all over India, Bangladesh, Nepal, Pakistan and Sri Lanka.

Present records : Manipur : *Chingmeirong* (785 m.)—1 ♀ (11 Sept. '83) from shrubby vegetation. *Jiribam* (150 m.)—1 ♂ (7 Oct. '84) from bovine-bait.

4. **Culex fuscocephala** (Theobald)

Culex fuscocephala Theobald, 1907, *Monogr. Cul.* 4 : 420 ; Barraud, 1934 : 424-426 ; Knight and Stone, 1977 : 208.

The species is known from Oriental and eastern parts of Palearctic region. It has been recorded from all over Indian region.

Present records : Manipur : *Boljang* (775 m.)—1 ♂ (8 Oct. '83) from shrubby forest. *Bungmul* (850 m.)—2 ♀ ♀ (27 Nov. '84) from herb vegetation. *Chingmeirong* (785 m.)—16 ♂♂, 6 ♂♂ (11 Sept. '83—4 Dec. '84), 49 ♂♂, 24 ♀ ♀ (22 Jan. '84—25 Sept. '84) from shrubby vegetation of *Quercus acutissima* ; 3 ♀ ♀ (7 Jan. '84) from herb vegetation ; 10 ♂♂, 8 ♀ ♀ (10 Oct. '83) larvae were reared from a road side pool ; 2 ♂♂, 1 ♀ (14 Oct. '83) larvae reared from a rainy-pit ; 23 ♂♂, 19 ♀ ♀ (23 Oct. '83) larvae were reared from cart-trac ; 1 ♂ (6 Nov. '83) larvae reared from Foot-prints. *Churachandpur* (850 m.)—1 ♂, 1 ♀ (8 Oct. '83) larvae were reared from road side pool. *Gwaltabi* (785 m.)—1 ♂, 2 ♀ ♀ (19 Nov. '84) from shrubby vegetation. Jiribam (150 m.)—4 ♀ ♀ (7 Oct. '84) from bovine-baits. *Khongampat* (785 m.)—1 ♂ (27 Nov. '83), 9 ♂♂, 1 ♀ (12 Aug. '84) from herb vegetation. *Khongsong* (650 m.)—1 ♀ (9 Sept. '84) larva was reared from road-side rainy pool. *Koubru-leikha* (1, 040 m.)—1 ♂ (12 Aug. '84) from shrubby vegeta tion. *Kwakta* (760 m.)—3 ♂♂, 5 ♀ ♀ (8 Oct. '83) from shrubby vegetation. *Mantripukhri* (785 m.)—16 ♀ ♀ (21 Oct. '83—4 Dec. '83) from cattle-shed ; 14 ♀ ♀ (23 Oct. '83—29 Nov. '83), 34 ♀ ♀ (8 Apr. '84—14 Oct. '84) from human-bait ; 1 ♀ (7 Nov. '83), 2 ♂♂, 28 ♀ ♀ (13 Mar. '84—21 Oct. '84) attracted to bulb-light ; 90 ♀ ♀ (14 Nov. '83—26 Nov. '83), 567 ♀ ♀ (25 Feb. '84—29 Oct. '84) from bovine-baits ; 2 ♀ ♀ (28 Nov. '83) from human dwellings. *Mao* (1, 850 m.)—1 ♂, 1 ♀ (8 Sept. '85) larvae reared .from rainy-pool. *Moreh* (150 m.)—3 ♀ ♀ (18 Aug. '84) from human-bait ; 8 ♂♂, 9 ♀ ♀ (18 Aug. '84) larvae reared from road-side rainy pits ; 1 ♀ (19 Aug. '84) larvae reared from a rainy pool in forest. *Nungba* (750 m.)—1 ♀ (8 Oct. '84) from bovine-bait. Tamenglong (1, 200 m.)—1 ♀ (8 Sept. '84) from bovine-bait. *Tongou-Lonkoy* (820 m.)—1 ♂, 1 ♀ 9 Ju. '84) from herb vegetation. *Zaphou* (1,000 m.)—2 ♀ ♀ (21 Oct. '85—22 Oct. '85) from human-bait. Associative breeders were *Anopheles nigerrimus*, *A. kochi*, *A. vagus*, *Aedes caecus* and *Culex pseudovishuni*.

5. **Culex gelidus** Theobald

Culex gelidus Theobald, 1901, *Monogr. Cul* : 20 ; Barraud, 1934 : 407-409 ; Knight and Stone. 1977 : 209.

This species was known to be distributed in Oriental region, South and South-Western palearctic region. It also extends upto New Guinea in Australian region. Recorded from all-over India.

Present records : Manipur : *Bungmul* (850 m.)—1 ♀ (27 Nov. '84), from herb vegetation. *Chingmeirong* (785 m.)—52 ♂♂, 34 ♀ ♀, (11 Sept. '83—4 Dec. '83), 33 ♂♂,

27 ♀ ♀ (9 Jun. '84—25 Sept. '84) from shrubby vegetation. *Jiribam* (150 m.)—1 ♀ (7 Oct. '84) and 1 ♀ (7 Oct. '84) from herb vegetatian and bovine-bait respectively. *Khonghampat* (785 m.)—2 ♂♂, 1 ♀ (10 Sept. '83) from herb vegetation. *Mantripukhri* (785 m.)—18 ♀ ♀ (12 Sept. '83—31 Oct. '83), 3 ♀ ♀ (15 Sept. '84—15 Oct. '84) collected from cattle-shed ; 5 ♀ ♀ (11 Oct. '83--13 Nov. '83), 1 ♀ (14 Jul. '84), 4 ♂♂, 28 ♀ ♀ (11 Jul. '84—21 Oct. '84) attracted to bulb-light ; 4 ♀ ♀ (23 Oct. '83—30 Oct. '83), 2 ♀ ♀ (27 Jul. '84—14 Oct. '84) from human bait ; 14 ♀ ♀ (14 Nov. '83), 501 ♀ ♀ (10 Ju. '84—29 Oct. '84) from bovine baits. *Moreh* (150 m.)—1 ♀ (19 Aug. '84) from shrubby forest. *Tongou-Lonkoy* (820 m.)—1 ♀ (9 Jul. ,84) from herb vegetation.

6. **Culex hutchinsoni Barraud**

Culex hutchinsoni Barraud, 1924, *Indian J. Med. Res.* 11 : 1261 ; Barraud, 1934 : 423-424 ; Knight and Stone, 1977 : 210.

The species has its range of distribution in Oriental region only. In India, it has been recorded from Manipur and Meghalaya.

Presents records : Manipur : *Khongampat* (785 m.)—2 ♂♂ (16 Dec. '84) from herb vegetation.

7. **Culex infula** Theobald

Culex infula Theobald. 1901, *Monogr. Cul.* 1 : 370 ; Sirivanakarn, 1976, 12 (2) : 71-75 : Knight, 1978 : 43-44.

The species comes under the category of Oriental endemic fauna. The species has been recorded from Assam, Maharashtra and Manipr.

Present records : Manipur : *Chingmeirong* (785 m.)—2 ♂♂, 1 ♀ (22 Aug. '84) from shrubby vegetation.

8. **Culex mimulus** Edwards

Culex mimulus Edwards, 1915, *Bull. Ent. Res-* 5 : 284 ; Barraud 1934 : 412 ; Knight and Stone, 1977 : 212.

This species has its range of distribution in Oriental, Palearctic and Australian region. It has been recorded from all over India.

Present records : Manipur : *Khurkhul* (830 m.)—1 ♂ (29 Jan. '84), from herb vegetation. *Langol·hill* (785 m.)—1 ♀ (19 Feb. '83) from shrubby vegetation. *Mantri-pukhri* (785 m.)—2 ♂♂ (25 Mar. '84) larvae reared from pond margin. *Moreh* (150 m.)—1 ♂, 6 ♀ ♀ (19 Aug. '84) larvae reared from rainy-pool in forest. *Nungba* (750 m.)—20 ♂♂, 9 ♀ ♀ (9 Oct. '84-8 Oct. '84) larvae reared from rainy-pool. *Tamenglong* (1, 200 m.)—3 ♂♂ (8 Sept. '84) from shrubby forest· Associated breeders were *Anopheles nigerrimus*,

A. annularis, *A. maculatus*, *A. maculatus* var. *willmorei*, *Aedes caecus* and *Culex pseudovishnui*.

9. **Culex pseudovishnui** Colless

Culex pseudovishnui Colles, 1957, *Ann. trop. Med. Parasit :* 51 ; Sirivanakarn, 1976, 12 (2) : 116 ; Knight and Stone, 1977 : 221.

This species has been recorded to be distributed all over Orient. It is recorded to be widely distributed all over India.

Present records : Manipur : *Boljang* (775 m.)—2 ♂♂ (8 Oct. '83) from shrubby forest. *Bullian* (775 m.)—2 ♀♀ (8 Oct. '83) from shrubby forest. *Chandel* (1,500 m.), 1 ♂, 2 ♀♀ (22 Oct. '85) from forest vegetation. *Chingmeirong* (785 m.)—109 ♂♂, 310 ♀♀ (11 Sept. '83—4 Dec. '13), 179 ♂♂, 85 ♀♀ (25 Mar. '84—14 Oct. '84) collected from shrubby vegetation of *Quercus acutissima* ; 2 ♂♂, 1 ♀ (14 Oct. '83), 1 ♂ (25 Mar. '84) larvae were reared from rainy pits, 1 ♀ (14 Oct. '83) from road side pool ; 1 ♀ (6 Nov. '83) from foot-prints ; 34 ♂♂, 33 ♀♀ (15 Mar. '84-15 Oct. '84) reared from larvae from pond margins. *Geljang* (850 m.)—1 ♂, 2 ♀♀ (27 Nov. '84) larvae reared from a muddy-pit. *Gwaltabi* (785 m.)—2 ♂♂, 1 ♀ (19 Nov. '14) from shrubby vegetation. *Jiribam* (150 m.)—1 ♂, 2 ♀♀ and 1 ♀ (7 Oct. '84) from herb vegetation and bovine-bait respectively. *Kanglatongbi* (790 m.)—2 ♀♀ (12 Aug. '84) from herb vegetation. *Khongampat* (785 m.)—25 ♂♂, 4 ♀♀ (27 Nov. '83), 3 ♂♂, 2 ♀♀ (29 Jan. '84-12 Aug. '84) from herb vegetation. *Koubru-leikha* (1,040 m.)—3 ♂♂ (12 Aug. '84) from shrubby vegetation. *Kwakta* (760 m.)—3 ♂♂. 8 ♀♀ (8 Oct. '83) from mulberry shrubs. *Langol-hill* (785 m.)—5 ♂♂ (26 Jan. '84-29 Jul. '84) from pit shelters. *Mantripukhri* (785 m.)—15 ♀♀ (2 Oct. '83-31 Oct. '83), 5 ♀♀ (15 Sept. '84-15 Oct. '84) from cattle-shed, 1 ♂, 12 ♀♀ (11 Oct. 83-7 Nov. '83), 22 ♂♂, 81 ♀♀ (12 Jun. '84-1 Nov. '84) attracted to bulb-light, 40 ♀♀ (23 Oct. '83-15 Nov. '83), 68 ♂♂ (27 Mar. '84-26 Sept. '84) from human-bait ; 2 ♂♂, 9 ♀♀ (14 Nov. '83-26 Nov. '83), 498 ♀♀ (6 Feb. '84-29 Oct. '84) from bovine-bait ; 1 ♀ (15-Apr. '84) larva was reared from muddy-pit in a dried pond. *Mao* (1,850 m.)—1 ♀ (8 Sept. '85) from human-bait. *Moltam-hill* (820 m.) —1 ♂ (1 Nov. '84) from shrubby vegetation ; 1 ♂, 2 ♀♀ (1 Nov. '84) larvae reared from medows-pool. *Moreh* (150 m.)—2 ♀♀ (18 Aug. '84-19 Aug. '84) from shrubby vegetation ; 8 ♀♀ (18 Aug. '84) from human-bait ; 1 ♀ (19 Aug. '84) from nala margin pits, 1 ♂, 2 ♀♀ (19 Aug. '84) from herb vegetation. *Motbung* (1,025 m.)—2 ♂♂ (12 Aug. '84) from herb vegetation. *New-heaven* (1,600 m.)—1 ♀ (19 Nov. '84) larva was reared from a pit in paddy-field. *Nungba* (750 m.)—1 ♀ (8 Oct. '84) from bovine-bait. *Tongou Lonkoy* (820 m.)—1 ♂ (9 Jul. '84) from herb vegetation. *Toranglobi* (765 m.)—3♂♂, 1 ♀ (1 Nov. '84) larvae were reared from a road side pool. *Tuibang* (800 m.)—1 ♂ (8 Oct. '83) from herb vegetation. *Zaphou* (1,000 m.)—19 ♂♂ (21 Oct. '85) from human-bait. Associated breeder were *Anopheles barbirostris*, *A. annularis*, *A. subpictus*, *A.*

vagus, *Culex bitaeniorhynchus*, *C. fuscocephala*, *C. mimulus*, *C. tritaeniorhynchus*, *C. vishnui* and *C. malayi*.

10. Culex quinquefasciatus Say

Culex quinquefasciatus Say, 1823, *J. Acad. nat. Sci. Philad.* 3 : 10 ; Barraud. 1934 : 420-423 ; Knight, 1978 : 46.

This species is cosmotropical in distribution. It has been recorded from all over India.

Present records : Manipur : *Bungmul* (850 m,)—2 ♂♂, 2 ♀♀ (27 Nov. '84) from herb vegetation. *Chingmeirong* (785 m.)—4 ♂♂, 8 ♀♀ (11 Sept. '83), 34 ♂♂, 19 ♀♀ (22 Jan. '84-28 Jul. '84) from shrubby vegetation. *Churachandpur* (850 m.)—2 ♂♂ (1 Nov. '84) from herb vegetation. *Gwaltabi* (785 m.)—1 ♂ (19 Nov. '84) from shrubby vegetation. *Imphal* (785 m.)—6 ♀♀ (10 Oct. '84) from human dwellings, 2 ♂♂, 4 ♀♀ (1 Nov. '84) from cattle-shed. *Jiribam* (150 m.)—1 ♀ (7 Oct. '84) from cattle-shed, 2 ♂♂, 4 ♀♀ (7 Oct. '84) from discarded motor tyres, 1 ♀ (7 Oct. '84) from herb vegetation, 8 ♀♀ (8 Oct. '84) from human dwellings. *Kalinamei* (1,800 m.)—6 ♂♂, 7 ♀♀ (8 Sept. '85) larvae reared from road side drain. *Khongampat* (785 m.)—2 ♂♂, 3 ♀♀ (1 Feb. '84-16 Dec. '84) from herb-vegetation. *Khurkhul* (830 m.)—2 ♀♀ (29 Jan. '84) from herb—vegetation. *Kwakta* (760 m.)—1 ♂ (8 Oct. '83) from shrubby vegetation. *Mantripukhri* (785 m.)—18 ♂♂, 32 ♀♀ (12 Sept. '83-23 Dec. '83), 1 ♂, 1 ♀ (6 Jan. '84), 113 ♂♂, 280 ♀♀ (23 Jan. '84-15 Dec. '84) from cattle-shed, 9 ♀♀ (23 Oct. '83-29 Nov. '83), 116 ♀♀ (13 Feb. '84-14 Oct. '84) from human-baits, 2 ♂♂, 3 ♀♀ (7 Nov. '83-12 Nov. '83), 1 ♂, 11 ♀♀ (13 Mar. '84-21 Oct. '84) attracted to bulb-light, 1 ♀ (14 Nov. '83), 33 ♀♀ (24 Jan. '84-29 Oct. '84) from bovine-baits, 19 ♂♂, 18 ♀♀ (15 Nov. '83-23 Dec. '83), 184 ♂♂, 150 ♀♀ (11 Jan. '84-14 Oct. '84) from human dwellings, 6 ♂♂, 6 ♀♀ (6 Jan. '84-11 Feb. '84) from abondoned house, 8 ♂♂, 10 ♀♀ (23 Jan. '84) from wooden-logs, 4 ♀♀, 1 ♂ (13 Feb. '84) from herb-vegetation. *Moreh* (150 m.)—8 ♀♀ (18 Aug. '84) from human-baits, 29 ♂♂, 33 ♀♀ (19 Aug. '84) from human dwellings. *Mao* (1,850 m.)—1 ♂, 5 ♀♀ (9 Sept. '85) from human dwellings, 1 ♂ 1 ♀ (8 Sept. '85) larvae were reared from a rainy-pool, 10 ♂♂, 11 ♀♀ (9 Sept. '85) from discarded tar barrel. *Nungdalal* (1,100 m.)—1♂, 1♀ (7 Sept. '84) larvae reared from road side rainy-pool. *Tamenglong* (1,200 m.)—4 ♀ % (9 Nov. '84) from human dwellings. *Tuibang* (800 m.)—1 ♂, 2 ♀♀ (8 Oct. '83) from herb vegetation. *Ukhrul* (2,000 m.)—5 ♂♂, 2 ♀♀ (7 Jul. '84) from herb vegetation, 1 ♀ (8 Jul. '84), larva was reared from rainy-pool. *Zaphou* (1,000 m.)—3 ♀♀ (21 Oct. '85), 2 ♂♂, 23 ♀♀ (22 Oct. '85) from human-bait. Associated breeders were *Anopheles maculatus*, *A. maculatus* var. *willmorei*, *A. vagus*, *Aedes aegypti*, *A. albopictus*, *Armigeris subalbatus*, *Culex sinensis*, *C. theleri*, *C. harrisoni*, C. *pallidothorax* and *C. fuscanus*.

11. Culex sinensis Theobald

Culex sinensis Theobald, 1903, *Monogr. Cul.* 3 : 180 ; Barraud, 1934 : 394-395 ; Knight and Stone, 1977 : 222.

The species has wide distribution-range in Oriental and Palaearctic regions. In India, the species has been recorded from Assam, Bihar, Madhya Pradesh, Manipur, Meghalaya, Mizoram, Nagaland and Orissa,

Present records : Manipur : *Chandel* (1,500 m.)—1 ♂ (22 Oct, '85) from mixed vegetation. *Chingmeirong* (785 m.)—26 ♂♂, 10 ♀♀ (27 Jun. '84—25 Sept. '84) collected from shrubby vegetation of *Quercus acutissima*. *Kalinamei* (1,800 m.)—2 ♂♂ (8 Sept. '85) larvae reared from road side drain. *Koubru-leikha* (1,040 m.)—2 ♂♂, 2 ♀♀ (12 Aug. '84) from shrubby vegetation. *Kwakta* (760 m.)—2 ♂♂, 2 ♀♀ (8 Oct. '83) from shrubby vegetation. *Langol-hill* (785 m.)—2 ♂♂ (29 Jul. '84) from pit-shelter. *Mantripukhri* (785 m.)—1 ♀ (14 Nov. '83), 12 ♀♀ (23 Jun. '84—13 Oct. '84) from bovine-bait, 2 ♂♂, 8 ♀♀ (27 Jun. '84—23 Sept. '84) attracted to bulb-light, 3 ♂♂ (10 Jul. '84—23 Aug. '84) from human-bait. *Moreh* (150 m.)—2 ♀♀ (18 Aug. '84) from human-bait. *Phedinga* (900 m.)—2 ♂♂ (12 Aug. '84) from shrubby vegetation. *Tongou-Lonkoy* (820 m.)—1 ♂ (9 Jul, '84) from herb vegetation.

12. Culex theleri Theobald

Culex theleri Theobald, 1903, *Monogr. Cul.* 3 :187 ; Barraud, 1934 : 416-418 ; Knight and Stone, 1977 : 225.

The wide distribution range of the species includes southern and eastern Ethiopian region, southern Palearctic region and northern Oriental region. In India, the species has been recorded from Arunachal Pradesh, Himachal Pradesh, Jammu & Kashmir, Punjab, Manipur and Nagaland.

Present records : Manipur : *Kalinamei* (1,800 m.)—4 ♂♂, 1 ♀ (8 Sept. '85) larvae reared from road side drain. *Ukhrul* (2,000 m.)—10 ♀♀ (7 Jul- '84) from herb vegetation, 3 ♂♂, 4 ♀♀ and 12 ♂♂ 2 ♀♀ (8 Jul. '84) larvae were reared from discarded motor tyres and rainy-pools respectively. Associated breeders were *Culex quinquefasciatus* and *C. sinensis*.

13. Culex tritaeniorhynchus Giles

Culex tritaeniorhynchus Giles, 1901, *J. Bomb. Nat. His. Soc.* 13 : 606 ; Barraud, 1934 : 404-406 ; Knight and Stone, 1977 : 226.

This species has a wide range of distribution in eastern Palearctic region ; Ethiopian region ; Mediterranean and Middle east ; Micronesia ; and Oriental region. It has been recorded from all over India including Andaman Island.

Present records : Manipur : *Chingmeirong* (785 m.)—30 ♂♂, 17 ♀♀ (11 Sept. '83 —29 Nov. '83), 114 ♂♂, 48 ♀♀ (22 Jan. '84—25 sept. '84) from shrubby vegetation, 1 ♂, 1 ♀ (30 Oct. '83) from herb vegetation. *Jiribam* (150 m.)—1 ♀ (7 Oct. '84) from cattle-shed, 8 ♀♀ (7 Oct. '84) from bovine-bait, 4 ♀♀ (7 Oct. '84) larvae were reared from rainy-pool. *Khongampat* (785 m.)—10 ♂♂, 3 ♀♀ (27 Nov. '83) 3 ♂♂, 2 ♀♀ (12 Aug. '84) from herb vegetation. *Koubru-leikha* (1,040 m.)— 2 ♂♂ (12 Aug. '84) from shrubby vegetation. *Khurkhul* (830 m.)—2 ♀♀ (19 Jan, '84) from herb vegetation. *Kwakta* (760 m.)—4 ♂♂, 9 ♀♀ (8 Oct. '83) from shrubby vegetation. *Langol-hill* (785 m.)—12 ♂♂, 9 ♀♀ (29 Jul. '84) from pit-shelters. *Mantripukhri* (785 m.)—4 ♀♀ (12 Sept. '83—31 Oct. '83), 1 ♀ (22 Aug. '84) from cattle-shed, 5 ♀♀ (11 Oct. ,83—7 Nov. '83), 13 ♂♂, 51 ♀♀ (13 Mar. '84—1 Sept. '84) attracted to bulb-light, 1 ♂, 19 ♀♀ (23 Oct. '83—14 Feb. '83). 35 ♀♀ (11 Mar. '84—14 Oct. '84) from human-bait, 4 ♀♀ (14 Nov. '83), 207 ♀♀ (25 Feb. 84—29 Oct. '84) from bovine-bait. 1 ♀ (13 Feb. '84) from herb-vegetation. *Mao* (1,850 m.)—1 ♀ (8 Sept. '85) from cattle-shed. *Moreh* (150 m.)—1 ♀ (19 Aug. '84) from shrubby vegetation. 1 ♀ 19 Aug. '84) from grooves at nala margins in forest, 2 ♀♀ (19 Aug. ,84) from herb-vegetation. *Tongou-Lonkoy* (820 m.)—1 ♀ (9 Jul. '84) from herb vegetation. *Zaphou* (1,000 m.)—9 ♀♀ (21 Oct. '85—22 Oct. '15) from human-bait. Associated breeders *Anopheles nigerrimus*, *A. annularis* and *Culex pseudovishnui.*

14. **Culex vishnui** Theobald

Culex vishnui Theobald, 1901, *Monogr. Cul.* 1 : 355 ; Barraud, 1934 : 400-402 ; Knight and Stone, 1977 : 228.

This species is known from south and south western Palearctic region and oriental region. Recorded from all over Indian region, including Andaman Islands.

Present records : Manipur : *Chingmeirong* (785 m.)—1 ♀ (11 Sept. '83), 11 ♂♂, 24 ♀♀ (9 Jun. '84—14 Oct. '84) from *Quercus acutissima* plantation. *Kanglatongbi* (1,000 m.)—2 ♀♀ (12 Aug. '84) from herb vegetation. *Khongampat* (785 m.)—2 ♂♂, 1 ♀ (27 Nov. '83) from herb-vegetation. *Langol-hill* (735 m.)—4 ♂♂ (29 Jul. '84) from pit-shelter. *Mantripukhri* (785 m.)—1 ♂, 6 ♀♀ (13 Mar. '84—23 Sept. '84) attracted over bulb-light, 33 ♀♀ (4 Apr. '84—29 Oct. '84) from bovine-baits, 1 ♀ (25 Apr. '84) from human-bait. Associated breeders were *Anopheles nigerrimus* and *Culex pseudovishnui.*

15. **Culex whitmorei** (Giles)

Taeniorhynchus whitmorei Giles, 1904, *J. trop. Med.* 7 : 367 ; Barraud, 1934 : 406-407 ; Knight and Stone, 1977 : 228.

The species is known from Oriental, Palearctic and Australian region. Recorded from all over India.

Present records : Manipur : *Boljang* (775 m.)—1 ♀ (8 Oct. '83) from shrubby-vegetation. *Chandel* (1,500 m.)—1 ♀ (22 Oct. '85) from mixed vegetation. *Chingmeirong* (785 m.)—5 ♂♂, 3 ♀ ♀ (18 Sept. '83—4 Dec. '83), 3 ♂♂, 13 ♀ ♀ (14 Apr. '84—25 Sept. '84) from shrubby vegetation. *Geljang* (850 m.)—1 ♀ (27 Nov. '84) from shrubby vegetation. *Jiribam* (150 m.)—4 ♀ ♀ (7 Oct. '84) from bovine-bait. *Kanglatongbi* (1,000 m.) —2 ♀ ♀ (12 Aug. '84) from herb vegetation. *Khongampat* (785 m.)—1 ♂ (27 Nov. '83), 7 ♂♂, 9 ♀ ♀ (12 Aug. '84—16 Dec. '84) from herb vegetation. *Koubru-leikha* (1,040 m.) 1 ♂ (12 Aug. '84) from shrubby vegetation. *Kwakta* (760 m.)—3 ♂♂, 18 ♀ ♀ (8 Oct. '83) mulberry plantation. *Mantripukhri* (758 m.)—6 ♀ % (11 Oct. '83—19 Oct. '83), 5 ♂♂, 4 ♀ ♀ (11 Jul. '84—23 Sebt. '84) attracted to bulb-light, 8 ♀ ♀ (23 Oct. '83), 1 ♀ (24 Jun. '84), 20 ♀ ♀ (10 Jul. '84—14 Oct. '84) from human-bait, 17 ♀ ♀ (10 Jun. '84—13 Oct. '84) from bovine-bait, 1 ♀ (14 Oct. '84) from human-dwellings, 1 ♂ (19 Nov. '84) from shrubby vegetation. *Moreh* (150 m.)—2 ♀ ♀ (18 Aug. '84) from human-bait. *Tongou-Lonkoy* (820 m.)—1 ♀ (9 Jul. '84) from herb vegetation. *Zaphou* (1,000 m.)—1 ♀ (21 Oct. '85) from human dwellings, 2 ♀ (21 Oct. '85) from human-bait.

16. **Culex harrisoni** Sirivanakarn

Culex harrisoni Sirivanakarn, 1977, *Mosq. Syst.* 9 (2): 102-104.

The species was known earlier from Thailand only.

Present records : Manipur : *Mao* (1,850 m.)—1 ♂ (8 Sept. '85) larva was reared from a discarded motor-tyre, 1 ♂, 1 ♀ (9 Sept. '85) larvae reared from a discarded tar-barrel. Associated breeders were *Culex quinquefasciatus*, *C. pallidothorax* and *Uranotaenia bimaculata*.

17. **Culex nigropunctatus** Edwards

Culex nigropunctatus Edwards, 1926, *Bull. Ent, Res.* 17 : 121 ; Barraud, 1934 : 383-385 ; Knight and Stone, 1977 : 231.

The species has its distribution in Oriental region with northward extension upto Ryukyu-Retto. In India, It has been recorded from Andhra Pradesh, Assam Karnataka, Manipur, Meghalaya, Nagaland and Tamil Nadu.

Present records : Manipur : *Chingmeirong* (785 m.)—1 ♂ (22 Aug. '84) from shrubby vegetation. *Mantripukhri* (785 m.)—1 ♂ (27 Jul. '84) attracted to bulb-light.

18. **Culex pallidothorax** Theobald

Culex pallidothorax Theobald, 1905, *J. econ. Biol.* 1 : 32 : Barraud, 1934 : 381-382 ; Knight and Stone, 1977 : 232.

This species has its distribution range in Orient, south western Palearctic region and upto New Guinea in Australian region. Recorded from all over Indian region.

Present records : Manipur : *Khongampat* (785 m.)—1 ♂, 1 ♀ (27 Nov. '83) from herb vegetation. *Mao* (1,850 m.)—2 ♀ ♀ (8 Sept. '85) collected from a pigsty, 3 ♂♂, 1 ♀ (8 Sept. '85) larvae were reared from a discarded motor-tyre, 1 ♀ (8 Sept. '85) larva was reared from a tree-hole, 1 ♀ (9 Sept. '85) larva was reared from a discarded tar-barrel. Associated breeders were *Culex quinquefasciatus*, *C. harrisoni* and *Uranotaenia bimaculata*.

19. **Culex brevipalpis** (Giles)

Stegomyia brevipalpis Giles, 1902, *Hand book*, 2nd ed : 384 ; Barraud, 1934 : 348-351 ; Knight and Stone, 1977 : 234.

This species has its distribution in Oriental region with the extension upto New Guinea in Australian region and north-ward upto Ryukyu Islands in Palearctic region. The species is common in India except the north western part of the country.

Present records : Manipur : *Chingmeirong* (785 m.)—1 ♀ (4 Dec. '83), 1 ♀ (12 Jul. '84) from shrubby-vegetation. *Moreh* (150 m.)—37 ♂♂, 42 ♀ ♀ (18 Aug. '84—19 Aug. '84) from tree-holes, 1 ♂ (18 Aug. '84) from shrubby-vegetation. *Nungba* (750 m.)—2 ♂♂, 1 ♀ (8 Oct. '84) from tree-hole, 12 ♂♂, 4 ♀ ♀ (9 Oct. '84) larvae were reared from a discarded rain-gauze with turbid, dark coloured water having decaying leaves. Associated breeders were *Aedes albopictus* and *Armigeres subalbatus*.

20. **Culex malayi** (Leicester)

Aedes malayi Leicester, 1908, *Stud. Inst. Med. Res. F. M. S.* : 184 ; Barraud, 1934 : 358-359 ; Knight and Stone, 1977 : 237.

This has been recorded from China, Hong Kong, New Guinea and Oriental region. The species has its distribution all over India including Andaman Islands.

Present records : Manipur : *Chingmeirong* (785 m.)—16 ♂♂, 5 ♀ ♀ (18 Sept. '83—4 Dec. '83), 1 ♂, 4 ♀ ♀ (12 Jul. '84—14 Oct. '84) were collected from shrubby vegetation of *Quercus acutissima*, 1 ♀ (25 Aug. '84) larva was reared from a pond-margin. *Churachandpur* (850 m.)—1 ♂ (1 Nov. '84), from herb-vegetation. *Khongampat* (785 m.)—1 ♀ (16 Dec. '84) from herb-vegetation. *Mantripukhri* (785 m.)—3 ♂♂, 3 ♀ ♀ (12 Nov. '83—20 Nov. '83), 7 ♂♂, 4 ♀ ♀ (15 Aug. '84—8 Nov. '84) were attracted to bulb-light. *Moreh* (150 m.)—1 ♂ (19 Aug. '84) was collected from a hole at nala margin in dense forest. Associated breeders were *Anopheles nigerrimus*, *A. annularis* and *Culex pseudovishuni*.

21. **Culex bengalensis** Barraud

Culex bengalensis Barraud, 1934 : 371 ; Colless, 1965 : 293 ; Bram, 1967 : 83 ; Knight 1978 : 51.

Recorded from China, Indonesia, Malaysia and Thailand. In India, it is known from Manipur, Meghalaya and West Bengal.

Present records : Manipur : *Geljang* (820 m.)—1 ♂ (27 Nov. '84) collected from shrubby-forest.

22. Culex cinctellus Edwards

Culex cinctellus Edwards, 1922, *Indian. J. Med. Res.* 10 : 281 ; Barraud, 1934 ; 366-367 ; Sirivanakarn, 1977 : 33 ; Knight and Stone, 1977 : 241.

The species has its distribution in Oriental and north western Palearctic region. Recorded from Kerala and Manipur in India.

Present records : Manipur : *Chingmeirong* (785 m.)—2 ♂♂ (2 Oct. '83), 2 ♂♂ (9 Jun. '84) from *Quercus acutissima* plantation.

23. Culex infantulus Edwards

Culex infantulus Edwards 1922, *Indian J. Med. Res.* 10 : 287 ; Sirivanakarn, 1977 : 26 ; Knight and Stone, 1977 : 243.

The species has its distribution range in Oriental and Palearctic region. The species is known from Andhra Pradesh, Kerala and Manipur in India.

Present records : Manipur : *Moreh* (150 m.)—1 ♂ (18 Aug. '84) from tree-hole, 13 ♂♂, 2 ♀♀ (19 Aug. '84) from a hole at nala margin in forest.

24. Culex minor Leicester

Culex minor Leicester, 1908, *Cul. Malaya* : 126 ; Barraud, 1934 : 370-372 ; Knight 1978 : 53.

The species is widely distributed in Oriental region and west Irian. In India, it has been recorded from Andaman Islands, Bihar, Himachal Pradesh, Maharastra, Manipur, Meghalaya, Orissa and West Bengal.

Present records : Manipur : *Mao* (1,850 m.)—1 ♂ (8 Sept. '85) larva was reared from a tree-hole.

25. Culex rubithoracic Leicester

Culex rubithoracis Leicester, 1908. *Cul. Malaya* : 119 ; Barraud, 1934 : 367-368 ; Sirivanakarn, 1977 : 37 ; Knight and Stone, 1977 : 246.

The species is known from Oriental and Palearctic region. In India, recorded from Assam, Karnataka, Manipur, and West Bengal.

Present records : Manipur : *Bungmul* (850 m.)—1 ♀ (27 Nov. '84) from herbs in a trench. *Chingmeirong* (785 m.)—5 ♂♂, 4 ♀♀ (11 Sept. '83—29 Nov. '83) from shrubby vegetation. *Geljang* (850 m.)—1 ♂ (27 Nov. '84) from shrubby forest of *Lithocarpus dealbata*. *Mantripukhri* (785 m.)—1 ♀ (10 Sept. '84) attracted over bulb-light.

26. Culex fuscanus Wiedemann

Culex fuscanus Wiedemann, 1820, *Dipt. Exot.* 1 : 9 ; Barraud, 1934 : 341-343 ; Delfinado, 1966 ; 97 Knight and Stone, 1977 : 248.

The species has its wide distribution range in Oriental, Palearctic and Australian region. It has been recorded from all over Indian region.

Present records : Manipur : *Chingmeirong* (785 m.)—7 ♂♂, 2 ♀♀ (23 Oct. '83-25 Dec. '83), 15 ♂♂, 5 ♀♀ (27 Jun. '84-25 Sept. '84) from shrubby vegetation. *Koubru-leikha* (1,040 m.)—1 ♂ (12 Aug. '84) from shrubby vegetation. *Mantripukhri* (785 m.)—1 ♀ (13 Nov. '83), 2 ♀♀ (23 Sept. '84-20 Oct. '84) from bulb-light, 1 ♀ (9 Oct. '83) larva was reared from a tape-water pit. *Tamenglong* (1,200 m.)—3 ♂♂. 1 ♀ (8 Sept. '84) larva was reared from a discarded motor-tyre with heavy decaying of animal skin. Associated breeders were *Aedes aegypti*, *A. albopictus*, *Armigeres subalbatus* and *Culex quinquefasciatus*.

27. Culex halifaxi Theobald

Culex halifaxi Theobald, 1903, *Monogr. Cul.* 3 : 231 ; Barraud, 1934 : 344-345 ; Knight and Stone, 1977 : 249.

The species is known from Oriental, Australian and Palearctic region. In India, it has been recorded from Assam, Himachal Pradesh, Karnataka, Madhya Pradesh, Meghalya, Manipur. Sikkim, Tamil Nadu, Uttar Pradesh and West Bengal.

Present records : Manipur : *Moreh* (150 m.)—1 + (19 Aug. '84) from shrubby vegetation. *Ukhrul* (2,000 m.)—2 ♂♂ (7 Jul. '84-8 Jul. '84) larvae were reared from a discarded motor-tyre. Associated breader was *Anopheles gigas*.

SUMMARY

The extensive survey during 1983 to 1985 from Manipur state shows the presence of 27 species under the genus *Culex*. The recorded species are *Culex bitaeniorhynchus*, *C. edwardsi*, *C. epidesmus*, *C. fuscocephala*, *C. gelidus*, *C. hutchinsoni*, *C. infula*, *C. mimulus*, *C. pseudovishnui*, *C. quinquefasciatus*, *C. sinensis*, *C. tritaeniorhynchus*, *C. vishnui*, *C. whitmorei*, *C. harrisoni*, *C. nigropunctatus*, *C. pallidothorax*, *C. brevipalpis*, *C. malayi*, *C. bengalensis*, *C. cinctellus*, *C. infantulus*, *C. mtnor*, *C. rubithoracic*, *C. fuscanus* and *Cx. halifaxi*. The present communication includes the distribution record of these species.

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AN IDENTIFICATION KEY TO THE REPTILES OF THE KALAKAD WILDLIFE SANCTUARY, TAMIL NADU, INDIA

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INTRODUCTION

Reptiles, despite the fact that they are predominant, are neglected in the past by the resource managers and the administrators in-charge of the conservation areas such as the sanctuaries and the biosphere reserves in India. One reason is that the information on the herpetology of the protected areas is scanty and no keys covering the reptiles are published. Another is that the definitive volumes on Indian reptiles by Malcolm Smith (1931, 1935, 1943) were written with the specialist in mind. The present key, based on recent material taken from stations located in the heart of the KWLS by the scientists of the Southern Regional Station (SRS) of the Zoological Survey of India (ZSI) and the findings of other workers, is expected to fulfill an urgent need.

The majority of reptiles inhabiting the sanctuary are included in the key, but further study is needed to determine the entire herpetofauna of KWLS. It is felt, therefore, that this work will enable the biologists/naturalists interested in the herpetology of the KWLS to identify the reptiles of the area and thereby facilitate future recognition of species not previously recorded from the sanctuary.

PHYSIOGRAPHY OF THE KALAKAD SANCTUARY

The Kalakad Wildlife Sanctuary is located in Nanguneri Taluq, Tirunelveli District of Tamil Nadu (See Maps 1-2) and lies between latitudes 8°25'N and 8°35'N and longitudes between 77°25'E and 77°35'E. The hills are covered with dry deciduous forest on the lower slopes and evergreen (Shola type) forests on the upper reaches, crossed by rivers and mountain streams. The highest peak is Kalakad Peak (1775 M) and the other noteworthy peaks are Velimalai (1011 M), Kakachi (1233 M), Netterikkal (1350 M), and Tiruvanamalai Peak (1387 M). Of the small but useful rivers springing from the hills, mention should be made of Pachayar, Kilmanimuthar, Nambiar and Kodumudiar.

With an evolutionary lineage dating back to about 50 million years, the KWLS could boast of the richest and least disturbed patch of 100^2 km of shola forest found in Peninsular India today. It is, therefore, appropriate that the entire Kalakad Reserve Forest was converted into a Wildlife Sanctuary in 1976.

THE KEY

NOTE : The nomenclature, adopted here, follows broadly that of Malcolm Smith (*op. cit.*), but with certain modifications suggested by Gloyd (1977), Loveridge and Williams (1957), Malnate (1960), McDowell (1964), Mittleman (1952), Savage (1952) and Stimson *et al.* (1977).

TURTLES AND TORTOISES

1. Hind feet elephantine ; toes not webbed. Indian Star Tortoise, *Geochelone elegans* (Schoepff), 1792.
   Hind feet not elephantine ; toes webbed. 2
2. Forefeet semi paddle shaped and with three claws only ; shell covered with smooth skin ; lower shell with a cutaneous flap, under which the hind-limb may be concealed. Southern Flap-shelled Turtle, *Lissemys punctata granosa* (Schoepff), 1801.
3. Forefeet distinctly paddle-shaped, with five claws ; shell covered with horny shields ; lower shell without a cutaneous flap. The peninsular Pond Turtle *Melanochelys trijuga trijuga* (Schweigger), 1812.

LIZARDS

1. Tongu slender, deeply forked ; granular scales on the back ; size large, adult exceeding 300 mm or more in length. Common Indian Monitor, *Varanus bengalensis* (Daudin), 1802.
   Tongue not as above ; dorsal scales not granular ; adult rarely exceeding 200 mm in length. 2
2. Top of head with helmet-like knob ; digits fused into opposable bundles ; tail prehensile, watch-spring-like ; colour changeable. Indian chameleon, *Chamaeleo zeylanicus* Laurenti, 1768.
   Without the above combination of characters. 3
3. Top of head without symmetrical plates. 4
   Top of head with symmetrical plates. 17
4. Eyelids movable ; digits free. 5
   Eyelids immovable ; digits clawed. 11
5. Ribs elongated, supporting a wing-like expansion. Flying lizard, *Draco dussumieri* Dum. & Bibr., 1837.
   Ribs not elongated ; no wing-like expansion. 6
6. Hind foot with four toes only. The Fan-throated Lizard, *Sitana ponticeriana* Cuvier, 1844.
   Hind foot with five toes. 7

7. Body depressed ; no proper dorsal crest. Peninsular Rock-lizard, *Psammophilus dorsalis* (Gray), 1831.

   Body not depressed ; dorsal crest distinct. 8

8. No fold or pit in front of the shoulder. Indian Garden Lizard, *Calotes versicolor* (Daudin), 1802.

   A fold or pit in front of the shoulder. 9

9. Fold in front of the shoulder extending across the throat ; a white spot below the eye. Elliott's Forest Calotes, *Calotes elliotti* Gunther, 1864.

   Fold in front of the shoulder not exceeding across the throat ; no white spot below the eye. 10

10. Dorsal scales not larger than the ventrals ; colour bright green, with whitish crossbars. Green calotes, *Calotes calotes* (Linn.), 1758.

    Dorsal scales distinctly larger than the ventrals ; colour green, with broad, black transverse bars. Large-scaled calotes, *Calotes grandisquamis* Gunther, 1875.

11. Digits not dilated. Pupil of eye round. 12

    Digits strongly dilated. Pupil vertical. 13

12. Black with small granules, intermixed with much larger keeled scales ; ventral scales Smooth ; brown above, with blackish and whitish markings. Ornate Dwarf Gecko, *Cnemaspis ornata* (Beddome), 1870.

    Back with small granules, intermixed with slightly larger keeled tubercles ; ventral scales keeled ; brown above, clouded with paler and darker markings. Beddome's Dwarf Gecko, *Cnemaspis beddomei* (Theobald), 1876.

13. Subdigital lamellae single. Colour greyish-brown, with dark spots. Southern Forest Gecko, *Dravidogecko anamallensis* Gunther, 1875.

    Subdigital lamellae divided. 14

14. Dorsal tubercles strongly keeled and arranged in regular longitudinal series. 15

    Dorsal tubercles rounded, smooth, feebly keeled, not regularly arranged. 16

15. Subdigital lamellae in straight, transverse series. Brown above, with darker spots which often unite to form undulating bars on the back. Rock Gecko, *Hemidactylus maculatus* Dum. & Bibr., 1836.

    Subdigital lamellae in oblique series. Light brown or greyish, with dark brown spots which do not unite to form undulating bars on the back. Spotted Indian House Gecko, *Hemidactylus brooki* Gray, 1845.

16. Tail feebly depressed. Colour grey or pinkish brown or uniform or with dark longitudinal stripes and a pair of eye streaks. Southern House Gecko, *Hemidactylus frenatus* Schlegel, 1836.

    Tail strongly depressed. Colour grey, with distinct dark markings which may beeither

wavy crossbars or rhomboidal spots and a dark eye streak. Bark Gecko, *Hemidactylus leschenaulti* Dum. & Bibr., 1836.

17. Limbs robust, long. 18
Limbs feeble, short. 20

18. Back with dorso-lateral stripes only. 19
Back with well-defined vertebral and dorso-lateral series. Beddome's Mabuya, *Mabuya beddomii* (Jerdon), 1870.

19. Back with small dark markings ; sides with white spots ; postnasal present or absent. Bronze Grass Skink, *Mabuya macularia* (Blyth), 1853.
Back uniform bronze or green ; sides without distinct spots ; no postnasal. Common Skink, *Mabuya carinata* (Schneider), 1801.

20. Tympanum exposed and superficial. Colour brown, with dark spots on the back, which in the juveniles are usually confluent into longitudinal lines down the back. Dotted Garden Skink, *Riopa punctata* (Linn.), 1766.
Tympanum (if distinct), more or less small, situated in a depression. ... 21

21. Claws retractile into a sheath. Travancore Cat Skink, *Ristella travancorica* (Beddome), 1870.
Claws not retractile into a sheath. 22

22. Lower eyelid with a transparent disc. Black-striped Ground Skink, *Scincella laterimaculatum* (Boulenger), 1887.
Lower eyelid scaly. 23

23. Supranasals present. Ceylon Arboreal Skink, *Dasia haliana* (Haly & Nevill), 1887.
No supranasals. Slender Skink, *Sphenomorphus dussumieri* (Dum. & Bibr.), 1839.

SNAKES

1. Eyes concealed ; teeth only in the upper jaw ; body worm-like, covered with uniform scales. Common Blind Snake, *Ramphotyphlops braminus* (Daudin), 1803.
Eyes exposed ; teeth in both jaws ; body not worm-like ; ventral scales distinctly enlarged. 2

2. Traces of hind-limbs, projecting as claw-like spurs on each side of the vent ; pattern of regular, large brown or reddish-brown, black-edged spots. Indian Python, *Python molurus* (Linn.), 1758.
No traces of hind-limbs ; pattern not as above. 3

3. No poison fangs In the front of the mouth. 4
Poison fangs in the front of the mouth. 26

4. Ventrals narrow, not as broad as the body ; tail extremely short, ending in a spiny-shield or tip. 5

Ventrals as broad as the body ; tail not short nor ending in a shield, cylindrical, pointed. 8

5. Tail terminating in a flattened, rounded rugose shield. Red-bellied Uropelt, *Rhinophis sanguineus* Beddome, 1863.
Tail not as above. 6

6. Tail more or less compressed, distinctly rounded above. Ashambu Uropelt, *Uropeltis liura* (Gunther), 1875.
Tail obliquely truncate above. 7

7. Truncated portion of the tail small, feebly eonvex, nevee quite flat ; brown, with small yellow spots on the underside. Elliot's Uropelt, *Uropeltis ellioti* (Gray), 1858.
Truncated portion of the tail large, distinctly flat or concave ; yellowish below, with large black or brown patches or crossbands. Tirunelveli Uropelt, *Uropeltis arcticeps* (Gunther), 1875.

8. Dorsal scales smooth throughout. 9
Atleast some of dorsal scales keeled. 21

9. Anterior teeth in both jaws much enlarged ; eye very dark, pupil scarcely visible in life. 10
Anterior teeth in both jaws not much enlarged ; pupil of eye distinctly visible in life. 11

10. Brown above, with white crossbars ; anal plate divided ; loreal shield touching internasal. Common Wolf Snake, *Lycodon aulicus* (Linn.), 1754.
Blackish above, with pale yellow crossbars ; anal plate undivided ; loreal shield not touching internasal. Travancore Wolf Snake, *Lycodon travancoricus* (Beddome), 1870.

11. Ventrals notched and with lateral keel. 12
Ventrals normal. 14

12. Scales in 17 rows ; vertebral row of scales not enlarged ; head barred with black and yellow ; back with a dorsal pattern of reddish or orange spots shaped like tetrapetalous flowers. Golden Tree Snake or 'Flying' Snake, *Chrysopelea ornata* (Shaw), 1802.
Scales in 13 to 15 rows ; vertebral scales enlarged ; pattern of the head and the back not as illustrated above. 13

13. Eye moderate ; head with a black temporal stripe ; back with a pair of buff lateral stripes. Common Indian Bronze-back, *Dendrelaphis tristis* (Daudin), 1803.
Eye rather large ; no lateral stripes on the body ; no black temporal stripe on the head. Large-eyed Bronze-back, *Dendrelaphis grandoculis* (Boulenger), 1890.

14. Head triangular and pupil of eye vertical. Indian Gamma Snake on Common Cat Snake, *Boiga trigonata* (Schneider), 1802.
Head not triangular ; pupil of eye not vertical. 15

15. Pupil of eye round. **16**
Pupil of eye horizontal. **19**

16. Head and nape black or with distinctive dark markings ; medium to large snakes, total length exceeding 450 mm. **17**

Head and nape without the pattern as illustrated above ; dwarfed snakes, total length not exceeding 450 mm ; head with a series of dark spots on each side, the remnants of temporal stripes. Striped-neck Snake, *Liopeltis calamaria* (Gunther), 1858.

17. Scales in 17 rows. **18**
Scales in 15 rows. Russell's Kukri Snake, *Oligodon taeniolatus* (Jerdon), 1853.

18. No loreal shield ; head with crenate-shaped markings ; back with large paired spots ; ventrals fewer than 160. Travancore Kukri Snake, *Oligodon travancoricus* Beddome, 1877.

Loreal shield present or absent ; head with 3 distinct chevron-shaped markings ; back with well defined black crossbands ; ventrals 200 or more. Banded Kukri Snake, *Oligodon arnensis* (Shaw), 1802.

19. Snout ending in a pointed fleshy appendage. **20**
Snout not ending in a pointed fleshy appendage. Gunther's Whip Snake, *Ahaetulla dispar* (Gunther), 1864.

20. Fleshy appendage on snout formed entirely by the rostral shield ; snout with a median groove ; colour green. Common Green Whip Snake, *Ahaetulla nasuta* (Lacepede), 1789.

Fleshy appendage on snout formed by a number of small scales ; snout without a median groove ; colour grey or brown, with blackish spots. Brown Whip Snake, *Ahaetulla pulverulenta* (Dum. & Bib.), 1854.

21. Scales in 21 or more rows. **22**
Scales in 19 rows. **23**

22. Scales strongly keeled throughout the body ; anal plate divided ; grass-green in colour. Green keelback, *Macropisthodon plumbicolor* (Cantor), 1839.

Scales smooth anteriorly, feebly keeled posteriorly ; anal undivided ; colour dark brown, with black crossbars containing white ocelli. Trinket Snake, *Elaphe helena* (Daudin), 1803.

23. Ventrals 190 or more ; adult exceeding 1.25 m in length ; lips and throat stippled with black. Rat Snake, *Ptyas mucosus* (Linn.), 1758.
Ventrals 187 or less ; adult rarely exceeding 1.25 m in length. ... **24**

24. Body with a pattern of alternating dark spots. **25**
Body with a pattern of lateral stripes. Striped Keelback, *Amphiesma stolata* (Linn.), 1758.

25. Two black streaks from the eye to the gape ; ventrals 158 or more ; colour olivaceous or yellowish, with numerous black spots arranged in the pattern of a chessboard. Checkered Keelback, *Xenochrophis piscator* (Schneider), 1799.
One yellow, black-egged streak from the eye to the gape ; ventrals 150 or fewer ; colour olive-brown or brown, with a series of yellow spots or transverse bars. Beddome's Keelback, *Amphiesma beddomei* (Gunther), 1864.

26. Head triangular, covered with tiny head shields or numerous small scales ; pupil vertical. 27
Head oval, covered with well-developed symmetrical shields ; pupil round. 31

27. A deep sensory pit between the nostril and the eye on each side of the face. 28
Face without a sensory pit as above. Russell's Viper, *Vipera russelli* Shaw, 1797.

28. Head covered with large symmetrical shields ; snout turned up at the end like a hump. Hump-nosed pit Viper, *Hypnale hypnale* Merrem, 1820.
Head covered with scales ; snout not as above. 29

29. Upper head scales very large ; scales in 12-15 rows. Colour bright green, with a white to yellowish stripe on the sides. Large-scaled Pit Viper, *Trimeresurus macrolepis* Beddome, 1862.
Upper head scales not markedly large ; scales in 19-21 rows. Colour and pattern not as above. 30

30. Upper head scales strongly imbricate ; supraoculars broken up into several shields ; colour green or brown, with brown or black spots which may unite to form a zigzag. Malabar Pit Viper, *Trimeresurus malabaricus* (Jerdon), 1854.
Upper head scales scarcely imbricate ; supraoculars narrow ; brown above and whitish below, with a dorsal series of brown spots which may unite to form a zigzag ; nape with a prominent -shaped mark. Horse-shue pit Viper, *Trimeresurus strigatus* Gray, 1842.

31. Scales along centre of back distinctly enlarged. Common Indian Krait, *Bungarus caeruleus* (Schneider), 1801.
Scales along centre of back not enlarged (except in *O. hannah*) ; neck not dilatable into a hood (in life). 32

32. Scales in 13-15 rows, Slender Coral Snake, *Calliophis melanurus* (Shaw), 1802.
Scales in 15-25 rows, disposed obliquely ; neck dilatable into a hood (in life). 33

33. Scales in 15 rows ; head with a pair of large occipital shields. King Cobra, *Ophiophagus hannah* (Cantor), 1836.

Scales in 19-25 rows ; head without the occipital shields. Indian Cobra, *Naja naja naja* (Linn.), 1758

SUMMARY

A key to the identification of sixty one species of reptiles occurring in the **Kalakad** Wildlife Sanctuary (KWLS) in Tamil Nadu, India is presented.

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AN UPDATED SYSTEMATIC INDEX AND BIBLIOGRAPHY OF THE REPTILES OF THE WESTERN GHATS, INDIA

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INTRODUCTION

Reptiles constitute a conspicuous component of the faunistically rich Western Ghats (see map). Despite the pioneering herpetological exploration of the various hills of the *ghats* in the recent years, the biologists, the conservationists, the forest officials and others face a major handicap because of the non-availability of a handy and an uptodate systematic index to the species of the reptiles that have been reliably reported as part of the fauna of the Western Ghats and the lack of a readily accessible bibliography on the subject. This is the main reason for presenting this paper which is intended to meet the primary requirements of the increasing number of herpetologists and others interested in the reptile fauna of the Western Ghats and to save them from having to duplicate their efforts.

This task has been undertaken in the realisation that this work may contain omissions. It is hoped that the users of this paper will discover them and inform me.

SYSTEMATIC INDEX

The taxonomic arrangement of the index broadly follows the lines laid down by Malcolm Smith (1931, 1935, 1943).

Additions, deletions and other changes reflect the literature since the issue of Smith's works. Rare species are indicated by an asterisk.

Order TESTUDINES Batsch 1788

TURTLES AND TORTOISES

Fam. 1. EMYDIDAE Gray 1825

Gen. 1. **Heosemys** Stejneger 1902

1. *H. silvatica* Henderson 1912*
2. *Melanochelys trijuga trijuga* (Schweigger) 1814

2a. *M. t. coronate* (Anderson) 1879

Fam. 2. TESTUDINIDAE Gray 1825

Gen. 3. **Geochelone** Fitzinger 1835

3. *G. elegans* (Schoepff) 1792

Gen. 4. **Indotestudo** Lindholm 1929

4. *I. forsteni* (Boulenger) 1907

Fam. 3. TRIONYCHIDAE Bell 1828

Gen. 5. **Lissemys** M. A. Smith 1931

5. *L. punctata punctata* Bonnaterre 1789

Gen. 6. **Trionyx** Geoffroy 1809

6. *T leithi* Gray 1872

Order SQUAMATA Oppel 1811

Suborder SAURIA Macartney 1803

LIZARDS

Fam. 4. GEKKONIDAE Gray 1825

Gen. 7. **Cnemaspis** Strauch 1887

7. *C. indica* (Gray)

8. *C. wynadensis* (Beddome) 1870

9. *C. sisparensis* (Theobald) 1876

10. *C. ornata* (Beddome) 1870

11. *C. beddomei* (Theobald)

12. *C. mysoriensis* (Jerdon) 1853

13. *C. kandiana* (Kelaart) 1852

14. *C. goaensis* Sharma 1976

15. *C. gracilis* (Beddome) 1870

16. *C. jerdoni* (Theobald) 1868

17. *C. tropidogaster* (Boulenger) 1885

18. *C. littoralis* (Jerdon)

19. *C. nairi* Inger et al

Gen. 8. **Dravidogecko** Smith 1933

20. *D. anamallensis* (Guenther) 1875

Gen. 9. **Hemidactylus** Oken 1817

21. *H. triedrus* (Daudin) 1802

22. *H. maculatus* Dum. & Bibr. 1836

23. *H. brooki* Gray 1845

24. *H. prashadi* M.A. Smith 1935

25. *H. frenatus* Schlegel 1836

26. *H. leschenaulti* Dum. & Bibr. 1836

Gen. 10. **Hemiphyllodactylus** Bleeker

27. *H. typus aurantiacus* Beddome 1870*

Fam. 5. AGAMIDAE Gray 1827

Gen. 11. **Draco** Linnaeus 1758

28. *D. dussumieri* Dum. & Bibr. 1837

Gen. 12. **Sitana** Cuvier 1829
29. *S. ponticeriana* Cuvier 1844
Gen. 13. **Otocryptis** Wagler 1830
30. *O. beddomii* Boulenger 1885*
Gen. 14. **Salea** Gray 1845
31. *S. horsfieldi* Gray 1845
32. *S. anamallayana* Beddome 1878
Gen. 15. **Calotes** Cuvier 1817
33. *C. versicolor* (Daudin) 1802
34. *C. nemericola* Jerdon 1853
35. *C. grandisquamis* Guenther
36. *C. calotes* (Linnaeus) 1758
37. *C. rouxi* Dum. & Bibr. 1837
38. *C. elliotti* Guenther 1864
Gen. 16. **Psammophilus** Fitzinger 1843
39. *P. dorsalis* (Gray) 1831
40. *P. blanfordanus* (Stoliczka) 1871
Fam. 6. CHAMAELEONIDAE Gray 1820
Gen. 17. **Chamaeleo** Laurenti 1768
41. *Chameleo zeylanicus* Laurenti 1768
Fam. 7. SCINCIDAE Gray 1825
Gen. 18. **Mabuya** Fitzinger 1826
42. *M. macularia* (Blyth) 1853
43. *M. carinata* (Schneider) 1801
44. *M. beddomii* (Jerdon) 1870
45. *M. clavicola* Inger et al
Gen. 19. **Dasia** Gray 1839
46. *D. haliana* Haly & Neviu 1887*
Gen. 20. **Sphenomorphus** Fitzinger 1843
47. *S. dussumieri* Dum. & Bibr. 1839
Gen. 21. **Scincella** Mittleman 1950
48. *S. travancorica* (Beddome) 1870
49. *S. palnicum* (Boettger) 1892
50. *S. beddomei* (Beddome) 1870
51. *S. laterimaculatum* (Boulenger) 1887
52. *S. bilineatum* (Gray) 1846
Gen. 22. **Riopa** Gray 1839
53. *R. punctata* (Gmelin) 1799
54. *R. guentheri* (Gray) 1831
55. *R. lineata* (Gray) 1839

56. *R. goaensis* Sharma 1976

Gen. 23. **Ristella** Gray 1839

57. *R. rurki* Gray 1839

58. *R. travancorica* (Beddome) 1870

59. *R. guentheri* Boulenger 1887

60. *R. beddomii* Boulenger 1887

Gen. 24. EUMECES Weigmann 1834

61. *E. poonaensis* Sharma 1970

Fam. 8. LACERTIDAE Gray 1825

Gen. 25. **Cabrita** Gray 1838

62. *C. leschenaulti* (Milne-Edward) 1829

Gen. 26. **Ophisops** Menetries 1832

63. *O. beddomei* (Jerdon) 1870

64. *O. jerdoni* Blyth 1853

Fam. 9. VARANIDAE Gray 1827

Gen. 27. **Varanus** Merrem 1120

65. *V. bengalensis* (Daudin) 1802

SUBORDER SERPENTES Linnae 1758

SNAKES

Fam. 10. TYPHLOPIDAE Boulenger 1890

Gen. 28. **Ramphotyphlops** Fitzinger 1843

66. *R. braminus* (Daudin) 1803

Gen. 29. **Typhlops** Oppel 1811

67. *T thurstoni* Boettger 1890*

68. *T beddomei* Boulenger 1890*

69. *T acutus* (Dum. & Bibr.) 18 44

Fam. 11. UROPELTIDAE Gray 1845

Gen. 30. **Melanophidium** Guenther 1864

70. *M. punctatum* Beddome 1871

71. *M. bilineatum* Beddome 1870

72. *M. wynaudense* (Beddome) 1863

Gen. 31. **Platyplectrurus** Guenther 1868

73. *P. trilineatus* Beddome 1871

74. *P. madurensis madurensis* Beddome 1877

Gen. 32. **Teretrurus** Beddome 1886

75. *T. sanguineus* Beddome 1867

Gen. 33. **Brachyophidium** Wall 1921

76. *B. rhodogaster* Wall 1921.

Gen. 34. **Plectrurus** Dumeril

77. *P. perroteti* Dum. & Bibr. 1854

78. *P. guentheri* Beddome 1863
79. *P. aureus* Beddome 1880
80. *P. canericus* (Beddome) 1870

Gen. 35. **Uropeltis** Cuvier 1829

81. *U. ellioti* Gray 1858
82. *U. nitidus* (Beddome) 1878*
83. *U. ocellatus* (Beddome) 1863
84. *U. dindigalensis* (Beddome) 1877
85. *U. beddomei* (Guenther) 1862
86. *U. Woodmasoni* (Theobald) 1876
87. *U. macrolepis macrolepis* (Peters) 1843
87a. *U. m. mahableshwarensis* Chari 1955
88. *U. ceylanicus* Cocteau 1833
89. *U. arcticeps* (Guenther) 1875
90. *U. rubromaculatus* (Beddome) 1867
91 *U. rubrolineatus* (Guenther) 1875
92. *U. myhendrae* (Beddome) 1886
93. *U. broughami* (Beddome) 1878
94. *U. maculatus* (Beddome) 1878
95. *U. petersi* (Beddome) 1878
96. *U. liura* (Guenther) 1875
97. *U. pulneyensis* (Beddome) 1863
98. *U. smithi* Gans 1966

Gen. 34. **Rhinophis** Hemprich 1820

99. *R. sanguineus* Beddome 1863*
100. *R. fergusonianus* Boulenger 1896*
101. *R. travancoricus* Boulenger 1892

Fam. 12. BOIDAE Gray 1842

Gen. 35. **Python** Daudin 1803

102. *P. molurus molurus* (Linnae) 1758

Gen. 36. **Eryx** Daudin 1803

103. *E. conicus* (Schneider) 1801

Fam. 13. COLUBRIDAE Cope 1893

Gen. 37. **Elaphe** Fitzinger 1833

104. *E. helena* (Daudin) 1803

Gen. 38. **Ptyas** Fitzinger 1843

105. *P. mucosus* (Linnae) 1758

Gen. 39 **Argyrogena** Werner 1924

106. *A. ventromaculatus* (Gray & Hardwicke 1834)
107. *A. fasciolatus* (Shaw) 1802

Gen. 40. **Liopeltis** Fitzinger 1843
108. *L. calameria* (Guenther) 1858
Gen. 41. **Coronella** Laurenti 1768
109. *C. brachyura* (Guenther) 1866
Gen. 42. **Oligodon** Boie 1827
110. *O. venustus* (Jerdon) 1853
111. *O. travancoricus* Beddome 1877
112. *O. taeniolatus* (Jerdon) 1853
113. *O. arnensis* (Shaw) 1802
114. *O. affinis* Guenther 1862
115. *O. brevicauda* Guenther 1862
116. *O. nikhili* Whitaker & Dattatri 1982
Gen. 43. **Dendrelaphis** Boulenger 1890
117. *D. grandoculis* (Boulenger) 1890
118. *D. bifrenalis* (Boulenger) 1890*
119. *D. caudolineatus* (Guenther) 1869*
120. *D. tristis* (Daudin) 1803
Gen. 44. **Chrysopelea** Boie 1826
121. *C. ornata* (Shaw) 1802
Gen. 45. **Lycodon** Boie 1826
122. *travancoricus* (Beddome) 1870
123. *L. flavomaculatus* Wall 1907*
124. *L. aulicus* (Linnae) 1754
Gen. 46. **Dryocalamus** Guenther 1758
125. *D. gracilis* (Guenther) 1864*
Gen. 47. **Sibynophis** Fitzinger 1843
126. *S. subpunctatus* Dum. & Bibr. 1854*
Gen. 48. **Xenochrophis** Guenther 1864
127. *X. piscator* (Schneider) 1799
Gen. 49. **Amphiesma** Dum. Bibr. 1854
128. *A. stolata* (Linnae) 1758
129. *A. beddomei* (Guenther) 1864
130. *A. monticola* (Jerdon) 1853
Gen. 50. **Macropisthodon** Boulenger 1893
131. *M. plumbicolor* (Cantor) 1839
Gen. 51. **Atretium** Cope 1861
132. *A. schistosum* (Daudin) 1863
Gen. 52. **Rhabdops** Boulenger 1893
133. *R. olivaceus* (Beddome) 1863
Gen. 53. **Xylophis** Beddome 1878

134. *X. perroteti* (Dum. & Bib.) 1854
135. *X. stenorhynchus* (Guenther) 1875

Gen. 54. **Boiga** Fitzinger 1826
136. *B. trigonata* (Schneider) 1802
137. *B. ceylonensis* (Guenther) 1858
138. *B. forsteni* (Dum. & Birr.) 1854
139. *B. dightoni* (Boulenger) 1894

Gen. 55. **Ahaetulla** Meise & Henning 1932
140. *A. perroteti* (Dum. & Bibr.) 1854
141. *A. dispar* (Guenther) 1864
142. *A. nasuta* (Lacepede) 1789
143. *A. pulverulenta* (Dum. & Bibx.) 1854

Fam. 14. ELAPIDAE Boie 1827

Gen. 56. **Bungarus** Daudin 1803
144. *B. caeruleus* (Schneider) 1801

Gen. 57. **Calliophis** Gray 1834
145. *C. melanurus* (Shaw) 1802
146. *C. beddomei* Smith 1943
147. *C. bibroni* (Jan) 1858

Gen. 58. **Naja** Laurenti 1758
148. *Naja naja naja* (Linnae) 1758

Gen. 59. **Ophiophagus** Guenther 1864
149. *O. hannah* (Cantor) 1836

Fam. 15. VIPERIDAE Bonnaparte 1840

Gen. 60. **Vipera** Laurenti 1768
150. *V russelli russelli* (Shaw) 1797

Gen. 61. **Hypnale** Fitzinger 1843
151. *H. hypnale* (Merrem) 1820

Gen. 62. **Trimeresurus** Lacepede 1804
152. *T. macrolepis* Beddome 1862
153. *T. malabaricus* (Jerdon) 1854
154. *T. strigatus* Gray 1842
155. *T. gramineus* (Shaw) 1802
156. *T. huttoni* Smith 1949

SUMMARY

An updated systematic index and scientific literature published on the reptiles of the Western Ghats since the issue of Malcolm Smith's volumes (1931, 1935, 1943) in the *Fauna of British India* series have been provided.

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A NEW *SOSTICUS* SPIDER FROM INDIA (ARANEAE : GNAPHOSIDAE)

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INTRODUCTION

A new species of the genus *Sosticus* Chamberlin, 1922, belonging to the family Gnaphosidae is described.

MATERIAL

The description is based on one female specimen.

The spiders of the genus *Sosticus* are very little known. The genus was erected by Chamberlin (1922) to accommodate two species collected from North America and subsequently Fox (1938) described a third species from Indiana. Ubick and Roth (1973) through synonymy reduced the three species to one. Platnick and Shadab (1976) described two more species from North America. Gajbe (1979) reported this genus for the first time from India and described four species from India. Tikader (1982) described one more species from India.

While studying the spiders of the family Gnaphosidae the author encountered a new species of *Sosticus* which is described here.

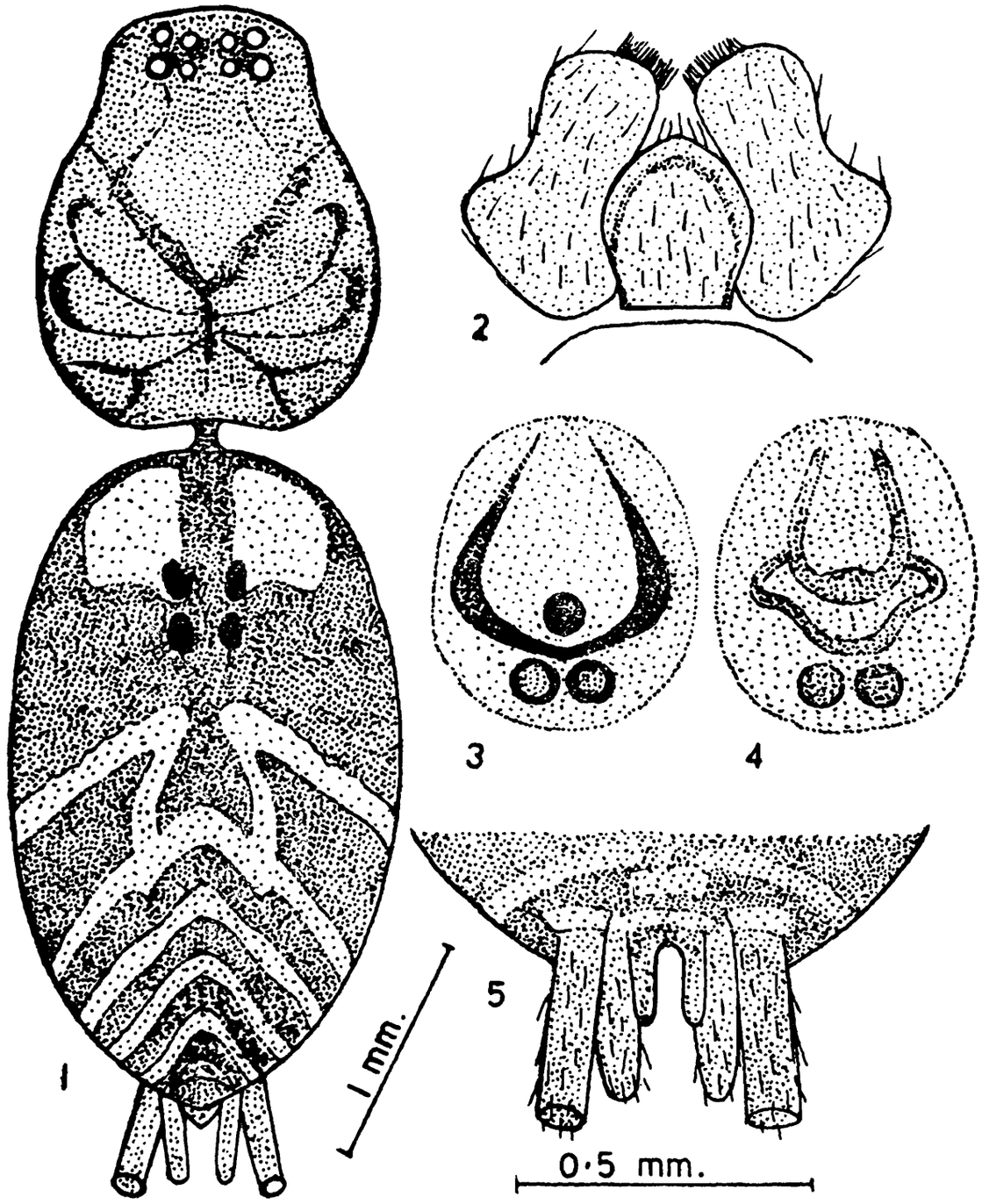
The type specimen is deposited in the National Zoological Collections, Zoological Survey of India, Calcutta.

Sosticus pawani sp. nov.

General : Cephalothorax and legs reddish-brown, abdomen brownish-black. Total length 5·00 mm. Carapace 1·80 mm. long, 1·60 mm. wide ; abdomen 3·00 mm. long, 1·90 mm. wide.

Cephalothorax : Longer than wide, oval, narrow in front, clothed with pubescence and some spine like long hairs, provided at posterior middle with conspicuous short fovea with black streaks diverging from fovea to lateral sides of carapace. Eye rows distinctly separated ; eyes pearly white except anterior medians which are black ; posterior row of eyes very slightly longer than anterior row ; anterior row of eyes slightly procurved (as seen from in front), with medians smaller than laterals and closer to adjacent laterals than to each other ; posterior row of eyes straight, with medians oval, smaller than laterals and closer to adjacent laterals than to each other ; median ocular quadrangle longer than wide and wider behind than in front. Clypeal height more than diameter of anterior

median eye. Sternum heart-shaped, pointed behind, strongly rebordered, clothed with fine hairs. Labium longer than wide ; anterior end of labium and maxillae provided with



Figs. 1-5. *Sosticus pawani* sp. nov.
Fig. 1. Dorsal view of female, legs omitted.
Fig. 2. Labium and maxillae.
Fig. 3. Epigyne.
Fig. 4. Spermathecae.
Fig. 5. Spinnerets.

conspicuous scopulae ; shape as in fig. 2. Chelicerae moderately strong, vertical ; inner margin provided with two minute teeth and outer margin with three minute teeth. Legs

relatively long and thin, clothed with hairs and some spines. Patella of all legs much larger and dorsally provided with two longitudinal black patches ; tibia IV provided with two dorsal spines ; scopulae reaching base of matatarsi I and II and middle of metatarsi III and IV ; leg formula 4123. Male unknown.

Abdomen : Longer than wide, oval, narrowing posteriorly, clothed with pubescence and provided with two pairs of sigilla and chevrons as in fig. 1 ; ventral side lighter than dorsal. Epigyne as in fig. 3. Spermathecae as in fig. 4. Anterior spinnerets widely separated ; posterior spinnerets longer and larger than others as in fig. 5.

Type-specimen : *Holotype* female in spirit, other details as below.

Type-locality : INDIA, Himachal Pradesh, Ragul Kalpa village, Solan district. 15.IV.1970, Coll. *K. K. Mahajan.*

This species closely resembles *Sosticus sundargarhensis* Gajbe but differs from it as follows : (i) Inner margin of chelicera provided with two minute teeth but in *S. sundargarhensis* inner margin with one minute tooth. (ii) Abdomen provided with chevrons but in *S. sundargarhensis* abdomen provided with two transverse white bands. (iii) Epigynum having epigynal suture pointed distally and the spermathecae are rounded.

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EVENTS IN A NATURAL POPULATION OF *DAPHNIA LUMHOLTZI* SARS (CRUSTACEA : CLADOCERA)

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1. INTRODUCTION

In India the information available on the natural population of zooplankton is scanty. However certain life cycle studies of cladocerans were made in the laboratory by Navaneethakrishnan and Michael (1971), Murugan and Sivaramakrishnan (1973, 1976) and Murugan (1975a, 1975b, 1977). The few studies made on the natural populations are by the Michael (1962) and S. Vijayaraghavan (1970) and Sharma and Dattagupta (1984). From Lake Pewa, Nepal, seasonality of *Daphnia lumholtzi* was studied by Swar and Fernando. (1979).

Near Madras, quite a number of perennial and semiperennial freshwater bodies are existing. Under a programme of studying the zooplankton periodicity of these freshwaters, periodical collections were made. In Kamakoti pond, near Kamak otinagar, 10 km. west of Madras city, a sudden bloom of *Daphnia lumholtzi*, a rare cladoceran was recorded for the first time. Hence a study was made with special reference to this phenomenon. This pond is having an area of 0·5 hectare with an average depth of 0·5 M. Only during rainy months this tank will be filled up with rain water.

2. MATERIAL AND METHODS

After noting down the air and water temperature, pH of the water was estimated by employing a Hellige-neo-comparator. The plankton collections were made by using a net with a diameter of 25 cm, (0·3 mm. meshsize). The net was thrown to that 2·55 M. of the attached rope was in the water. For each sample four throws were made. (Hebert, 1977). The collected samples were preserved in 5% formalin and made upto 250 ml. From this subsample of 2 ml. was examined in Sedgewick-rafter cell for counting purposes. Total number of specimens collected were given. Samples were collected from 5th February 1981 to 28th May 1981.

3. RESULTS

Between 5 February 1981 and 6 March 1981, plankton samples were represented with *Ceriodaphnia cornuta*, *Mesocyclops leuckartii* calanoid copepods and very few *Daphnia*

lnmholtzi. But on 9 March 1981, the other forms were less in number and the collected sample was full of *Daphnia lumholtzi.* Again the sample collected on 13 March 1981 was almost like a monoculture of *Daphnia lumholtzi.* But on 21 March 1981, *Daphnia lumholtxi* started diminishing in numbers with few only on 26 March 1981. On 4 April 1981, only one example was encountered while counting. From 8 May 1981, these forms werecompletely absent.

3.1. COMPOSITION OF *DAPHNIA LUMHOLTZI*

	9th Mar.	*13th Mar.*	*21st Mar.*	*26th Mar.*
Parthenogenetic females with eggs.	250	725	375	125
Parthenogenetic females without eggs.	9375	8375	2625	875
Neonata	1250	4000	2000	250
Embryo with head rudiment	1375	125	375	250
Released eggs	5125	750	725	750

Also among *Daphnia lumholtzi* certain peculiar forms with bent shell spines were noted.

4. DISCUSSION

Eventhough there are instances of sudden blooming of certain cladocerans like *Daphnia magna* Straus, *Daphnia similis* Claus (Mitra and Thakurta, 1973) and *Moina dubia* (Parabramam et. al 1967) so far no account of blooming of *Daphnia lumholtzi* is available from India. Moreover *Daphnia lumholtzi* is a very rare cladoceran and as per Fernando (1980) not even a single representative was available from 95 zooplankton samples collected from tropical (south) India. However *Daphnia lumholtzi* has been recorded earlier by Brehm (1950), Biswas (1971), Nayar (1971), Michael (1973) and Sharma and Dutta Gupta (1984).

In Kamakoti tank; it is interesting to note that *Daphnia lumholtzi* started increasing in number from 9th March 1981 at such a rapid rate that the samples collected on 13 March 1981 were full of these forms. The population on the whole lasted only for a month as per the collections. During this period the temperature ranged from 26·0°C to 30·5°C and the pH was between 7·0 and 7·3. During the same period plenty of *Gerris* sp. were noted in the surface. In Lake Pewa, Nepal also maximum number of *Daphnia lumholtzi* was found in the samples during May and June. They reappeared in the samples in July and were present till December. (Swar and Fernando, 1979).

Here all the specimens of *Daphnia lumholtzi* collected including the egg bearing females were helmeted forms. But considering the previous records of *Daphnia lumholtzi* in India, reveals that among the specimens eollected from probe bed of Pulta water works (Brehm, 1950) the females with eggs had unarmoured round head. The helmeted forms by egg bearing famales were also recorded by him from a tank in Cuttack, Orissa. On the other hand Nayar (1971) recorded both the forms from two different places namely helmeted forms

form Mount Abu of Rajasthan and non-helmeted forms from Udaipur, Rajasthan. Biswas (1971) has recorded non-helmeted forms from Rajasthan. Swar and Fernando (1979) have recorded only helmeted forms from Nepal. While discussing about cyclomorphossis in *Daphnia lumholtzi*, Sharma and Dattagupta (1984) have attributed temperature as the main factor influencing the head and tail length.

In Chingleput tank near Madras, *Daphnia lumholtzi* were noted in the samples in few numbers only during January and February 1980. On the contrary *Daphnia lumholtzi* were collected in large numbers from Ooty lake at an altitude of 2500 M. both during 11th March 1978 and during 16th March 1979 (Raghunathan, 1985).

The specimens of *Daphnia lumholtzi* collected from Kamakoti tank.and the few specimens from Chingleput tank were helmeted. The specimens collected from Ooty lake were also helmeted but the helmet size were comparatively smaller. Further the few forms collected with bent shell spines from Kamakoti tank deserve further investigations.

SUMMARY

While qualitative collections of zooplankton were made from different freshwaters in and around Madras, *Daphnia Lumholtzi* Sars, a rare cladoceran was observed in large numbers fr om Kamakoti pond during March 1981. A study was made on this natural population of *Daphnia lumholtzi.*

Key words : *Daphnia lumholtzi*, cladocera, population.

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Murugan, N. 1977. The biology of *Sinocephalus acutirostratus* king (cladocera : daphnidae). Hatchability of the perthenogenetic egg cultured in artificial media. *Hydrobiologia* **54** (3) : 273-277.

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Rec. zool. Surv. India, 91 (2) : 189-202, 1992

ANOPHELINES (DIPTERA : CULICIDAE) OF THREE DISTRICTS (EAST KAMENG, LOWER SUBANSIRI AND UPPER SUBANSIRI) OF ARUNACHAL PRADESH AND THEIR PERSPECTIVE IMPACT ON HUMAN AND NONHUMAN HOSTS

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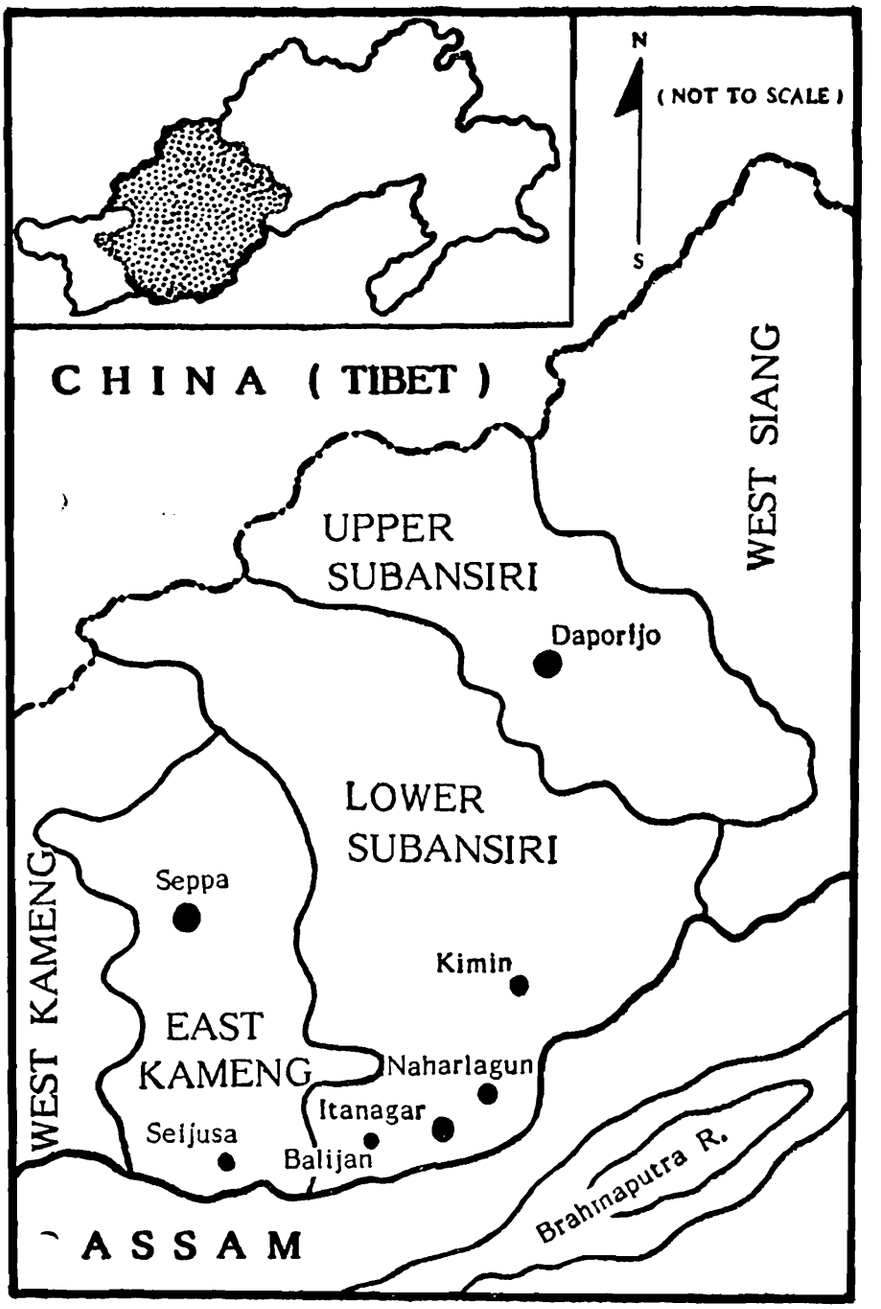
INTRODUCTION

East Kameng, Lower Subansiri and Upper Subansiri Districts form a part of the western side of Arunachal Pradesh. This area is bounded by China (Tibet) and West Kameng District (Arunachal) in the north, West Siang District (Arunachal) in the east, Assam in the south and West Kameng District (Arunachal) in the west. The entire area is a mountainous terrain (alt. 200-5500 m.). The area comp rises a cross-section of the foot hills, the plateau and the lofty mountains extending northward in a succession of steep and towering ridges receding a away to the snow-clad peaks of the Himalayas along the international border. From the northern height flow a number of rivers down to south. These rivers form the main river system which in its southward course meet the river Brahmaputra in Assam. The climatic conditions offering high rainfall, favourable temperature gradients and humidity have caused a rich assemblage of floral resources. The total population of these districts enumerated 195,428 as per 1981 census (Jha, 1985). The life style of the people along with social fabric is found to be responsive to and compatible with the physical environment.

Information on the mosquitoes of Arunachal Pradesh as a whole is very scanty. The study of the anopheline fauna in Arunachal made practically no headway except a few by Misra (1956) and Sen *et al.* (1972). Misra (*loc. cit.*) reported 6 species while Sen *et al.* recorded 14 species from the Tirap areas. The present survey and observations were undertaken to update this faunal information. Moreover, rapid developmental changes have taken place in this region during last decade. The perspective impact of this anopheline

fauna on total health status of this region was also assessed. A key to the available species of the area is appended for easy recognition of the species.



Text-fig. 1. Sketch map of East Kameng, Lower Subanasiri and Upper Subansiri Districts showing the places of mosquito collections; inset : map of Arunachal Pradesh showing the area of above three Districts (shaded space).

Material and Methods

The surveys were carried out in 86 days in 21 villages and township areas of the districts of East Kameng, Lower Subansiri and Upper Subansiri during different seasons of 1986 and 1987. Adult mosquitoes resting outdoors, indoors (human plus mixed dwellings), in cattlesheds and biting cattles were collected by suction tube in the mornings and evenings.

Outdoor resting adult mosquitoes were collected from the shrubs around cattle and human dwellings, forests and tree holes. Collections were made from each village or locality from a minimum of 10 cattlesheds and human dwellings. All field collected mosquitoes were brought to the Kimin laboratory of NMEP for identification and preservation. Mosquitoes were identified using the keys of Christophers (1933) and Rao (1984). The system of stone and Delfinado (1973) was followed for nomenclature of the species.

SYSTEMATIC ACCOUNT

Family CULICIDAE

Subfamily ANOPHELINAE

Tribe ANOPHELINI

1. **Anopheles aconitus** Donitz

1902. *Anopheles aconitus* Dönitz, *Z. Hyg. Insekt Krankh* **41** : 70 (Type-loc. : Sumatra, Indonesia).
1903. *Myzomyia albirostris* Theobald, *Monogr. Cul.* 3 : 24 (Type-loc. : Malaysia).
1912. *Myzomyia brahmachari* Christophers, *Paludism* 5 : 11 (Type-loc. : Calcutta, West Bengal, India).
1933. *Anopheles* (*Myzomyia*) *aconitus* : Christophers, *Fauna Br. India*, Diptera 4 : 216.
1973. *Anopheles* (*Cellia*) *aconitus* : Stone & Delfinado, *Catalog Dipt. Orient. Reg.* 1 : 273.

Material examined : 585 ♀ ♀. INDIA : ARUNACHAL PRADESH, East Kameng District, Seijusa area, 149 ex., ii., iii. & xi. 1986 : Lower Subansiri District, Balijan, 5 ex., iv. 1986 ; Naharlagun 323 ex., vii. & viii. 1987 ; Itanagar, 65 ex., vii. & viii. 1987 ; Kimin and Lora Basti, 43 ex., xi. 1987 (detail vide Tables 1 & 2).

Distribution : INDIA : Arunachal Pradesh, Assam, West Bengal, Bihar, Madhya Pradesh, Uttar Pradesh, Tamil Nadu, Kerala, Karnataka, Andaman Is. ; BANGLADESH ; BURMA ; SRI LANKA ; MALAYSIA ; INDONESIA (Sumatra) ; SULAWESI.

2. **Anopheles annularis** Van der Wulp

1884. *Anopheles annularis* Van der Wulp, *Notes Leyden Mus.* 6 : 249 (Type-loc. : Java, Indonesia).
1900. *Anopheles fuliginosus* Giles, *Handbook Gnats or Mosquitoes* ed. 1 : 161 (Type-loc. : Calcutta, West Bengal, India).
1901. *Anopheles jamesii* Liston, *Indian Med. Gaz.* 36 : 444 (Type-loc. : Maharastra, India).
1901. *Anopheles leucopus* Dönitz, *Insektenbörse* 18 : 37 (Type-loc. : Sumatra, Indonesia).
1908. *Chagasia* ? *lineata* Ludlow, *Can. Ent.* 40 : 50 (Type-loc. : Philippines).
1911. *Nyssorhynchus fuliginosus* var. *adiei* James & Liston, *Monogr. anoph. mosq. India*, ed. 2 : 90 (Type-loc. : Maharastra, India).
1933. *Anopheles* (*Myzomyia*) *annularis* : Christophers, *Fauna Br. India*, Diptera 4 : 300.
1973. *Anopheles* (*Cellia*) *annularis* : Stone & Delfinado, *Catalog Dipt. Orient. Reg.* 1 : 273.

Material examined : 1953 ♀ ♀. INDIA : ARUNACHAL PRADESH, East Kameng District, Seijusa area, 181 ex., ii., iii. & xi. 1986 ; Seppa, 22 ex., iv. 1987 ; Lower Subansiri

District, Balijan, 62 ex., iv. 1986 ; Naharlagun, 335 ex., vii. & viii. 1987 ; Itanagar, 61 ex., vii. & viii. 1987 ; Kimin and Lora Basti, 45 ex., xi. 1987 ; Upper Subansiri District, Daporijo area, 1247 ex., vi. 1986 & v. 1987 (detail vide Tables 1 to 3).

Distribution : INDIA : Arunachal Pradesh, Assam, West Bengal, Bihar, Uttar Pradesh, Delhi, Rajasthan, Maharastra, Karnataka, Madhya Pradesh, Gujarat, Andhra Pradesh, Khshmir, Punjab, Goa, Tamil Nadu, Kerala ; BANGLADESH ; BURMA ; SRI LANKA ; NEPAL ; PAKISTAN ; CHINA ; TAIWAN ; MALAYSIA ; INDONESIA ; PHILIPPINES ; THAILAND ; VIET-NAM.

3. **Anopheles barbirostris** Van der Wulp

1884. *Anopheles barbirostris* Van der Wulp, *Notes Leyden Mus.* 6 : 248 (Type-loc. : Java, Indonesia).
1902. *Anopheles marlini* Laveran, *C. r. Se´nac. Soc. Biol.* 54 : 907 (Type-loc. : Kampuchea).
1933. *Anopheles (Anopheles) barbirostris* : Christophers, *Fauna Br. India,* Diptera 4 : 155.
1973. *Anopheles (Anopheles) barbirostris* : Stone & Delfinado, *Catalog Dipt. Orient. Reg.* 1 : 268.

Material examined : 2139 ♀ ♀ INDIA : ARUNACHAL PRADESH, East Kameng District, Seijusa area, 299 ex., ii., iii. & xi. 1986 ; Seppa, 69 ex., iv. 1987 ; Lower Subansiri District, Balijan, 114 ex., iv 1986 ; Naharlagun, 578 ex., vii. & viii. 1987 ; Itanagar, 111 ex., vii. & viii. 1987 ; Kimin and Lora Basti, 116 ex., xi. 1987 ; Upper Subansiri District, Daporijo area, 852 ex., vi. 1986 & v. 1987 (detail vide Tables 1 to 3).

Distribution : INDIA : Arunachal Pradesh, Assam, Meghalaya, West Bengal, Bihar, Karnataka, Maharastra, Madhya Pradesh, Gujarat, Uttar Pradesh, Delhi, Punjab, Haryana, Kashmir, Andhra Pradesh, Orissa, Goa, Tamil Nadu, Kerala, Andaman Is., Lakshadweeps ; BANGLADESH ; NEPAL ; BURMA ; SRI LANKA ; PAKISTAN ; INDONESIA (Java) ; KAMPUCHEA.

4. **Anopheles balabacensis** Baisas

1936. *Anopheles leucosphyrus* var. *balabacensis* Baisas, *Philipp. J. Sci.* 59 : 65 (Type-loc. : Philippines).
1973. *Anopheles (Cellia) balabacensis* : Stone & Delfinado, *Catalog Dipt. Orient. Reg.* 1 : 273.

Material examined : 3 ♀ ♀ INDIA : ARUNACHAL PRADESH, Lower Subansiri District, Naharlagun, 3 ex., vii & viii. 1987 (detail vide Table 2).

Distribution : INDIA : Arunachal Pradesh, Assam, Meghalaya, Tripura, West Bengal, Punjab, Karnataka, Kerala, Tamil Nadu, Andaman Is. ; BANGLADESH ; BURMA ; INDONESIA ; MALAYSIA ; PHILIPPINES ; THAILAND ; KAMPUCHEA ; CHINA ; TAIWAN.

5. **Anopheles culicifacies** Giles

1901. *Anopheles culicifacies* Giles, *Entomologist's mon. Mag.* 37 : 197 (Type-loc. : Hoshangabad, Madhya Pradesh, India).
1901. *Anopheles indica* Theobald, 1901, *Monogr. Cul.* 1 : 183 (Type-loc. : Madras, India).
1901. *Anopheles Listoni* Giles, *Entomologist's mon. Mag.* 37 : 197 (Type-loc. : Maharastra, India).

Table 1. Results of entomological survey showing prevalence of diffrent anopheline species in different biotopes in places of East Kameng District, Arunachal Pradesh.

Places (Localities)	Period	Biotopes	Total time spent (hrs.)	ANOPHELINE SPECIES COLLECTED																		TOTAL
				aconitus	annularis	barbirostris	balabacensis	culicifacies	gigas	nigerrimus	jamesii	jeyporiensis	karwari	kochi	maculatus	philippinensis	splendidues	subpictus	vagus			
Seijusa area & Bali Basti	17.2.86 to 28.2.86	outdoor resting	58	11	14	23	–	–	–	35	–	17	—	26	79	15	76	—	28			324 (8.74)
		indoor resting	66	8	7	18	–	–	–	22	–	11	—	15	42	7	51	—	16			197 (5.31)
		cattleshed resting	37	15	22	31	–	–	–	37	–	16	—	27	144	12	79	—	28			411 (11.09)
		cattle biting	35	13	12	21	–	–	–	30	–	17	—	22	78	14	57	—	30			294 (7.93)
Seijusa area (Township)	1.3.86 to 7.3.86	outdoor resting	31	9	9	15	–	–	–	23	–	9	—	13	53	6	33	—	12			182 (4.91)
		indoor resting	33	6	8	13	–	–	–	15	–	7	—	11	31	3	22	—	12			128 (3.45)
		cattleshed resting	18	8	19	24	–	–	–	29	–	11	—	18	71	11	53	—	27			271 (7.31)
		cattle biting	20	11	13	20	–	–	–	24	–	9	—	15	68	8	41	—	23			232 (6.26)
Seijusa area & Mobusa vill.	21.11.86 to 30.11.89	outdoor resting	17	14	16	20	–	–	–	29	7	11	—	6	41	12	53	—	26			235 (6.34)
		indoor resting	22	20	21	25	–	–	–	29	–	16	—	5	31	10	33	—	20			210 (5.66)
		cattleshed resting	19	21	28	68	–	–	–	84	11	23	—	29	95	25	112	—	39			535 (14.43)
		cattle biting	35	13	12	21	–	–	–	30	5	17	—	22	78	14	57	—	30			299 (8.06)
Seppa (Pabua vill., Tassamlora vill. & Nari camp)	4.4.87 to 13.4.87.	outdoor resting	18	–	6	11	–	–	3	14	–	–	—	—	16	5	—	—	10			65 (1.75)
		indoor resting	24	–	4	13	–	–	2	9	–	–	—	4	20	3	—	—	7			62 (1.67)
		cattleshed resting	–	–	–	–	–	–	–	–	–	–	—	—	—	—	—	—	—			—
		cattle biting	55	–	12	45	–	–	7	59	–	–	—	13	91	6	—	—	28			261 (7.04)
		TOTAL	488	149	203	368	–	–	12	469	23	164	—	226	938	151	667	—	336			3706
				(4.02)	(5.47)	(9.23)	(–)	(–)	(0.32)	(12.65)	(0.62)	(4.42)	(—)	(6.09)	(25.31)	(4.07)	(18.00)	(—)	(9.06)			(100)

Figures in parentheses indicate the percentage

Table 2. Results of entomological survey showing prevalence of diffrent anopheline species in different biotopes in places of Lower Subansiri District, Arunachal Pradesh.

Places (Localities)	Period	Biotopes	Total time spent (hrs.)	ANOPHELINE SPECIES COLLECTED																TOTAL
				aconitus	annularis	barbirostris	balabacensis	culicifacies	gigas	nigerrimus	jamesii	jeyporiensis	karwari	kochi	maculatus	philippinensis	splendidus	subpictus	vagus	
Balijan	18.4.86	outdoor resting	55	—	12	21	—	—	—	27	—	2	—	18	67	5	—	—	18	170 (1.87)
(Tagung vill.	to	Indoor resting	63	—	22	31	—	—	—	26	—	—	—	23	84	12	—	—	17	215 (2.36)
& Nishi Basti)	29.4.86	crttleshed resting	41	2	15	35	—	5	—	42	—	—	—	23	79	14	—	4	40	259 (2.85)
		cattle biting	38	3	13	27	—	—	—	27	—	—	—	22	993	9	—	2	36	332 (2.55)
Naharlagun	24. 7.87	outdoor resting	118	120	122	206	3	—	—	257	108	112	105	183	278	71	147	—	312	2024 22.30)
(Model vill.	to	indoor resting	130	50	68	83	—	—	—	100	64	48	52	99	177	44	83	—	156	1024 (11·28)
Likhi vill.	5.8.87	cattleshed resting	45	71	69	138	—	—	—	187	61	54	65	87	178	42	118	—	229	1299 (14·31)
& Township)		cattle biting	47	82	76	151	—	—	—	218	76	72	83	136	190	57	142	—	249	1532 (16·87)
Itanagar (Ganga	24.7.87	outdoor resting	25	19	22	29	—	—	—	37	16	18	24	28	57	13	39	—	49	351 (3.86)
vill. & Township)	to	Indoor resting	32	14	16	23	—	—	—	21	12	14	19	19	42	11	27	—	32	251 (2·75)
	5. 8.87	cattleshed resting	13	15	10	31	—	—	—	38	15	12	10	37	48	7	23	—	41	287 (3.16)
		cattle biting	15	17	13	28	—	—	—	45	13	10	18	21	60	9	36	—	47	317 (3.40)
Kimin & Lora	21.11.87	outdoor resting	37	9	17	37	—	—	–	48	14	3	18	26	59	8	27	—	47	313 (3.44)
Basti	to	indoor resting	47	3	11	19	—	—	—	28	4	—	9	15	42	3	21	—	31	186 (2.04)
	26.11.87	cattleshed resting	18	17	9	33	—	—	—	48	19	4	12	25	67	7	33	—	57	331 (3·64)
		cattle biting	19	14	8	27	—	—	—	52	13	—	17	37	48	11	20	—	40	287 (3.16)
		TOTAL	743	436	503	919	3	5	—	1201	415	349	432	799	1569	323	716	6	1401	9077
				(4.80)	(5.54)	(10.12)	(0.03)	(0.05)	—	(13.23)	(4.57)	(3.84)	(4.75)	(8.80)	(17.28)	(3.55)	(7.88)	(0.06)	(15.43)	(100)

Figures in parentheses indicate the percentage

1911. *Myzomyia culifacies* var. *punjabensis* James, *in* James & Liston, *Anopheline mosquitoes of India*, ed. 2 : 72 (Type-loc. : Punjab, India).
1933. *Anopheles* (*Myzomyia*) *culicifacies* : Christophers, *Fauna Br. India*, Diptera 4 : 216.
1973. *Anopheles* (*Cellia*) *culicifacies* : Stone & Delfinado, *Catalog Dipt. Orient. Reg.* 1 : 274.

Material examined : 5 ♀ ♀. INDIA : ARUNACHAL PRADESH, Lower Subansiri District, Balilan, 5 ex., iv, 1986 (detail vide Table 2).

Distribution : INDIA : Arunachal Pradesh (New record), Assam, Meghalaya, West Bengal, Bihar, Orissa, Madhya Pradesh, Maharastra, Karnataka, Goa, Gujarat, Delhi, Uttar Pradesh, Haryana, Rajasthan, Punjab, Kashmir, Andhra Pradesh, Kerala, Tamil Nadu ; BANGLADESH ; BURMA ; NEPAL ; PAKISTAN ; SRI LANKA ; AFGHANISTHAN ; IRAN ; OMAN ; CHINA ; VIET-NAM.

6. **Anopheles gigas** Giles

1901. *Anopheles gigas* Giles, *Entomologist's mon. Mag.* 37 : 196 (Type-loc. : Coonoor, Tamil Nadu, India).
1933. *Anopheles* (*Anopheles*) *gigas* : Christophers, *Fauna Br. India*, Diptera 4 : 130.
1973. *Anopheles* (*Anopheles*) *gigas* : Stone & Delfinado, *Catalog Dipt. Orient. Reg.* 1 : 268.

Material examined : 12 ♀ ♀. INDIA : ARUNACHAL PRADESH, East Kameng District, Seppa area, 12 ex., iv. 1987 (detail vide Table 1).

Distribution : INDIA : Arunachal Pradesh (New record), Assam, Meghalaya, Sikkim, West Bengal, Madhya Pradesh, Gujarat, Uttar Pradesh, Haryana, Kashmir, Himachal Pradesh, Punjab, Tamil Nadu ; BANGLADESH ; SRI LANKA ; PAKISTAN ; SULAWESI.

7. **Anopheles nigerrimus** Giles

1900. *Anopheles nigerrimus* Giles, *Handbook Gnats or mosquitoes* ed. 1 : 161 (Type-loc. : Calcutta, West Bengal, India).
1902. *Anopheles bentleyi* Bentley, *Indian med. Gaz.* 37 : 15 (Type-loc. : Assam, India).
1903. *Myzorhynchus minutus* Theobald, *Monogr. Cul.* 3 : 91. (Type-loc. : Lahore, Pakistan).
1933. *Anopheles hyrcanus* var. *nigerrimus* : Christophers, *Fauna Br. India*, Diptera 4 : 145.
1936. *Anopheles hyrcanus* var. *williamsoni* Baisas and Hu, *Mon. Bull. Philipp. Hlth. Ser.* 16 : 222 (Type-loc. : Malaysia).
1951. *Anopheles venhuisi* Bonne-Wepster, *Docum. neerl. indones. Morb. trop.* 3 : 284 (Type-loc. : Java, Indonesia).
1973. *Anopheles* (*Cellia*) *nigerrimus* : Stone & Delfinado, *Catalog Dipt. Orient. Reg.* 1 : 270.

Material examined : 3090 ♀ ♀. INDIA : ARUNACHAL PRADESH, East Kameng District, Seijusa area, 387 ex., ii., iii. & ix. 1986 ; Seppa, 82 ex., iv. 1987 ; Lower Subansiri District, Balijan, 122 ex., iv. 1986 ; Naharlagun, 762 ex., vii & viii. 1987 ; Itanagar, 141 ex., vii & viii. 1987 ; Kimin and Lora Basti, 176 ex., xi. 1987 ; Upper Subansiri District, Daporijo area, 1427 ex., vi. 1986 & v. 1987. (detail vide Tables 1 to 3).

Distribution : INDIA : Arunachal Pradesh, Assam, Meghalaya, Manipur, Nagaland,

West Bengal, Bihar, Madhya Pradesh, Haryana, Himachal Pradesh, Maharastra, Karnataka, Uttar Pradesh, Delhi, Punjab, Gujarat, Goa, Orissa, Andhra Pradesh, Kerala, Tamil Nadu, Lakshadweeps ; BANGLADESH ; BURMA ; SRI LANKA, PAKISTAN ; CHINA ; MALAYSIA ; INDONESIA ; THAILAND.

8. **Anopheles jamesii** Theobald

1901. *Anopheles jamesii* Theobald, *Monogr. Cul.* **1** : 134 (Type-loc. : Quilon, Kerala, India).
1901. *Anopheles jamesii* Liston, *Indian med. Gaz.* 36 : 444 (=*A. annularis* Van der Wulp).
1902. *Anopheles jamesii* : Stephens & Christophers, *Repts. Mal. Comm. R. Soc.*, series 6 & 7.
1904. *Anopheles jamesii* : James & Liston, *Anopheline Mosquitoes of India* ed. 1 : 93.
1911. *Anopheles jamesii* : James & Liston, *Anopheline mosquitoes of India* ed. 2 : 91.
1929. *Anopheles jamesii* : Borel, *Arch. Inst. Past. Indochine* no. 9 : 55.
1933. *Anopheles (Myzomyia) jamesii* : Christophers, *Fauna Br. India*, Diptera 4 : 291.
1973. *Anopheles (Cellia) jamesii* : Stone & Delfinado, *Catalog Dipt. Orient. Reg.* 1 : 274.

Material examined : 438 ♀ ♀ INDIA : ARUNACHAL PRADESH, East Kameng District, Seijusa area, 23 ex., xi. 1986 ; Lower Subansiri District, Naharlagun, 309 ex., vii. & viii. 1987 ; Itanagar, 56 ex., vii. & viii. 1987 ; Kimin and Lora Basti, 50 ex., xi. 1987 (detail vide Tables 1 and 2).

Distribution : INDIA : Arunachal Pradesh (New record), Assam, Meghalaya, West Bengal, Orissa, Andhra Pradesh, Karnataka, Maharastra, Goa, Kerala, Tamil Nadu ; BANGLADESH ; BURMA ; SRI LANKA ; MALAYSIA ; VIET-NAM ; CHINA.

9. **Anopheles jeyporiensis** James

1902. *Anopheles jeyporiensis* James, *Scient. Mem. offrs. med. sanit. Deps. India* 2 : 32. (Type-loc. : Jeypore Hill tracts, Vizagapatnam Dist., Andhra Pradesh, India).
1903. *Anopheles jeyporiensis* : Theobald, *Monogr. Cul.* 3 : 66.
1933. *Anopheles (Myzomyia) jeyporiensis* : Christophers, *Fauna Br. India*, Diptera 4 : 220.
1973. *Anopheles (Cellia) jeyporiensis* : Stone & Delfinado, *Catalog Dipt. Orient. Reg.* 1 : 275.

Material examined : 513 ♀ ♀ INDIA : ARUNACHAL PRADESH, East Kameng District, Seijusa area, 164 ex., ii., iii. & xi. 1986 ; Lower Subansiri District, Balijan, 2 ex., iv. 1986 ; Naharlagun, 286 ex., vii. & viii. 1987 ; Itanagar, 54 ex., vii. & viii. 1987 ; Kimin and Lora Basti. 7 ex., xi. 1987 (detail Vide Tables 1 and 2).

Distribulion : INDIA : Arunachal Pradesh, Assam, Meghalaya, West Bengal, Bihar, Orissa, Madhya Pradesh, Uttar Pradesh, Gujarat, Maharastra, Karnataka, Andhra Pradesh, Tamil Nadu, Kerala ; BURMA ; VIET-NAM ; KAMPUCHEA ; TAIWAN.

10. **Anopheles karwari** (James)

1903. *Nyssorhynchus karwari* James *in* Theobald, *Monogr. Cul.* 3 : 102 (Type-loc. : Karwar, Maharastra, India).
1904. *Anopheles karwari* : James & Liston, *Anopheline mosquitoes of India* ed. 1 : 89.
1908. *Anopheles karwari* : Leicester, *Stud. Inst. Med. Res. F. M. S.* 3 : 39.
1921. *Anopheles karwari* : Rodenwaldt, *Tijds. Ent.* 64 : 155.

1933. *Anopheles* (*Myzomyia*) *karwari* : Christophers, *Fauna Br. India*, Diptera 4 : 288.
1973. *Anopheles* (*Cellia*) *karwari* : Stone & Delfinado, *Catalog Dipt. Orient. Reg.* 1 : 275.

Material examined : 432 ♀ ♀ INDIA : ARUNACHAL PRADESH, Lower Subansiri District, Naharlagun, 305 ex., vii. & viii. 1987 ; Itanagar, 71 ex., vii. & viii. 1987 ; Kimin and Lora Basti, 56 ex., xi. 1987 (detail vide Table 2).

Distribution : INDIA : Arunachal Pradesh (New record), Assam, Meghalaya, West Bengal, Bihar, Orissa, Maharastra, Karnataka, Goa, Andhra Pradesh, Tamil Nadu, Kerala ; Widespread in the Oriental Region up to New Guinea.

11. **Anopheles kochi** Donitz

1901. *Anopheles kochi* Dönitz, *Insektenbörse* 18 : 36 (Type-loc. : Sumatra, Indonesia).
1901. *Anopheles ocellalus* Theobald, *Monogr. Cul.* 1 : 174 (Type-loc. : Malaysia).
1908. *Cellia flava* Ludlow, *Can. Ent.* 40 : 32 (Type-loc. : Philippines).
1910. *Christophersia halli* James, *Paludism* 1 : 33 (Type-loc. : Sylhet, Bangladesh).
1933. *Anopheles* (*Myzomyia*) *kochi* : Christophers, *Fauna Br. India*, Diptera 4 : 172.
1973. *Anopheles* (*Cellia*) *kochi* : Stone & Delfinado, *Catalog Dipt. Orient. Reg.* 1 : 275.

Material examined : 1474 ♀ ♀. INDIA : ARUNACHAL PRADESH, East Kameng District, Seijusa area, 209 ex., ii., iii. & xi. 1986 ; Seppa, 17 ex., iv. 1987 ; Lower Subansiri District, Balijan, 86 ex., iv. 1986 ; Naharlagun, 505 ex., vii. & viii. 1987 ; Itanagar, 105 ex., vii. & viii. 1987 ; Kimin and Lora Basti, 103 ex. , xi. 1987 ; Upper Subansiri District, Daporijo area, 149 ex., vi. 1986 & v. 1987 (detail vide Tables 1 to 3).

Distribution : INDIA : Arunachal Pradesh, Assam, Meghalaya, West Bengal, Andaman Is., BANGLADESH ; BURMA ; MALAYSIA ; PHILIPPINES ; INDONESIA ; MOLUCCAS.

12. **Anopheles maculatus** Theobald

1901. *Anopheles maculatus* Theobald, *Monogr. Cul.* 1 : 171 (Type-loc. : Hong Kong).
1910. *Nyssorhynchus pseudowillmori* Theobald, *Monogr. Cul.* 5 : 65 (Type-loc. : Jalpaiguri Duars, West Bengal, India).
1911. *Anopheles maculatus* : James & Liston, *Anopheline mosquitoes of India* ed. 2 : 87.
1924. *Anopheles maculatus* var. *dravidicus* Christophers, *Indian J. med. Res.* 12 : 297 (Type-loc. : Nilgiri Hills, Tamil Nadu, India).
1925. *Myzomyia hanabusai* Yamada, *Scient. Rep. Govt. Inst. infect. Dis. Tokyo Univ.* 4 : 471 (Type-loc. : Taiwan).
1933. *Anopheles* (*Myzomyia*) *maculatus* : Christophers, *Fauna Br. India*, Diptera 4 : 278.
1973. *Anopheles* (*Cellia*) *maculatus* : Stone & Delfinado, *Catalog Dipt. Orient. Reg.* 1 : 275.

Material examined : 3921 ♀ ♀. INDIA : ARUNACHAL PRADESH, East Kameng District, Seijusa area, 811 ex., ii., iii., & xi. 1986 ; Seppa, 127 ex., iv. 1987 ; Lower Subansiri District, Balijan, 323 ex., iv. 1986 ; Naharlagun, 823 ex., vii. & viii. 1987 ; Itanagar, 207 ex., vii & viii. 1987 ; Upper Subansiri District, Daporijo area, 1414 ex., vi. 1986 & v. 1987 (detail vide Tables 1 to 3).

Distribution : INDIA : Arunachal Pradesh, Assam, Meghalaya, Nagaland, West Bengal, Bihar, Orissa, Madhya Pradesh, Uttar Pradesh, Haryana, Punjab, Himachal Pradesh, Kashmir, Maharastra, Goa, Karnataka, Andhra Pradesh, Tamil Nadu, Kerala ; BANGLADESH ; BURMA ; NEPAL ; SRI LANKA ; PAKISTAN ; HONG KONG ; CHINA ; Lesser SUNDA IS.

13. **Anopheles philippinensis** Ludlow

9012. *Anopheles philippinensis* Ludlow, *J. Am. med. Ass.* 39 : 426 (Type-loc. : Philippines).
1906. *Pyretophorus freerae* Banks, *Philipp. J. Sci.* (D) 1 : 993.
1920. *Anopheles pampangensis* Brunetti, *Rec. Indian Mus.* 17 : 114 (n. name for *philippinensis* (Ludlow, in error).
1933. *Anopheles (Myzomyia) philippinensis* : Christophers, *Fauna Br. India,* Diptera 4 : 307.
1973. *Anopheles (Cellia) philippinensis* : Stone & Delfinado, *Catalog Dipt. Orient. Reg.* 1 : 277.

Material examined : 731 ♀ ♀. INDIA : ARUNACHAL PRADESH, East Kameng District, Seijusa area, 137 ex., ii., iii. & xi. 1986 ; Seppa, 14 ex., iv. 1987 ; Lower Subansiri District, Balijan, 40 ex., iv. 1986 ; Naharlagun, 214 ex., vii. & viii. 1987 ; Itanagar, 40 ex., vii. & viii. 1987 ; Kimin and Lora Basti, 29 ex., xi. 1987 ; Upper Subansiri District, Daporijo area, 257 ex., vi. 1986 & v. 1987 (detail vide Tables 1 to 3).

Distribution : INDIA : Arunachal Pradesh, Assam, Meghalaya, Manipur, West Bengal, Bihar, Orissa, Karnataka, Maharastra ; BANGLADESH ; MALAYSIA ; THAILAND ; VIET-NAM ; CHINA.

14. **Anopheles splendidus** Koidzumi

1920. *Anopheles splendidus* Koidzumi, *Daiwan Kenkyujo Hokoku* 8 : 23 (Type-loc. : Taiwan).
1903. *Nyssorhynchus maculipalpis* var. *indiensis* Theobald, *Monogr. Cul.* 3 : 99 (Type-loc. : Nagpur, Maharastra, India ; nec. *A. sinensis* var. *indiensis* Theobald, 1901).
1904. *Anopheles maculipalpis* James & Liston, *Anopheline mosquitoes of India* ed. 1 : 95 (Type-loc. : India ; nec. *A. maculipalpis* Giles, 1902).
1933. *Anopheles (Myzomyia) splendidus* : Christophers, *Fauna Br. India,* Diptera 4 : 296.
1973. *Anopheles (Cellia) splendidus* : Stone & Delfinado, *Catalog Dipt. Orient. Reg.* 1 : 277.

Material examined : 1583 ♂♂, ♀ ♀. INDIA : ARUNACHAL PRADESH, East Kameng District, Seijusa area, 667 ex., ii., iii. & xi. 1986 ; Lower Subansiri District, Naharlagun, 490 ex., vii. & viii. 1987 ; Itanagar, 125 ex., vii. & viii. 1987 ; Kimin and Lora Basti, 101 ex., xi. 1987 ; Upper Subansiri District, Daporijo area, 200 ex., vi. 1986 and v. 1987 (detail vide Tables 1 to 3).

Distribution : INDIA : Arunachal Pradesh, West Bengal, Bihar, Orissa, Madhya Pradesh, Uttar Pradesh, Delhi, Punjab, Haryana, Himachal Pradesh, Kashmir, Gujarat, Maharastra, Goa, Karnataka, Andhra Pradesh, Tamil Nadu, Kerala ; NEPAL ; BURMA ; PAKISTAN ; VIET-NAM ; KAMPUCHEA ; TAIWAN ; CHINA.

Table 3. Results of entomological survey showing prevalence of different anopheline species in different biotopes in places of Upper Subansiri District, Arunachal Pradesh.

Places (Localities)	Period	Biotopes	ANOPHELINE SPECIES COLLECTED																	TOTAL
			Total time spent (hrs.)	aconitus	annularis	barbirostris	balabacenssis	culicifacies	gigas	nigerrimus	jamesii	jeyporiensis	karwari	kochi	maculatus	philippinensis	splendidus	subpictus	vagus	
Daporijo	13.6.86	outdoor resting	61	—	307	179	—	—	—	356	—	—	—	107	341	69	53	—	149	1561 (23.87)
(township)	to	indoor resting	68	—	193	85	—	—	—	106	—	—	—	42	177	36	—	—	64	703 (10.75)
	29.6.86	cattleshed resting	41	—	299	171	—	—	—	330	—	—	—	57	262	48	25	—	175	1367 (20.90)
		cattle biting	43	—	266	185	—	—	—	277	—	—	—	81	302	53	19	—	167	1350 (20.64)
Daporijo	21.5.87	outdoor resting	24	—	47	54	—	—	—	115	—	—	—	42	91	11	23	—	33	416 (6.36)
(Forest colony,	to	indoor resting	28	—	40	34	—	—	—	57	—	—	—	24	52	11	18	—	26	262 (4.00)
Ligu vill. &	29.5.87	cattleshed																		
Sikarajo vill.)		resting	26	—	58	74	—	—	—	101	—	—	—	53	105	18	31	—	40	480 (7.34)
		cattle biting	25	—	37	70	—	—	—	85	—	—	—	43	84	11	31	—	39	400 (6.11)
		TOTAL	316	—	1247	852	—	—	—	1424	—	—	—	449	1414	257	200	—	693	6539
				(—)	(19.07)	(13.02)	(—)	(—)	(—)	(21.82)	(—)	(—)	(—)	(6.86)	(21.62)	(3.93)	(3.05)	(—)	(10.59)	(100)

Figures in parentheses indicate the percentage

15. Anopheles subpictus Grassi

1899. *Anopheles subpictus* Grassi, *Rc. R. Acad. Lincei* 8 : 101 (Type-loc. : Calcutta, West Bengal, India).
1899. *Anopheles rossii* Giles, *J. Trop. Med.* 2 : 63 (Type-loc. : Calcutta, West Bengal, India).
1903. *Aldrichia error* Theobald, *Monogr. Cul.* 3 : 353 (Type-loc. : Calcutta, West Bengal, India).
1904. *Anopheles subpictus* : James & Liston, *Anopheline Mosquitoes of India* ed. 1 : 109.
1933. *Anopheles (Myzomyia) subpictus* : Christophers, *Fauna Br. India*, Diptera 4 : 231.
1973. *Anopheles (Cellia) subpictus* : Stone & Delfinado, *Catalog Dipt. Orient. Reg.* 1 : 278.

Material examined : 6 ♀ ♀ INDIA : ARUNACHAL PRADESH, Lower Subansiri District, Balijan, 6 ex., iv. 1986 (detail vide Table 2).

Distribution : INDIA : Arunachal Pradesh, Assam, Meghalaya, Tripura, West Bengal, Bihar, Orissa, Madhya Pradesh, Uttar Pradesh, Punjab, Haryana, Himachal Pradesh, Rajasthan, Gujarat, Maharastra, Goa, Karnataka, Andhrh Pradesh, Tamil Nadu, Kerala, Lakshadweeps ; BANGLADESH ; BURMA ; NEPAL ; SRI LANKA ; PAKISTAN ; AFGHANISTHAN ; IRAN ; CHINA ; MALAYSIA ; INDONESIA ; THAILAND ; MALDIVE ; BISMARCK IS. ; NEW GUINEA.

16. Anopheles vagus Dönitz

1902. *Anopheles vagus* Dönitz, *Z. Hyg. Infektkrankh* 41 : 80 (Type-loc. : Sumatra, Indonesia).
1902. *Anopheles formosaensis* I. Tsuzuki, *Saikingaku Zasshi* 75 : 28 (Type-loc. : Formosa).
1902. *Anopheles immaculata* James, *Scient. Mem. Offrs. med. sanit Deps. India* 2 : 35 (Type-loc. : Ennur, Tamil Nadu, India).
1903. *Anopheles immaculatus* Theobald, *Monogr. Cul.* 3 : 23 (Type-loc. : Goa, India).
1907. *Anopheles formosaensis* var. *trimaculatus* Tsuzuki, *Zool. Jb.* (1) 25 : 549 (Type-loc. : Formosa).
1917. *Myzomyia indefinita* var. *flava* Swellengrebel, *Geneesk, Tijdschr. Ned.-Indie* 57 : 807 (Type-loc. : Java, Indonesia).
1923. *Anopheles vagus* : Senior-White, *Catalog Indian Ins.* Pt. 2 : 34.
1933. *Anopheles (Myzomyia) vagus* : Christophers, *Fauna Br. India*, Diptera 4 : 241.
1973. *Anopheles (Cellia) vagus* : Stone & Delfinado, *Catalog Dipt. Orient. Reg.* 1 : 279.

Material examined : 2430 ♀ ♀ INDIA : ARUNACHAL PRADESH, East Kameng District, Seijusa area, 291 ex., ii., iii. & xi. 1986 ; Seppa, 45 ex., iv. 1987 ; Lower Subansiri District, Balijan, 111 ex., iv. 1986 ; Naharlagun, 946 ex., vii. & viii. 1987 ; Itanagar, 169 ex., vii. & viii. 1987 ; Kimin and Lora Basti, 175 ex., xi. 1987 ; Upper Subansiri District, Daporijo area, 693 ex., vi. 1986 & v. 1987 (detail vide Tables 1 to 3).

Distribution : INDIA : Arunachhl Pradesh, Assam, Meghalaya, Manipur, Tripura, West Bengal, Bihar, Orissa, Madhya Pradesh, Maharastra, Karnataka, Goa, Gujarat, Andhra Pradesh, Tamil Nadu, Kerala, Pondicherry, Andaman Is., Lakshadweeps ; ANGLADESH ; BURMA ; SRI LANKA ; TAIWAN ; MOLUCCAS ; and Widespread in Oriental Region.

Key to the Anopheline species (females) to the area

1. Wing with dark areas involving costa, subcosta, and first longitudinal vein (R_1) less than four in numbers. (Subgenus *Anopheles*) ... 2
— Wing with dark areas involving costa, subcosta and first longitudinal vein (R_1) at least four in numbers. (Subgenus *Cellia*) ... 4
2. Inner quarter of costa with pale interruption, a large pale spot on the wing fringe between 5·2 and 6. ... *gigas* Giles
— Inner quarter of costa mainly dark, though there may be a few scattered pale scales. ... 3
3. Palpi with distinct pale markings. ... *nigerrimus* Giles
— Palpi devoid of any pale markings ... *barbirostris* Van der Wulp
4. Tip of hind tarsi (5th tarsal segment) white ... 9
— Tip of hind tarsi (5th tarsal segment) not white ... 5
5. Apical and subapical pale bands of palpi nearly of equal length. ... 6
— Pale apical band of palpi always broader than subapical pale band. ... 7
6. Intermediate dark area between apical and subapical pale bands of palpi much broader than either of the two bands. ... *culicifacies* Giles
— Intermediate dark area between apical and subapical pale bands of palpi much proader either of the two bands. ... *aconitus* Dönitz
7. Pale apical band of palpi a little broader than subapical pale band, the intermediate dark area much broader than either of two bands. ... *jeyporiensis* James
— Pale apical band of palpi distinctly broader than subapical pale band ; the intermediate dark area either of the same size of apical band or smaller than that. Tarsi of front legs with broad pale bands. ... 8
8. Dark intermediate area between two pale bands at apex of palpi is almost equal in length of the apical pale band. ... *subpictus* Grassi
— Dark intermediate area between two pale bands at apex of palpi markedly narrow and less than one-third of apical pale area. ... *vagus* Dönitz
9. Hind tarsi with only one segment or less white, commonly with white bands above this. ... 10
— Hind tarsi with a continuous white area on at least two terminal segments. ... 13
10. Femora and tibiae speckled. ... 11
— Femora and tibiae not speckled ... *karwari* (James)
11. Sixth vein (2nd A) of wing with more than three dark spots. ... *balabacensis* Baisas
— Sixth vein (2nd A) of wing with not more than three dark spots. ... 12
12. Half 5th hind tarsal segment of whitish ; palpi with four pale bands. Prominent black scale tufts on ventral side of each abdominal segment. ... *kochi* Dönitz
— Whole of 5th hind and one-third of 4th hind tarsal segments white with a dark band on 4th segment ; palpi with three pale bands. ... *maculatus* Theobald
13. Femora and tibiae speckled. ... 14

— Femora and tibiae not speckled. ... 15

14. Palpi with two broad apical pale bands equal, palpi speckled. ... *splendidus* Koidzumi
— Palpi with two apical pale bands unequal. At least two segments of dorsum of abdomen clothed with golden scales. ... *jamesii* Theobald
15. Ffth vein (Cu) of wing mainly dark with a dark spot at its bifurcation ... *annularis* Van der Wulp
— Fifth vein (Cu) of wing continuously pale and no dark spot at its bifurcation. Distal end of tarsal segment 1 of hind leg inconspicuously white-marked. ... *philippinensis* Ludlow

RESULTS

During these surveys, a total of 19,322 anopheline mosquitoes (females) belonging to 16 species were collected. Among them *A. maculatus* was most common (East Kameng—25·31% ; Lower Subansiri—17·28% ; Upper Subansiri—21·62%) and only slight morphological variations were seen in different population, *A nigerrimus*, *A vagus* and *A barbirostris* were found in large number from all the localities. *A. annularis* and *A. philippinensis* were collected in considerable number from almost all villages and human settlements (Tables 1 to 3). Of 4 new introductions in Arunachal Pradesh only *A. culicifacies* is a primary vector of malaria in parts of its range of distribution.

DISCUSSION

The protocol described in this paper provides a basis for realizing the extent or probablity of contact between human, nonhuman hosts and mosquitoes in various biotopes. However, the quantification obtained be carefully qualified as the variation in housing and surrounding conditions in various localities may also influence the number of mosquito biting/catching.

The results of this survey should of course be supplemented by more pertinent data so as to quantitate the actual degree of concurrence between mosquitoes and hosts in studies of the 'Feeding Index' (Kay *et al.*, 1979). It would also help in order to put forward a more thorough analysis of host-feeding patterns based on precipitin-test analysis. The host-mosquito concurrence factor may be derived from data on the relative availability of hosts and the mosquitoes indoors and outdoors. This, in turn, can point out to the overall risk to the human population. For example, from the Upper Subansiri District's data of *A. annularis* it revealed that, in Daporijo township during June 1986, the relative proportion of occurrence indoors and outdoors was 1 : 1·77 (Table 3). During the first quarter of night when *A. annularis* was most active, approximately whole of the human population used to remain indoors. The risk of human being affected by malaria parasite through *A. annularis* thus appears to be considerably greater in outdoors than in indoors. On the

basis of relative risk assessment appropriate measures are required to be taken up. In fact, the zooprophylactic effect of domestic pigs and wild or semidomesticated mammals indispersed among social gatherings or aborigines stay outdoor, seem to suppress the transmission of malaria to some extent in Arunachal Pradesh.

Entomological observations in outdoor conditions, in cattlesheds and inside the human residence reveal that *A. maculatus*, *A. nigerrinmus*, *A. vagus* and *A. barbirostris* are the most commonly encountered anopheline species. None of these species is recorded to be a primary or secondary vector of malaria throughout its zone of distribution. However,

Table 4. Statement showing epidemiological situation of malaria in Kameng, Lower Subansiri and Upper Subansiri Districts of Arunachal Pradesh

Name of the Districts	Year	Blood slide collected/ examined	Blood slide positive for malarial parasite	Presence of P falciparum	Death due to malaria
Kameng (East plus West)	1985	13168	1370	203	—
	1986	9644	1072	188	—
	1987	8544	514	144	—
	1988 (up to Nov.)	7226	558	130	—
Lower Subansiri	1985	34194	1595	213	—
	1986	32746	2046	270	—
	1987	29722	2047	225	—
	1988 (up to Nov.)	30786	2267	267	—
Upper Subansiri	1985	25087	3322	205	—
	1986	27564	3036	119	—
	1987	19025	1723	119	—
	1988 (up to Nov.)	20148	2166	102	—
	TOTAL	257854	21716	2275	—

Source : Directorate of Health Service, Govt. of Arunachal Pradesh

recent surveys reveal high incidence of malaria in this region (Table 4). It is noteworthy that most of the malaria cases were due to *Plasmodium vivax* but during last few years

incidence of *P. falciparum* has been increasing. Of the recognised vector species in the country and those present in this area, the population of *A. balabacensis* and *A. culicifacies* are extremely low and may not be responsible for any significant malaria transmission. *A. philippinensis* is not a vector of malaria in this part of the country but increases in its densities especially after rains, may be causing considerable nuisance. This species is virtually disappeared (NMEP, 1970) and lost its influence of transmitting malaria in many areas like, southern West Bengal. *A. annularis* which was regarded to be a secondary vector in certain areas of India (Timber, 1935 ; Viswanathan *et. al.*, 1941 ; Panigrahi, 1942 ; Senior-White *et al.*, 1943) has now replaced the former species of primary importance like, *A. philippinensis* to become the vector of primary importance, as in rural West Bengal (Ghosh, *et al.*, 1985). The densities of *A. annularis* are reasonably high from May to at least August in this area. Though neither *A. philippinensis* nor *A. annularis* has been found incriminated with the parasite but there are ample circumstancial evidence that indicate towards these two species as the candidate vector species. This however must be regarded as an inconclusive opinion. On the other hand there is record that in the absence of the principal vector species in Nepal, sporadic malaria transmission was caused by *A. annularis* (Parajuli *et al.*, 1981). This fact indicates the wide area of vectorial efficiency of *A. annularis*.

Repaid development, large scale construction and many other opportunities induced people to come to Arunachal in large numbers. Inter alia, many labour groups come from many malaria endemic areas, including region with *Plasmodium falciparum* incidence. They often stay in temporary huts and settle down in clusters ('bastis'). These bastis have enough malariogenic potential. The anti-parasitic and anti-mosquito measures for malaria are inadequately implemented. Thus the present situation poses reasonable threat to the overall health status of the State. There is, therefore, an urgent need for visualizing the problem and to reorganise anti-mosquito as well as malaria control operation in this part of the country so as to protect the people from the ravages of malaria.

SUMMARY

The paper deals with the anopheline mosquito collection from the districts of East Kameng, Lower Subansiri and Upper Subansiri of Arunachal Pradesh. It is based on by some recent collections made by the NMEP team of Kimin (Arunachal Pradesh). A total of 16 species of *Anopheles* are recorded of which, *A. culicifacies*, *A. gigas*, *A. jamesii* and *A. karwari* are noted for the first time from this State.

The observations provided a moderate basis for assessing the extent of contact between human and nonhuman hosts and mosquitoes in different biotopes like, inside human residences, cattlesheds and outdoor conditions. Parasitological surveys in Arunachal Pradesh revealed that there is upsurge of malaria cases in different districts. Both *Plasmodium vivax* and *P. falciparum* cases were noted. Entomological observations brought out the importance of the available anopheline species in transmission of malaria in this area.

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LABORATORY STUDIES ON THE LIFE HISTORY OF FOUR SPECIES OF COLLEMBOLA FROM N. E. INDIA

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INTRODUCTION

Work on the life history of collembola species under laboratory conditions in relation to various environmental factors is very meagre.

Maclagen (1932) was one of the earliest who showed that soil pH had a profound effect on the oviposition of *Sminthurus viridis*(L.) Davidson (1934) showed that pH 5.5-7.0 was favourable for oviposition in the same species. Milne (1960) suggested that quantity of food and moisture content rapidly changed the oviposition, fecundity and mortality in various species of Arthropleone collembola.

The earliest work on environmental factors affecting the development of collembola was that of Choudhuri (1960, 1963) who showed the effect of temperature on the development of three species of the genus *Onychiurus*. Marshall and Kevan (1962) also showed that an increase in temperature simultaneously increased the oviposition rate and reduced the time of hatching in *Folsomia candida* (Willam). Sharma and Kevan (1963a) recorded the influence of temperature on the development, mortality and fecundity of *Isotoma notabilis*.

Green (1964a, 1964b) revealed moisture as the one factor in reducing mortality while crowding as the other affecting fecundity, which was reciprocal to the density of the culture media. Vail (1965) showed that the pH of activated charcoal had an effect on the colonization *Hypogastrura manubrialis*. A linear relationship was shown between the reciprocal of egg-developmental time and temperature by Hale (1965a, 1965b). Ashraf (1969) while working on the fecundity of *Onychiurus bhattii* Yosii showed that they differed considerably with pH and that most indlviduals survived around slight alkaline pH but died at pH beyond 9.7. Studies on food and the speed of establishment of a population of *Folsomia candida* revealed that it was proportional to the rate at which the food was supplied (Usher *et. al.*, 1971). Snider (1971) had shown in culture-experiments that the type and quality of diet can influence collembola growth and fecundity which is again attributed to pH.

The aim of the present study was to take up some important species of the dominant

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groups in N. E. India, to identify the reproductive strategies and to show their importance in the population-dynamics.

Material and Methods

The top surface layers of soil were taken for these experiments. The specimens from the soil samples were extracted in the usual way with the help of the modified Tullgren funnel series except that the collecting tubes contained triple distilled water. The species were then identified, removed and kept separately. All four species belonged to Family Entomobryidae. These were (1) *Seira indica* Yosii (2) *Seira lateralis* Yosii, (3) *Salina yosii* Salmon and (4) *Entomobrya kali* Imms.

The substrate preparation was done by the plaster-charcoal method after Hutson (1978), using charcoal in variable quantities for the differing pH values. These were placed in small borosil, heat resistant glass vivaria, 3 cm deep and 5 cm in diameter. Varying concentrations of salinity was made with the help of Sodium chloride solutions. These solutions were prepared by dissolving Analar Sodium chloride in triple-distilled water in the quantities required, as given by Richards (1954). However, when the moisture content of the substrate kept lowering a few drops of triple distilled water only was added to culture-media.

Experiments were conducted in incubators at temperatures of 20°, 25° and 30°C. The control experiment was conducted under ambient temperature in the laboratory. The pH used were 6.2, 5.2, and 4.2 for 20°, 25° and 30°C respectively while it was 4.2 for the room temperature (control). Salinity concentrations used were at 1%, 2% and 3% levels. In this respect the experiments were in the form of a randomized block-design where the first set of experiment comprised of 20°C, 6.2 pH and 1% salinity, the second set was at 25°C, 5.2 pH and 2% salinity, while the third was with 30°C, 4.2 pH and 3% salinity. The controls were at room temperature and 4.2 pH. Yeast in agar and boiled banana both sterilized were used as food. Five replicates of each experiment were conducted for all the four species undertaken.

For every experiment 2 individuals of each species were used, small enough not to have been previously oviposited. Males and females were differentiated by the presence of aedaegus and heavy cilia on the abdomen of the male in contrast to the female. Cultures were examined twice daily, once in the morning hours (1000 hrs.) and the other in the evening hours (1600 hrs.).

Food was administered just before sunset. Egg development time was calculated from the day of oviposition to when more than 50% of the eggs of a single batch had hatched. The significant differences between the results obtained for fecundity and mortality at the various tempearature, pH and salinity levels were tested statistically. Length measurements were taken twice daily and the population count was recorded. All experiments (five replicates each) were continued for each of the four species upto the sexually matured stage, which in the present case was upto the 6th instar.

RESULTS

Seira indica revealed that oviposition decreased (60 eggs), with increased pH and reduced temperature and salinity. As seen from Table I the number of eggs laid was seen maximum (78 eggs) under ambient conditions, even though the pH was low. But immediately after hatching (1st instar), there was a sudden drop (50 individuals) in the hatchability under lab-conditions, though it was not so, under the remaining three experimental conditions (70, 65 and 57 individuals). In the subsequent instars (second to sixth) though there was a steady drop in numbers, yet they more or less stabilized (25 to 30 individuals) at the last instar stage irrespective of the fecundity.

In *Seira lateralis*, oviposition depended on temperature as in *S. indica*. However, the number of eggs laid was much more and in fact nearly one and half times (90-100 eggs) than that of *S. indica*. The duration of days either for hatching or for the development of the instars, was observed to be maximum under maximum temperature regimes. However, in the development stages from first to sixth instar, there was negligible difference in the number of days between two moults (TableII). Simlarly the maximum diameter of eggs obtained at all experimental setups were more or less the same.

The third species *Salina yosii* showed a trend of oviposition and development similar to that of *S. indica* and *S. lateralis*. However, the number of eggs laid in this species was nearly double that of *S. indica* and one and half times that of *S. lateralis*. The maximum eggs laid (130-132) was under the maximum temperature and salinity and minimum pH values. However, the ambient temperature which recorded the maximum fecundity (130 eggs) showed the least survival (100 individuals) in the sixth instar, while even the least eggs (120 eggs) laid at the lowest temperature and salinity and highest pH values recorded 103 individuals for the last instar (Table lll).

The fourth species, *Entomobrya kali*, had the lowest oviposition rate which was nearly half that of *S. indica* (40 to 48 eggs). However, it was seen, that at maximum temperatures and highest salinity but with lowest pH not only the maximum eggs were laid but proportionally the survival was also maximum at the 6th instar stage, and as in all the other species the duration of days taken either for hatching or for the different stages between moults, was similar in this species also (Table IV).

It was seen that the maximum percentage (97%) of eggs hatched were in *Seira indica* at the highest temperature and the lowest (64%) was in the control experiment. A similar trend between these two conditions was observed in the mortality percentage for most of the instars.

Seira lateralis as in *Seira indica* revealed the highest percent of hatchability under maximum temperature series and also the lowest mortality in the first instar. The maximum adult survival was in minimum and medium temperature where nearly 60-64% was observed, while under maximum temperataure series only 50% was the survival percentage (Table V).

TABLE I

Experiment No.		Eggs	I instar	II instar	III instar	IV instar	V instar	VI instar
1	a.	60 ± 1·0	57±1·0	50 ± 1·0	45±1·0	40±1·0	25±1·0	25±1·0
	b.	7±2·74	7 ± 2·35	3±1·41	4±1·73	6±1·0	6±1·0	6±1·0
	c.	0·13 ± 0·01	0·25±0·01	0·32±0·01	0·58±0·01	0·58±0·01	0·69±0·01	0·85±0·01
2	a.	70±1·0	65±1·0	53±1·0	40±1·0	35±1·0	30±1·0	30±1·0
	b.	8±1·41	9±1·87	4±1·73	5±1·58	6±2·0	7±1·58	7±1·58
	c.	0·14±0·01	0·30±0·01	0·45±0·01	0·56±0·01	0·60±0·01	0·71±0·01	0·88±0·01
3	a.	72±1·0	70±1·0	60±1·0	50±1·0	40±1·0	30±1·0	30±1·0
	b.	10±1·87	10±1·87	5±1·58	6±2·00	7±2·74	8±2·55	8±2·35
	c.	0·16±0·01	0·31±0·01	0·47±0·01	0·57±0·01	0·63±0·01	0·72±0·01	0·90±0·01
4	a.	78±1·0	50±1·0	45±1·0	40±1·0	35±1·0	30±1·0	28±1·0
	b.	12±3·87	6±2·24	3±1·73	5±2·45	5±2·35	7±2·74	6±2·24
	c.	0·14±0·01	0·34±0·01	0·42±0·01	0·51±0·01	0·60±0·01	0·71±0·01	0·91±0·01

Table I : Fecundity/mortality (a), Days of development (b) and egg diameter/instar length (c) in *Seira indica* at different experimental setups (1-3) and Control (4).

TABLE II

Experiment No.		Eggs	I instar	II instar	III instar	IV instar	V instar	VI instar
1	a.	90±1·0	81±1·0	71±1·0	70±1·0	65±1·0	60±1·0	55±1·0
	b.	15±2·92	10±1·87	5±1·58	7±1·87	6±1·41	7±1·41	7±2·74
	c.	0·11±0·01	0·35±0·01	0·48±0·01	0·60±0·01	0·70±0·01	0·86±0·01	0·94±0·01
2	a.	96±1·0	90±1·0	80±1·0	72±1·0	64±1·0	62±1·0	61±1·0
	b.	10±3·0	11±2·55	7±2·40	8±2·74	8±1·12	8±2·35	8±2·83
	c.	0·20±0·01	0·45±0·01	0·55±0·01	0·63±0·01	0·71±0·01	0·88±0·01	0·98±0 01
3	a.	102±1·0	98±1·0	82±1·0	70±1·0	60±1·0	55±1·0	50±1·0
	b.	16±8·94	12±2·83	8±2·74	7±2·69	8±2·24	9±2·55	9±3·32
	c.	0·21±0·01	0·46±0·01	0·60±0·01	0·70±0 01	0·74±0·01	0·90±0·01	1·15±0·01
4	a.	110±1·0	100±1·0	90±1·0	79±1·0	71±1·0	67±1·0	59±1·0
	b.	17±4·95	9±1·73	6±1·22	6±2·24	7±1·22	8±2·74	7±2·45
	c.	0·22±0·02	0·41±0·01	0·56±0·00	0·61±0·01	0·68±0·00	0·83±0·02	0·93±0·01

Table II : Fecundity/mortality (a), Days of development (b) and egg diameter/instar length (c) in *Seria lateralis* at different experimental setups (1-3) and Control (4).

TABLE III

Experiment No.		Eggs	I instar	II instar	III instar	IV instar	V instar	VI instar
1	a.	120±1·0	110±1·0	107±1·0	105±1·0	104±1·0	103±1·0	103±1·0
	b.	10±2·92	11±3·0	5±2·0	6±1·0	7±2·74	7±2·74	7±2·06
	c.	0·24±0 01	0·55±0·01	0·70±0·01	0·80±0·01	0·92±0·01	1·15±0·01	2·05±0·01
2	a.	126±1·0	124±1·0	114±1·0	113±1·0	108±1·0	106±1·0	104±1·0
	b.	11±4·1	12±2·74	7±2·74	7±2·74	9±2·83	8±2·45	8±2·45
	c.	0·27±0·01	0·58±0·01	0·74±0·01	0·94±0·01	1·10±0·01	1·18±0·01	2·50±0·01
3	a.	130±1·0	128±1·0	120±1·0	118±1·0	115±1·0	111±1·0	108±1·0
	b.	12±3·46	14±3·74	8±2·24	9±2·24	10±2·29	9±4·03	9±3·74
	c.	0·28±0·01	0·59±0·01	0·76±0·02	0·98±0·00	1·12±0·01	1·22±0·01	2·52±0·01
4	a.	132±1·0	130±1·0	110±1·0	108±1·0	106±1·0	104±1·0	100±1·0
	b.	10±1·41	6±1·0	7±1·58	8±2·0	8±2·35	8±2·35	9±2·83
	c.	0·27±0·02	0·56±0·01	0·65±0·01	0·71±0·01	0·85±0·0	0·98±0·01	1·80±0·01

Table III : Fecundity/mortality (a), Days of development (b) and egg diameter/instar length (c) *Salina yosii* at different experimental setups (1-3) and Control (4).

TABLE IV

Experiment No.		Eggs	I instar	II instar	III instar	IV instar	V instar	VI instar
1	a.	40±1·0	35±1·0	34±0·56	32±1·0	31±1·0	28±1·0	27±1·0
	b.	2±0·71	5±1·22	6±1·29	7±2·74	8±2·74	8±2·24	8±2·83
	c.	0·47±0·02	0·70±0·01	0·85±0·01	0·96±0·00	1·10±0·01	1·40±0·01	3·25±0·01
2	a.	42±1·0	30±1·0	28±1·0	26±1·0	24±1·0	22±1·0	20±1·0
	b.	3±1·41	6±1·41	7±2·0	8±2·83	10±3·0	9±3·54	9±1·0
	c.	0·47±0·01	0·75±0·02	0·91±0·01	0·99±0·01	1·14±0·01	1·60±0·01	3·60±0·01
3	a.	48±1·0	40±1·0	38±1·0	36±1·0	35±1·0	33±1·0	30±1·0
	b.	4±1·41	7±2·0	8±2·0	9±2·0	11±3·67	10±3·67	10±1·23
	c.	0·48±0·01	0·78±0·01	0·98±0·01	1·10±0·01	1·30±0·01	1·90±0·01	3·70±0·01
4	a.	44±1·0	36±1·0	32±1·0	31±1·0	30±1·0	28±1·0	26±1·0
	b.	2±0·71	4±1·0	5±2·0	6±2·83	7±2·0	8±2·74	8±2·74
	c.	0·43±0·02	0·68±0·01	0·72±0·01	0·85±0·01	1·06±0·01	1·20±0·01	3·10±0·01

Table IV : Fecundity/mortality (a), Days of development (b) and egg diameter/instar length (c) in *Entomobrya kali* at different experimental setups (1-3) and Control (4).

TABLE V

Experiment No.		Hatchability	I instar	II instar	III instar	IV instar	V instar	VI instar	Adult
1	(A)	95·00	5·00	12·28	10·00	11·11	37·50	00·00	41·67
	(B)	90·00	10·00	12·35	1·41	7·14	7·69	8·33	61·11
	(C)	91·67	8·33	2·73	1·87	0·95	0·96	0·00	85·83
	(D)	87·50	12·50	2·86	5·88	3·13	6·45	3·57	67·50
2	(A)	92·36	7·14	18·46	24·53	12·50	14·29	0·00	42·86
	(B)	93·75	6·25	11·11	10·00	11·11	3·13	1·61	63·54
	(C)	98·41	1·59	8·06	0·88	4.42	1·85	1·87	82·54
	(D)	71·43	28·57	6·67	7·14	7·69	8·33	9·09	47·62
3	(A)	97·22	2·78	14·29	16·67	20·00	25·00	0·00	41·67
	(B)	96·08	3·92	10·20	14·63	14·29	8·33	9·09	49·02
	(C)	98·46	1·54	6·25	1·67	1·69	3·48	2·70	83·08
	(D)	83·33	16·67	5·00	5·26	2·78	5·71	9·09	62·50
4	(A)	64·10	48·72	10·00	11·11	12·50	11·42	6·67	35·90
	(B)	90·97	9·09	10·00	12·22	10·13	5·63	11·94	53·64
	(C)	98·48	1·52	15·38	1·82	1·85	1·89	3·85	75·76
	(D)	81·82	18·18	11·11	3·13	3·23	6·67	7·14	59·09

Table V : The natality and mortality percentages in the four species of Collembola (A : *Seira indica*, B : *Seira lateralis*, C : *Salina yosii* and D : *Entomobrya kali*) under the different experimental setups (1-3) and Control (4).

In *Salina yosii*, the percentage of hatching was seen to be nearly the same (98.5%) at medium, maximum and ambient temperatures while the minimum (92%) was under minimum temperature. However, a reverse trend was observed in the mortality percentage of 1st instar, and no clear cut uniformity was seen in any of the other instars. The percentage of adult survival at the end of the experiment was seen to be maximum under maximum temperature (nearly 86%), while the lowest (76%) was observed in the control. In the other two experimental conditions, the percentage survival was very near to the maximum recording 83% (Table V).

Entomobrya kali in contrast to all the other three species, recorded the maximum percentage of hatchability (nearly 88%) under low temperatures, while the lowest (71%) was seen under medium temperature series. The percentage of mortality from the first to sixth instar, as well as the adult was nearly the same under the different experimental setups except that significant maximum mortality (28%) was seen for the first instar at medium temperatures (Table V).

In all the species, the maximum number of males in relation to females was seen to be in medium temperatures. This was significantly shown for *Seira indica* and *Seira lateralis*. However, in *Salina yosii* and *Entomobrya kali*, the male-female ratio was more or less the same under the different experimental conditions (Table VI).

Table VI

Experiment No.	A	B	C	D
1	1·5 : 1	1·5 : 1	1·42 : 1	2·9 : 1
2	4·6 : 1	1·9 : 1	1·36 : 1	3·0 : 1
3	2·4 : 1	1·5 : 1	1·30 : 1	1·9 : 1
4	2·8 : 1	1·0 : 1	1·43 : 1	2·2 : 1

Table VI : The male : female ratio in the four species of Collembola (A : *Seira indica*, B : *Seira lateralis*, C : *Salina yosii*, D : *Entomobrya kali*) under the different experimental setups (1-3) and Control (4).

It was seen that in *Seira indica* fecundity was highly positively significant, $p < 0.01$, and no significance between temperature and the numbers in each instar. Temperature and the number of days were significant only in the egg (hatching) and in the V and VI instars development, all positively significant, the former at $p < 0.05$ and the latter two at $p < 0.01$

level. Temperature was significant for the I, III, IV and VI instars all at $p < 0.01$ level. pH had the same correlation except that it was negatively correlated. Salinity revealed a more or less similar phenomenon as temperature. The multivariate analysis was highly significant at $p < 0.01$ levels in all cases except for the egg stage and the V instar where the level of significance was at $p < 0.05$ (Table VII).

In *Seira lateralis*, temperature, with either egg-numbers or number of instars, showed no significance at all, except in the second instar stage. Temperature and number of days involved in hatching and in development of instars I, II, was positively significant at $p < 0{\cdot}01$. Finally temperature with egg-diameter or length of the various instars was seen to be positively signifcant. pH was non-significant either for the egg-number or the number of different instars, but was negatively significant with the number of days and the length of the various stages. The multiple correlation values were all positively significant at $p < 0.01$ (Table VIII).

In *Salina yosii* the various environmental factors seem to follow a similar pattern of significant correlations, whether it was temperature, pH or salinity.

The multiple correlation showed a positive significance in all cases at $p < 0.01$ level except for the V instar where the level was at $p < 0.05$ and for the I instar it was not significant (Table IX).

In *Entomobrya kali* it was seen that the various environmental factors with either the number of eggs or number of instars had no significance except that pH showed a negative significance only for the I instar at $p < 0{\cdot}01$ level. The number of days and the eggs hatching period was seen to be significant with all environmental factors except pH which was negatively significant. Multiple correlation was seen to be highly positively significant at $p < 0.01$ level except for the first instar where it was not significant (Table X).

Discussion

The present study incorporated the life history of four dominant species of collembola of the family Entomobryidae from abandoned jhum fallows in N. E. India. Two of the species were from the youngest and two were from the oldest abandoned fallows. The primary aim was to identify from life history studies in laboratory, whether the population dynamics of these species could be correlated to field conditions. It is known that in many collembola the length of life-cycle varies in different species as also the time of the year when the eggs are laid. However, in most cases two or more generations may be produced within a year.

The results revealed that though the species were different and inhabiting different soil conditions, yet they revealed similarities in their life-history strategies. *Seira indica* had maximum production of eggs, maximum percentage of hatching and maximum size

TABLE VII

	Eggs	I instar	II instar	III instar	IV instar	V instar	VI instar
Temp. & Egg No./Instar No.	0·850**	0·233	0·302	0·307	0·272	0·344	0·262
Temp. & Days	0·521*	0·285	0·293	0·210	−0·192	0·808**	0·713**
Temp. & Egg Dia./Instar length	0·217	0·857**	−0·041	0·819**	0·790**	−0·350	0·843**
pH & Egg No./Instar No.	−0·956**	−0·082	−0·191	−0·301	−0·154	−0·286*	−0·171
pH & Days	−0·579**	−0·031	−0·023	0·010	0·380	−0·826**	−0·640**
pH & Egg Dia./Instar length	−0·363	−0·951**	0·042	−0·741**	−0·658**	−0·355	−0·811**
Sal. & Egg No./Instar No.	0·957**	−0·091	0·067	−0·236	0·054	0·224	0·060
Sal. & Days	0·624**	−0·233	−0·217	−0·132	−0·421	0·716	0·451
Sal. & Egg Dia./Instar length	0·473**	0·954**	−0·099	0·545*	0·472*	−0·308	0·674**
Mult. Cor.	0·503*	0·968**	0·500*	0·987**	0·873**	0·500*	0·947**

* = $p<0·05$

** = $p<0·01$

Table VII : Correlation Co-efficient between the various experimental factors and the different life history stages of *Seira indica*.

TABLE VIII

	Eggs	I instar	II instar	III instar	IV instar	V instar	VI instar
Temp. & Egg No./Instar No.	0·101	0·195	0·444	−0·073	0·369	0·275	0·194
Temp. & Days	0·732**	0·904**	0·726**	0·213	−0·293	−0·263	−0·311
Temp. & Egg Dia./Instar length	0·529*	0·838**	0·975**	0·780**	0·446*	0·308	0·711**
pH & Egg No./Instar No.	−0·156	−0·029	0·335	−0·128	−0·312	−0·261	−0·118
pH & Days	−0·934**	−0·991**	−0·935**	−0·574**	−0·094	−0·109	0·006
pH & Egg Dia./Instar length	−0·692**	−0·708**	−0·885**	−0·487*	−0·080	0·076	−0·348
Sal. & Egg No./Instar No.	0·208	−0·095	0·212	0·059	0·200	0·204	0·042
Sal. & Days	0·990**	0·963**	0·967**	−0·082	0·324	0·292	0·041
Sal. & Egg Dia./Instar length	0·713**	−0·498*	0·738**	0·465*	−0·146	−0·320	0·176
Mult. Cor.	0·663**	0·979**	0·984**	0·966**	0·934**	0·967**	0·991**

* = $p < 0·05$

** = $p < 0·01$

Table VIII : Correlation Co-efficient between the various environmental factors and the different life history stages of *Seira lateralis*.

TABLE IX

	Eggs	I instar	II instar	III instar	IV instar	V instar	VI instar
Temp. & Egg No./Instar No.	0·177	−0·040	0·880**	0·402	0·290	0·283	0·305
Temp. & Days	0·890**	0·911**	0·750**	0·116	0·746**	0·686**	0·206
Temp. & Egg Dia./Instar length	0·762**	0·193	0·176	0·302	0·335	0·038	0·193
pH & Egg No./Instar No.	−0·109	−0·135	−0·324	−0·361	−0·264	−0·215	−0·354
pH & Days	−0·980**	−0·975**	0·568**	−0·114	−0·573**	−0·493	−0·039
pH & Egg Dia./Instar length	−0·663**	−0·232	−0·082	−0·033	−0·103	−0·230	−0·058
Sal. & Egg No./Instar No.	0·038	0·245	0·205	0·267	0·171	0·168	0·034
Sal. & Days	0·958**	0·910**	0·339	−0·234	−0·347	0·279	−0·257
Sal. & Egg Dia./Instar length	0·532*	0·308	−0·338	−0·237	−0·184	0·306	−0·326
Mult. Cor.	0·732**	0·397	0·978**	0·996**	0·983**	0·456*	0·999**

* = $p < 0·05$

** = $p < 0·01$

Table IX : Correlation Co-efficient between the various environmental factors and the difierent life history stages of *Salina yosii.*

TABLE X

	Eggs	I instar	II instar	III instar	IV instar	V instar	VI instar
Temp. & Egg No./Instar No.	0·428	0·188	0·182	0·146	0·330	0·226	0·235
Temp. & Days	0·881**	0·489*	0·250	0·204	0·324	0·422	0·232
Temp. & Egg Dia/Instar length	−0·166	0.166	0·119	0·206	0·460*	0·365	0·319
pH & Egg No./Instar No.	−0·306	−0·892**	−0·034	−0·026	−0·166	−0·150	−0·154
pH & Days	−0·773**	−0·389	−0·103	−0·084	−0·208	−0·307	−0·153
pH & Egg Dia./Instar length	0·361	−0·096	0·123	−0·037	−0·231	−0·123	−0·113
Sal. & Egg No./Instar No.	0·148	−0·130	−0·113	−0·086	0·000	0·119	0·054
Sal. & Days	0·651**	0·396	0·837**	0·098	0·226	0·308	0·201
Sal. & Egg Dia./Instar length	−0·553**	0·069	−0·373	−0·273	0·000	−0·130	−0·169
Mult. Cor.	0·882**	0·139	0·993**	0·986**	0·985**	0·996**	0·996**

* = $p < 0.05$

** = $p < 0.01$

Table X : Correlation coeffecient between the various environmental factors and the different life history stages of *Entomobrya kali*.

either of the egg diameter or the instar length when temperature and salinity was high and pH was low. Similarly in *Seira lateralis* it was so except that the number of eggs laid, the size of the eggs and different instars were more. *Salina yosii* also revealed a similar trend as in *Seira indica* and *Seira lateralis* except that the eggs were nearly double that of *S. indica* and one and half times that of *S. lateralis*. The egg diameter and the instar lengths increased in this species, while the percentage of hatching was similar to *S. indica* and *S. lateralis*. *Entomobrya kali* showed the lowest oviposition in comparison to all the others. All the other aspects were similar to *S. indica*. Percentage of hatching was however maximum at lower temperatures in this species.

The percentage of mortality in the various instars was minimum in *S. indica* under maximum temperature and salinity and low pH conditions. *S. lateralis* was similar to *S. indica*. In *Salina yosii* the maximum percentage mortality was seen in first instar under low temperature and salinity with high pH in contrast to *S. indica* and *S. lateralis*. In *Entomobrya kali* the percentage of mortality in various instars was more or less similar under the different environmental setups.

Temperature therefore, was related to either egg-development, duration of each instar, total life span of species and the production of males and females. Salinity also which was maximum at these higher temperatures might have played some role along with low pH. Green (1964a) revealed that limited reproductive period observed in laboratory conditions, will be different from field because the period of development was seen to be nearly three times under culture conditions in contrast to field. This was supported by Snider (1973) who got maximum eggs of *Folsomia candida* and also attained the maximum longivity. These are further supported by Marshall and Kevan (1962). The highest fecundity in the present study was seen in *Salina yosii* where the longivity was also maximum in comparison to the other species. The fecundity being less or the development period being enhanced may be attributed to the accumulation of excretory products (Christiansen, 1963 and Snider, 1973). Moreover the attribution of density could have played another important role in the growth and rate of development. Green (1964b) showed that fecundity could be increased by reducing the density of overcrowded cultures.

The present study did show that the high temperature and salinity had a definite relationship to fecundity and rate of development in all the species studied. The optimum temperature for hatching was shown to be (22-24°C) by Marshal and Kevan (1962) ; while Snider (1971) revealed that 21°C was optimum. Choudhuri (1963) :while agreeing that temperature is one criteria for the percontage of egg to complete the development yet he found no significant differences between the wide range of temperatures which he had used for *Onychiurus*.

The effect of salinity is understandable as conductance values have also been quite high during the high levels of population density under field conditions. Hutson (1974, 1978), showed that at higher conductivity collembola species is able to survive and

reproduce adequately. Such results are comparable with plant ecologists where the yield of crops was directly related to conductance and therefore to salinity.

However temperature was positively significant to fecundity while all others were non-significant in *S. indica*. Similarly except for the II instar in *S. lateralis* and *Salina yosii* where a positive significance existed, in all other cases there was no significance at all. Mortality therefore was not affected by temperature. Temperature did play a role in the development time either for the hatching period or for the different molts. In *Seira lateralis* and *Salina yosii* temperature was significantly related to egg diameter as also for *Seira indica* and *Seira lateralis* where other instars revealed some significance, while for *Salina yosii* it was non-significant and in *Entomobrya kali* for IVth instar only. This sort of variation revealed that *Seira indica and Seira lateralis* from the youngest abandoned fallow there was some correlation with temperature while for older abandoned fallow species like *Salina yosii* and *Entomobrya kali* there was very little significance, with temperature. Usually established species show very little variations with minor fluctuations of temperature.

pH was seen to be negatively but significantly correlated in all cases. Like temperature, pH also does not play any significant role in the oviposition rate. Similarly it did not reveal any significance in the mortality of the instars in any of these species. In relation to length of days of development, there was significance in all the species for hatching, though negative. In *Seira lateralis* and *Salina yosii* the length of developmental days of earlier instars also showed significant negative relationships while for *Seira indica* it was seen in the last two instars only.

Salinity also revealed a similar pattern like temperature for either fecundity or the number of instars as well as for the length of days of development and for different size measurements.

In most cases for all the species the multiple correlation was highly significant. This therefore proves that temperature and salinity acts positively in that with increase in temperature and salinity, there is a definite relationship with the length of days and the size of instar, while it is negatively significant for pH, hence higher the pH, lower these possibilities.

This has the support Niijima (1973) where she had observed a direct relationship between temperature and early maturity. Hutson (1974, 1978) had said that either one or all three factors (pH, conductivity and salinity) played a significant role in the species of collembola that he had used. In the present study we have also found that though individual factors do seem to play a role at times in some species, yet it was the synergestic effect of all the abiotic factors which seemed to be responsible forthe total life history strategy for the four species of collembola.

SUMMARY

The aim of the present study was to identily the reproduction strategies of some important speecies of the dominant groups of soil fauna from N. E. India and to relate it to their population dynamics in natural conditions. Experiments were carried out in four different species of collembola from abandoned jhum fallows. Their life histories were observed in relation to some environmental factors like temperature, pH and salinity. The various stages, their development and correlations are presented and discussed.

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MORPHOLOGICAL STUDY OF SPERMATOPHORE OF A COMMON INDIAN SCORPION *MESOBUTHUS TAMULUS TAMULUS* (FABR.)

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INTRODUCTION

The morphological and taxonomical studies of Indian scorpions have been updated recently by Tikader and Bastawade (1983). The biological observations of Indian scorpions have so far been neglected. Though the naturalists like Maccary (1810), Fabre (1925) and Pavlovsky (1924) reported about sexual behaviour in scorpions, nothing was exactly known, until Alexander (1956-57) described the procedure through which the spermatids are transferred from male genital apparatus to female genital apparatus. Later on many scorpiologists like Angermann (1955), Bucherl (1956), Maury (1973-75) and De Zolessi (1956) made considerable contributions to our understanding of the mating behaviour in scorpions from different countries. Mathew (1956) studied mating behaviour in *Heterometrus scaber* Pocock, a common species in Southern India. He also reported about the spermatophore in the postinsemination state in this species. Some more observations on these aspects have been put forth recently by Shulov and Amitai (1959-60), Williams (1971) and Francke 1979-84. The phylogenetic relationship of some chactoids have been discussed by Francke and Soleglad (1981) on the basis of hemispermatophores alongwith other characters.

Almost nothing has been reported, except Mathew (1956), about the morphology of either the pre or postinsemination state of the spermatophores in Indian scorpions. The present report deals with the morphological study of the spermatophore in the postinsemination state in *Mesobuthus tamulus tamulus* (Fabr.), a very common species around Pune, Maharashtra, India.

MATERIAL AND METHODS

Mature males and females of *Mesobuthus tamulus tamulus* (Fabr.) were collected live from under stones around Pune, Maharashtra. Each specimen was kept separately in a 500 ml plastic stopper glass jar, with a thick layer of sterilysed soil and a small piece of flat stone at the bottom. The jars were also provided with a wet cotton plug to maintain the humidity. Small cockroaches and house crickets were offered regularly to these specimens as their food. The cotton plug was changed every two days. The jars were cleaned after every 5 days to avoid fungal infection and mite and ant attacks. Each jar was covered with black paper to maintain darkness.

Two pairs of one male and one female were kept in two separate jars for daily observations on mating behaviour. These pairs didn't show any sort of affinity during the first two days, and were passive towards each other. On the third day one pair mated during night, leaving a postinsemination spermatophore on a flat stone kept inside the jar. Subsequently, on the fifth day the other pair also mated successfully during night and left a postinsemination spermatophore on a piece of stone. The actual mating behaviour in both cases could not be observed in detail.

THE SPERMATOPHORE

The spermatophore in scorpions is a transparent, pinkish brown, chitinous plus proteinous structure that is extruded and deposited by the male on a suitable substratum to transfer the spermatids into the female genital apparatus. This structure is different in size and shape in different families, genera and even sometimes in species of scorpions. It is thin, elongated and flagelliform in *Mesobuthus tamulus tamulus* (Fabr.) and measures about 15 to 18 mm in total length.

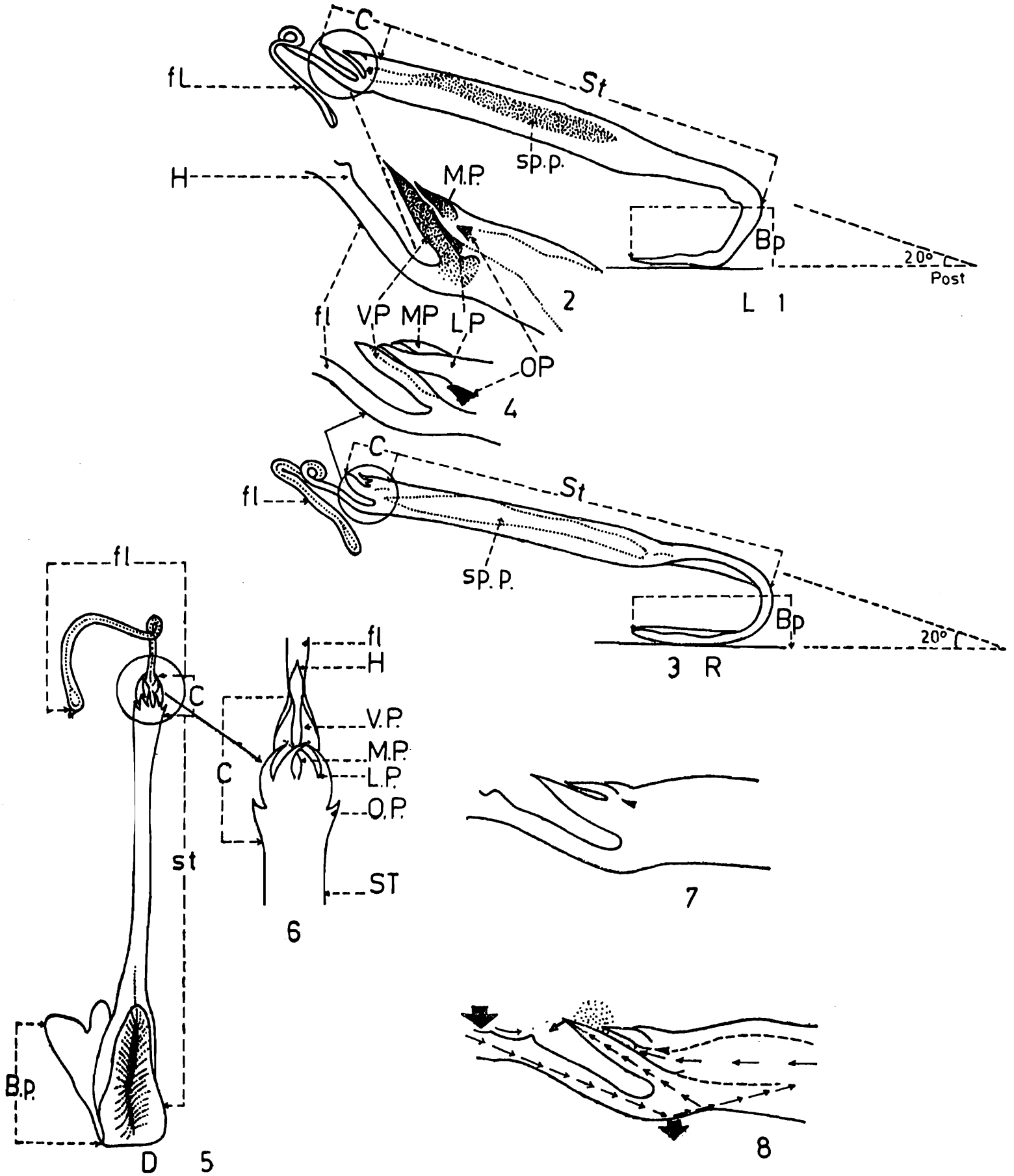
The spermatophore in postinsemination state in *M. tamulus tamulus* (Fabr.) is pinkish-brown, much darker on the capsular region, which is chitinous and pale, transparent on the stem and almost whitish on the flagellum (pl. 1 ; figs. 1, 3 & 5). Its four main parts are 1. Basal plate (Bp), 2. Stem (st.), 3. Capsule (C.) and 4. Flagellum (Fl.).

1. *Basal plate* (Bp) : It is a flat, thin and wing like structure (Figs. 1, 3 & 5) which is extruded first by male. When it comes out of the male genital apparatus it is cream white in colour and remains semisolid in nature, sticking to the ground firmly as it dries up (Alexander 1959)). After drying, it turns brownish and hard, helping to pull out the remaining part of the spermatophore and holding the spermatophore in a particular direction during mating.

2. *Stem* (St.) : This portion is a continuation of the Basal plate (Fig. 5) into a tubular, transparent, hollow structure. The basal plate rolles upward (Fig. 5), and the stem encloses a pair of spermatid packets (Fig. 1). This tubular stem measures about 8-10 mm in length, $2-2\frac{1}{2}$ mm in width and 4-5 mm in depth. The sperm packets lead distally into the capsular region by a narrow channel.

3. *Capsule* (C.) : This region consists of a complex structure with four pairs of different processes, termed as 1. Oblique process (Op), 2. Median process (Mp), 3. Lateral process (Lp) and 4. Ventral process (Vp). Alexander (1959) reported three pairs in *Parabuthus planicauda* Pocock. These processes protect the opening of the sperm packet, and help in transfering the spermatids into the female genital apparatus. The lateral view of the capsule (Figs. 2 & 4) reveal a duct between the median and ventral processes, through which spermatids exit from the spermpackets.

4. *Flagellum* (Fl) : The flagellum is the tubular extension of the ventro-distal portion of stem (Figs. 2 & 4). The halfs are stuck together on the median line jointly to



1. Lateral view (left side) of postinsemination spermatophore of *Mesobuthus tamulus tamulus* (Fabr.) 2. Lateral view of capsular region (Left). 3. Lateral view (Right side) of postinsemination spermatophore. 4. Lateral view of capsular region (Right). 5. Dorsal view of post insemination spermatophore. 6. Dorsal view of capsular region. 7. Lateral view of capsular region preinsemination condition. 8. Lateral view of capsular region arrows indicating site of pressures and release of spermatids.

form a single flagellum. This extension starts from the ventral side of the capsular region. There is a slightly raised portion on the dorsal side of the flagellum just below the distal end of the ventral process, and is termed the hook (H) (Figs. 2, 7 & 8). The flagellum is totally transparent and remains coiled or looped at one or two places (Figs. 1, 3 & 5). This part may be suggested as useful as an additional support for the female to click open the capsule and to obtain the spermatids (Figs. 7 & 8).

DISCUSSIONS

Scorpions, during their phylogeny have evolved a mating procedure that avoids the drying up of the spermatids at the time of their transfer from male to female. Such type has generally been paralleled in other groups of animals. The mating is initiated by laying the spermatophore by male and the spermatids were sucked in by female during mating. The buthoids differ from chactoids in having a flagelliform spermatophore so as to the *Mesobuthus tamulus tamulus* (Fabr.), a typical Indian buthoid form. An additional pair of ventral process is described for the first time in this species. The spermatophore is fixed on the substratum by the male in such a direction that no leakage of the spermatids is allowed ; where as the female, during their mating, presses the spermatophore untill the spermatids bust out through an apperature, formed on a capsular region (Figs. 7 and 8). *In Mesobuthus tamulus tamulus* (Fabr.) the spermatophore is pressed against the substratum upto the angle of 20° where it helps the female to take the spermatids.

SUMMARY

A detailed morphological study of the spermatophore, in the postinsemination state is given. The study is based on two such spermatophores extruded by two different males kept in the laboratory.

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A NEW *APODRASSODES* SPIDER FROM INDIA (ARANEAE : GNAPHOSIDAE)

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INTRODUCTION

A new species of the genus *Apodrassodes* Vellard, 1924, belonging to family Gnaphosidae is described.

MATERIAL

The description is based on one male specimen.

The genus *Apodrassodes* was established by Vellard (1924), with *A. Singularis* as type species, from Brazil. Platnick & Shadab (1983) in their revisionary work on genus *Apodrassodes*, newly synonymized three specific name and described three new species from South America and Central Chile.

While studying spiders of the family Gnaphosidae the author encountered a new species of *Apodrassodes* which is described here. This genus is being recorded for the first time from Asia.

The type specimen is deposited in the Nationol Zoological Collections, Zoological Survey of India, Calcutta.

Apodrassodes yogeshi sp. nov.

General : Cephalothorax and legs brown ; abdomen brownish-black. Total length 9·60 mm. Carapace 4·50 mm. long, 3·60 mm. wide ; abdomen 5·30 mm. long, 3·60 mm. wide.

Cephalothorax : Longer than wide, oval, rounded anteriorly, truncated posteriorly, widest behind coxae II, with long black setae in ocular and clypeal areas ; cephalic area slightly elevated, posterior middle provided with long, deep conspicuous fovea. Eyes silvery white except anterior medians which are dark ; posterior row slightly longer than anterior row ; both rows slightly procurved (as seen from in front) ; anterior medians circular ; laterals oval , medians slightly closer to adjacent laterals than to each other ; posterior medians irregularly rectangular ; laterals oval ; medians slightly closer to each other to adjacent laterals ; median ocular quadrangle longer than wide, wider

in front than behind. Clypeal height greater than diameter of anterior median eye. Chelicerae moderately strong, vertical ; inner margin with three small similar teeth and outer margin with three dissimilar teeth. Labium elongate, keg-shaped ; maxillae long, sinuous, obliquely depressed, provided with scopulae as in fig. 3. Sternum long, rebordered, with extensions to and between coxae. Coxae IV almost touching, provided with long hairs ; legs long and strong, clothed with hairs and spines ; tarsi and apical portions of metatarsi provided with thick conspicuous scopulae ; tarsi with two dentate

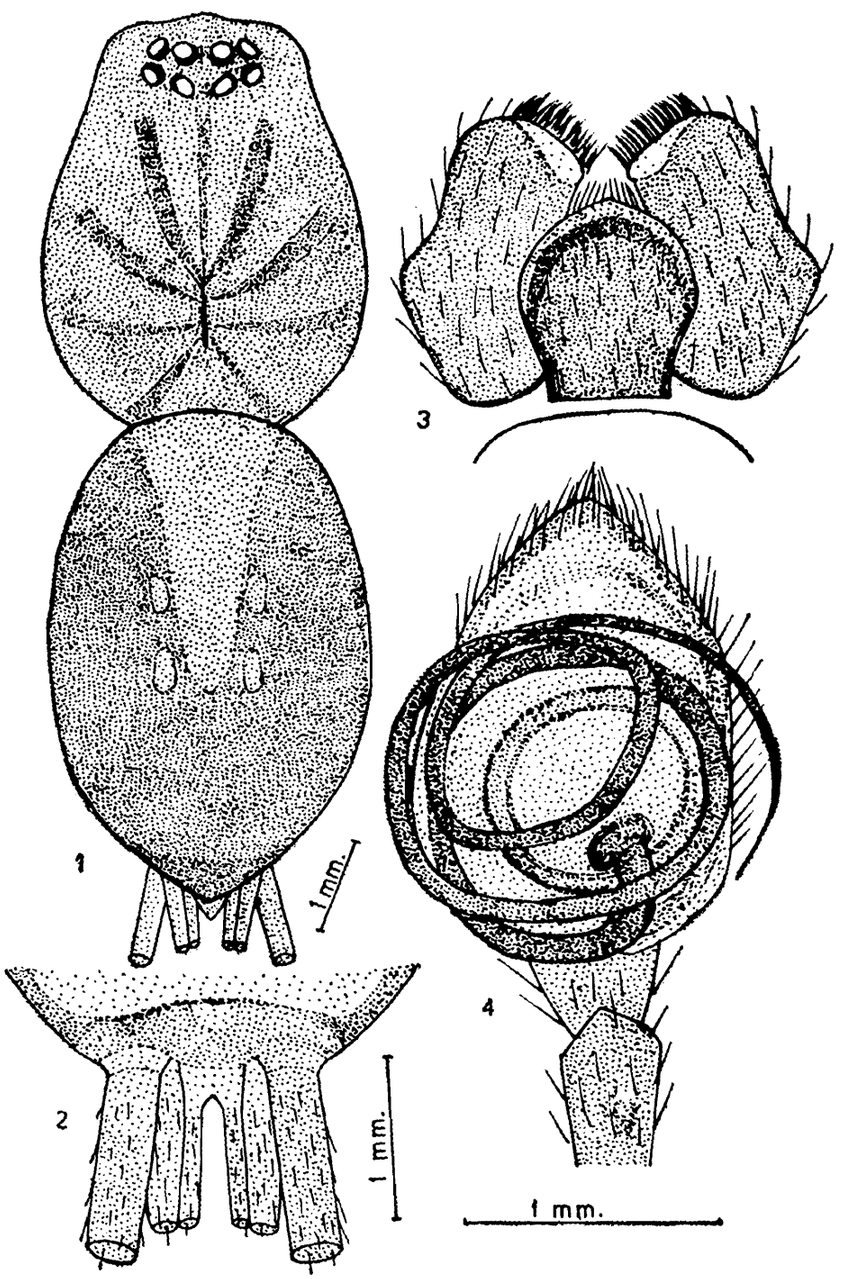

Fig. 1-4. *Apodrassodes yogeshi* sp. nov.

[1. Dorsal view of female, legs omitted. 2. Spinnerets. 3. Labium and maxillae. 4. Left male palp, ventral view.]

claws and claw tufts ; leg formula 4123. Male palp with long embolus coiling around cymbium as in fig. 4. Female unknown.

Abdomen : Longer than wide, oval, with white setae and with two pairs of orange muscle impressions, dorsally provided with orange coloured mid-dorsal longitudinal band extending up to middle of abdomen as in fig. 1 ; ventral side slightly lighter than dorsal. Spinnerets prominent, long ; anterior spinnerets widely separated, sclerotized and slightly longer than the others as in fig. 2.

Type-specimen : *Holotype* male, in spirit, other details as below.

Type-locality : India, Tripura State, Telianural, Dist. Tripura. 28.1.1971. Coll. *V. C. Agrawal.*

This species resembles *Apodrassodes mercedes* Platnick & Shadab but differs from it in colour of abdomen, cephalothorax and structure of male palp ; embolus making three complete coil and tegulum not prolonged distally.

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Rec. zool. Surv. India, 91 (2) : 231—233, 1992

A NEW *MEGAMYRMECION* SPIDER FROM INDIA (ARANEAE : GNAPHOSIDAE)

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Jabalpur (M. P.) India.

MATERIAL

The description is based on one female specimen.

The spiders of the genus *Megamyrmecion* are very little known. Tikader and Gajbe (1977) reported this genus for the first time from India and described one species.

While studying the spiders of the family Gnaphosidae the author encountered a new species of *Megamyrmecion* which is described here as a second species from India.

The type specimen is deposited in the National Zoological Collections, Zoological Survey of India, Calcutta.

Megamyrmecion jodhpurensis sp. nov.

General : Cephalothorax and legs dark reddish-green, abdomen yellowish-green. Total length 5·80 mm. Carapace 2·40 mm. long, 1·90 mm. wide ; abdomen 3·50 mm. long, 2·20 mm wide.

Cephalothorax : Longer than wide, convex, narrow in front ; cephalic region slightly high ; posterior middle provided with a conspicuous fovea and clothed with pubescence as in fig. 1. Anterior row of eyes procurved ; anterior medians circular, black, larger than laterals ; laterals elliptical in shape, with medians closer to adjacent laterals than to each other ; posterior row of eyes as long as anterior row, procurved, with eyes more or less—fig 1-5 equal and equidistant from each other ; posterior medians silvery white, elliptical in shape ; median ocular quadrangle longer than wide and wider in front than behind. Clypeus narrow, less than the diameter of anterior median eye. Sternum oval pointed behind clothed with hairs. Labium and maxillae longer than wide, labium not contiguous with maxillae ; anterior margin of maxillae provided with conspicuous scopula as in fig. 2. Chelicerae vertical ;

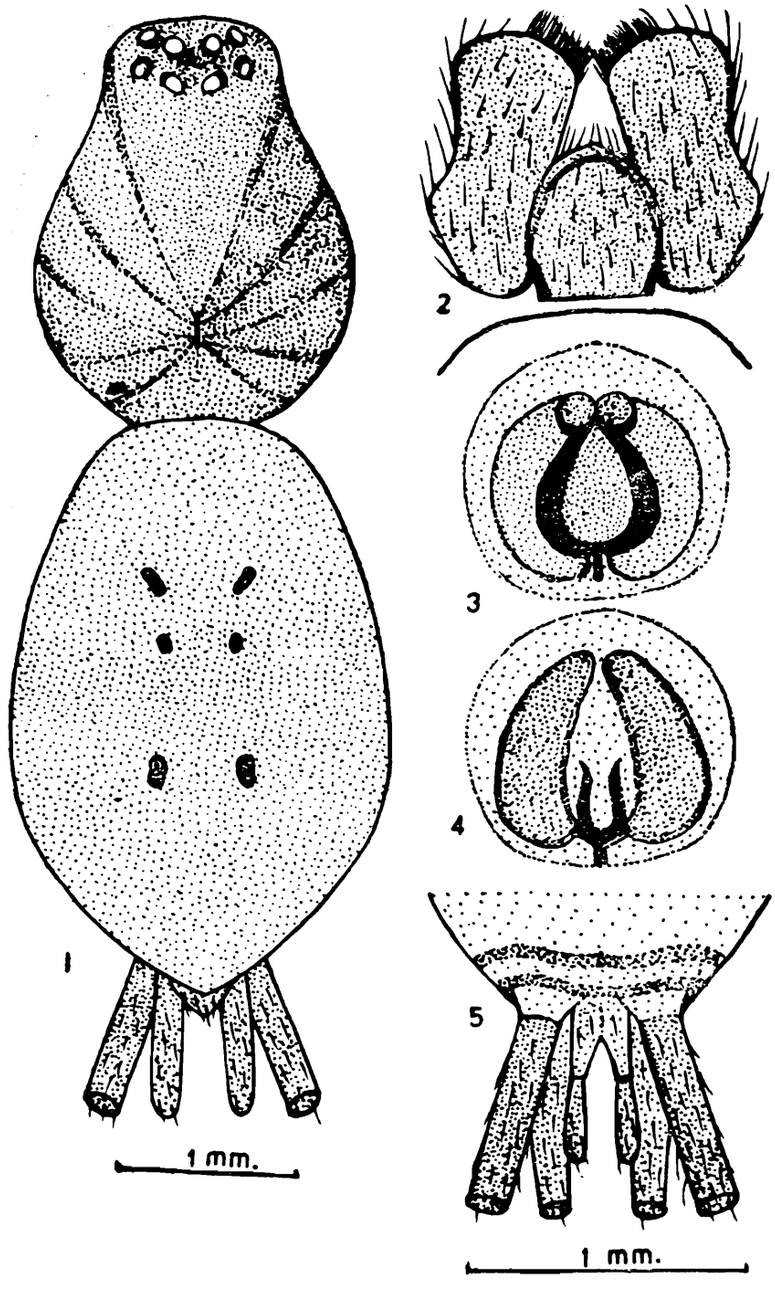

Fig. 1-5 : *Megamyrmecion jodhpurensis* sp. nov.

Fig. 1 : Dorsal view of female, legs omitted.
Fig. 2 : Labium and maxillae.
Fig. 3 : Epigyne.
Fig. 4 : Spermathecae.
Fig. 5 : Spinnerets.

inner margin without tooth but outer margin with two small teeth. Legs relatively long and strong, clothed with hairs and spines, with scopulae extending to base of metatarsi I and II. Leg formula 4123. Male unknown.

Abdomen : Longer than wide, more or less elliptical in shape, narrowed behind, clothed with pubescence and three pairs of sigilla. Ventral side lighter in colour than dorsal. Epigyne as in fig. 3. Spermathecae as in fig. 4. Spinnerests prominent, long as in fig. 5.

Type specimens : *Holotype* female, *paratypes* two females, in spirit, other details as below.

Type locality : INDIA, Rajasthan, Sangaria village, Jodhpur district, 3. viii. 1962. Coll. *Motilal.*

This species resembles *Megamyrmecion ashae* Tikader & Gajbe but can be separated in the colour of cephalothorax and abdomen, and by the structure of epigyne.

SUMMARY

A new species of the genus *Megamyrmecion* Reuss, 1834, belonging to the family Gnaphosidae is described.

ACKNOWLEDGEMENT

I am grateful to Dr. B. K. Tikader, Former Director, Zoological Survey of India for assigning the project and constant encouragement in my research work. I am thankful to Dr. P. D. Gupta, Officer-in-Charge, Central Regional Station, Zoological Survey of India, Jabalpur, for necessary facilities and to Miss Pratiksha Tiwari for typing the manuscript.

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Rec. zool. Surv. India, 91 (2) : 235—237, 1992

DESCRIPTION OF THE MALE OF *ULOBORUS DANOLIUS* TIKADER (ARANEAE : ULOBORIDAE)

U. A. GAJBE

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INTRODUCTION

A male spider of *Uloborus danolius* Tikader (Family : Uloboridae) is described for the first time.

Tikader (1969) described *Uloborus danolius* on the basis of female specimens collected from Danoli village, Ratnagiri district of Maharashtra. So far the male of this species has remained unknown. Therefore a description of male of *Uloborus danolius* is furnished here.

Uloborus danolius Tikader

1969. *Uloborus danolius* Tikader, *Proc. Indian Acad. Sci.*, 70 (3) : 129.
1977. *Uloborus danolius* : Tikader, *Rec. zool. Surv. India*, 72 : 162.
1981. *Uloborus danolius* : Tikader & Biswas, *Rec. zool. Surv. India, Occ. Paper*, No. 30: 15.

Specimens examined : 16 ♀♀, 10 ♂♂, Kachari Sawanga village, Katol Tahsil, Nagpur district, Maharashtra. Coll. *U.A. Gajbe*, 8. IV. 1986.

General : Cephalothorax and legs light yellowish green. Abdomen yellowish green. Total length 4·80 mm. Carapace 2·40 mm. long, 2·10 mm. wide ; abdomen 3·60 mm. long, 2·30 mm. wide.

Cephalothorax : Slightly longer than wide, narrow in front, with two conspicuous longitudinal deep brown broad patches on cephalothorax (Fig. 1.). Eyes black, in two rows with anterior row slightly longer than posterior row, anterior row slightly recurved, with anterior medians larger than laterals and closer to each other than to adjacent laterals ; posterior row with eyes almost equal in size, and with posterior medians slightly closer

to adjacent laterals than to each other ; median ocular quadrangle longer than wide and wider behind than in front. Clypeus narrow, its length little smaller than diameter of anterior median eyes. Sternum heart-shaped, pointed behind and rebordered at coxae of all legs, deep brown in colour. Legs long and strong, clothed with hairs and conspicuously banded with transverse black patches ; Legs I and IV longer than II and III. Male palp as in fig. 3.

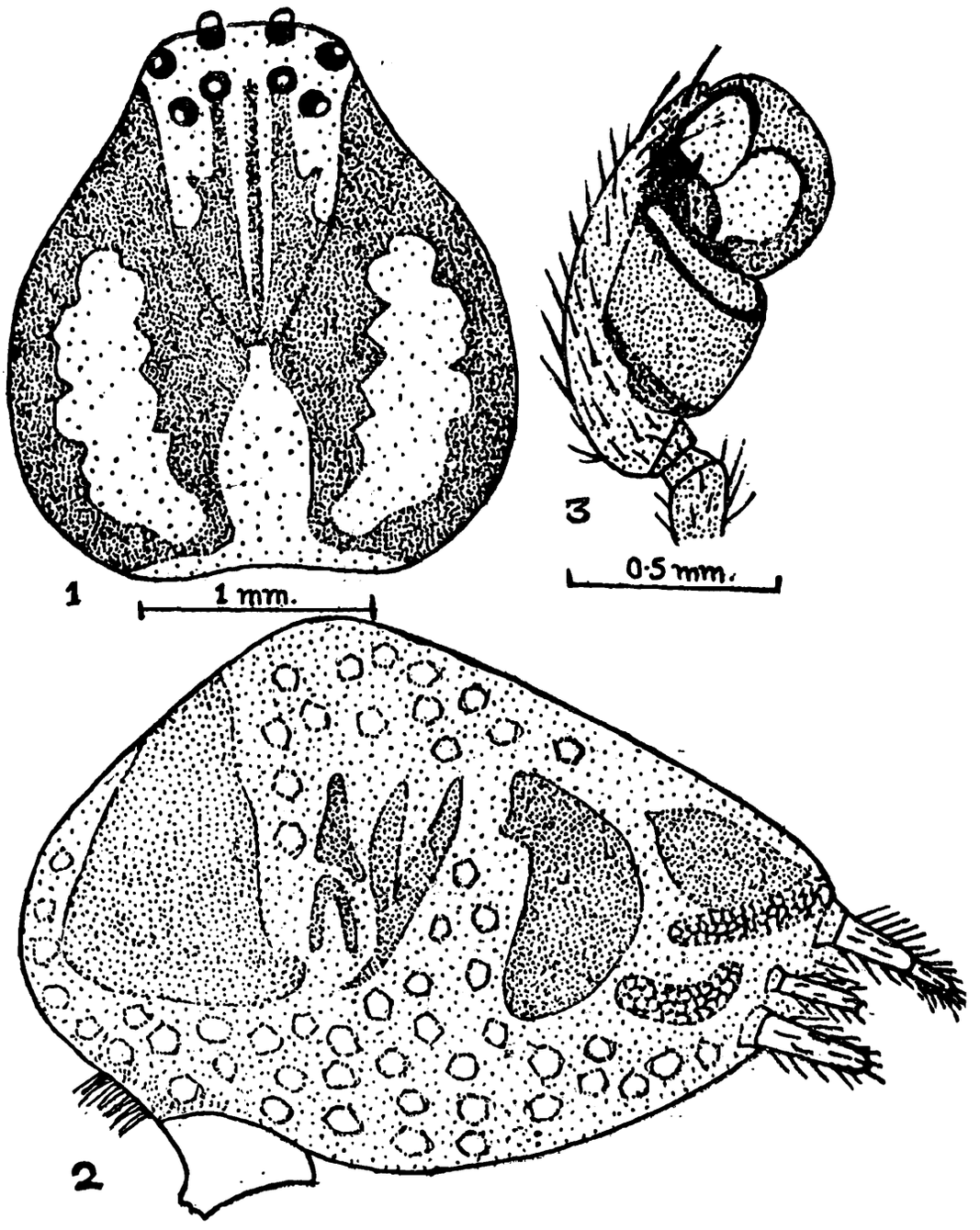

Fig. 1-3 : *Uloborus danolius* Tikder

Fig. 1 : Dorsal view of cephalothorax, legs omitted.
Fig. 2 : Lateral view of abdomen.
Fig. 3 : Male palp. (Ventral view).

Abdomen : Longer than wide, high and broad in front, clothed with pubescence and decorated with brownish patches and fine netlike structure as in fig. 2. Anterior dorsal side of abdomen provided with a hump. Mid-ventral side provided with longitudinal deep brown band extending from epigastric fold to cribellum.

Distribution : INDIA, Maharashtra, Danoli, Dist. Ratnagiri (Type-locality), Poona, Nagpur, West Bengal, Calcutta, Car-Nicobar.

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Rec. zool. Surv. India, 91 (2) : 239—245, 1992

GARRA KALAKADENSIS, A NEW CYPRINID FISH FROM KALAKAD WILDLIFE SANCTUARY, TIRUNELVELI DISTRICT, TAMIL NADU

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Zoological Survey of India
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INTRODUCTION

Kalakad Wildlife Sanctuary is located in the South-eastern part of Western Ghats, comprising the whole of the Kalakad reserve forest. The perennial rivers which drain the eastern part are the Pachaiyar, Netterikal, Nambiyar and Kodumudiar and the rivers draining the western aspect are the Keelmanimuthar and its tributaries, Kulirattiar and Kusanguliar. These and other seasonal rivulets and streams were surveyed by the Zoological Survey of India team headed by Dr R. S. Pillai, Scientist 'SD' and Officer-in-Charge, Southern Regional Station, Madras. Eight surveys were conducted by Dr M. Vasanth and party from August 1984 to April 1987.

The new species was collected from most of the localities, and *G. mullya* (Sykes) was also collected from Sengaltheri. In order to study the specific identity of the different varieties, specimens from two different areas viz. the Northwest (190-350 m., 300 m. and 390 m. Altitude) and the Southeast (850 m., 900 m. and 980 m. Altitude) of Kalakad were compared. 16 morphometric characters were compared as shown in Table 1. Measurements were made with dial calipers with an accuracy of 0·05 mm. and methods given in Menon (1964) were followed. The description is based on 51 specimens collected from different altitudes.

Garra kalakadensis sp. nov.

(Plate 1, figs. A and B)

Description : D. 2/8 ; P. 1/12-15 ; V. 1/7 ; A. 2/5 ; C. 18-19 ; L. l. 31-33 ; L. tr. $4\frac{1}{2}/2\frac{1}{2}$-$3\frac{1}{2}$; predorsal scales 9-11 ; preanal scales 16-21.

Dorsal profile straight to slightly arched ; depth of body 4·42 (3·56-4·95), length of head 3·51 (3·11-3·83) in S. L. ; width of head 1·35 (1·25-1·49) in length of head ; height of head 1·61 (1·52-1·82), pupil of eye at or slightly behind the middle of the length of head

Table 1.

MORPHOMETRIC PROPORTIONS IN Garra Kalakadensis sp. nov. FROM DIFFERENT ALTITUDES

CHARACTERS	190-350 m.	300 m.	390 m.	850 m.	900 m.	980 m.
Body depth/ S. L.	4·24 (3·83-4·51)	4·09 (3·56-4·24)	4·31 (3·70-4·84)	4·58 (4·18-4·92)	4·42 (4·19-4·63)	4·76 (4·61-4·95)
H. L./S. L.	3·51 (3·45-3·55)	3·55 (3·41-3·77)	3·46 (3·11-3·71)	3·47 (3·13-3·71)	3·53 (3·21-3·83)	3·50 (3·32-3·76)
H. L./H. W.	1·31 (1·26-1·36)	1·30 (1·25-1·34)	1·34 (1·25-1·42)	1·36 (1·28-1·44)	1·41 (1·31-1·49)	1·37 (1·30-1·46)
H. L./Height of head	1·66 (1·54-1·82)	1·58 (1·51-1·66)	1·62 (1·58-1·67)	1·60 (1·52-1·69)	1·63 (1·53-1·70)	1·58 (1·52-1·61)
H. L./Snout length	2·18 (2·15-2·25)	2·11 (1·94-2·29)	2·28 (2·11-2·51)	2·05 (1·87-2·21)	2·23 (2·06-2·59)	2·08 (1·94-2·27)
H. L./Eye diameter	4·76 (4·35-5·54)	4·48 (3·82-4·95)	5·21 (4·77-5·57)	4·76 (4·24-5·17)	4·52 (3·73-5·19)	4·63 (4·19-5·54)
H. L./I. O. W.	2·09 (1·97-2·22)	2·21 (2·05-2·37)	2·22 (2·13-2·37)	2·37 (2·24-2·56)	2·39 (2·14-2·94)	2·42 (2·21-2·52)
H. L./Length of disc	2·72 (2·51-2·86)	2·75 (2·57-2·95)	2·67 (2·55-2·85)	2·63 (2·32-2·90)	2·67 (2·45-3·27)	2·49 (2·25-2·88)
H. W./Width of disc	1·49 (1·39-1·60)	1·40 (1·29-1·49)	1·41 (1·30-1·48)	1·31 (1·26-1·38)	1·42 (1·28-1·71)	1·34 (1·23-1·43)

Width of disc/ Length of disc	1·41 (1·33-1·48)	1·52 (1·30-1·61)	1·41 (1·33-1·46)	1·47 (1·27-1·65)	1·33 (1·21-1·47)	1·36 (1·21-1·50)
Predorsal dist. S. L.	1·99 (1·91-2·06)	1·97 (1·92-2·01)	1·98 (1·80-2·12)	1·97 (1·85-2·10)	1·97 (1·89-2·08)	1·95 (1·88-2·03)
Pectoral/S. L.	3·94 (3·74-4·35)	3·99 (3·50-4·50)	3·80 (3·41-4·26)	3·76 (3·23-4·63)	4·08 (3·67-4·38)	4·23 (3·95-4·45)
Pectoral/H. L.	1·12 (1·07-1·22)	1·12 (0·97-1·29)	1·10 (1·01-1·20)	1·09 (0·87-1·41)	1·16 (1·00-1·28)	1·21 (1·11-1·28)
Vent to anal/Pelvic to anal fin	4·34 (3·94-4·57)	4·27 (3·51-4·91)	4·93 (4·32-5·96)	4·32 (3·72-4·94)	4·30 (3·59-5·36)	4·25 (3·87-4·85)
Width of C. P./ Length of C. P.	1·19 (1·13-1·26)	1·14 (1·07-1·21)	1·12 (1·01-1·25)	1·23 (1·15-1·35)	1·33 (1·1-1·53)	1·41 (1·30-1·48)
Length of Body cavity/S. L.	2·06 (2·01-2·12)	2·01 (1·94-2·08)	1·99 (1.87-2·08)	2·01 (1·96-2·09)	2·02 (1·90-2·14)	2·08 (1·90-2·14)
Pr. chamber of air bladder/S. L.		4·46 (4·20-4·76)		5·03 (4·60-5·64)	4·83 (4·04-5·66)	5·14 (4·21-5·76)
Length of air bladder/ S. L.		2·86 (2·71-3·07)		3·04 (3·02-3·07)	3·22 (2·78-3·55)	3·26 (2·90-3·63)

its diameter 4·68 (3·73-5·57), interorbital width 2·31 (1·97-2·94), snout 2·14 (1·87-2·59) in length of head length of disc 1·41 (1·21-1·65) in its own width, 2·65 (2·25-3·27) in head length ; width of disc 1·38 (1·23-1·71) in width of head ; predorsal distance 1·97 (1·80-2·12) in S. L. ; length of pectorals 1·13 (0·87-1·41) in head length, 3·98 (3·23-4·63) in S. L. ; distance from vent to anal fin 4·36 (3·51-5·96) in that between anterior origin of pelvic and anal fins ; width of caudal peduncle 1·25 (1·01-1·53) in its own length ; length of body cavity 2·03 (1·87-2·14) in S. L. ; posterior chamber of air bladder measured in 20 exs., 20·70 (17·36-24·75) percent in S. L. ; length of air bladder as measured in 18 specimens 31·95 (27·55-36·90) in S. L.

Chest and belly scaled, but scales on chest much reduced. In one specimen 49·0 mm S. L. there is an additional ray on the dorsal and anal fins.

Body colouration dark, sometimes lighter with a prominent lateral band extending to the middle rays of the caudal fin ; the first scale on the upper opercular margin very dark. Dorsal fin edge concave, in some the rays are darkened, and in some paler specimens, a faint band across the middle of the paired and vertical fins are seen.

Caudal lobes sometimes equal and in majority of the specimens the lower lobe is longer.

Two pairs of barbels, the nasal well-developed. In some large and mature specimens a distinct lateral tubercular area is seen almost projecting from the snout as lateral horns. In about 11 specimens dissected, the forms with tuberculate areas in the snout are found to be females.

Holotype : 77·0 mm S. L., 25. 4. 1987, Pachaiyar, 850 m. Alt. East of Sengaltheri, Kalakad Wildlife Sanctuary, Tirunelveli District, Tamil Nadu, Coll. Dr M. Vasanth. Reg. No. F. 2664, in the Depository of National Type Collections, Z. S. I., Calcutta.

Paratypes : 38 exs., 26·0 mm-66·0 mm S. L., Sengaltheri east (900 m.), 19.8.1984, Reg. No. F. 584 ; 5 exs., 49·0 mm-69·0 mm S. L., Nambiyar, (190-350 m.), 21.8.1986, Reg. No. F. 853 ; 26 exs., 21·0 mm-60·0 mm S. L., Thodathi odai, (390 m.), 25.8.1986, Reg. No. F. 854 ; 36 exs., 23·0 mm-75·0 mm S. L., Vilakkennai kasam (300 m.), 8.1.1987, Reg. No. F. 855 ; 28 exs. 20·0 mm-49·0 mm S. L., Pachaiyar (980 m.) near Karumandi amman temple, 24.4.1987, Reg. No. F. 856 and 144 exs., 25·0 mm-55·0 mm S. L., Pachaiyar (850 m.), east of Sengaltheri, 25.4.1987, Reg. No. F. 852, in Z. S. I., S. R. S. Madras.

Relationship : *Garra kalakadensis* sp. nov. differs from the widely distributed *G. mullya* (Sykes) in several characters viz. the marked difference in the position of vent which is near to anal fin in the former while in the latter it is well in advance of the anal fin ; the mental disc is well developed ; head length longer and body slender whereas in *G. mullya* (Sykes) the body is deeper, head shorter and mental disc restricted to the anterior third of the head, Plate : 2. (Fig A. & C.). The two differ in colour pattern also,

Garra kalakadensis sp. nov. shows some resemblance to *G. lamta* (Hamilton) in the presence of well developed lateral tubercular area (secondary sexual character) in the snout, the well developed mental disc and in its slender form. However in *G. lamta* (Ham.) the vent is very close to the anal fin, the pectoral fin is shorter, Plate : 2. (Fig. A. & B.) and the air bladder is much reduced (Menon, 1964).

DISCUSSION

While studying the fish material from Kalakad it was observed that some specimens were deeper with a prominent lateral band on a lighter body colour while some collected from the higher altitudes were of a uniform dark colour and with a more slender body. Within this population also, in some, the lateral band was prominent on a lighter ground colour.

A comparative study of the different morphometric characters of the populations from different areas and altitudes, to study the similarities or differences that exist in them are given in Table 1. It is seen that the two different varieties collected from different localities are the same species, as evidenced by their overlapping range in body proportions, and a gradual difference observed in certain body proportions may be changes brought about by difference in altitude and water flow.

With increase in altitude the following differences were observed viz. a reduction in body depth, slightly narrower head, a broader interorbital, better developed and broader mental disc, slender caudal peduncle and reduction in size of air bladder.

No differences were observed in the meristic characters except in the scalation on the chest, the preanal scales showing much variation within the population ranging from 16-21. In some specimens the chest is totally naked, while in some others the subcutaneous scales extend to this region, and in a few others the scales are quite visible between the pectoral base.

Regarding the length of pectoral and other fins, a positive correlation could not be arrived at. In general, *Garra* species from Kalakad Sanctuary have very well developed, long and horizontally placed, fan-like pectoral and ventral fins, with the outer rays muscular on the ventral side. The general tendency observed in Table 1 is towards a reduction in length with increase in altitude ; however, specimens collected from Pachaiyar at 850 m. have the longest pectorals, sometimes longer than head. The length is, however, found to be subject to much variation, and in one specimen (52·0 mm S. L.) it almost reaches the pelvic, which is also very long and extends beyond the anus reaching the anal fin ; a single freak specimen (45·0 mm S. L.) had very short pectorals extending only up to half the distance to pelvic origin.

The darker body colour seen in adults found in higher altitudes is probably to help in camouflage amongst dark rocks and pebbles in the upper evergreen forests. In the lower altitudes in the deciduous forests, however, the body colour is lighter to match the dull background.

From a study of the various characters which are subject to adaptive changes brought about by the stress factor in torrents, it could be suggested that in this stretch of Western Ghats, similar conditions have brought about highly adaptive modifications (viz. the stream-lined body which offers least resistance to water currents and the well-developed adhesive devices in the form of a powerful mental disc and muscular fan-like pectoral fins) encountered in the peninsular form as in *G. lamta* (Ham.) in the Himalayas, Darjeeling, Assam, Sikkim, Nepal and Pakistan.

Key to the species of *Garra* of Peninsular India

1. a. One pair of barbels ; proboscis trilobed ... *G. bicornuta* Rao
1. b. Two pairs of barbels ; proboscis may or may not be present 2
2. a. Proboscis present ... *G. gotyla stenorhynchus* (Jerdon)
2. b. Proboscis absent ... 3
3. a. Depth of body about 5 or more than 5 times in S. L. ... 4
4. a. Distance of vent to anal fin base 3 or less than 3 times in that between anterior origin of pelvic and anal fins (L. l.35-38) ... *G. mcClellandi* (Jerdon)
4. b. Distance of vent to anal fin base 4 or more than 4 times in that between anterior orgin of pelvic and anal fin base ... 5
5. a. Back scaled, chest and belly naked ; L. l.32-36 ... *G. menoni* Rema Devi and Indra
5. b. Back, chest and belly naked ; L. l.36-38 ... *G. Hughi* Silas
3. b. Depth of body less than 5 in S. L. ... 6
6. a. Vent to anal fin base less than 4 times in that between anterior origin of pelvic and anal fin, mental disc small, width of disc about 2 times in width of head ... *G. mullya* (Sykes)
6. b. Vent to anal fin base more than 4 times in that between anterior origin of pelvic and anal fin, mental disc large, width of disc less than 2 in width of head ... *G. kalakadensis* sp. nov.

SUMMARY

A new species *Garra kalakadensis* is described from Kalakad Wildlife Sanctuary, Tirunelveli district, Tamil Nadu and compared with the widely distributed *G. mullya* (Sykes) and the North Indian form *G. lamta* (Hamilton). Representative specimens from six different altitudes in two localities (N. E. & S. W.) are compared. A key to the species of *Garra* from peninsular India is given.

ACKNOWLEDGEMENTS

I am greatly indebted to Dr R. S. Pillai, Officer-in-Charge, Southern Regional Station for providing the fish material and for the encouragement and facilities given to me. My thanks are due to Dr M. Vasanth, Assistant Zoologist, Southern Regional Station, as leader of the survey party and for his picturesque description in the Station Book which was very useful to me, and for the fish photographs (plate 1), and to other members of the party for the efforts taken to collect the rich fish material. My sincere thanks are due to Dr A. G. K. Menon, Scientist Emeritus for his encouragement and for correcting the manuscript.

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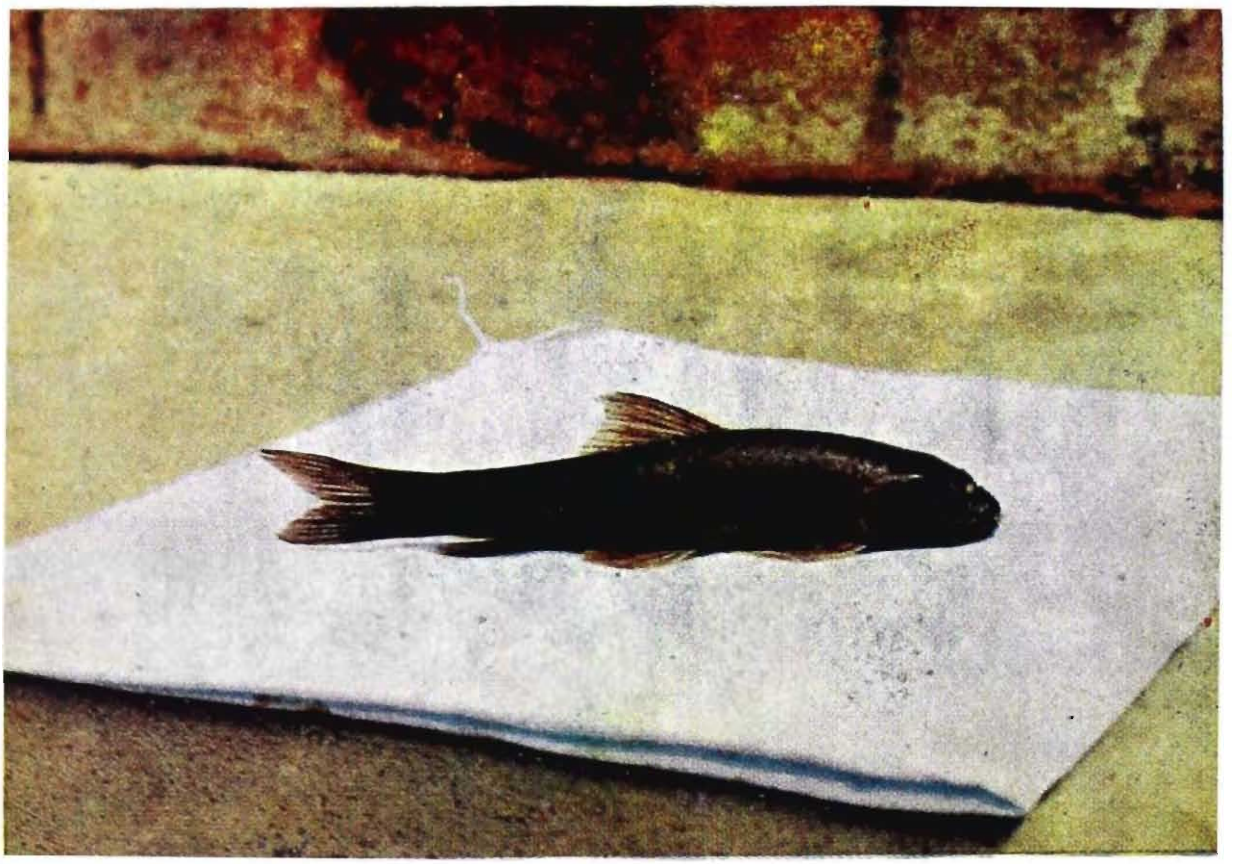


Fig. A : Lateral view of *Garra kalakadensis* sp. nov.

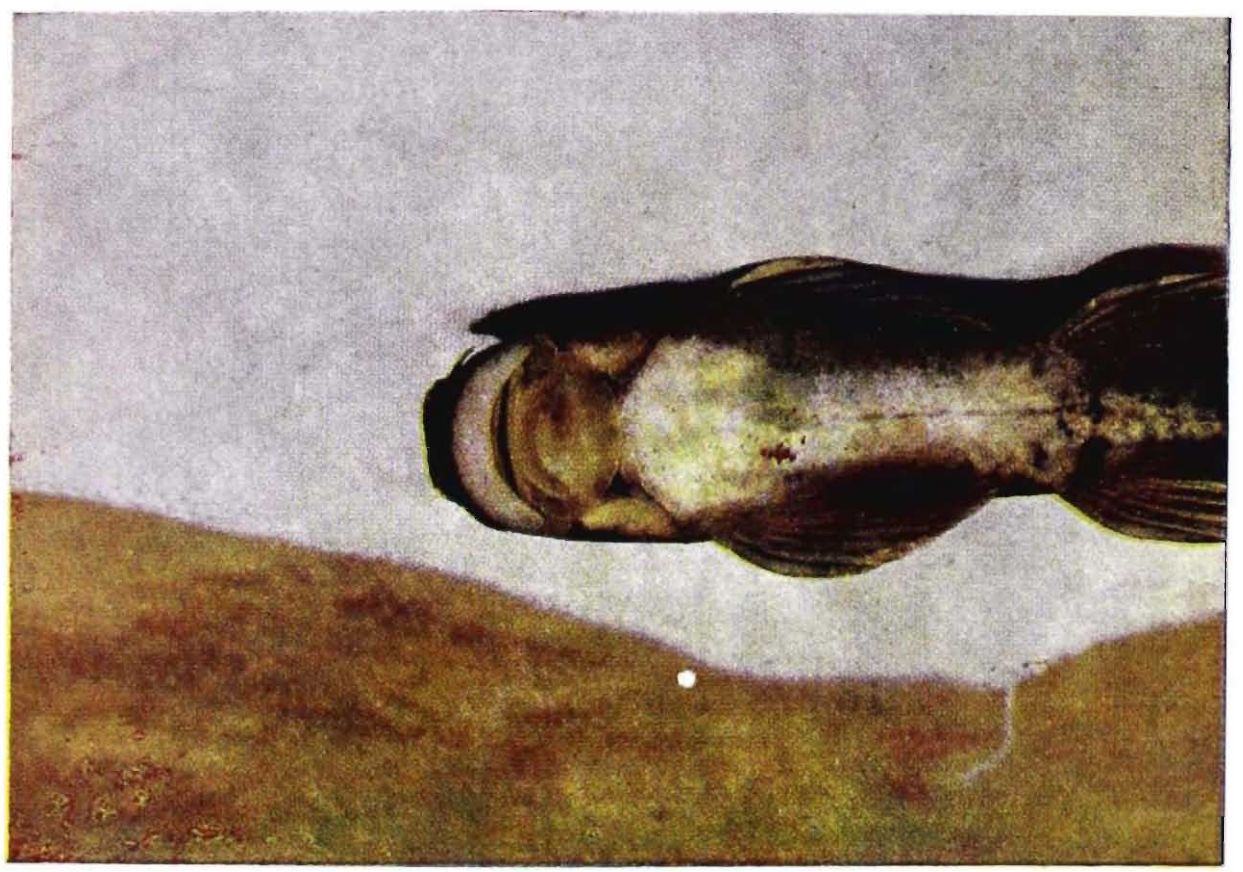
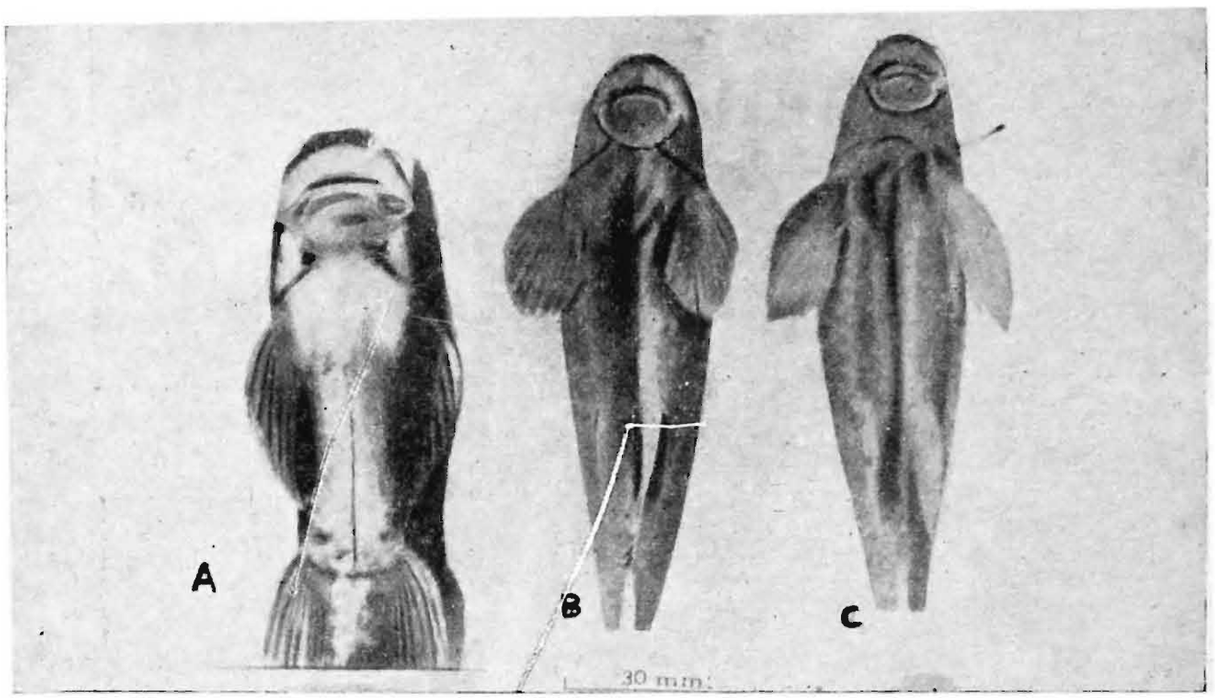


Fig. B Ventral view of *G. kalakadensis* sp. nov.

PLATE II

REMA DEVI



A. Ventral view of *Garra kalakadensis* sp. nov.
B. Ventral view of *Garra lamta* (Ham.)
C. Ventral view of *G. mullya* (Sykes)

} After Menon 1964.

Rec. Zool. Surv. India, 91 (2) : 247—250, 1992

A NEW *LIODRASSUS* SPIDER FROM INDIA (ARANEAE : GNAPHOSIDAE)

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INTRODUCTION

A new species of the genus *Liodrassus* Chamberlin, 1936, from Jabalpur District, M. P., belonging to the family Gnaphosidae is described.

MATERIAL

The description is based on one female specimen.

The genus *Liodrassus* was established by Chamberlin (1936) with *L. arizonicus* as type species from North America. Tikader and Gajbe (1977) reported this genus for the first time from India and described one species.

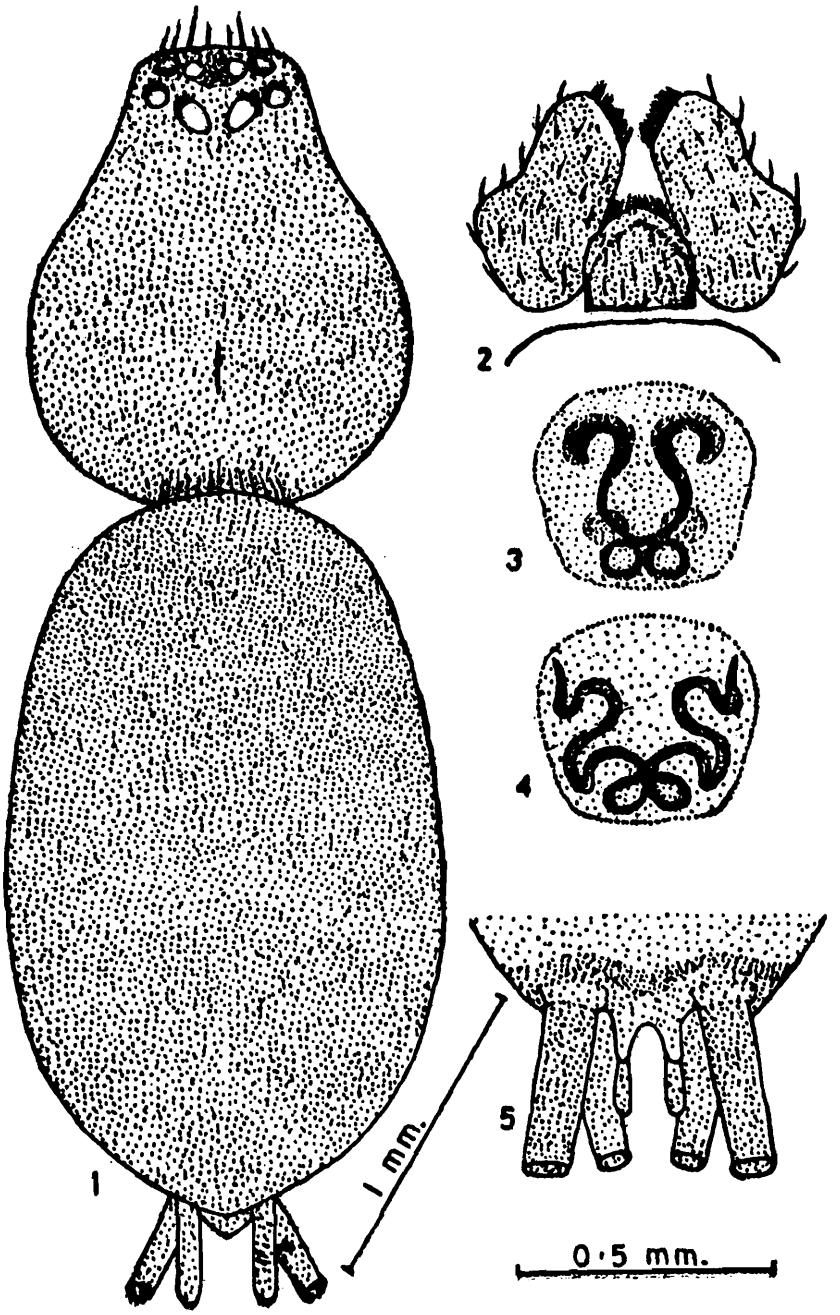
While studying the spiders of the family Gnaphosidae the author encountered a new species of *Liodrassus* which is described here as a second species from India.

The type specimen is deposited in the National Zoological Collections, Zoological Survey of India, Calcutta.

The species is named after Dr. B. K. Tikader, a wellknown arachnologist, as a token of the high regard which the author has for him.

Liodrassus tikaderi sp. nov.

General : Cephalothorax and legs reddish-green ; abdomen brown. Total length 3·80 mm. Carapace 1·50 mm. long, 1·20 mm. wide ; abdomen 2.40 mm. long, 1·40 mm. wide.



Figs. 1-5. *Liodrassus tikaderi* sp. nov.

Fig. 1. Dorsal view of female, legs omitted.
Fig. 2. Labium and maxillae.
Fig. 3. Epigyne.
Fig. 4. Spermathecae.
Fig. 5. Spinnerets.

Cephalothorax : Longer than wide, convex, narrow in front, with cephalic region slightly high ; posterior middle provided with an inconspicuous fovea and clothed with pubescence. Eyes pearly white except anterior medians which are circular and black ; posterior row of eyes slightly longer than anterior row. Anterior row of eyes slightly procurved (as seen from in front), with medians slightly larger than laterals ; laterals elliptical in shape, and medians closer to adjacent laterals than to each other ; posterior row of eyes procurved ; medians silvery white, elliptical in shape, much larger than laterals and closer to adjacent laterals than to each other as in fig. 1 ; median ocular quadrangle slightly longer than wide and narrower infront than behind. Clypeal height as large as diameter of anterior median eye. Sternum oval, slightly narrowed behind, rebordered, clothed with fine hairs. Labium triangular, not contiguous with maxillae ; anterior margin of maxillae provided with scopulae as in fig. 2. Chelicerae vertical ; inner margin without tooth but outer margin provided with three small teeth. Legs relatively long ;and strong, clothed with hairs and some spines ; scopulae extending to base of metatarsi I and II ; leg formula 4123. Male unknown.

Abdomen : More or less elliptical in shape, narrowed behind, clothed with pubescence ; ventral side lighter than dorsal. Epigyne as in fig. 3. Spermathecae as in fig. 4. Spinnerets prominent as in fig. 5.

Type-specimen : *Holotype* female in spirit, other details as below.

Type-locality : India, Madhya Pradesh, Amjhar Ghati on Jabalpur Dindori road, Jabalpur district, 27. XI. 1965. Coll. *H. P. Agrawal.*

This species resembles *Liodrassus mandae* Tikader & Gajbe but differs from it as follows : (i) Outer margin of chelicera provided with three teeth but in *L. mandae* outer margin with four teeth. (ii) Abdomen uniform but in *L. mandae* abdomen provided with muscular corrugations. (iii) Epigyne having intromittent orifice rounded and the spermathecae are triangular with spermathecal duct less coiled.

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Rec. Zool. Surv. India, 91 (2) : 251—261, 1992

OBSERVATIONS ON *LACCOPHILUS ANTICATUS ANTICATUS* SHARP (COLEOPTERA : DYTISCIDAE) AS A PREDATOR OF MOSQUITO LARVAE IN WEST BENGAL, INDIA.

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INTRODUCTION

Biological agents undoubtedly play an important part in controlling mosquitoes, and a study of these organisms forms only a phase of the complex subject spoken of generally as natural control or bio-environmental control. Increasing environmental concern over the widespread dependence on insecticides for vector control and also growing pesticide resistance create a need for newer mosquito control techniques. A more efficient use of known predators is one strategy.

Various predatory organisms occur in or near most habitats of mosquito immatures. Dytiscids or predaceous diving beetles are conspicuous among these. They are completely carnivorous (Balduf, 1935) and predation of mosquito larvae by dytiscids have been well accounted by various mosquito workers (James, 1961, 1964 b, 1967 ; Russell *et al.*, 1963 ; Jenkins, 1964 ; Notestine, 1971 ; Bay, 1974 etc.). Though the reports on predation by dytiscid beetles are not infrequent, a little is known about the quantitative relations between mosquito larvae and these beetle predators (James, 1964a, 1965 ; Roberts *et al.*, 1967 etc.).

Actual predation on mosquito larvae by the predaceous diving beetle, *Laccophilus anticatus anticatus* Sharp, common in many mosquito habitats in wetlands in West Bengal, is infrequently observed in nature. Destruction in the laboratory of a mosquito larval stock culture by a small population of beetles collected from field encouraged us to undertake this study. Further, reduction of larval mosquito on release of adult beetles in artificial breeding

ground of similar nature in field led us to infer their influence on destruction of mosquito larvae.

Included are experiments to determine the killing behaviour, changing patterns of prey consumption in different seasons, influence of container size on predation, influence of alternative prey on larval mosquito predation and average longevity of *L. a. anticatus*. These and related information are necessary to properly interpret the relationship between this predator and its prey.

HABIT—HABITAT OF BEETLE

L. a. anticatus are small (3-4 mm.), dorsally subflattened bicoloured (yellow and blackish), glabrous beetles. They find their most favourable haunting place in West Bengal, in marshy areas, in relatively shallow bodies of water rich in vegetation and small animal life. Often they are found where there is dense growth of filamentous algae like *Spirogyra*. Such habitats in periurban and rural areas are highly mosquitogenic and breed species like *Anopheles subpictus*, *A. vagus*, *A. hyrcanus*, *Culex vishnui*. This beetle thrives well where the water is shared by larvae or nymphs of other aquatic arthropods and insects which they consume. Dense submerged vegetation affords an abundance of food for the alternative prey. The adults are active and spend most of their time under water. They obtain air either by breaking through the surface film or from bubbles attached to the aquatic plants. The frequency of beetle's visit to the surface is said to be proportional to the beetle's activity and to temperature (Blunck, 1916 ; Benick, 1927). These beetles are semigregarious and are found in societies. They can also fly when necessary. They occur abundantly during the monsoon and post-monosoon hot seasons in temporary pools and weed infested ponds. They show cannibalistic tendencies in aquaria, which was noticed earlier by Hodgson (1953) in other species.

MATERIAL AND METHODS

Beetles were collected from pools in swampy areas at the outskirt of eastern Calcutta using a cloth sweepnet of ca. 20 cm. diameter and were transported to the laboratory in plastic buckets. A few mosquito larvae were provided during transit to avoid cannibalism. 5 beetles were placed to a 1-1tr. glass jar with plain tap water of pH 7 and a piece of aquatic weed from the natural nabitat. Forty IV instar larvae of *Aedes aegypti* mosquito were provided daily to each jar for maintaining the beetle in the laboratory. The water was changed on every seven days and the dead beetles were removed when noticed.

To determine the killing behaviour of beetle for mosquito larvae, a beetle unfed for 24 hours, was isolated in a 500-ml. clean glass jar with twenty IV instar larvae of *A. aegypti*

and was watched with a magnifying glass from a close range. Subsequently beetle predation was watched in a petri-dish under a binocular microscope. Four beetles were observed separately in containers to determine the frequency of predation.

In order to determine the destructive capacity of individual beetles for various stages of mosquito immatures, the beetles were isolated in jar (1-ltr.) with water. Ten each of I instar, III instar, IV instar and pupal stages of *A. aegypti* were added to all. After 24 hours, surviving larvae and pupae in all jars were counted and the difference in number of surviving larvae and pupae for each instar was attributed to beetle predation. After counting, new sets of immatures were replaced and the study was repeated for ten days.

To determine the rate of prey consumptions in different seasons of the year, the beetles were isolated in 1-ltr. jars. Twentyfive IV instar larvae of *A. aegypti* were added to all jars. Each day the number of prey consumed or killed during the previous 24 hours was recorded at 10·00 hrs. After counting, any remaining larvae or cadavers were replaced with twentyfive fresh larvae. Each container was observed for fifteen consecutive days. The procedure was repeated with new beetles for each season.

Another set of experiments involving containers of various sizes (250 ml., 500 ml., 1 ltr., 3 ltr.) and a single beetle per container with twentyfive IV instar prey larvae allowed estimating the effects of container size (in turn prey density) on predation. The variously sized containers used were cylindrical with a height to diameter ratio ca. 2·0.

The influence of alternative prey/food was studied by offering chironomid larvae (sp. indet.), in one group with fish flesh and in other group without fish flesh. Twenty IV instar *A. aegypti* larvae and an equal number of IV instar chironomid larvae were added to each 1-ltr. experimental jar. The number of larvae predated during a 24 hour period was recorded every day. This experiment was conducted in monsoon.

The longevity of the beetles was recorded from the laboratory maintained stocks.

RESULT

Prey capture and killing

L. a. anticatus was seen to locate its prospective prey when the latter was very close (8-10 mm.) to it. The senses of smell/taste seemed to determine the acceptibility or edibility of the animals seized. The beetles were normally not very fast-movers and became alert only when prey neared. After a stealthy approach beetles suddenly darted to capture their victims. They grasped the trunks of larvae with the first and second pairs of legs pressing them against their mouthparts. They chewed and tore the prey's body into solid bits which they ingested. They usually devoured all soft parts of the larval body leaving only the head and siphon. In at least twentyfive close observations the average consumption

time was 4 minutes (range 2-10 minutes depending upon hunger). The elapsed time between attacking two successive prey ranged from 10 to 150 minutes for 10 hours observation in a monsoon day.

Differential destruction of various stages

Individual beetles receiving only mosquito (immatures as prey destroyed an average of 3·36 III instar and 2·90 IV instar larvae within 24 hours. The 24-hour mortality of I instar larvae averaged only 0·86. Only one pupa was destroyed in a single replicate. Table 1 shows a prey preference for third and fourth instar larvae. First instar larvae are less preferred and pupae are seldom attacked.

Table 1

Predatory behaviour of *L. anticatus anticatus* on various stages *Aedes aegypti* immatures in 1·0 ltr. container

No. of days observed	No of containers observed	Prey instar	Total larvae destroyed	Per Cent predation	Mean No. of larvae destroyed/bcetle/24hrs.
10	3	I	26	12·09	0·86
		III	101	46·97	3·36
		IV	87	40·46	2·90
		Pupa	1	0·46	0·03

Seasonal fluctuation of predation

The daily predation by *L. a. anticatus* was not uniform. Considerable variability occurred in prey consumption in different seasons of the year. The beetle was least active in winter and the daily consumption was recorded to be only 0·95 larva (range 0-3). With the rise of atmospheric temperature the activity and feeding capacity of beetles increased considerably. In summer an average of 4·46 (range 2-8) larvae were consumed by a beetle within 24 hours. The consumption reached maximum in monsoon days when atmospheric temperature and humidity were both very high and predation reached an average of 7·93 (range 4-15) larvae within 24 hours. Fig. 1 compares rate of destruction of mosquito larvae by this beetle in container habitat, in different climatic seasons of the year. The correlation of predation with the atmospheric temperature and especially with the humidity is evident (Fig. 1).

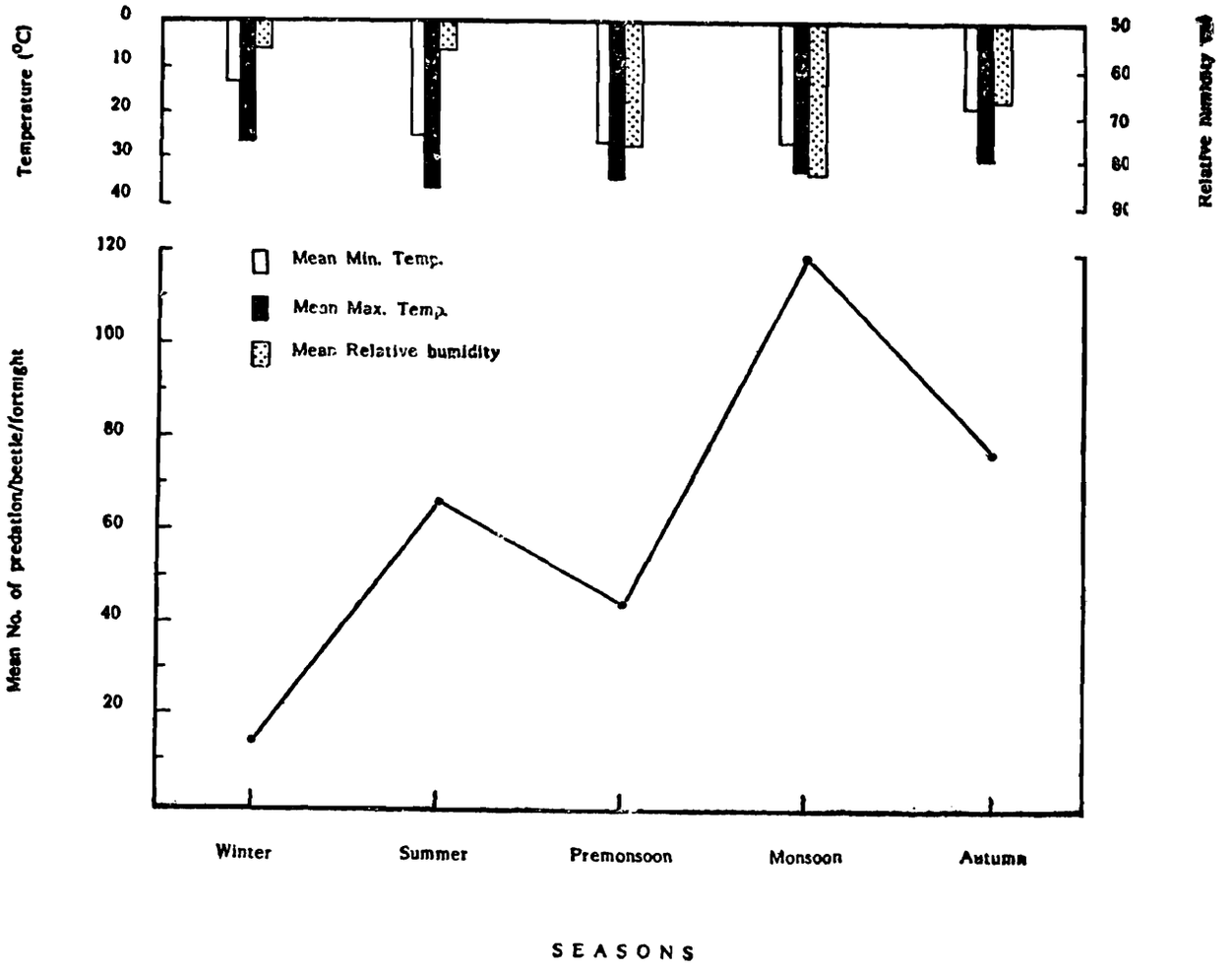

Fig. 1 : Mean fortnightly predation of *Aedes aegypti* larvae by one *Laccophilus anticatus anticatus* in different seasons of year.

Effect of container size on predation

In the experiment involving different size containers (0·25 ltr. to 3·0 ltr.), daily mean consumption varied directly (though not proportionately) with the size of containers. A 12-fold difference in volume resulted in only 1·45-fold difference in daily consumption. Fig. 2 suggests that predation was little dependent on prey density. This observation suggests that *L. a. anticatus* actively searches out its prey in larger arenas.

Effect of alternate prey on predation

In the alternative prey experiment neither mosquito nor chironomid larvae interfered with one another. The availability of chironomid larvae reduced mosquito larva consumption by approximately 37% (see Table 1). Surprisingly however, the presence of fish flesh seemed to reduce chironomid larval destruction by approximately 34%

(Table 2). From control replicates with only fish flesh, it was found that the beetles could thrive well on dead animal tissue alone if the water was not polluted. They did, however, shift to living prey when available.

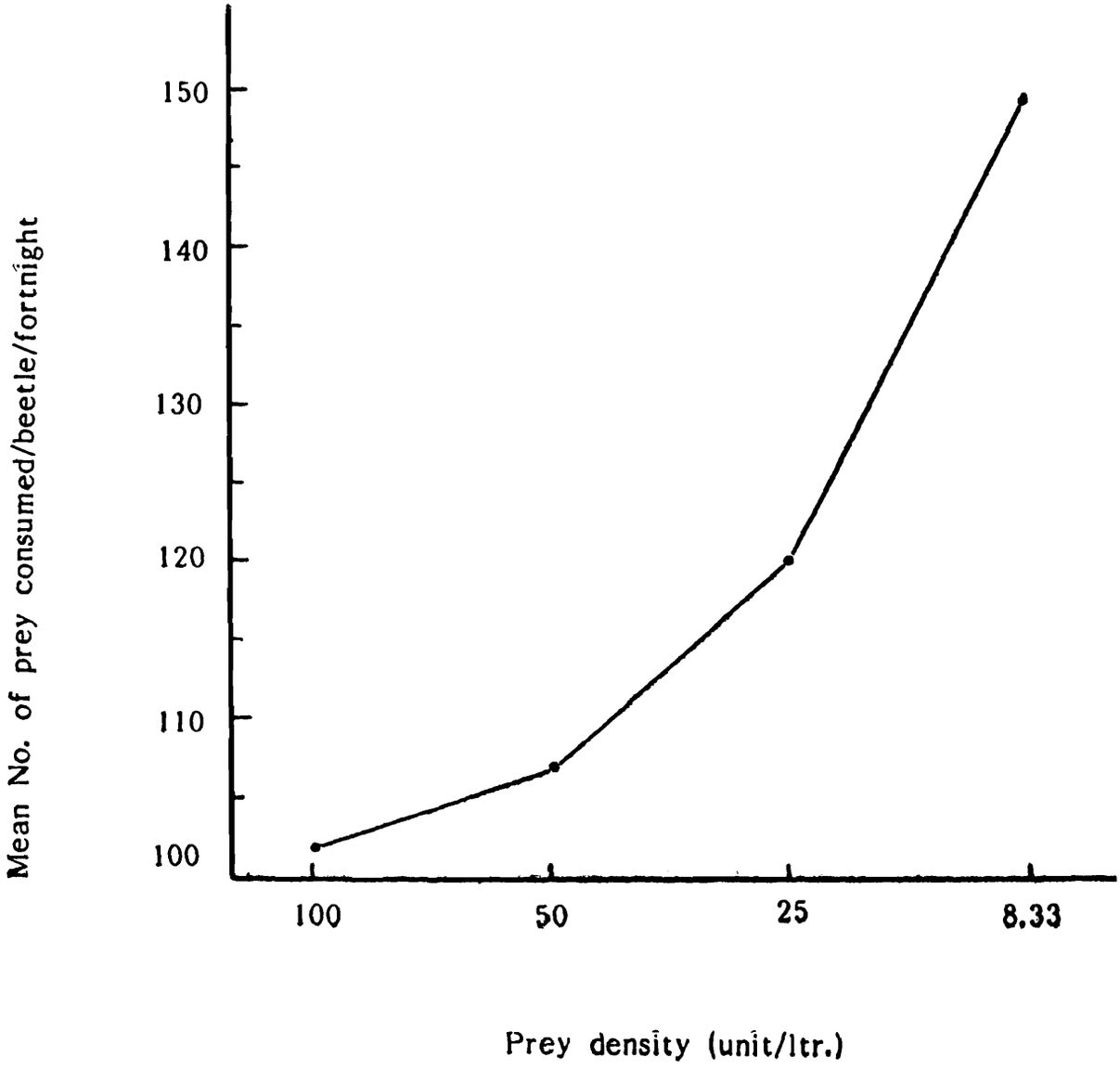

Fig. 2 : Mean fortnightly predation of *Aedes aegypti* larvae by one *Laccophilus anticatus anticatus* for various prey densities.

Table 2

Predatory behaviour of *Laccophilus anticatus anticatus of Aedes aegypti* and Chironomind larvae in presence and absence of fish flesh

Group	No. of days observed	No. of containers observed	Total No. of mosquito larvae predated	Total No. of chironomid larvae predated	Per Cent mosquito larvae predated	Per Cent chironomid larvae predated	Mean No. of mosquito larvae destroyed/ beetle 24 hrs.	Mean No. of chirnomid larvae destroyed/beetle/ 24 hrs.
I (plus fiish flesh)	15	3	211	127	62·43	37·57	4·68	2·82
II (minus fish flesh)	15	3	212	85	71·38	28·62	4·71	I·88

Longevity

The beetles receiving a regular supply of mosquito larvae in the laboratory stock lived for 28 days to 5 months 6 days, but majority survived between 50 to 60 days.

DISCUSSION

The pattern of prey capture by *L.* a. *anticatus* conforms typically to an insect with biting-chewing mouthparts. The adult beetles, unlike predaceous bugs, do not digest their food preorally. A midintestinal secretion flows forward into the crop where preliminary digestion takes place (Balduf, 1935). With the ingestion of enough food the beetles do not increase their body weight sufficiently to affect specific gravity or floating ability. Blunck (1923) noted that the food they take up is balanced by frequent elimination of rectal ampulla.

A monsoon peak in mosquito abundance in West Bengal coincides with the prevalence of shallow temporary breeding sites. Difference in climate affects the physiology and the duration of beetle's life cycle. Both the predator beetle and the prey insect are independently

influenced by seasonal climatic rythms, especially temperature and rain fall. These factors influence the synchronization of predator's acvity (≡prey consumption) and prey prevalence.

In the experiment involving different size containers, while the overall trends in the effects of container, size on predation rate is apparent, analysis of daily data indicates that little can be said concerning the expected predation on any particular day. These variabilities indicate that more factors influencing beetle's activity are involved in predation than just prey density. In spite of the obvious relationship between size and density, size of container definitely affected predatory activity apart from prey density. It is felt that the inability to obtain good correlation between dependent variables (*i. e.*, daily predation) and the number of prey larvae per litre was perhaps due to variable ratios of container surface area to predator. Beetles have however, demonstrated their ability to search out prey in larger habitats independent of lesser prey density.

Laboratory studies showed that *L. a. anticatus* preyed about equally on third and fourth instars of *Aedes* mosquito larvae but less so on chironomid larvae. It is assumed that the *Aedes* larvae, those move between the bottom and surface for feeding and respiration, often come close to beetles between midwater and surface stratum. Chironomid larvae, as mostly bottom dwellers, are less exposed to active zone of beetles. James (1964a) found that the larvae of mosquitoes are consumed faster than those of chironomids by *Laccophilus*. It perhaps suggests the preference of mosquito larvae over chironomid larvae. It is evident that the beetle can switch over its feeding to some dead animal matter and Bay (1972) even found it to prey upon its own eggs when the preferred diet was scarce. Borland (1971) noticed that this sort of behaviour does not occur if the beetles are provided with adequate mosquito larvae.

The ability of the predaceous diving beetle. *L. a. anticatus* to cause mortality of mosquito larvae in the laboratory is encouraging and obviously there are situations where similar incidence happens in nature. Its significance in nature however, needs to be better understood. Predators under laboratory conditions, are not as a rule able to noticably reduce larval populations in natural situations. It is, moreover, a recognised fact that to bring about a desired level of adult mosquito suppression by territorial larval reduction is difficult to attain. Ignoring such complex population models, the influence of this beetles against larval mosquito population is apparently indicated. Their spatial and temporal distribution overlap well with those of their prey, they have good longevity and interact for a long period with prey population, and they disperse relatively well. The opinion of authorities, however, differ regarding the importance of dytiscids against mosquito larvae. Chidester (1917), Twinn (1931), James (1964b), Notestine (1971) recognised dytiscids to have very good potential as aquatic predators whereas, Kuhlhorn (1961) in Germany recognised them to be of minor importance. Although mosquito control factors in India are not the same elsewhere, there are many common attributes.

Species of *Anopheles viz., subpictus, vagus, hyrcanus* appear quickly in newly filled depressions and temporary ponds, in marshy zones in West Bengal. These prey are followed almost simultaneously by considerable growth of aquatic vegetation and array of *Laccophilus* beetles. Although *Laccophilus* through regulation does not totally prevent mosquitoes from breeding in its habitat, it does generate mortalities to cause partial suppression of these mosquito populations.

SUMMARY

In the field predators of mosquito larvae can be very efficient against various species. Adult dytiscid beetles, *Laccophilus anticatus anticatus* sharp are semigregarious and occur in swampy humid zones of moderately large water bodies in West Bengal. Laboratory tests reveal that these beetles select mosquito larvae as prey over chironomid larvae. Prey consumption also varies with seasons of the year. In a fortnight, a single beetle on average is seen to predate 14 larvae of *Aedes aegypti* (L.) in winter, 67 in summer, 44 in pre-monsoon, 119 in monsoon and 77 in autumn days. The role of predation is to some extent affected by size of the containers. Individuals of *L. a. anticatus*, in laboratory, lived for 28 days to 5 months 6 days. These beetles were found to be responsible for low larval mosquito populations in their abode. The results of laboratory tests together with low larval population in temporary ponds and rain-fed depressions suggest that *L. a. anticatus* plays a significant biotic role in regulating the wetland mosquitoes in West Bengal.

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ON *THELOHANELLUS OPHTHALMICUS* (MYXOZOA : MYXOSPOREA) AND HISTOPATHOLOGICAL CHANGES DUE TO THIS PARASITE IN THE GILLS OF *CATLA CATLA*

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INTRODUCTION

Nigrelli and Smith (1938), while reviewing the results of earlier studies, stated that myxozoans did little, if any, harm to the host tissue. This view is still commonly held inspite of reports of pathological changes.

Nigrelli and Smith (1940) were the first to classify the host reaction to myxozoan invasion as an inflammatory reaction. They pointed out that changes caused by *Henneguya exilis* in the gills of *Ictalurus punctatus*, as described by Kudo (1929), were typical of inflammatory response, although this had not been recognised by Kudo himself.

Jakowaska and Nigrelli (1953) observed extensive damage associated with accumulation of lymphocytes and fibroblasts in host infected with *H. electricus*. They also found degenerative changes in the liver, kidney and heart. They did not, however, consider that this was a typical inflammatory response.

Myxobolus lintoni caused marked changes in the epidermis and hypodermis of skin leading to deformation of lesions which eventually developed into large tumour masses in *Cyprinodon variegatus* (Nigrelli and Smith, 1938). The tissue response in such cases manifests itself by the proliferation of fibroblastic material which forms a supportive framework for the developing spore mass. In addition to the local reaction of cyst production, hyperplasia of epithelium with increase in number of dermal gland cells, mucous and squamous cells was observed in *Ameiurus nebulosus* when infected with *H. ameiurensis* (Nigrelli and Smith, 1940). However, some of the myxozoan parasites appear to be innocuous and may not induce any response in the host tissue (Greven, 1956).

M. exiguus infecting the gills of mullet has been reported from the Black Sea (Petrushevskii and Schulman, 1961). The gill filaments were obliterated by cycts which burst causing extensive haemorrhage.

Aisa (1972) did not observe any histological changes in the gills of tench *Tinca tinca*, infected with *M. ellipsoides braemaeformis*. The only effect observed was that of mechanical pressure resulting in the reduction of cell layers surrounding the cyst, deformation or atrophy of the secondary lamellae, but the condition of the fish was not impaired appreciably.

Taylor and Haber (1974) reported granuloma formation as the host response in the trout infected with *Myxosoma cerebralis*. McCraren, Landolt and Hoffman (1975) described different manifestations of *Henneguya* infection in Channel catfish according to the tissues parasitised and site of spore formation ; there were two types of gill infections causing intra-and interlamellar cysts.

Dykova and Lom (1978) studied in detail the histopathological changes caused by *H. psorospermica* and *H. creplini* and observed various types of tissue reactions. They also found changes brought about by a change in the temperature. Kalavati and Narasimhamurti (1985) studied the histopathological changes brought about by *H. waltairensis* in *Channa punctatus*. Early stages induced hypertrophy of the host tissue with associated vacuolization of the cell cytoplasm. In later stages macrophages accumulated and the rupture of the cyst was associated with haemorrhage. Obviously, the histopathological changes produced by myxozoan parasites vary and are of different types.

Catla catla is one of the commonly reared carps in India. Gills, fins, eyes, spleen and intestine are usually found infested by the myxosporean parasite, *Thelohanellus ophthalmicus* Haldar, Das and Sharma, 1983 ; gill is the most frequently infected organ. An attempt has, therefore, been made to study the effect of *T. ophthalmicus* on the gill of *C. catla* and the corresponding host response by empoying various histological stains.

ABBREVIATIONS USED

Ca	Cartilage	NP	Neutrophil
CGN	Capsulogenous nucleus	NPC	Neck of polar capsule
Cy	Cyst	PC	Polar capsule
CyW	Cyst wall	PlC	Plasma cell
DS	Degenerating spores	PF	Polar filament
EP	Eosinophil	RZ	Repairing Zone
Fb	Fibroblast	S	Spores
GF	Gill filaments	Sb	Sporoblasts
IBS	Interbranchial septum	SGL	Secondary gill lamellae
ILC	Interlamellar cells	SP	Sporoplasm
IV	Iodinophilous vacuole	SPNi	Sporoplasmic nuclei
LC	Lymphocyte	SW	Spore wall

MATERIAL AND METHODS

Catla catla were examined for myxosporean parasites. Spores were mounted in glycerine jelly to clear the coils of polar filaments inside the polar capsules. Dry smears of spores were stained with Giemsa after fixation in acetone free methnol. Permanent

preparations were made with Heidenhain's iron haematoxylin after fixation in hot Schaudinn's fixative (50°C).

For scanning electron microscopy, spores were fixed in 4% glutaraldehyde in phosphate buffer, washed, dehydrated and critical point dried in carbon dioxide. Specimens were gold coated in sputter coater and finally scanned under JEM 1200 EX JEOL make electron microscope.

For histopathological studies infected gill filaments of small sized *C. catla* were isolated and cleaned free from adhering mucous, using a fine camel hair brush without causing damage either to the lamellae or to the cysts. Gill filaments were fixed either in 10% neutral formalin, Carnoy's fluid or alcoholic Bouin's fluid and sectioned at 5-7μm thickness. Sections were stained with haematoxylin-eosin, periodic acid-Schiff, alcian blue method, and Giemsa's stain to study the various histological changes.

RESULTS

Thelohanellus ophthalmicus Haldar, Das and Sharma, 1983

Syn. : *T seni*, apud Chakravarty and Basu, 1948

[Fig. 1 (a-b), Plate I (a-g)]

Cyst : Milky-white coloured present mostly in the fins and gills ; spherical in the fins [Plate I (c)], 0·152-0·475mm in diameter, oblong in the gill arch [Plate I (b)] 0·442-0·608 × 0·190-0·494mm and elongated in the gill filaments [Plate I (a)] 0.323-1·235 × 0·190-0·437mm in size ; located in the proximal side of gill filaments. Rarely, cysts are also seen in the spleen and intestinal wall.

Spore : Pyriform in valvular view, anterior end narrow and rounded, posterior end broad [Fig. I (a), Plate I (d) (f)]. Saucer-shaped in sutural view [Plate I (g)]. Valves symmetrical and uniformly thick with prominent and straight sutural ridge [Plate I (g)]. Sutural line visible with scanning electron microscope [Plate I (g)]. Polar capsule one, pear-shaped, more than half of spore length, a small tubular neck visible at the anterior end, contains 6-7 coils of polar filaments [Fig. I (a), Plate I (d)]. Polar filament thread-like when extruded [Fig. I (b)] ; rounded capsulogenous nucleus present at the periphery of polar capsule near the posterior end on the lateral side [Fig. I (a), Plate I (e)] Sporoplasm cup-shaped, granular, homogeneous [Fig. I (a), Plate I (d)]. An oval iodinophilous vacuole present in the sporoplasm [Fig. I (a), Plate I (e)]. Two sporoplasmic nuclei present in the sporoplasm lateral to iodinophilous vacuole, placed obliquely in most of the spores but horizontal in some [Fig. I (a), Plate I (e)].

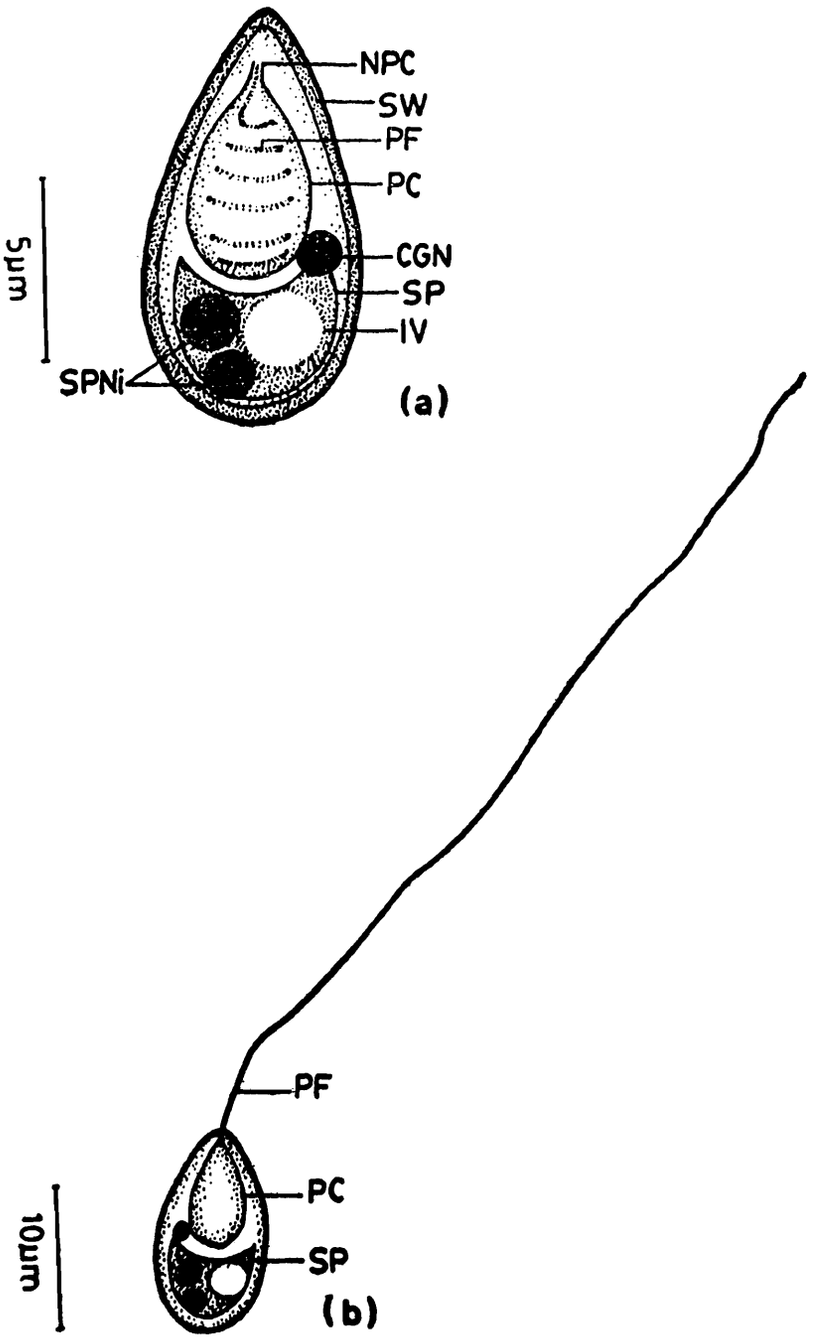

Fig. 1 : *Thelohanellus ophthalmicus* Haldar, Das and Sharma, 1983
(a) A spore in valvular view : Schaudinn/Iron haematoxylin,
(b) A spore with polar filament extruded : Methanol/Giemsa.

*Measurement :

Spore

length	11-14	(12·4, 0·952)	breadth	7-9	(7·967, 0·741)
Polar capsule					
length	6-7	(6·233, 0·359)	breadth	4·5-6	(4·933, 0·359)
Polar filament		62-71			
Iodinophilous vacuole		1·7-2× 1·1-2			

(Figures within parentheses indicate mean and standard deviation of fifteen specimens)

* All the measurements are in microns (µm) unless otherwise stated

Host : *Catla catla* (Hamilton)

Site of infection : Gills, fins, spleen and intestine

Locality : Harike (Punjab) ; India

Dates of collection : 19th and 20th February 1986

Remarks : Polar filaments of present specimens are quite long as compared to those in the original description [27·5-50·5 (39·4)]. Haldar, Das and Sharma (1983) reported this parasite from the eye of *C. catla*.

Chakravarty and Basu (1948) redescribed *T. seni* (Southwell and Prashad, 1918) Kudo, 1933 from the gills of *Catla catla*. But from the figures and measurements given by Chakavarty and Basu (1948) the specimen seems quite different from those described by Southwell and Prashad (1918). The spores, as illustrated by Southwell and Prashad (1918), are pointed at the anterior end and have a smaller polar capsule whereas in the diagram given by Chakravarty and Basu (1948) spores are narrower with bluntly pointed anterior end and a larger capsule. It is evident that Chakravarty and Basu's specimens are quite different from those described by Southwell and Prashad (1918). However, they resemble *T ophthalmicus* Haldar, Das and Sharma, 1983 (which is also described from *Catla catla*) in shape and size.

HISTOPATHOLOGICAL STUDIES

Gills of *Catla catla* were found heavily infested with *Thelohanellus ophthalmicus*. The cysts were present between the gill filaments on the proximal side of the gills near the gill arch [Plate I (a)]. Cysts showed heavy burdens of parasites [Plate II (c), (d)]. Observations on fully formed myxozoan cyst show that cyst wall is formed of a layer of stratified epithelium, a band of connective tissue and a layer of granulated cytoplasm beneath it. It contains a large number of immature spores (sporoblasts) along the periphery [Plate II (e)] and lumen is filled with mature spores embedded in the matrix of mucous material [Plate II (e), (f)]. The connective tissue band is positive to PAS and Alcian blue [Plate II (g), (h)].

Large amount of mucous is secreted in the infected fish. The damage done to the gill tissue is quite extensive. Mechanical pressure, due to increase in size of the cyst, results in destruction of gill lamellae [Plate II (c)], displacement of musculature of the interbranchial septum [Plate III (a)] and necrosis of the tissue surrounding the cysts [Plate II (c), III (b)]. Cartilage [Plate II (d)] and the secondary lamellae are replaced by the developing cyst [Plate II (c)]. Secondary gill lamellae are completely destroyed in the proximal area of the gill filaments and also above the cysts on the distal side of gill filaments [Plate II (c), III (b)]. Damaged epithelial cells and pillar cells exfoliate. This results in atrophy, degeneration and other necrobiotic changes.

Clubbing of the gill filaments takes place due to excessive proliferation of interlamellar cells, filling up spaces between secondary lamellae [Plate III (c)].

Tissue reaction is manifested by cyst formation or fibrosis due to the proliferation of fibroblastic material which forms a supportive framework for the developing spore mass [Plate II (c), (d)]. Cysts are produced by the host around the parasite to minimise the irritation caused due to the presence of parasite.

In addition, focal accumulation of a large number of neutrophils, eosinophils, some lymphocytes and a few plasma cells in the immediate vicinity of the infection is observed, showing a typical inflammatory response. Only a few erythrocytes are observed in this area [Plate III (d-h)]. Repairing of the host tissue at the site of infection is also seen [Plate IV (a), (b)] where fibroblasts, lymphocytes, a few plasma cells and neutrophils are observed among the degenerating spores [Plate IV (c), (d)].

DISCUSSION

An acute infection of *Thelohanellus ophthalmicus* Haldar, Das and Sharma, 1983 is observed in the gills of *Catla catla*. The epithelium of gills forms a barrier between the fish's blood and the surrounding water. Gaseous exchange needed to sustain life takes place through this barrier. Any morphological alteration by the parasites hinders the respiratory, secretory and excretory function of this organ.

Clubbing of the gill filaments due to excessive proliferation of interlamellar cells is an adaptive measure to protect the gill filaments from continual irritation caused by the lack of an adequate external gill covering. Clubbing of the gill lamellae was also observed by Takashima (1982).

Large amount of mucous is secreted which is an indication of the irritant nature of the parasite. It is presumed that abundant mucous mechanically disrupts gill function and causes asphyxiation of the fish.

Host response to this parasite is quite adequate as large number of neutrophils, eosinophils, lymphocytes and plasma cells are observed in the immediate vicinity of the cyst. Repairing of the infected tissue is also clearly observed in the gills. A large number of inflammatory cells are present along with the degenerating spores. A few fibroblasts are also seen in this repairing zone indicating a strong host response for this parasite. This is not typical of granuloma formation, as observed by Dykova and Lom (1978) in the gills of a perch as tissue response to *H. psorospermica*, as the pseudoepithelial cells are not observed surrounding this mass in the present study. Dykova and Lom (*loccit*) found that when the cyst is full of mature spores an inflammatory reaction is mounted resulting in the rapid replacement of the cyst by gtanulomatous tissue. Their observations are in agreement with those of Finn and Nielsen (1971a, b) and Lucky (1970) who found that host tissue response to *Myxobolus ellipsoides* begins only when the parasite has reached a certain minimum size. Dykova and Lom stated that at first relatively small cysts are overlaid by massive hyperplasia of the adjacent epithelium. This is followed by invasion of the parasitic mass by macrophages, which

remove the spores by phagocytosis. Later infiltration by fibroblasts and histiocytes complete the typical granuloma formation. The outer layers of the granuloma are formed by pseudo-epithelial cells derived from mesenchymal cells. In contrast to this, in the present studies cysts are not invaded by inflammatory cells ; instead, infiltration of neutrophils, eosinophils, lymphocytes and plasma cells is observed close to the cyst. The spores are seen in this inflamed mass ; the latter is infiltrated by fibroblasts resulting in repairing tissue adjacent to the cyst. Almost similar findings were given by Hoffman, Putz and Dunbar (1965), while discussing the histopathology of *Myxosoma cartilagini* in centrarchid fish.

Recently Kalavati and Narasimhamurti (1985) studied the histopathological changes in the gills of *Channa punctatus* infected with *Henneguya waltairensis* but the host response was poor in that case. They did not observe hypertrophy of the host tissue and vacuolisation of the associated cytoplasm. They also observed that when the cysts were mature, degenerative changes appeared more conspicuous and were associated with accumulation of macrophages ; the rupture of the cyst was associated with haemorrhage with this parasite. Rupturing of the cyst is not observed in the present studies.

An early healing response to *Henneguya ameiurensis* in the barbels of *Ameiurus nebulosus* was seen by Nigrelli and Smith (1940). However, they could not observe later stages of repair. Besides the mucoid material in the cysts, they observed lymphocytes, some fibroblasts and occasionally melanophores.

In conclusion, degeneration and repairing of the host tissue as host response, confirms the pathogenic nature of this parasite.

SUMMARY

Thelohanellus ophthalmicus Haldar, Das and Sharma, 1983 was found infecting the gill filaments of a freshwater fish, *Catla catla*. Morphological studies on this parasite have been carried out using light microscopy and scanning electron microscopy. Histopathological changes caused by *T ophthalmicus* in the gills of *Catla catla* have been studied in detail using various histological stains.

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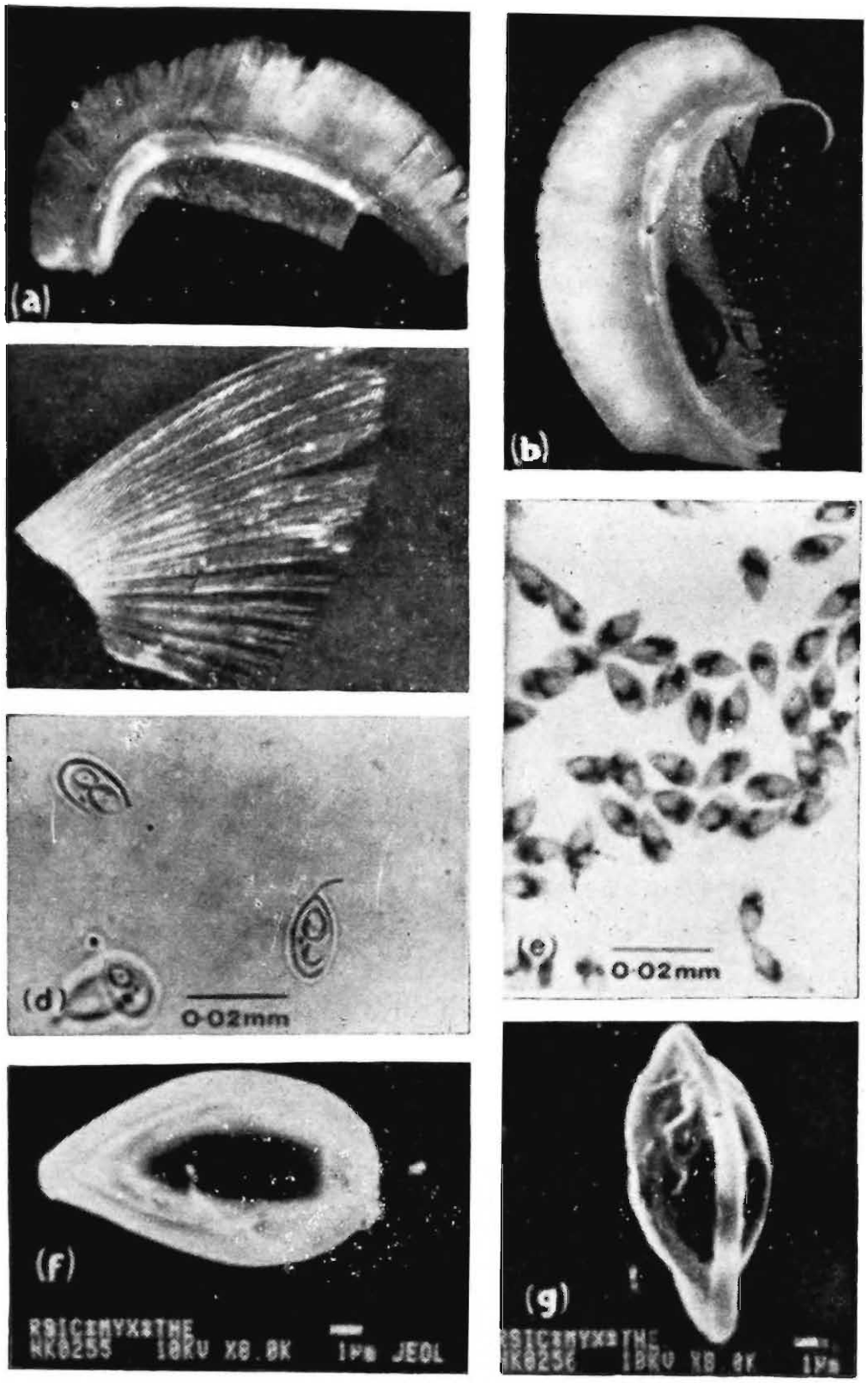
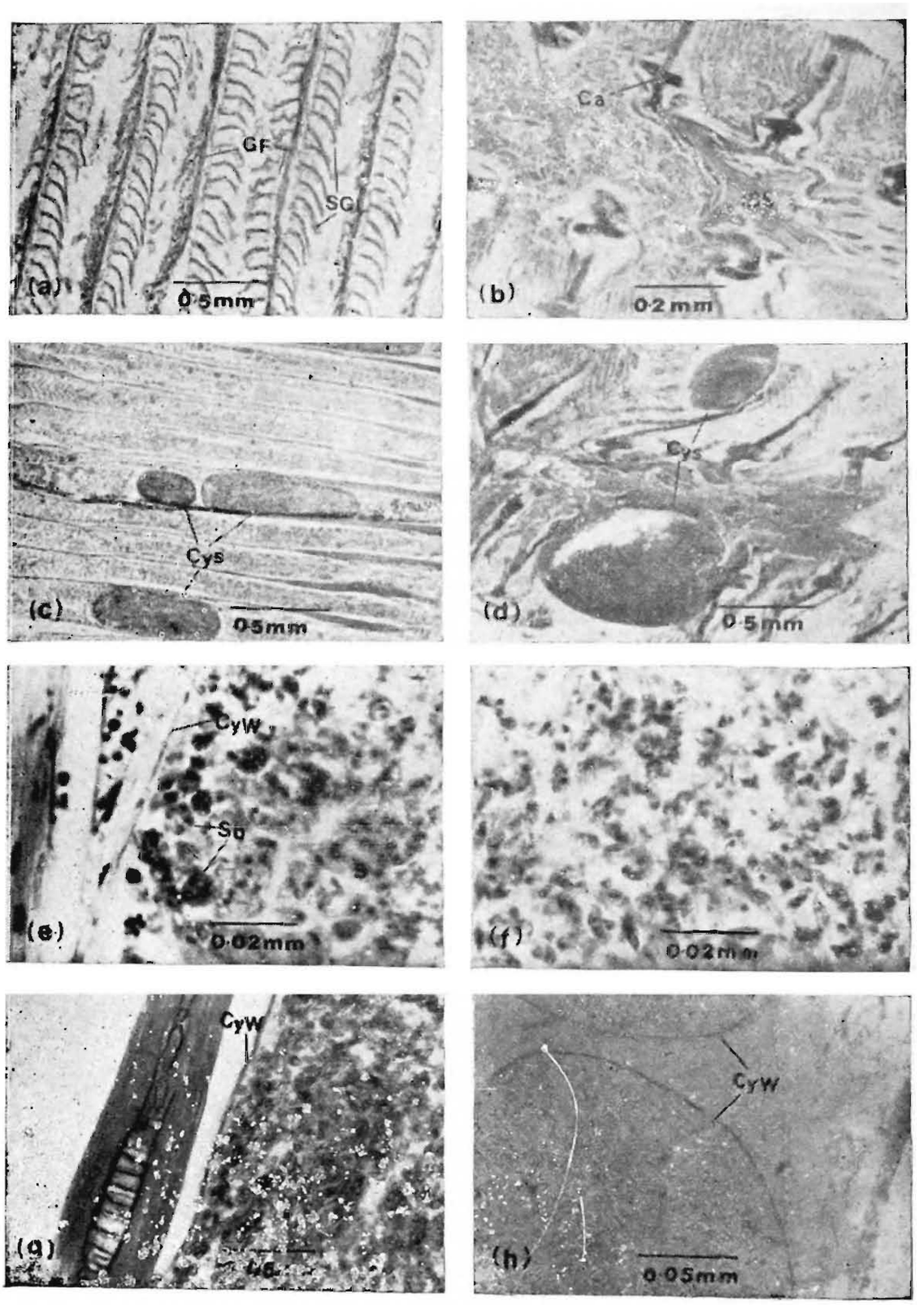


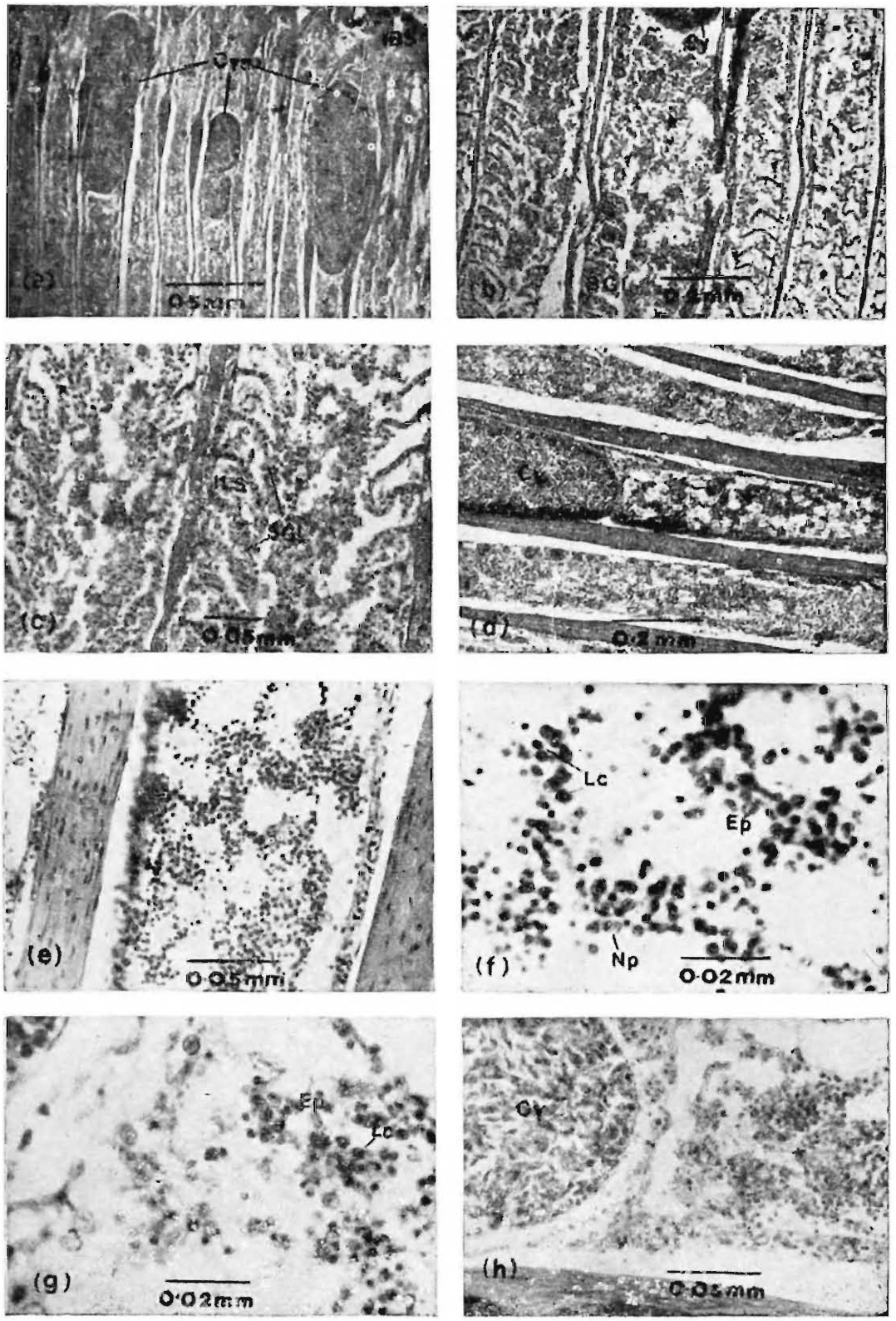
Thelohanellus ophthalmicus

(a) Gill of *Catla catla* showing cysts (→) in the proximal side of gill filaments, (b) Gill of *Catla catla* showing cysts (→) in the gill arch, (c) Fin of *Catla catla* showing cysts (→), (d) Fresh spores in valvular view showing coils of polar filament inside the polar capsule and part of the polar filament extruded, (e) Spores stained with iron haematoxylin showing sporoplasmic (→) and capsulogenous(⋯→) nuclei, (f) Scanning electron micrograph of spore in valvular view, (g) Scanning electron micrograph of spore in sutural view showing sutural ridge (→) and sutural line (⋯→).



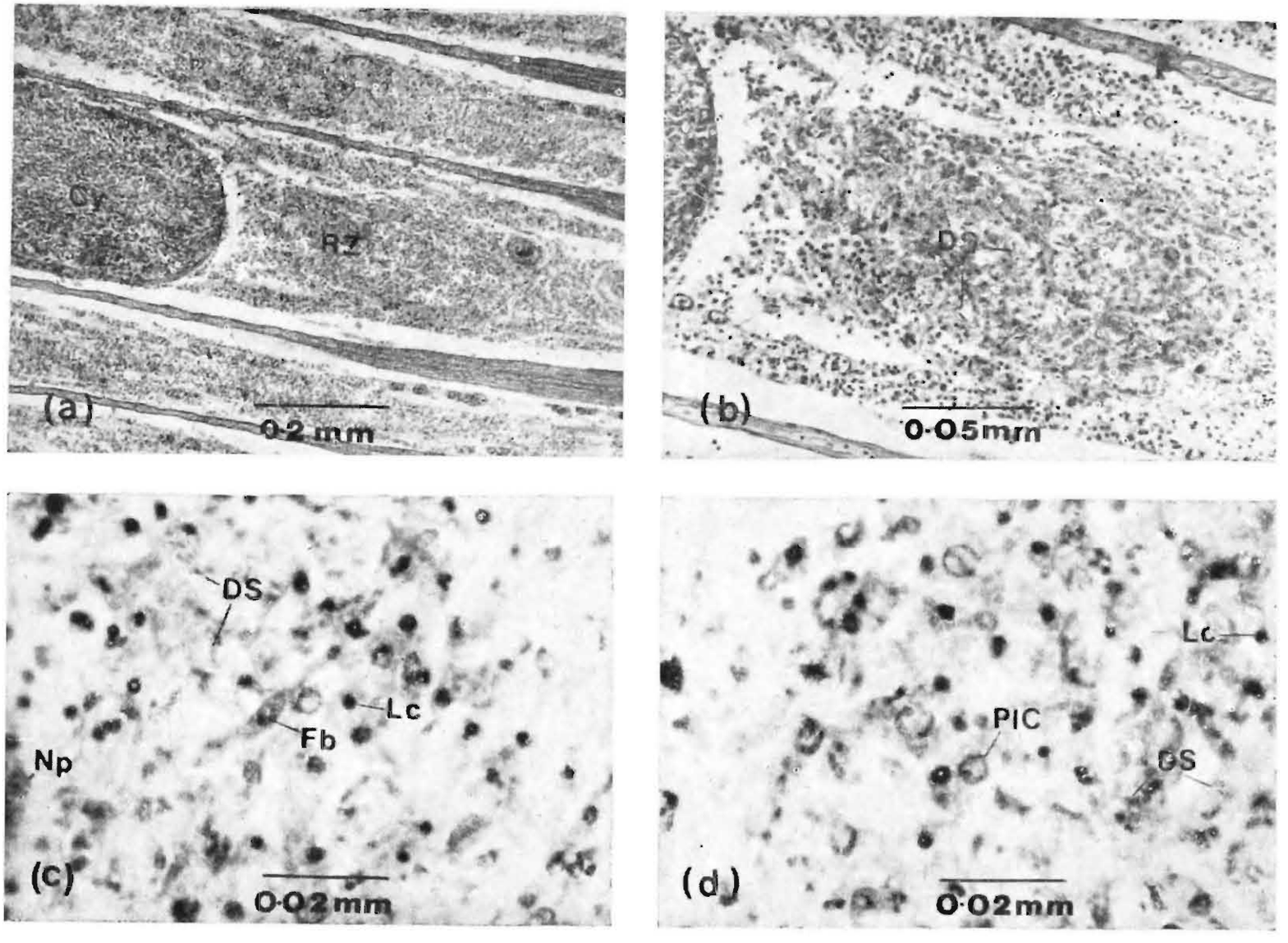
Thelohanellus ophthalmicus

(a) T. S. normal gill : Haematoxylin-eosin, (b) L. S. normal gill : Haematoxylin-eosin, (c) T. S. infected gill showing cysts of *Thelohanellus ophthalmicus* : Haematoxylin-eosin, (d) L. S. infected gill showing cysts : Haematoxylin-eosin, (e) A portion of the cyst enlarged to show immature spores (sporoblasts) towards the periphery and mature spores in the centre of the cyst : Haematoxylin-eosin, (f) Centre of the cyst showing mature spores : Haematoxylin-eosin, (g) Section of the infected gill stained with PAS to show the connective tissue layer of the cyst wall, (h) Section of the infected gill stained with alcian blue to show the connective tissue layer of the cyst wall.



Thelohanellus ophthalmicus

(a) A section of infected gill through interbranchial septum showing displacement of the musculature due to the cyst : Haematoxylin-eosin, (b) Necrotic gill tissue (*) near the cyst : Haematoxylin-eosin, (c) Clubbing of gill filaments due to excessive proliferation of inter lamellar cells : Haematoxylin-eosin, (d) Focal accumulation of white blood cells (*) near the cyst : Haematoxylin-eosin, (e) A portion of Plate III (d) enlarged : Haematoxylin-eosin, (f) A portion of Plate III(e) enlarged to show neutrophils, eosinophils and lymphocytes : Haematoxylin-eosin, (g) A portion of Plate III(d) enlarged to show accumulation of eosinophils and lymphocytes near the cyst : Haematoxylineosin, (h) Focal accumulation of white blood cells (*) near the cyst : Haematoxylin-eosin.



Thelohanellus ophthalmicus

(a) Repairing of the host tissue near the cyst : Haematoxylin-eosin, (b) Repairing zone enlarged showing degenerating spores among the repairing tissue : Haematoxylin-eosin, (c) A portion of Plate IV(b) enlarged to show fibroblasts, lymphocytes and neutrophils among degenerating spores : Haematoxylin-eosin, (d) A portion of Plate IV(b) enlarged to show plasma cells, and lymphocytes among degenerating spores.

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DEVELOPMENT OF ASYMMETRY AND HANDEDNESS IN THE FIDDLER CRAB *UCA (CELUCA) TRIANGULARIS BENGALI* CRANE, 1975 INHABITING THE ADYAR ESTUARY AND BACKWATER

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INTRODUCTION

The male fiddler commands instantaneous recognition due to its enlarged cheliped of one side (Plate 1). The allometrically enlarged cheliped which arises due to inequality of growth rate (Gould, 1966) at times accounts for 48% of the body weight of the fiddler. Handedness and development of handedness had always been attracting scientific workers to the male fiddlers (Haseman, 1907 ; Morgan, 1923, 1924 ; Vernberg and Costlow, 1966 ; Yamaguchi, 1977 ; Ahmed, 1978 ; Jones and Georges, 1982). Cheliped asymmetry is useful in sexual discrimination (Salmon and Stout, 1962), agonistic encounters and waving display (Crane. 1975) while percentage of handedness is considered to be tool in taxonomy (Jones and George, 1982).

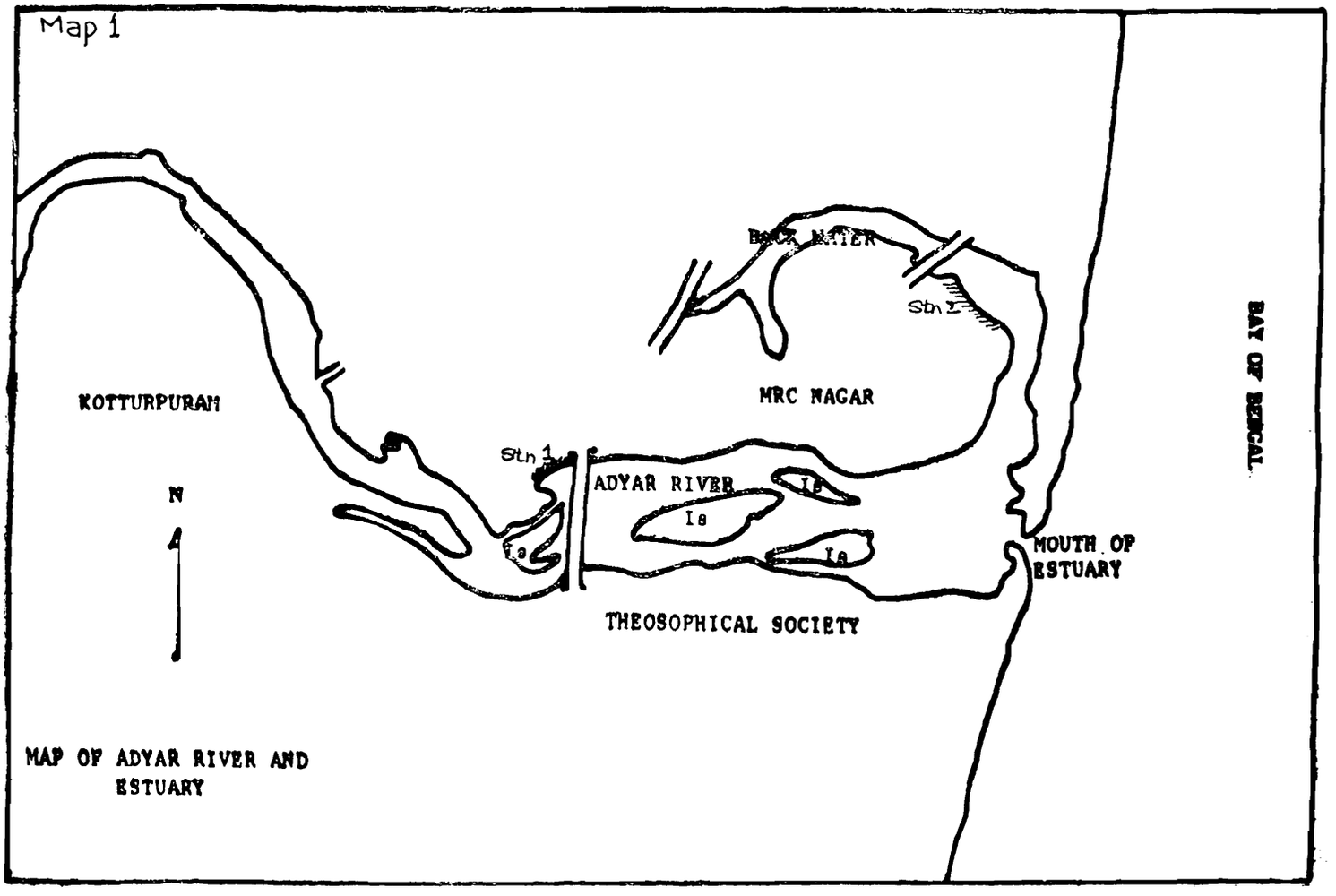
Work done so far at the macrolevel in the East and West still leaves our understanding incomplete. Little is known about handedness and development of handedness of the fiddlers in the Indian subcontinent. Fiddlers from the western parts of the world, especially *Uca pugilator*, *U. pugnax*, *U. minax* and *U, cumulanta* start exhibiting sexual differentiation from 1·7 to 3 mm carapace width while no difference could be noticed in the structure of cheliped of *U. (C.) triangularis* occurring in the Adyar backwater of Madras, India below 3·6 mm carapace width. Only after this stage, a slight enlargement in the size of the right or left cheliped could be noticed. Males with two large claws could not be located at all over the period of three years while those with two small chelipeds were seen rarely.

On handedness in *Uca*, Morgan (1923) and Vernberg and Costlow (1966) have observed that if the enlarged claw is amputated a new large claw develops at the same

locus and the other small claw does not enlarge so that asymmetry is not shifted to the other side. Further observations of Morgan (1923) indicate that if the left cheliped is removed from the fiddlers with 2·0 to 3·5 mm carapace widths, 57% of the fiddlers regenerated small claws only so that symmetry results; the rest had enlarged right cheliped. None developed enlarged left claws. The present study is to compare the development of handedness with other species of *Uca* studied by Morgan (1923), Vernberg and Costlow (1966) and Ahmed (1978) and to analyse the influence of asymmetry on the carapace.

Materials and methods

Random collection of the study material *U.* (*C.*) *triangularis bengali* was done from the resident populations of the Adyar estuary and backwater from two stations (Map 1). The occurrence of fiddlers could be seen throughout the year. Juveniles could be located only



MAP 1

seasonally, more during January-February. The number of right handed males was more at any point of time in the resident populations of the MRC Nagar area. Symmetrical stage crabs of less than 4 mm carapace width and asymmetrical juvenile males of 4 to 7 mm carapace width were captured at the waterline and upper burrow areas by bare hands. These were immediately transported to the laboratory and kept as such for one day. The dead ones were removed and the survivors were measured for carapace width and cheliped length on a Mitu-Toyo dial calipers (0·05 mm accuracy). The fiddlers were divided into two sets, one consisting of symmetrical stage crabs of less than 4 mm carapace width and the other asymmetrical, more than 4 mm but less than 7 mm carapace width. The sets were again divided into subsets according to carapace width and the claws were pinched with a stainless steel forceps. Crabs whose left, right and both chelipeds pinched were maintained separately in polypropylene troughs of 10 litre capacity. The crabs were fed on Kheema (mashed mutton meal) or mashed trash fish. Fresh supply of brine was maintained from the collection spot atleast twice a week. In the smaller class of fiddlers occasional presence of juveniles of *lactea annulipes* could not be ruled out. In some cases moulting occurred twice within the experimental period. On a few occasions discontinuity of the experiment could not be avoided and hence those were repeated. The entire laboratory and field work lasted for a year (June, 1983—May, 1984).

For the statistical analysis, 106 crabs of varying sizes were collected at random and measurements of carapace width, length and cheliped length were taken after preserving them in a 5% formaldehyde solution.

Results

The results are presented in Tables I and II. Set I : (a) Slightly enlarged right claw pinched (4-7 mm).

Regeneration of the lost limb was noticeable from the 4th day and the process of formation of the limb was completed on 12th day. Considerable increase in size of the regenerated right cheliped could be observed from the 18th day. None of the animal showed any increase in the size of the left cheliped worth recording. When moulting occurred just after pinching regeneration was found to be accelerated. Of the 132 crabs pinched 75 survived till the 28th day. The animals were maintained in the laboratory till the 78th day and during this period mortality was very limited.

(b) Slightly enlarged left claw pinched (4-7 mm).

Of the 131 crabs subjected to extirpation, 78 survived till the 28th day. No enlargement of the right cheliped could be observed. After 78 days of maintenance in the laboratory,

Table I

HANDEDNESS IN CELUCA TRANGULARIS AFTER REMOVAL OF CHELIPED AND SURVIVORSHIP (SET I)

SIZE	AMPUTATION	Day 1	Day 4	Day 8	Day 12	Day 18	Day 28	Enlarged Left	Enlarged Right
	Left	42	37	31	27	27	21	21	×
4-4·9 mm	Right	39	30	27	24	21	20	×	20
	Both	55	31	26	21	21	21	7	14
	Left	36	31	29	25	23	20	20	×
5-5·9 mm	Right	31	27	23	19	19	17	×	17
	Both	78	59	46	41	41	37	12	25
	Left	53	47	45	40	37	37	37	×
6-7 mm	Right	62	53	49	42	40	38	×	38
	Both	89	69	61	56	49	41	11	30
Total		**485**	**364**	**340**	**295**	**278**	**252**	108	**144**

Table II

HANDEDNESS IN CELUCA TRIANGULARIS AFTER REMOVAL OF CHELIPED AND SURVIVORSHIP (SET II)

SIZE	AMPUTATION	Day 1	Day 4	Day 8	Day 12	Day 18	Day 28	Females	Enlarged Left	Enlarged Right
Less than	Left	33	24	19	17	16	14	4	4	6
2 mm	Right	29	21	18	16	12	11	4	2	5
Both		63	30	23	21	17	16	×	4	12
	Left	39	29	28	26	25	23	4	6	13
2 to 2·9 mm	Right	42	31	30	30	24	21	7	7	7
	Both	74	46	30	22	22	16	×	7	9
	Left	54	47	41	38	36	31	9	6	16
3 to 3·9 mm	Right	46	40	37	35	31	27	3	11	13
	Both	81	32	28	21	17	14	×	5	9
Total		**461**	**300**	**254**	**226**	**200**	173	**31**	**52**	**90**

the morphometric characters of the carapace and cheliped were compared with the natural resident populations and no significant variation could be seen.

(c) Both claws pinched (4-7 mm).

Of the 222 crabs amputated only 99 survived till the end of the experiment. 30 turned out to be left handed, the right handed ones being the rest and all of them developed a new enlarged cheliped only at the locus of amputation. Percentage survival was very low due to excess trauma of pinching when compared to the other subsets.

Set II : (a) Symmetrical stage right claw pinched (less than 4 mm).

Of the 117 crabs amputated 59 survived. 14 turned out to be females, 20 males with left enlarged claw and 25 with right enlarged cheliped,

(d) Symmetrical stage left claw pinched (less than 4 mm).

Of the 126 crabs pinched 68 survived and the end product constituted of 17 females, 16 left handed and 35 right handed males. Percentage survival was comparable to (a).

(c) Both claws pinched (less than 4 mm).

Of the 238 fiddlers subjected to experimentation only 46 survived indicating a mortality of nearly 80% while in the 4-7 mm group it was only 55%, the visible effect being the inability to withstand the trauma.

Interestingly in Set II (c) where both the claws were amputated, no female survived ; indicating the probable physiologically frail condition. The number of males with right handedness was nearly two times when compared to left handed ones.

When regenerated chelipeds were cut off again on the 28th day, only 15 survived (6 left handed and 9 right handed) till the end of the 5'st day. But the survivors did not indicate any shift in the direction of asymmetry.

In statistical analysis, the estimated relationship was

$$Y = \underset{(2\cdot6700)}{-5\cdot4188} + \underset{(1\cdot1918)}{0\cdot1440} \times 2i + \underset{(0\cdot4475)}{0\cdot8385} \times 3i + \underset{(0\cdot2609)}{1\cdot1917} \times 4i$$

based on the model

$Y = B_1 + B_2 \times 2_i + B_3 \times 3_i + B_4 \times 4_i + e_i$ where

Y_i = the male propodus length of ith sampled crab.

2_i = 0 if the ith sampled crab is left handed.
1 if the ith sampled crab is right handed.

3_i = the ccrapace length.

4_i = the carapace width on the assumption that ei's are random residuals which are independently normally distributed with the same mean 0 and (unknown) variance. The analysis of variance using ordinary least square method and t test is presented in Table III.

Table III

ANALYSIS OF VARIANCE BY ORDINARY LEAST SQUARES & t TEST

Source	d. f.	Sum of squares	Mean sum of squares	F. ratio
Due to regression	3	3352·3	1117·4	31·2534
Residual	102	3646·9	35·753	
	105	6999·2		

The F statistic indicates that the above model significantly explains the relation between the male propodus length on the other three study variables. The value of $R^2 = 0{\cdot}4790$ indicates that about 48% of the variation found in the male propodus length is explained by these three variables. On a closer examination of the beta coefficients it is revealed that the average (expected) length is not significantly more for a right handed crab than a left handed crab (B_2 having a t value of 0·1208). The t value corresponding to coefficient of carapace width is 1·874 which also is not significant. Hence it is evident that the male propodus length is not dependent on carapace length. However, the coefficient corresponding to carapace width with a t value of 4·5675 is highly significant. The result indicates that the variation in the propodus length is mainly dependent on carapace width among the study variables. A further analysis of the effect of right or left handedness on the mean carapace width indicates non-interference of handedness (t value of carapace width being 1·56 and the handedness being 0·99).

Discussion

Fritsch (1968) while discussion the philosophy of right and left in Science and life remarked that asymmetry is the mark of the organic in general, life and argued that,

right is no better than left either functionally or physically. Ethological information on the fiddlers does not indicate any superiority of right handedness over left. In addition, both right and left handed fiddlers occur in the same population, their ratio being different for different species (Takeda and Yamaguchi, 1973 ; Frith and Frith, 1977 ; Williams and Heng, 1981 ; Jones and George, 1982), It is still a matter of different opinions whether right handedness is determined genetically or is the result of an interplay of the environmental conditions and the genetic constitution or differential expression of hormonal activity. Again, shifting of asymmetry from one side to another in the life of the fiddlers during early stages poses a problem in some species.

Morgan (1923, 1924) could locate occasionally the presence of males with two enlarged chelipeds while others (Vernberg and Costlow, 1966 ; Yamaguchi, 1977) could rear such individuals in the laboratory. In *U. (C.) triangularis bengali* under natural conditions and in the laboratory, not a single individual with two enlarged chelipeds could be noted. As opined by Ahmed (1978) such occurrence may be species specific or production of specific environmental conditions.

Shifting of asymmetry from one side to another has been noted in *U. rapax* (Vernberg and Costlow, 1966) and *U. cumulanta* (Ahmed, 1978), Yamaguchi (1977) stated that at the symmetrical stage, if *U. lactea*-male loses one cheliped, the other becomes enlarged and that if in the very young stages both the chelipeds are extirpated the crab does not develop enlarged cheliped at all. In the present study, no shifting of asymmetry occurred in *triangularis bengali* providing evidence in favour of genetic determination of handedness. In contrast to the observations of Yamaguchi (1977) the young crabs which suffered simultaneous extirpation of both the chelipeds developed either right or left handedness. In the larger stages also enlargement of cheliped occurred only at the locus of extirpation and the remaining claw did not derive the potential to enlarge in the absence of the extirpated enlarged claw indicating the validity of Huxley's (1932) hypothesis that the center for development of asymmetry in *Uca* lies somewhere near the base of the claws. It is possible that handedness being a secondary sexual character may be maintained by the androgenic hormone (Adiyodi and Adiyodi, 1970) supplementing the genetic constitution. The regenerated enlarged cheliped (Plate 1) does not appreciably vary from the one possessed by the fiddler under natural conditions. This is in contrast to the observation of Yamaguchi and Takeda (1973) in some cases of *U. marionis* where the regenerated larger chela was toothless. Successive loss of cheliped does not lead to shift in handedness.

Yerkes (1901) and Yamaguchi (1977) stated that handedness in the fiddlers is determined by chance but the latter tends to deviate from his own view that it is reasonable to consider handedness to be a genetic expression in some species. The autotomy or loss of cheliped at a particular stage marks the beginning of development

of asymmetry. Yamaguchi (1977) indicated that differences in temperature may be leading to the loss of cheliped. It my be considered that the genetically pre-programmed event is triggered by the temperature factor. Shedding of one of the cheliped may be of some physiological advantage (osmoregulation ?) during terrestrialization of young crabs.

The morphometric studies in relation to handedness indicate that the male propodus length is not significantly dependent on right or left handedness or carapace length. The male propodus length is dependent on the carapace width. The propodus length of the left and right handed crabs do not vary significantly. Even though it is concluded that male propodus length is dependent on carapace width, while predicting the propodus length one has to take cognisance of carapace length as well due to the presence of multicolinearity ($r=0{\cdot}49$) which is explained through the significant linear correlation between carapace wldth and length. Left or right handedness does not affect the carapace morphology to noticeable extent.

Summary

Extirpation expriments indicate that asymmetry in *triangularis* may be the expression of genetic constitution rather than an interplay of genetic and environmental factors. No shifting of asymmetry could be noticed. Handedness does not appear to influence the carapace morphology. Right handedness though prevalent does not appear to be better than left. Shedding of one claw at a particular stage seems to be a programmed event than by chance. The regenerated claw does not appear to be different from the one lost. A question has been raised whether the loss of cheliped may be considered as a means of terrestrialization.

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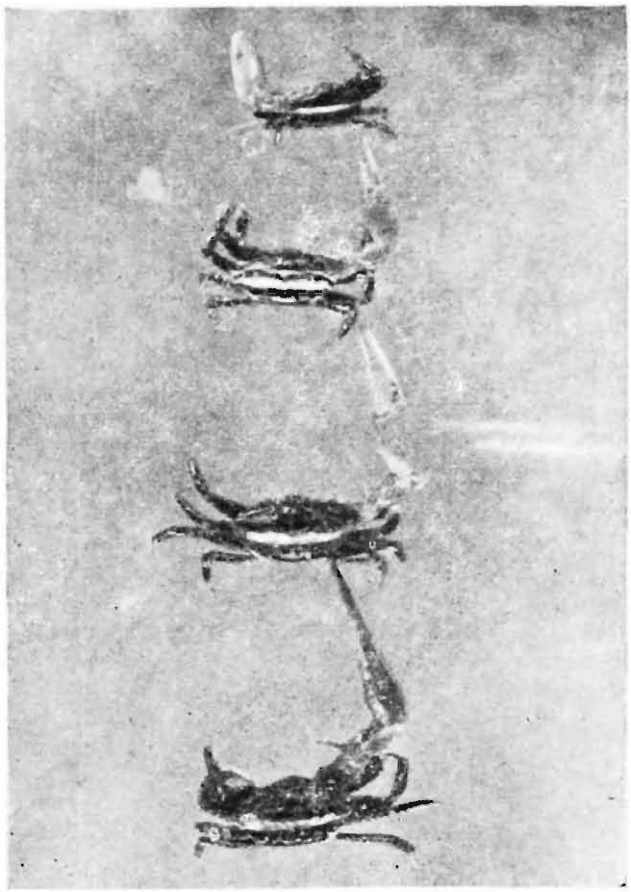
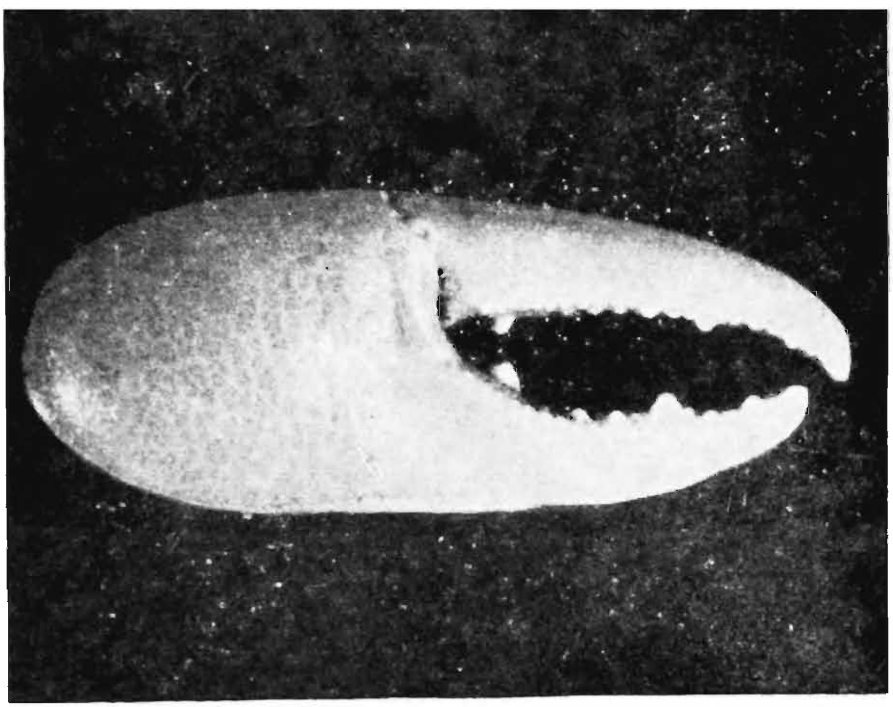
KRISHNAN PLATE I



Handedness in *U.* (*C*) *triangularis bengali*

KRISHNAN PLATE II



Regenerated claw