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MALACOFAUNA OF JABALPUR

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Zoological Survey of India

INTRODUCTION

Jabalpur, with her unique ecological condition, offers an ideal habitat to a rich fauna of molluscs. But till date, no comprehensive report dealing with the land and freshwater molluscs of Jabalpur in particular is available except some work of Agrawal (1976, 1977). The present work attempts to provide an uptodate document on the land and freshwater molluscs of Jabalpur, taking into account the recent changes made in nomenclature and classification.

Topography : Jabalpur, situated on the shores of holy river Narmada and lying in plains of tributaries Hiran, Gour, Ken and Sone. There are Kariapather hillock to the northeast, Sita Pahad and Khandari hills to the east, Madan Mahal hills and rocks outcrops to the southwest. The main water reservoir of Khandari and Pariyat are located to the northeast direction of the city. Several lakes and water tank used for culture surround the town its cardinal points are 23°10' N latitude and 79°57' E longitude, on Deccan Plateau with height of 393 meters and surrounded on all sides by most ancient basalt rocks with thick forest all round having about 1386-mm/yr rainfall. The highest maximum temperature recorded is 46.7°C while the lowest minimum was zero degree Celcius.

THE CLASSIFICATION FOLLOWED HERE IS AFTER VAUGHT (1989)

SYSTEMATIC LIST

Freshwater Molluscs

Class GASTROPODA

Subclass PROSOBRANCHIA

Order MESOGASTROPODA

Family 1. AMPULLARIIDAE

Genus *Pila* (Bolten) Roeding, 1798

(i) *Pila globosa* (Swainson)

(ii) *Pila virens* (Lamarck)*

Family 2. VIVIPARIDAE

Genus ***Bellamya*** Jousseaume, 1886

- (iii) *Bellamya bengalensis f. mandiensis* (Kobelt)
- (iv) *Bellamya dissimilis* (Mueller)

Family 3. THIARIDAE

Genus ***Tarebia*** H. and A. Adams, 1854

- (v) *Tarebia lineata* (Gray)*

Subclass PULMONATA

Order BASOMMATOPHORA

Family 4. LYMNAEIDAE

Genus ***Lymnaea*** Lamarck, 1799

- (vi) *Lymnaea (Pseudosuccinea) acuminata f. typica* (Lamarck)
- Lymnaea (Pseudosuccinea) acuminata f. brevissima* (Annandale & Rao)
- Lymnaea (Pseudosuccinea) acuminata f. patula* (Troschel)
- Lymnaea (Pseudosuccinea) acuminata f. rufescens* (Gray)
- (vii) *Lymnaea (Pseudosuccinea) luteola f. ovalis* (Gray)
- Lymnaea (Pseudosuccinea) luteola f. australis* (Annandale & Rao)
- Lymnaea (Pseudosuccinea) luteola f. impura* (Troschel)

Family 5. PLANORBIDAE

Genus ***Indoplanorbis*** Deshayes, 1834

- (viii) *Indoplanorbis exustus* (Deshayes)

Class BIVALVIA

Subclass PTERIOMORPHIA

Order UNIONOIDA

Superfamily UNIONACEA

Family 6. UNIONIDAE

Genus ***Lamellidens*** Simpson, 1900

- (ix) *Lamellidens corrianus* (Lea)
- (x) *Lamellidens marginalis* (Lamarck)

Genus ***Parreysia*** Conrad, 1853Subgenus ***Parreysia s.str.***

- (xi) *Parreysia (Parreysia) favidens* (Benson)
- (xii) *Parreysia (Parreysia) corrugata* (Mueller)

Subgenus ***Radiatula*** Simpson, 1900

(xiii) *Parreysia (Radiatula) andersoniana* (Nevill)

(xiv) *Parreysia (Radiatula) caerulea* (Lea)

Subclass HETERODONTA

Order VENEROIDA

Family 7. CORBICULIDAE

Genus ***Corbicula*** Megerle Vou Muehlfeld, 1811

(xv) *Corbicula inflata* (Clessin)*

(xvi) *Corbicula occidens* (Deshayes)*

(xvii) *Corbicula picta* (Clessin)*

(xviii) *Corbicula striatella* (Deshayes)

Land Molluscs

Class GASTROPODA

Subclass PROSOBRANCHIA

Order STYLOMMATOPHORA

Family 8. CERASTUIDAE

Genus ***Rhachis*** Albers, 1850

(xix) *Rhachis bengalensis* (Lamarck)*

(xx) *Rhachis punctatus* (Anton)

Family 9. ARIOPHANTIDAE

Genus ***Euplecta*** Semper, 1870

(xxi) *Euplecta acuducta* (Benson)*

Family 10. SUBULINIDAE

Genus ***Glessula*** von Martens, 1860

(xxii) *Glessula mullorum* (Blanford)

(xxiii) *Glessula paaupercula* (Blanford)

Genus ***Opeas*** Hutton, 1834

(xxiv) *Opeas gracile* (Hutton)

Genus ***Zootecus*** Westerland, 1867

(xxv) *Zootecus insularis* (Ehrenberg)

Genus ***Subulina*** Beck, 1837

(xxvi) *Subulina octona* (Bruguiere)

Subclass GYMNOMORPHA

Order SOLEOLIFERA

Family 11. VERONICELLIDAE

Genus ***Filicaulis*** (Smiroth)

(xxvii) *Filicaulis (Eleutherocaulis) alte* (Ferussac)

*Recorded from literature only.

Key to the families of freshwater molluscs

1. Shell with a single valve 2
 - Shell with two valves 6
2. Shell operculate 3
 - Shell without an operculum 5
3. Operculum with concentric growth lines 4
 - Operculum with spiral growth lines THIARIDAE
4. Operculum calcareous AMPULLARIIDAE
 - Operculum horny VIVIPARIDAE
5. Shell elongate with a distinct spire, columellar axis typically twisted LYMNAEIDAE
 - Shell discoidal, spire depressed, columellar axis not twisted PLANORBIDAE
6. Shell ovately trigonal with concentric sculpture CORBICULIDAE
 - Shell subrhomboid or transversely elongate, without concentric sculpture UNIONIDAE

Key to the families of land molluscs

1. Animal slug like, without a shell VERONICELLIDAE
 - Animal covered by a shell 2
2. Shell elongately ovate to turreted, distinctly higher than broad 3
 - Shell depressed to depressedly turinate, broader than high ARIOPHANTIDAE
3. Shell broad ovate, usually with bands CERASTUIDAE
 - Shell narrow, cylindrically turreted without bands SUBULINIDAE

SYSTEMATIC ACCOUNT
FRESHWATER MOLLUSCS

Class GASTROPODA
Subclass PROSOBRANCHIA
Order MESOGASTROPODA
Family 1. AMPULLARIIDAE
Genus ***Pila*** (Bolten) Roeding, 1798

1798. *Pila* (Bolten) Roeding, Museum Boltenianum, pt. 2. p. 145 (in part)

1989. *Pila* (Bolten) Roeding : Subba Rao, *Handbook Freshwater Molluscs of India.*, p. 57.

Shell large or very large, globose, smooth, spire short, aperture large, body whorl inflated, umbilicus usually open, operculum thick, calcareous. Amphibious in habit.

Pila globosa (Swainson)

1822. *Ampullaria globosa* Swainson, *Zool. illustration*, Vol. 2, pl. cxix.

1989. *Pila globosa* : Subba Rao, *Handbook Freshwater Molluscs of India*, p. 58, fig. 80.

Materials examined : (i) 4 exs., Devtal, 18.07.1960; (ii) 4 exs., Jabalpur-Nagpur road, 18.07.1960, (iii) 3 exs., Pachpedi, 19.07.1960; (iv) 3 exs., Chamanpur about 10 kms. on Bhedaghat road, 28.10.1960, Coll. S. Chakrapany.

Diagnosis : Shell globose, very smooth, olive, spire depressed, margin of the aperture thick, fulvous, grooved umbilicus small, contracted, placed near the base.

Distribution : INDIA : Madhya Pradesh, Assam, Bihar, Maharashtra, Orissa, Uttar Pradesh and West Bengal.

Family 2. VIVIPARIDAE

Genus ***Bellamya*** Jousseaume

1886. *Bellamya* Jousseaume, *Bull. Soc. Zool., France*, II : 478.

1989. *Bellamya*, Subba Rao, *Handhook Freshwater Molluscs of India*, p. 44.

Shell oblong, rather thin with bands or faint spiral striae, adult shell usually without ridges or spines. Body whorls rounded or subangulate, rarely keeled, aperture subcircular, peristome simple. Operculum thin, nucleus sublateral. Right tentacle in male short and curved. Ovoviviparous. Inhabits stagnant water.

Key to the species

1. Shell with dark spiral bands *B. bengalensis f. mandiensis* (Kobelt)
- Shell without any spiral bands *B. dissimilis* (Mueller)

***Bellamya bengalensis f. mandiensis* (Kobelt)**

1909. *Viviparus bengalensis* var. *mandiensis* Kobelt, *Nachr. Malak. Ges.* **60** : 414 In Martini Chemnitz. *Conch. Cab.* **2** : 414, pl. 77, fig. 8-9.

1989. *Bellamya bengalensis f. mandiensis*, Subba Rao, *Handbook Freshwater Molluscs of India*, P. 45, fig. 56.

Materials examined : (i) 9 exs., Gour river on Jabalpur Mandla road, 27.05.1961, Coll. D. Banerjee; (ii) 23 exs., Bhilonda village, about 20 kms from ZSI C.R.S. 25.07.1961, 1 ex., Vedinagar Nagpur road, 6.02.1962, 1 ex., Tewar village, 31.10.1962, Coll. P. Singh; (iii) 1 ex., Narmada river, Jabalpur 31.10.1962, Coll. R.C. Sharma.

Diagnosis : Spire more conical and little narrower than typical form, aperture not quite so broad, but more projecting, umbilicus broader, well developed alternating broad and narrow spiral bands.

Distribution : INDIA : Madhya Pradesh, common to northwestern India from Allahabad to Punjab and west to Mumbai.

***Bellamya dissimilis* (Mueller)**

1774. *Nerita dissimilis* Mueller, *Hist. Verm. Test.* pt. 2 : 184. Type-locality : Not given.

1989. *Bellamya dissimilis*, Subba Rao, *Handbook Freshwater Molluscs of India*, p. 48, figs. 64-67.

Materials examined : 7 exs., Garha area, 30.08.1961. Coll. P. Singh.

Diagnosis : Shell somewhat conic, smaller, narrowly and deeply umbilicate. Without dark spiral bands. With faint microscopic spiral striae. Body whorl subangulate at the periphery, rim of aperture often black.

Distribution : INDIA : Madhya Pradesh, Orissa, Pondicherry and common throughout India. *Elsewhere* : Bangladesh; Malaysia; Myanmar; Pakistan and Sri Lanka.

Subclass PULMONATA

Order BASOMMATOPHORA

Family 4. LYMNÆIDAE

Genus *Lymnaea* Lamarck

1799. *Limnaea* Lamarck, *Prodr. Nouv. Clas. Coq.*, p. 75.

1989. *Lymnaea*, Subba Rao, *Handbook Freshwater Molluscs of India*, p. 124.

Shell ovate, thin, with a large body whorl, spire exerted usually large, columella spirally twisted. Inhabits all types of freshwater habitat as including temporary water bodies.

Key to the species

1. The outerlip very much expanded and convex in outline, spire short and acuminate
..... *L. acuminata* (Lamarck)
- The outerlip not very much expanded, spire longer, less acuminate *L. luteola* (Gray)

Subgenus ***Pseudosuccinea******Lymnaea (Pseudosuccinea) acuminata f. typica*** (Lamarck)

1822. *Limnaea acuminata* Lamarck, *Hist. nat Anim. Sans, Vert.* **6**(2) : 160. Type-locality : "Bengale".

1989. *Lymnaea (Pseudosuccinea) acuminata f. typica*, Subba Rao, *Handbook Freshwater Molluscs of India*, p. 127. figs. 258-259.

Materials examined : 1 ex., 29.06.1964. Coll. S. Chakrapany.

Diagnosis : Shell thin, semitransparent, ovate with a short acuminate spire, body whorl much inflated, a little angular above, aperture large and columella twisted.

Distribution : INDIA : Madhya Pradesh and common throughout India. *Elsewhere* : Bangladesh, Myanmar and Pakistan.

Lymnaea (Pseudosuccinea) acuminata f. rufescens (Gray)

1820. *Limnaea rufescens* Gray, in Sowerby's *Genera of Recent & fossil shells*, **1**(7) : *Limnaea*. fig. 2.

1989. *Lymnaea (Pseudosuccinea) acuminata f. rufescens*, Subba Rao, *Handbook Freshwater Molluscs of India*, p. 127. Figs. 254-255.

Materials examined : 1 ex., 6.02.1962 Coll. S. Chakrapany.

Diagnosis : Shell uniformly narrowly elongate with a long spire, aperture uniformly less expanded and broadly angulate above.

Distribution : INDIA : Madhya Pradesh and common throughout India. *Elsewhere* : Bangladesh, Myanmar and Pakistan.

Lymnaea (Pseudosuccinea) acuminata f. patula (Troschel)

1837. *Limnaea patula* Troschel, in Weigman's *Archiv. fur. Naturg.* **3** : 167.

1989. *Lymnaea (Pseudosuccinea) acuminata f. patula*, Subba Rao, *Handbook Freshwater Molluscs of India*, p. 126. Figs. 256-257.

Materials examined : (i) 1 ex., Amarkantak, 29.06.1964, Coll. S. Chakrapany; (ii) 1 ex., Tewar village, 29.06.1964, Coll. P. Singh.

Diagnosis : Shell narrower than in *typica*, spire relatively large, anterior extremity of aperture tapering.

Distribution : INDIA : Madhya Pradesh and common throughout rest of India.

Lymnaea (Pseudosuccinea) acuminata f. brevissima (Annandale & Rao)

1925. *Limnaea acuminata* Annandale & Rao, *Rec. Indian Mus.*, **27** : 182, fig. III-1.

1989. *Lymnaea (Pseudosuccinea) acuminata f. brevissima*, Subba Rao, *Handbook Freshwater Molluscs of India*, p. 126.

Materials examined : 1 ex., Jabalpur, 6.02.1962, Coll. S. Chakrapany.

Diagnosis : This form is closely related to the *L. acuminata* but differs in the spire being still further reduced with less than 3 whorls in the spire. According to Annandale & Rao (1925) this feature is apparently an abnormality.

Distribution : INDIA : Madhya Pradesh and Maharashtra.

***Lymnaea (Pseudosuccinea) luteola f. ovalis* (Gray)**

1820. *Limnaea ovalis* Gray, In Sowerby's Genera of Shells, **1** : *Limnaea*, fig. 4.

1989. *Lymnaea (Pseudosuccinea) acuminata f. ovalis*, Subba Rao, *Handbook Freshwater Molluscs of India*, p. 128, figs. 266, 267, 283, 284.

Materials examined : 1 ex., Lamaghat, Narmada river, 29.06.1964, Coll. S. Chakrapany.

Diagnosis : Shell subglobose, body whorl globosely inflated without any compression, spire short and abruptly pointed or acuminate.

Distribution : INDIA : Madhya Pradesh & rest throughout India. *Elsewhere* : Myanmar and Srilanka.

***Lymnaea (Pseudosuccinea) luteola f. australis* (Annandale & Rao)**

1925. *Limnaea (Pseudosuccinea) f. australis* Annandale & Rao, *Rec. Indian Mus.*, **27** : 184.

1989. *Lymnaea (Pseudosuccinea) luteola f. australis*, Subba Rao, *Handbook Freshwater Molluscs of India*, p. 128, figs. 279-280.

Materials examined : 1 ex., Paharikhera, Jabalpur, 26.02.1963, Coll. J.S. Bhatti.

Diagnosis : A smaller form, spire comparatively longer, body whorl well-rounded, sutures rather shallow.

Distribution : INDIA : Madhya Pradesh and rest throughout India. *Elsewhere* : Bangladesh, Myanmar, Pakistan and Srilanka.

***Lymnaea (Pseudosuccinea) luteola f. impura* (Troschel)**

1837. *Limnaea impurus* Troschel in Weigman's *Archiv fur. Naturg.* **3** : 172.

1989. *Lymnaea (Pseudosuccinea) luteola f. impura*, Subba Rao, *Handbook Freshwater Molluscs of India*, p. 128, 129, figs. 281-282.

Materials examined : 1 ex., Mandla road, Jabalpur, 3.10.1962, Coll. P. Singh.

Diagnosis : Differs from the typical form in being narrower and the spire being a little more pointed. The apical portion very often appears black.

Distribution : INDIA : Madhya Pradesh and rest throughout India. *Elsewhere* : Myanmar and Srilanka.

Family 5. PLANORBIDAE

Genus *Indoplanorbis* Annandale & Prashad

1921. *Indoplanorbis* Annandale & Prashad. *Rec. Indian Mus.* **22**(4) : 578.

Animal sinistral, foot relatively broad and short. leaf shaped, broadly rounded anteriorly and pointed posteriorly. Branchial process lobed. The genus is monotypic.

Indoplanorbis exustus (Deshayes)

1834. *Planorbis exustus* Deshayes, *Voy. Belang. Indo. Orient Zool.*, p. 417, pl. 1, figs. 11-13.

1989. *Indoplanorbis exustus* : Subba Rao, *Handbook Freshwater Molluscs of India*, p. 142. figs. 326-327.

Materials examined : 6 exs., Baltara village, Sagar road, 19.01.1962. Coll. S. Chakrapany.

Diagnosis : Shell greenish brown, finely ridged, spire rather flattened, whorls 3, last large, aperture angularly raised, then depressed, sloped, expanded below, rather produced.

Distribution : Madhya Pradesh, Throughout the plains of India. *Elsewhere* : Celebes, Indochina, Java, Malaya, Myanmar, Pakistan, Persia, Srilanka and Thailand.

Class BIVALVIA

Subclass PTERIOMORPHIA

Order UNIONOIDA

Superfamily UNIONACEA

Family 6. UNIONIDAE

Key to the genera

1. Shell thin and broadly elongate, cardinals compressed elongate, lamellar teeth long
Lamellidens (Simpson)
- Shell thick and rounded to subrhomboid, tumid, cardinals heavy, vertically striate, lamellar teeth short *Parreysia* (Conrad)

Genus *Lamellidens* Simpson

1900. *Lamellidens* Simpson, *Proc. U.S. natn. Mus.*, (Washington), **22** : 854.

1989. *Lamellidens* : Subba Rao, *Handbook Freshwater Molluscs of India*, p. 164.

Exhalant aperture with a row of minute tubercles in its extreme lateral margins, inhalant aperture with a single row of short and stout tentacles.

Key to the species

1. Shell oblong-ovate, periostracum with a light brown border *L. marginalis* (Lamarck)
- Shell narrow, elliptical, periostracum uniformly dark brown *L. corrianus* (Lea)

***Lamellidens corrianus* (Lea)**

1834. *Unio corrianus* Lea, *Trans. Amer. Philos. Soc.*, **6**(2) : 65, pl. 9, fig. 25. Type-locality : India.

1989. *Lamellidens corrianus* : Subba Rao, *Handbook Freshwater Molluscs of India*, p. 165. figs. 386-387.

Materials examined : 1 ex., Pariyat tank, 23.06.1961, Coll. R.C. Sharma.

Diagnosis : Shell narrow, elliptical, transverse, very inequilateral, subangular behind, valves very thin, beaks scarcely prominent, cardinal teeth thin and bladed, 2 cardinals in each valve, lateral teeth long, thin and nearly straight, nacre pearly white and iridescent. Periostracum smooth and dark brown.

Distribution : INDIA : Madhya Pradesh, Tamilnadu, West Bengal. *Elsewhere* : Bangladesh and Myanmar.

***Lamellidens marginalis* (Lamarck)**

1819. *Unio marginalis* Lamarck, *Hist. Nat. Anim. Sans. Vert.*, **4** : 39. Type-locality : Bengal.

1989. *Lamellidens marginalis* : Subba Rao, *Handbook Freshwater Molluscs of India*, p. 168. figs. 404-405.

Materials examined : 2 exs., Shahpura Railway Bridge, 12.05.1962, Coll. V.S. Durve.

Diagnosis : Shell oblong ovate, valves covered with periostracum of blackish brown with a light brown border on the ventral margin. Umbo not elevated, posterior side broad, roundly angular, margins produced to a narrow wing, dorsal margin slightly curved, ventral margin slightly contracted in middle, hinge with two cardinals in right valve, interior nacreous.

Distribution : INDIA : Madhya Pradesh, widely distributed in India. *Elsewhere* : Bangladesh, Myanmar and Srilanka.

Genus *Parreysia* Conrad

1853. *Parreysia* Conrad, *Proc. Acad. nat. sci. Philad.*, **6** : 267.

1989. *Parreysia* : Subba Rao, *Handbook Freshwater Molluscs of India*, p. 180.

Shell heavy and inflated, rounded to subrhomboidal with distinct radial zig zag ribs on beaks, periostracum smooth, cardinals heavy, ragged or vertically striate, lamellar teeth short, cavity of beaks somewhat deep. All 4 gills marsupial, supra anal opening rather widely separated from the anal, the inner lamina of the inner gill entirely connected with the abdominal etc.

Key to the subgenus

1. Shell with centre of ventral margin swollen, thick, beak sculpture strong *Parreysia* s.st.
- Shell with almost straight ventral margin, comparatively thin, beak sculpture not strong, surface covered with radiating or zig zag shaped or divaricate ridges *Radiatula* Simpson

Subgenus ***Parreysia*** s.str.**Key to the species**

1. Shell scarcely inequilateral *P. (P.) corrugata* (Mueller)
- Shell more inequilateral *P. (P.) favidens* (Benson)

***Parreysia (Parreysia) favidens* (Benson)**

1862. *Unio favidens* Benson, *Ann. Mag. Nat. Hist.*, (3)10 : 188. Type-locality : Bhitoura on the Ganges between Cawnpore and Allahabad.

1989. *Parreysia favidens* : Subba Rao, *Handbook Freshwater Molluscs of India*, p. 180. figs. 466, 467, 484, 485.

Materials examined : (i) 3 exs. Pariyat Tank, 23.06.1961, Coll. S. Chakrapany; (ii) 1 ex., Damoh, 3.10.1962, Coll. H. Khajuria.

Diagnosis : Shell thick and heavy, inflated, with strong zig zag ribs on beak, inequilateral and angulate both on anterior and posterior margin, cardinal teeth strong and broad.

Distribution : INDIA : Madhya Pradesh and rest of India. *Elsewhere* : Bangladesh and Pakistan.

***Parreysia (Parreysia) corrugata* (Mueller)**

1774. *Mya corrugata* Mueller, *Verm. Terr. Et. Fluv.*, pt. 2, p. 214. no. 398. Type-locality : Rivers of Coromandel.

1989. *Parreysia (Parreysia) corrugata* : Subba Rao, *Handbook Freshwater Molluscs of India*, p. 179. figs. 448-449.

Materials examined : 1 ex., Damoh, 3.10.1962, Coll. H. Khajuria.

Diagnosis : Shell green, elliptical to oval, scarcely inequilateral, smooth, umbones prominent, sculptured with somewhat radiating, oblique, linear ridges, ventral margin convex, lunule well marked, cardinal teeth strong, not lamellar.

Distribution : A common species with a wide range of distribution. Madhya Pradesh, Andhra Pradesh, Bihar, Karnataka, Maharashtra and Punjab. *Elsewhere* : Bangladesh.

Subgenus ***Radiatula*** Simpson, 1900**Key to the species**

1. In mature forms the entire shell is sculptured *P. (R.) andersoniana* (Nevill)
- In mature forms only umbonal region is sculptured *P. (R.) caerulea* (Lea)

***Parreysia (Radiatula) andersoniana* (Nevill)**

1877. *Unio andersoniana* Nevill, *J. Asiat. Soc. Beng.*, **46** : 40. Type-locality : Myadong, Upper Burma.

1989. *Parreysia (Radiatula) andersoniana* : Subba Rao, *Handbook Freshwater Molluscs of India*, p. 187. figs. 508-509.

Materials examined : 1 ex., Gwarighat, 24.06.1964, Coll. D.N. Basu.

Diagnosis : Easily distinguished by more irregular shape, thinner texture, by the acute angulation, greater production posteriorly and by the more developed sculpture, umbo indistinct, pallial line prominent.

Distribution : INDIA : Madhya Pradesh, Assam and West Bengal. *Elsewhere* : Myanmar.

***Parreysia (Radiatula) caerulea* (Lea)**

1831. *Unio caerulea* Lea, *Trans. Amer. Phil. Soc.*, **4** : 95.

1989. *Parreysia (Radiatula) caerulea* : Subba Rao, *Handbook Freshwater Molluscs of India*, p. 188. figs. 516-517.

Materials examined : 1 ex., Jabalpur, Gwarighat, 24.06.1964, Coll. D.N. Basu.

Diagnosis : Shell comparatively thin, elongated than the preceding species, ventral margin more or less straight, beak not strongly sculptured, highly variable in shape and structure, posterior umbonal carina very distinct, in young shells the whole umbonal region is sculptured with zig zag ribs.

Distribution : INDIA : Madhya Pradesh Assam, Bihar, Orissa, Punjab, Uttar Pradesh and West Bengal. *Elsewhere* : Bangladesh, Myanmar, Nepal and Pakistan.

Subclass HETERODONTA

Order VENEROIDA

Family 7. CORBICULIDAE

Genus ***Corbicula*** Megerle von Muehlfeld

1811. *Corbicula* Megerle von Muehlfeld, *Mag. Gesell. Naturf.*, Berlin, **5** : 56.

1989. *Corbicula* : Subba Rao, *Handbook Freshwater Molluscs of India*, p. 200.

Shell subtrigonal, thick, with strong concentric ribs, prominent and centrally placed umbone, ligament prominent and external, hinge with three cardinal teeth in each valve, lateral teeth elongated.

***Corbicula striatella* (Deshayes)**

1854. *Corbicula striatella* Deshayes, *Proc. Zool. Soc. London*, **22** : 344. Type-locality : Pondicherry.

1989. *Corbicula striatella* : Subba Rao, *Handbook Freshwater Molluscs of India*, p. 204. figs. 575-576.

Materials examined : (i) 3 exs., Pariyat river at Maharajpur village, 7.05.1963, Coll. S. Chakrapany; (ii) 1 ex., Bheraghat, 3.10.1962, 4 exs., Gour river south of Gouriyaaghat, 15.06.1963, Coll. H. Khajuria; (iii) 11 exs., Narmada river south west of Bilpathar village, 26.03.1964, Coll. J.S. Bhatti.

Diagnosis : Shell thick of moderate size, tumid, ovately triangular, shining brown, very strongly concentrically ribbed, umbo distinctly raised.

Distribution : INDIA : Madhya Pradesh and common throughout India. *Elsewhere* : Myanmar and Pakistan.

LAND MOLLUSCS

Class GASTROPODA

Subclass PROSOBRANCHIA

Order STYLOMMATOPHORA

Family 8. CERASTUIDAE

Genus *Rhachis* Albers

1850. *Rhachis* Albers, *Die Helicien.*, p. 164. (= *Rachis* auctt.-err)

2004. *Rhachis* : Mitra, Dey and Ramakrishna, *Pictorial Handbook on Indian Land Snails*, p. 139.

Shell elongate, deeply umbilicate, dextral, smooth, usually with bands, aperture ovately elongate, columellar margin straight, expanded and strongly reflected partially covering the umbilicus. Peristome simple with straight margins.

Mostly arboreal in habit. Two species have been found in Jabalpur.

Rhachis punctatus (Anton)

1839. *Bulimus punctatus* Anton, *Verz. Conch.*, p. 42.

2004. *Rhachis punctatus* : Mitra, Dey and Ramakrishna, *Pictorial Handbook on Indian Land Snails*, p. 140, figs. C31.

Materials examined : 3 exs., Pachpedi, 5.01.1964, Coll. H.P. Agrawal.

Diagnosis : Shell ovately conical, distinctly perforate, marked with transverse streaks throughout and a single narrow chocolate band below the periphery, pale white, whorls 7-8, fairly rounded, last whorl with single band, rarely an indistinct second band exists, apex acute, aperture ovate, peristome slightly thickened, columella dilated and and reflected. Differs being more conical and narrower, having the transverse streaks throughout and also possessing a single band instead of 3-4.

Distribution : INDIA : Madhya Pradesh, Jharkhand, Maharashtra, Orissa, Uttar Pradesh, West Bengal and the whole of South India. *Elsewhere* : Africa and Srilanka.

Family 10. SUBULINIDAE

Key to the genus

1. Columella truncate below, not continuous with basal lip (2)
 - Columella rounded below, continuous with basal lip (3)
2. Columella obliquely truncate, sutures crenulated, outer lip sharp *Subulina* Beck
 - Columella abruptly truncate, sutures simple, outer lip blunt *Glessula* von Martens
3. Shell striate or decussate, peristome thickened *Zootecus* Westerland
 - Shell smooth except some weak striae, peristome thin *Opeas* Albers

Genus *Glessula* von Martens

1860. *Glessula* von Martens, *Die Heliceen.*, 2 : 254.

2004. *Glessula* : Mitra, Dey and Ramakrishna, *Pictorial Handbook on Indian Land Snails*, p. 156.

Shell small to moderate, imperforate, rather narrowly elongate to cylindrical, with a blunt apex, Smooth (without strong sculpture) aperture ovate. Peristome simple, columella deeply concave, truncates at the base. Sole of the foot without distinct median area, pedal margin absent.

Inhabits moist shady places with plenty of foliage etc. Many of the species are ovo-viviparous in nature.

Key to the species

1. Aperture pyriform, peristome internally slightly labiate, whorls 7 ... *G. paupercula* (Blanford)
 - Aperture semicircular, peristome obtuse, whorls 6 *G. mullorum* (Blanford)

Glessula paupercula (Blanford)

1861. *Glessula paupercula* Blanford, *J. Asiat. Soc. Beng.*, 30 : 62. pt. 1, fig. 16.

Materials examined : 2 exs., Jabalpur, Rani Durgavati Samadhi, 25.09.1966, Coll. H.P. Agrawal.

Diagnosis : Shell narrow, elongately turreted, finely vertically striate, sutures impressed, slightly marginate, whorls 7 convex at sides, aperture pyriform, peristome internally slightly labiate, columella arched and truncate.

Distribution : INDIA : Madhya Pradesh, Andhra Pradesh, Keral and Tamilnadu.

Glessula mullorum (Blanford)

1861. *Achatina mullorum* Blanford, *J. Asiat. Soc. Beng.*, 30 : 362, pl. 1, fig. 16.

1914. *Glessula mullorum* : Gude, *Fauna British India*, Mollusca, 2 : 431.

Materials examined : 4 exs., Tilwaraghat, 14.07.1966, Coll. H.P. Agrawal.

Diagnosis : Shell oblong turreted, rather solid, subdistantly striate, spire conical, apex obtuse, suture impressed, whorls 6, convex, body whorl rounded; aperture semicircular, vertical, margins joined by callus, columella arcuate and truncated base, peristome obtuse.

Distribution : INDIA : Madhya Pradesh, Kerala and Tamilnadu.

Genus *Opeas* Albers

1850. *Opeas* Albers, *Die Heliceen.*, p. 175.

2004. *Opeas* : Mitra, Dey and Ramakrishna, *Pictorial Handbook on Indian Land Snails*, p. 161.

Shell small, elongate turreted, imperforate or narrowly perforate, whorl rather flatly convex, smooth or microscopically striate, suture moderately deep. Aperture ovate, peristome thin, columella usually concave and rounded below, not sinuate, margin slightly reflected.

Oviparous in nature and produces small spherical eggs.

Opeas gracile (Hutton)

1834. No. 5, *Bulimus?* (mihi) *gracile* Hutton, *J. Asiat. Soc. Beng.*, **3** : 93.

2004. *Opeas gracile* : Mitra, Dey and Ramakrishna, *Pictorial Handbook on Indian Land Snails*, p. 162, figs. 119, 120.

Materials examined : 2 exs., Sita Pahari, 25.09.1966, Coll. H.P. Agrawal.

Diagnosis : Shell thin, transparent, elongate, with a gradually tapering spire, feebly striate imperforate or very narrowly perforate, whorls 10-12, rounded, aperture semi ovate, columella vertical, slightly reflected, outer lip almost straight, slightly edged.

Distribution : INDIA : Madhya Pradesh and Andhra Pradesh.

Genus *Zootecus* Westerland

1867. *Zootecus* Westerland, *Fauna Paerct Binnen Cochyl.*, **3** : 75.

2004. *Zootecus* : Mitra, Dey and Ramakrishna, *Pictorial Handbook on Indian Land Snails*, p. 164.

Shell rather small, pale or white, perforate, pyriform, cylindric with conic summit or cylindric tapering, 7-10 compactly coiled whorls, the last rounded below. Protoconch striate, not bulbous. Axis slender and straight, Narrowly perforated throughout. Aperture small, widely ovate, the peristome thickened, blunt, columellar margin straight or concave, with reflexed edge, continuous with the basal lip.

Zootecus insularis (Ehrenberg)

1831. *Zootecus insularis* Ehrenberg, *Symb. Phys. Anim. Evert.*, (1) : Moll.

2004. *Zootecus insularis* : Mitra, Dey and Ramakrishna, *Pictorial Handbook on Indian Land Snails*, p. 165, fig. 125.

Materials examined : 3 exs., Rani Durgavati Samadhi, 25.09.1966, Coll. H.P. Agrawal.

Diagnosis : Shell subcylindrical, perforate, whitish with decussating sculpture, whorls 7, sutures impressed, aperture vertical ovate, apex rather obtuse, lip of the aperture thickened and reflected. Viviparous in nature, dentition achatinoid.

Distribution : INDIA : Madhya Pradesh, Andhra Pradesh, Bihar, Delhi, Gujarat, Jammu & Kashmir, Maharashtra, Punjab, Rajasthan, Uttar Pradesh. *Elsewhere* : Myanmar, Pakistan, Red sea and Srilanka.

Genus ***Subulina*** Beck

1837. *Subulina* Beck, *Index Moll.*, p. 36.

2004. *Subulina* : Mitra, Dey and Ramakrishna, *Pictorial Handbook on Indian Land Snails*, p. 152.

Shell turreted, imperforate, narrow, thin, brownish or rather translucent, apex obtuse, whorls rounded, smooth or plicate at the sutural regions. Aperture oblique, ovate, columella concave, truncate below.

Subulina octona (Bruguiere)

1798. *Bulimus octonus* Bruguiere, *Encyl. Metn. Vers.*, 1 : 325.

2004. *Subulina octona* : Mitra, Dey and Ramakrishna, *Pictorial Handbook on Indian Land Snails*, p. 152, fig. 104.

Materials examined : 1 ex., Pachpedi, 25.09.1966, Coll. H. Khajuria.

Diagnosis : Shell thin, translucent, yellowish, turreted, gradually tapering to an obtuse apex, striate throughout, strongly on lower whorls 8-9, rounded, sutures deep and crenulate, last whorl rounded. Aperture suboblique, ovate, columellae arched and obliquely truncate at the base, peristome thin.

Distribution : INDIA : Madhya Pradesh, Andhra Pradesh, Andaman & Nicobar islands, Maharashtra, Tamilnadu. *Elsewhere* : Widely distributed through Europe, West Indies, West Africa, North and South America, Srilanka and other islands like Mauritius, Seychelles, New Caledonia etc.

Family 11. VERONICELLIDAE

Genus ***Filicaulis*** Simroth

1913. *Filicaulis* Simroth, *Reise in Ostafrika v.a. Voeltzkaw Stuttgart*, p. 202.

Body elongate, oval when contracted, linear when extended. A deep furrow present around the margin separating the mantle from the foot. Head retractile under the mantle, two pairs of tentacles, upper pair longer and cylindrical, the lower shorter. Foot when retracted does not extend over the anus, anal opening slit like, not covered by any flap.

Hermaphrodite, both self and cross fertilization takes place.

Subgenus ***Eleutherocaulis*** Simroth, 1913

1913. *Filicaulis* Simroth, *Reise in Ostafrika v.a. Voeltzkaw Stuttgart*, p. 202.

Filicaulis (Eleutherocaulis) alte (Ferussac)

1821. *Vaginalis alte* Ferussac, *Table syst. Linnaeus.*, p. 14.

1979. *Laevicaulis alte* : Bishop, *Mem. Qd. Mus.*, **18**(1) : 5.

1991. *Laevicaulis alte* : Subba Rao and Mitra, *Rec. zool. Surv. India, Occ. Pap.*, **126** : 36.

2002. *Filicaulis (Eleutherocaulis) alte*, Mitra and Dey, *State Fauna Series : Molluscs of Andhra Pradesh Part-I* (Land and Freshwater), p. 53.

Materials examined : 1 ex., Jabalpur, a garden in Napier Town, 17.08.1960, Coll. R.C. Sharma.

Diagnosis : Animal lacking a shell, elongate and linear when extended, mantle pigmented with dark brown color, usually with a yellowish band down the middle, foot narrow and transversely grooved.

Distribution : INDIA : Madhya Pradesh, Andaman & Nicobar Islands, Andhra Pradesh, Bihar, Gujarat, Maharashtra, Pondicherry, Punjab, Rajasthan, Tamilnadu, Uttar Pradesh and West Bengal. *Elsewhere* : East Africa, Mauritius, Reunion Island, Malagasy, Hong Kong, China, Formosa, Indonesia, New Caledonia, Loyalti Island, Malay Peninsula & Archipelago and Australia.

GENERAL DISCUSSION & SUMMARY

Regarding the faunal resources of mollusca in Jabalpur consolidated list of freshwater and land molluscs includes five families of freshwater gastropods and 2 families of freshwater bivalves are recorded. In addition, 4 families of land molluscs had also been found.

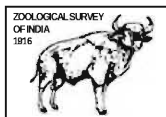
A total of 27 different species of which 18 freshwater and 9 land forms. Among the freshwater forms 13 species were studied and five recorded from literature. Out of these 13 species, 7 species are gastropods and six species are bivalves. Among the land forms 8 species were studied and one is recorded from literature. Agrawal (1977) recorded 4 species of *Corbicula*, out of those only one species i.e. *Corbicula striatella* is valid now. The existence of other 3 species is doubtful. Two species of *Glessula* viz. *Glessula pauprecula* & *Glessula mullorum* are now for the first time recorded from here mentioned as endemic to Western Ghats and Peninsular India by Ramakrishna and Mitra (2002). So, this work is not enough, further faunal explorations are necessary to find out the real picture.

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WATERBIRD-MEDIATED CHANCE-DISPERSAL OF FISHES : A NATURAL PROCESS AFFECTING RANGE OF DISTRIBUTION AND BIOGEOGRAPHY OF FISHES

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INTRODUCTION

Many biogeographers have reported from time to time instances of waterbird-mediated dispersal of organisms, often speculating on this phenomenon enhancing the natural distribution of plants and animals (Darwin, 1859; Ridley, 1930; Proctor, 1959).

Waterbirds are considered passive dispersers of the propagules of aquatic invertebrates, by transporting them, either internally (through gut contents) or externally (adhered to feet and feathers), thus facilitating dual means of dispersal : internal dispersal or endozoochory and external dispersal or ectozoochory (Darwin, 1859; Proctor *et al.*, 1967). Evidences on dispersal of amphipod crustaceans, through internal transport, by waterfowl have come from the studies of Daborn (1976) and Swanson (1984). Maguire (1963) has reported the waterbird-aided transport of aquatic organisms, which adhere to the plumage of birds, thus facilitating their passive dispersal and colonization in isolated water bodies. Through one experimental study, Segerstrale (1954) established that the amphipod *Gammarus lacustris* (Sars) adhered to plumage of a duck could retain its hold for over 2 hours. Vagvolgyi (1975) has documented instances of small snails found attached to bird feathers, getting dispersed to far away habitats.

Species enjoying wide distribution may comprise either morphologically similar complexes of sibling species or widely distributed conspecifics. Whatsoever, the wider distribution of species is indicative of their inherent ability and potential for getting dispersed, and make possible the gene flow from one area of distribution to another (Bohonak, 1999). Indirect evidences supporting the long distance dispersal of organisms by waterbirds have come from the studies of genetic populations of far-flung placed aquatic invertebrates, which reveal that the geographical distance between the

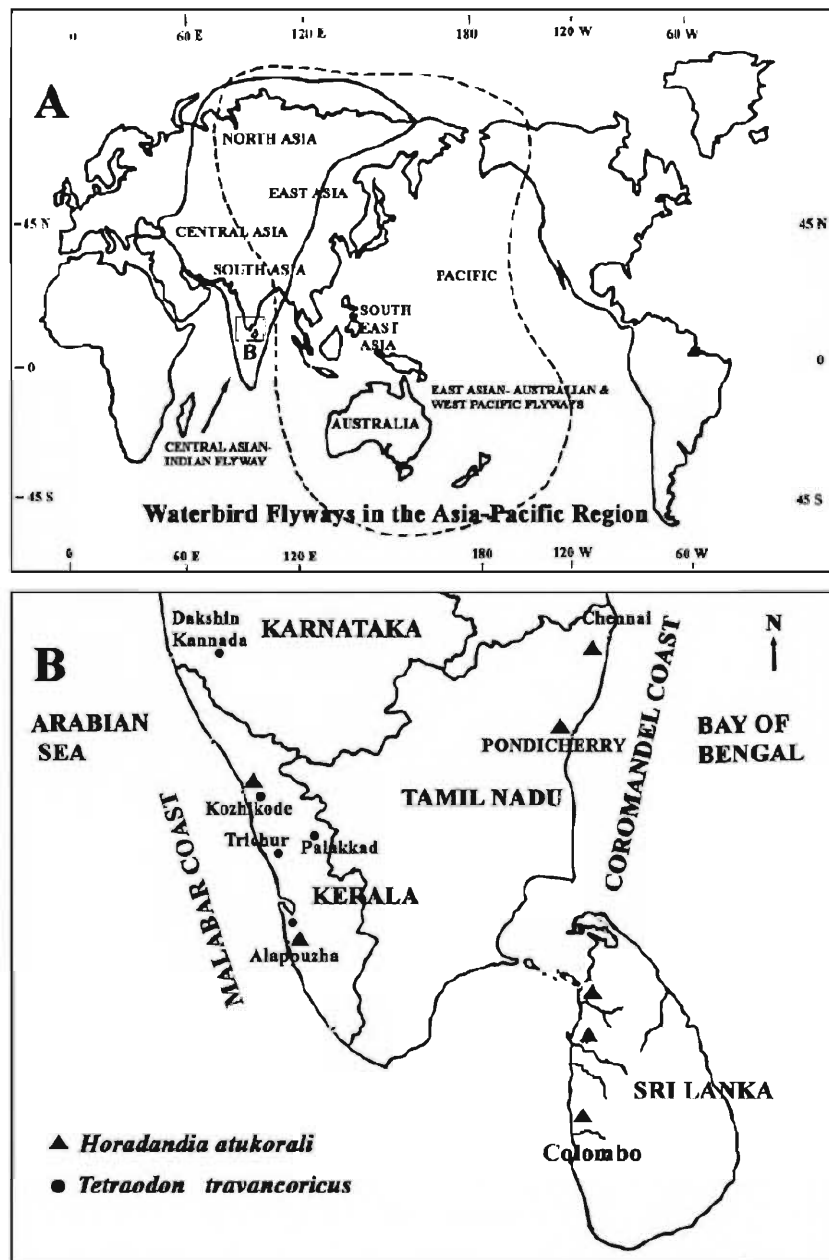


Fig. 1. : Link between the waterbird flyways and waterbird-mediated chance dispersal of prey fishes.

- A.** The waterbird-mediated chance dispersal events probably follow forage movements of waterbirds in a North $\rightarrow$ South direction of their flyway (Central Asian-Indian Flyway).
- B.** Extension of ranges of distribution of fish species : *H. atukorali* and *T. travancoricus*, in south India, probably aided by waterbird-mediated chance dispersal (distribution follows in a South $\rightarrow$ North direction of long/short distance forage movements of birds).

sub-populations is normally not related to their genetic distance (Freeland *et al.*, 2000a). The patterns of genetic distribution and biogeography of certain widespread freshwater invertebrates have been observed to follow the direction of major waterfowl flyways (Freeland *et al.*, 2000b; Taylor *et al.*, 1998).

Though waterbird-mediated dispersal of aquatic organisms is a frequently occurring phenomenon in nature, its relevance to the dispersal of fishes is seldom addressed and documented. Its significance remains apparently underestimated even while realizing that fishes, like aquatic invertebrates, constitute an important diet-component of waterfowl, particularly of piscivorous ones. Peterka (1989) has pointed out the possibility of freshwater systems getting stocked with fish-eggs or fry by waterbird-mediated dispersal, thereby enhancing the productivity of the systems. The relative importance of the waterbird-mediated dispersal of certain fish species, in comparison with distributional patterns of isolated populations of species offered by other competing means (Rosen, 1978; McDowall, 1978), has not been properly evaluated, probably due to lack of adequate supporting evidences.

This paper discusses some observations based on field studies on the possible passive dispersal of freshwater fishes by waterbirds, emphasizing its zoogeographic significance in the extension of range of distribution of fishes.

METHODOLOGY

In the present study, we have recorded some cases of the life of small fresh water fish species in odd aquatic habitat environs. These are illustrated as location-specific field observations. In this context, we have also considered the dispersal trends of the illustrated fish species from literature while linking up the case study observations on them, in order to derive at a conclusion with logical reasoning.

Field Observations :

Case study I

‘Madaipara’ in Kannur District, Kerala (India), is very characteristic for its lateritic plateau-land of about 600 hectares, abruptly raised to an elevation of 40 meters. Overlooking from the plateau top is the vast floodplains of the Kuppam River in the neighbouring Ezhome village in the coastal plains of the district.

During a field survey of this tableland, we observed small assemblages of freshwater fishes of two species, *Puntius vittatus* Day and *Aplocheilichthys blocki* (Arnold), thriving in two small pools in the plateau. It was a puzzle as to how these two fish species, in small populations, got established in the pools formed during the monsoon period. The plateau’s topography naturally prevented the chance-immigration of these species in to the pools from other water bodies. After the rainy season,

the pools gradually dried up by November-December. Our regular observations revealed that prior to the drying up of the pools, waterbirds, such as pond-herons and egrets, preyed on the fish-stock of the pools.

The pools got replenished by the succeeding southwest monsoon rains (June to August), and initially there was no fish life in them. We also noticed some of the water birds, especially pond herons and egrets, occasionally frequenting the water pools. It was observed that waterfowl often with mud-stuck feet and soiled feathers used the pools for preening and cleaning activities. It was indicative of the birds' arrival from the foraging ground, presumably after feeding.

As happened in the previous year, the fish life revived in the pools, initially with the species *P. vittatus*, and then with *A. blocki*. The small fish population, hardly about 100 individuals comprising both the species, thrived in the pools till October-November, but again succumbed to predation by waterbirds, once the pools started drying up.

We observed this phenomenon recurring in the succeeding seasons also, which was monitored for three-more years (from 1998 to 2000). The small fish population temporarily established in the pools, observed during one visit in November 2005, also contained a few individuals of *Puntius ticto* and *Pseudosphromenus cupanus*, yet other two small forage fishes of waterfowl.

The fish species sighted in plateau-pools have some unique attributes, such as, smaller size, short breeding cycles, and high fecundity and reproductive potential than most of the other freshwater fishes. They are sought after by waterbirds owing to their ubiquitous presence in almost all freshwater habitats.

The inference from our observations is that the fish life in the tableland pools was seasonally influenced and enhanced by the visits of the waterfowl.

Case study II

Another interesting case of distribution of a fish is that of *Horadandia atukorali* Deraniyagala, reported from the freshwater bodies in the coastal plains of Kerala, Tamil Nadu and Pondicherry in South India. *H. atukorali*, a small carp-let about 3 cm long, was earlier thought to be endemic to Sri Lanka, until Rema Devi and Menon (1992) reported it from a pond in the Pathiramanal Island in the Vembanad Lake in Southern Kerala. Later, it was reported from Kumarakom (Rema Devi *et al.*, 1996) close to the Vembanad Lake, and also from Kalpakkam near Chennai (Tamil Nadu) and Villianur (Pondicherry) along the East Coast (Rema Devi, 1996).

H. atukorali is a prolific breeder whose eggs, remaining attached to submerged weeds, hatch in 36-48 hours, and its life cycle is so compressed that the reproductive life of this fish is over in a year (Brittan, 1961). In its original habitat in Sri Lanka, the species is a still or slow swimming fish, frequenting less saline mangrove swamps and less polluted canals, rice fields and similar waters, wherein its population increases to noticeable proportion (Pethyagoda, 1991).

It was quite intriguing to find *H. atukorali* along with three other small species of fishes, in a recent collection from the freshwater tank, Mananchira, in the Calicut City, North Kerala (Gopi *et al.*, 2004b). The tank with an area of 100 sq. m is well protected on all sides, and since the 1980s has been in use as the main drinking water-supply source of the city. Prior to starting the water supply scheme, this old tank had been thoroughly revamped by deepening and draining out processes, and sanitation works. Obviously there was little chance for the occurrence of any characteristic biota such as fish in the tank, at least in the beginning. Hence, the occurrence of fishes in the tank at present, as evidenced by our recent fish-collection, calls for an explanation since our attempts at collecting fishes from the tank, for a few years in the past, had not yielded any positive results.

The fish collection from the waters of the tank (on 6.1.2003) comprised of the freshwater species, *H. atukorali*, *A. blocki*, *P. vittatus* and *P. cupanus*. All these four species were in moderate abundance in the tank waters, amidst the grassy weeds. The fish community of the tank consisted only of small fish species, notably *H. atukorali*. It was also observed that piscivorous waterbirds like Little Cormorant (*Phalacrocorax niger*), Little Grebe (*Podiceps ruficollis*), Little Egret (*Egretta garzetta*), Median Egret (*Egretta intermedia*) and Pond Heron (*Ardeola grayii*) frequented the tank waters in good number. Hence it is inferred that these fish species have in all probability been passively dispersed to the tank environs by the piscivorous waterbirds that usually frequent the freshwater habitats in search of feeding grounds.

Case study III

The Malabar Pufferfish, *Tetraodon travancoricus* Hora & Nair, is a small species about 2-3 cm long, described from the Pamba River system that empties into the Vembanad Lake. Since the description of this species in 1941, it remained elusive for nearly four decades, hence deriving it the status as a rare/vulnerable species. There has been no record of this fish from any other habitat till 1993 when Inasu (1993) collected the fish-samples during May, June and September (1992), from the inundated brickyards at Pudukkad, Trichur, Kerala, and later Biju, *et al.*, (1999) made their collections, during the summer months (January to May), from the fresh water bodies at localities : Thattekad and Kalady of Periyar River, Kanakkankadavu of Chalakudy River and Puzhakkal of Ketchery River. Further, Rema Devi *et al.*, (1996) identified this species from Kerala, and the specimens of *T. travancoricus* in the samples hold the data of the collection-sites as : “a ditch near Kottayam Railway Station” (5 exs., Dec., '87), “Minachil River, Kottayam” (2exs., 5.12.1987) and “Pathiramanal Island (pond), Vembanad Lake” (1 ex., 7.4.90). Based on these specimens in the fish collection, Ahlander (1998) has also reported the distribution of this species along the coastal belts in southern Kerala.

During a faunal exploration of Alappuzha District in South Kerala in April-May, 2004, many dozens of specimens of the Malabar Pufferfish *T. travancoricus* were collected from Thavanakadavu,

near Cherthala. The collection-site, the mouth of a small stream-inflow-creek with very shallow waters, littered with floating duckweeds, harboured this pufferfish population in great abundance. The association of this species with the duckweeds offering shade and shelter was very conspicuous. It was also observed that waterfowl, in good number, foraging in shallow waters also joined the puffer fish population as an integral component of the habitat site.

We could collect this species, during the summer months (2003), from a waterpool in the almost dried up Kalpathypuzha tributary of the Bharathapuzha River in Palakkad District. From northern Kerala, Shaji and Easa (1998) have reported this “vulnerable” species in the upland river habitats of the Chaliyar drainage system. We have noticed this puffer fish in our sample collections from the freshwater bodies, including the irrigation channels in the coastal plains, associated with the Chaliyar River. But, from the river systems of Kerala north of Chaliyar River, this puffer fish has not so far been reported.

The distribution of *T. travancoricus* became more interesting when Rema Devi *et al.*, (2000) reported these tiny tetraodontids from the aquatic environs of the evergreen forests, around Mavincar, Dakshin Kannada, at 50 m above MSL, indicating the extension of its range of distribution to Karnataka. It indicates a dispersal trend for the species towards northern geographical ranges, irrespective of its population-distribution being earlier reported only from the riverine-brackishwater habitat systems of Kerala. The earlier assessed rarity status of this species is in conflict with its current well-dispersed status based on its known range of distribution and abundance. All the recorded cases of extension of range of distribution of this species seem to have resulted by subsequent dispersal events.

A notable observation is the ubiquitous association of the waterbirds with the aquatic habitat environs, wherefrom this puffer fish has been reported. Thattekad is a recognized bird sanctuary in Kerala. The collection-localities in Trichur District are not too far off from the Kole wetland system, which is a well-known waterfowl habitat. Waterfowl community is an inseparable biotic component of the Vembanad Lake ecosystem, and the habitat areas like Pathiramanal Island surrounded by the lake waters, and Kumarakom, a waterfront beach-hamlet, are shelter-abodes for many nesting waterbirds.

Given the bionomics of this species, such as its reclusive, shade and shelter loving nature, and the slow-swimming movement, the occurrence of *T. travancoricus* in odd aquatic habitats/microhabitats such as artificial tanks/abandoned water bodies in paddy fields, an isolated ditch (near Kottayam Railway Station), a pond in a small island (Pathiramanal island), a depleting water pool in an almost barren river bed (Kalpathypuzha) or upland aquatic environs amidst forested areas (Mavincar, Dakshin Kannada) are quite intriguing. It appears that the piscivorous birds tend to passively play a role in the dispersal of their prey species aiding in the extension of their range of distribution, probably employing mutualism.

Case study IV

The distribution of *Horaichthys setnai* Kulkarni, the smallest known fish, in India, about 2 cm long, generally known as Thready Killifish, is very characteristic. Primarily an estuarine form, also living temporarily in freshwaters, this tiny species inhabits the creeks of backwaters along the West Coast. Kulkarni (1940) described it from the backwaters and tanks along the West Coast (type locality, Navalaki, Kathiawar coast) of Mumbai. Far from its type locality, Job (1940) reported this species from the coastal backwaters of Cochin and Trivandrum (localities : Cheranellore and Mannummel). Considering the fluviatile nature of the species and the long stretching coastline of the West Coast, Job (1940) and Silas (1959) presumed the distribution of the species along the West Coast of India, from the Gulf of Kutch (Gujarat) to Trivandrum (Kerala), despite its populations exhibiting far-isolated distributional trends.

Karamchandani and Pandit (1971) located this species from Narmada River at Jhanor as far inland as 64 Km from sea, and from the freshwater sites of Tapti River, at Kathor and Bodhan, far interior from the sea, and noted the tendency of the fish to ascend the rivers to the freshwater zones. But, *H. setnai*, usually found in the puddles and pools of stagnant brackish waters, is a slow swimming species forming swarms near surface of water, mostly amidst aquatic plants (Jayaram, 1999). This species shows discontinuous distribution as evidenced from records.

The species has remained elusive even after exhaustive ichthyological collection efforts in Kerala (Shaji and Easa 2001), for more than three decades. However, the occurrence of this species, quite far away from the already known distributional areas of the coastal backwaters along the West Coast (South Kerala, Mumbai coast and Gulf of Kutch) was noticed by us, during August 2001, in the inundated paddy floodplains of Ezhome village, in Kannur District in northern Kerala. A habitat site serving as a natural sanctuary of this species, associated with a small island, namely, Thekkumbad was also located, during November 2001, in the estuarine waters of Kuppam River (Gopi, *et al.*, 2004a). The population of the Thready Killifish very well thrived in the shallow waters amidst the mangrove patch on the inundated mudflat of the island. During the seasonal flooding of the areas in monsoon period, they became ubiquitously present in dense populations in the adjoining floodplains within the island as well as in the floodplains of Ezhome. As the season's rain ebbed and the water level gradually receded, the entire floodplain areas of Ezhome and Thekkumbad Island, abound with the populations of prey-fish species (such as *H. setnai*, *P. vittatus*, *A. blocki*, besides many other species and aquatic invertebrates), became a habitat-zone of intense foraging activity of innumerable waterbirds. The discontinuous distribution of *H. setnai* in its known range appears to have been influenced by the waterbird-mediated dispersal processes.

DISCUSSION

In this field-oriented study highlighting the probable dispersal of fishes by waterbirds, we have concentrated on only a limited number of species, a few species of fish and some water-

birds feeding on them, to postulate some assumptions on waterbird-mediated chance dispersal of fishes.

Small forage fishes, unlike the larger forms, have higher reproductive potential, with shorter breeding cycles enabling them to build up their populations with minimum requirements of space and time. In ecological perspectives, these species have abundance in their number at any time of the year in their habitats, and such habitats are better foraging sites of waterbirds.

Waterbirds like herons and egrets prey upon fish and other aquatic organisms from the shallow, weed-infested or muddy margins of the inundated paddy fields, floodplains and other freshwater habitats, whereas cormorants, teals and dabchicks are capable of foraging from deep waters. It is likely that waterbirds while scouring the weeds or debris in the shallow margins or muddy edges of water bodies for their prey, like small fishes, the viscid egg masses of the prey species sheltered amidst water-weeds or in the vicinities, are sometimes dislodged and get adhered to the feet or body of the bird; it is a near certain possibility during breeding phase of the small prey fishes, when their fertilized ova or eggs are abundantly available in the habitat waters. The fish ova/seeds that accidentally get stuck to the body or mud-smeared-feet of a bird, get the chance to be carried while the bird moves from one habitat to another, thus passively dispersing the fish ova to the allied or new habitats.

Waterbird-mediated long/short distance dispersal of adult fishes, sub adults or fingerlings, may be unlikely, since the larger size of the dispersal material and its exposure to desiccation during long transport are likely to be limiting factors. But, the slimy fish ova or seeds are at an advantage, over fingerlings, with their better adaptability to resist desiccation and retain the viability for longer durations even after removal from water (Darwin, 1859). Bilton *et al.*, (2001) have observed in the case of freshwater invertebrates that many seeds and resting eggs are likely to be highly resistant to desiccation.

The occurrence and establishment of populations of small fishes, such as *P. vittatus*, *H. attukorali*, *A. blocki*, *P. cupanus*, etc., in the Mananchira Tank waters (Calicut, Kerala), an almost refreshed system of a freshwater pond-habitat, can be surmised in the light of the feeding ecology of waterbirds that visit this pond system for foraging. As for the tiny carp-let *H. attukorali*, in the present study, the waterbird-mediated dispersal appears to offer a sound reason for its occurrence and establishment in a rejuvenated system, far away from its primarily and secondarily known home habitats (freshwater wet plains of Sri Lanka and South India, respectively). In the case of *H. attukorali*, or *T. travancoricus*, the populations currently exhibit discontinuity in the range of distribution with explicit geographic isolation. Despite this isolation factor, the sub populations from varied habitat zones are morphologically indistinguishable, i.e. they are having little inter-population differentiation, consistent with morphological similarity across the species' range, indicating an on-going gene flow between the populations. It is indirect evidence suggesting the distribution having followed

the waterbirds' flyways. Even if the lack of association between genetic and geographic distances in the populations does not serve as an evidence for bird-mediated dispersal, the other facts that the populations are not at equilibrium (at far-isolated locales) in the range of distribution, and that the naturalization/colonization events are independent of the geographical distances/barriers suggest that the dispersal trends are more frequent in the direction of birds' foraging movements, between stopover areas, during long or short distance flights.

This mode of dispersal seems to have greatly influenced the dispersal of small fish species, particularly the small, surface and sub-surface dwelling prey-fishes, to become, biogeographically, the widely distributed fishes. Such fishes, sometimes in striking colours, have small size, no pronounced growth of spines, and comparatively shorter breeding cycles, with high turn out of progenies, all of which suite to the advantages of the waterbirds preying on them.

Chance dispersals of fishes, passively by waterbirds, from their home-habitats to allied aquatic bodies elsewhere, at times, result in the extension of range of distribution of the species. It is understandable that the chance dispersal of species, over time, in a slow or frequent manner enables a species to 'skip' to new areas, slowly extending its range of distribution, sometimes marked with a discontinuity in the distributional pattern. It leads to the shuffling of the patterns of distribution within the range of occupation. As can be seen, the period of collection/observation of the fish species *H. attukorali* and *T. travancoricus* from varied locales, as reported by different workers, cited in the present study, coincides with the period of intense foraging activity of waterbirds.

The cypriniform fishes have become, in general, the dominant freshwater group in their known distributional range. In most places, the species of the small-sized cyprinoids are the principal forage fishes of waterbirds. The cyprinid fishes of the large speciose group, the genus *Puntius* (Cyprinidae) in the Oriental Region, for example, are widely distributed in South Asia. Most of them do not grow to large size, but compensate with their abundance, and have become important forage fishes. Biogeographically, how these small fishes (e.g. *P. vittatus*, *P. ticto*, etc.) happened to have their distribution in a very wider geographic range, across the Indian subcontinent? Our field observations on the small forage fish species, *P. vittatus*, *H. attukorali*, *H. setnai*, *A. blocki*, *P. cupanus* and *T. travancoricus*, associated with the piscivorous waterbirds, seem to suggest that these small forage fishes have been enjoying the advantage of the waterbird mediated dispersal in their biogeography and evolutionary progress. The principle of mutualism seems to have been in play in the feeding ecology and prey-predator relationship of waterbirds and prey-fishes. Thus there is compelling reason to consider that some cyprinoid fish-groups, like *Puntius*, exhibiting remarkable geographical radiation and great diversity in species in their evolutionary history, must have benefited by the waterbird mediated dispersal, thereby enjoying wider range of distribution and dominance.

The Little Cormorant from its earlier status as being a doubtless resident bird, with no record of breeding in Kerala, rose to the level, later, with a notable population distributed in the wetland

environs of southern Kerala, but till then seldom spread to northern Kerala and further north (Neelakantan, 1986). But, currently, they are among the very common species found in almost all available freshwater systems in the southern states (perhaps major part of the country, even), seen foraging from lowland floodplains and ponds to upland or highland water bodies like lakes, reservoirs and even the temporary aquatic habitats amidst the forest environment. Similarly, two other local resident waterbirds, the Pond heron and Little egret, also exhibit more vagrant, explorative feeding movements to the extent that, within their reasonable range of occupancy, no freshwater habitat system can be seen without their presence.

Given the facts that the long migratory journeys of many waterbirds follow the Central Asian-Indian Flyway in the Asia Pacific region (Fig. 1. A), the alignment of India and Sri Lanka in a North-South than an East-West direction, falling in the same migratory Flyway, and the tendency of many of the waterbirds following common flyway routes, to and fro, connecting both the countries for foraging purpose, it is likely that waterbirds while undertaking long or short distance movements in either direction may stop over at suitable aquatic habitats for foraging. Many migratory shorebirds make use of the foraging grounds of the coastal and inland wetlands like, jheels, inundated paddy fields, floodplains and even temporary or seasonal pools in the uplands of both the countries (India and Sri Lanka).

A migratory waterfowl from Sri Lanka carrying a few freshly gathered fish-ova/eggs (of *H. atukorali*, for example) from a fresh water habitat, accidentally trapped on its feet, or feather, can easily make a cross-over flight to the nearest, allied habitat in the west/east coastal plains in South India, which is only about 100 Km or less from Sri Lanka. As for ducks known to fly at speeds of 60-70 km/h, and waders at speeds 50-60 km/h, this distance can easily be covered in one and a half to two hours without affecting the viability of fish-propagules, in case they carry them as dispersal agents.

Another possibility is that the waterbird-mediated chance-dispersal of the prey-fish species usually occur at higher frequency levels, from an original or core habitat zone harbouring abundance of the prey-fish population to a near or distant allied aquatic habitat. The species propagules attaining their access to other habitat locales may successfully establish themselves in the new habitats, provided the conditions are suitable for their naturalization. It is therefore not the dearth of frequency of the waterbird-mediated dispersal of the species concerned, but the colonization/naturalization process of the subpopulation that ultimately determines the success of its establishment in a new habitat. It seems to be a key reason why the trend of discontinuity in the extended range of distribution is reflected in the dispersal events of these species. The relative densities of populations of *H. atukorali*, with highest concentration in its prime center of occurrence, i.e., Sri Lanka, and in lesser densities in the extended ranges of distribution in Kerala, Tamil Nadu and Pondicherry, are indicative of such selective naturalization in tune with natural selection.

Thus, it becomes evident that from the presently naturalized habitats in southern Kerala, or even from its original habitats in Sri Lanka, the same species has got access to the isolated tank system (Mananchira in Calicut district, Kerala) and to the fresh water wet plains of the east coast in Tamil Nadu and Pondicherry. The freshwater wet plains of the West Coast and East Coast of India despite having the formidable barrier of the Western Ghats System in between, the dispersal of this species has happened. The logical explanation is that the extension of range of distribution of this species might have taken place, through the waterbird-mediated chance dispersal. In similar modes, the extension of range of *Tetraodon travancoricus* seems to have also taken place along the west coastal freshwater habitats from southern Kerala to Karnataka (see, Fig. 1. B).

Our conclusion is that the waterbird-mediated passive dispersal of fish, particularly of prey-fish species of piscivorous waterbirds, is very probable in the freshwater habitats frequented by waterbirds, unless hampered by the adversities like excessive dispersal-delay or lack of viability of the dispersal propagules. Trends of wider distribution often exemplified by the small fish species are to a great extent indicative of the resultant causes and effects of waterbird-mediated species dispersals that have been taking place in natural aquatic habitat systems.

We have not considered one key factor here, that is, the adaptability of the bird-dispersed species to the new environment and its potential to compete with other species to establish itself in the new aquatic environment. It appears to be one key factor that causes the discontinuity of the distribution in the known wider range of these species.

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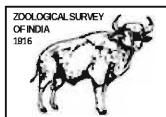
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FLY POLLINATORS : ASSESSING THEIR VALUE IN BIODIVERSITY CONSERVATION AND FOOD SECURITY IN INDIA

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INTRODUCTION

Human beings depend on animal pollination directly or indirectly for about one third of the food they eat. Over 75 percent of the food and medicinal plants that benefit mankind and 90 percent of all flowering plants rely on pollination by animals to produce healthy seeds and fruits. Pollinators also provide an essential ecosystem service that contributes to the maintenance of biodiversity and ensures the survival of plant species including crop plants. Pollination is required for seed production, to improve seed quality, to create hybrid seeds and also to increase uniformity of crop ripening (Kearns *et al.*, 1998).

Flies (Diptera) are among the most common insects that visit flowers, and their association with flowers has a long history. Flies are also considered to be primitive pollinators of the earliest flowering plants with their suctorial or lapping mouthparts (Kevan and Baker, 1983). Fossil evidence shows that some of the important flower-visiting fly families-such as Syrphidae (flower flies), Bombyliidae (bee flies), Empididae (dance flies), Acroceridae (small-headed flies), Apioceridae (flower-loving flies) and Nemestrinidae (tangle-vein flies) were present as early as in the late Jurassic or early Cretaceous.

Diptera are probably the second most common order of flower visitors and pollinators today (after Hymenoptera). In tropical areas, the diversity of Diptera can rival or exceed that of Hymenoptera (Inouye, 2001). A preliminary estimate (Buchmann and Nabhan, 1996) indicates that 14, 126 species of Diptera are involved in the process of pollination in the tropical world.

Generally, agriculture occupies more than one third of the land in most countries of the world. It is widely believed that pollination is in such serious jeopardy from the view points of agricultural productivity and food security (Kevan *et al.*, 2001) that the Convention on Biological Diversity and the Food and Agricultural Organization of the United Nations have recently (1998–2000)

taken on leading roles internationally in this area. Nevertheless, little information is available on how pollination deficits affect the costs of food production.

Pollination by flies (myiophily) is economically important. In tropical areas flies are the primary pollinators of cacao and they also pollinate mango, cashew and tea like other cash crops. Roubik (1995), listed pollinators of 785 species of cultivated plants in the tropics, and 26–31 of these plants are apparently pollinated only by flies, 32 or 33 by flies as the primary pollinators, and 87–101 by flies as secondary pollinators.

Unfortunately, no such separate information of fly pollinators is available for India as a whole or in agricultural crops. Therefore, this is our first and foremost duty to prepare an inventory of dipteran species involved in the process of pollination of agricultural, horticultural and medicinal crop plants. In this context, we have tried to prepare a preliminary document on fly pollinators, their value and role in the field of agricultural, horticultural and on medicinal plants in India. We have made efforts to review the whole pollination by flies in India and also included our works on fly pollinators in the recent past.

A total of 42 families (Nematocera 12 & Brachycera 30) of Diptera are reported as flower visitors in the tropical world (Roubik, 1995), of them 38 families (Nematocera 12 & Brachycera 26) are present in India, The present communication reports 70 species of Diptera of 9 families which pollinate 63 species of crop plants of 29 families in India.

This communication presents lists of fly pollinators and their visited plant species (Table 1) and also agricultural, horticultural and medicinal plant species and their fly pollinators (Table 2), Both the lists have been prepared alphabet-wise and also incorporates the family name of each of the fly and plant species respectively. This will serve as a baseline data on fly pollinators of economic importance in India and will encourage the pollination scientists to make use of the fly species more and more in ensuring our food security and maintenance of biodiversity.

FLIES

The Diptera are minute to small soft-bodied insects, commonly known as (true) flies and include many familiar insects such as mosquitoes, black flies, midges, fruit flies, blowflies and houseflies. A highly mobile head with large compound eyes, antennae of variable size and structure; suctorial mouthparts; prothorax and metathorax small and fused with large mesothorax; wings present only on mesothorax. The major morphological feature which distinguishes flies from other insects is their reduced hind wings, termed halteres (small, club-like structures that function as balancing organs during flight), legs with 5-segmented tarsi; abdomen with variable number of visible segments, simple female genitalia and complex male genitalia in most species and presence of cerci.

VALUE

Flies have been systematically overlooked by pollination biologists. These tiny insects have generally been considered only a minor or secondary contributor to pollination of some plants, many of which are crops. In part, this attitude is due to lacking a number of characters in comparison to bees and wasps— (i) flies are more or less omnivorous, (ii) they do not nurse their brood, they take nectar for their own consumption and so they are not a busy collector, (iii) their pollinating activity is irregular, (iv) they are not having any specialized organ to carry the pollen (pollen basket in case of bees). But on the other hand flies may be the important pollinators under certain climatic conditions (cloudy weather, high wind speeds *etc.*). Moreover, majority of the flies are present in the field at all times of the year unlike the strictly periodic and more demanding bumble bees and honey bees.

A recent review (Larson *et al.*, 2001, *unpub.manus.*) that details the pollen-carrying abilities, constancy, and effectiveness of fly pollinators indicates that flies may contribute significantly to the pollination process. The predominance of flies on certain arctic and alpine flowers makes their contributions particularly important in these environments (Downes 1965, Hocking 1968, Mani 1968, Kevan 1972, Pojar 1974, Arroyo *et al.*, 1982, 1985, Primack 1983, Shaw and Taylor 1986, Inouye and Pyke 1988, Kearns and Inouye 1994, Elberling & Olesen 1999).

STUDIES ON MYIOPHILY IN INDIA

As far as knowledge goes studies of insect pollination for crop production in India began with launching of a crash programme for the development of sunflower cultivation in the country by the Government of India in the early 1960's (Veeresh, 1993). The two national and one International seminar held on pollination during 1983, 1990 and 1993 have helped to inculcate the awareness of the importance of insect pollinators in the conservation of plant species and enhancing crop production in India.

The literature on insect pollination in India is exceptionally rich but mostly concentrated on bees in comparison to other major insect pollinators. Mani and Sarvanan (1999) stated that, pollination studies in the recent past show a pronounced bias towards bee pollination. As may be expected, it also reflects in agriculture and horticultural fields in India. On the contrary, very little attention has been paid to the members of Diptera.

A perusal of literature reveals that the role of flies in the process of pollination, efficiency and importance to enhance the crop production in India, was said first by Kapil and Jain (1980). Some of the recent works on pollination of cauliflowers are contributed by a number of workers like Priti & Sihag (1997), Kakkar (1981), Sharma *et al.*, (1974), and Tewari and Singh (1983). All of these studies revealed that Diptera is one of the major pollinators of cauliflowers. Priti & Sihag (1998) reported 20 insect species of flower visitors of *Daucus carota*, of them 6 species are dipteran.

In another study Sihag (1986) observed that, among the insect visitors of carrot, flies are the second most efficient pollinator after bees. Goyal *et al.*, (1989) reported 71 insect species belonging to 31 families and 8 orders on carrot bloom in Himachal Pradesh.

During this study flies have also proved themselves as dominant pollinators after the bees. An enormous work has been done on crops of Himachal Pradesh. Misra and Kumar (1993) reported a number of dipteran species of the genus *Musca*, *Orthellia* (Family Muscidae); *Eristalis*, *Scaeva*, *Sphaerophoria*, *Episyrphus*, *Ischiodon*, *Melanostoma* (Family Syrphidae) are common visitors of mustard.

In a study of pollinator efficiency, flower visitors of onion revealed that, numerically the species strength of Diptera is more than Hymenoptera (Priti, 1998). Kumar *et al.*, (1985) stated that the Diptera are the predominant pollinators after Hymenoptera in onion at Himachal.

Reddi (1993) stated that cashew plantation in India are generally less attracted to honey bees because of the poor nectar yields. He showed that 37% of the insect visitors of the flowers of cashew were flies compared to 12% of bees. He also stated that, maintaining fly population in cashew orchards can lead to increase yields.

McGregor (1976), Free (1993), Bangyu *et al.*, (1997) and Batra (1997) reported the syrphids (Diptera) are one of the major insect pollinators of the apple trees. Dhara and Tandon (1993) observed that among the 5 major pollinator species of *Zizyphus mauritiana* (ber), 60 percent species are Diptera. Mitra *et al.*, (2002) also reported 2 species of fly flower visitors/pollinators of *Zizyphus mauritiana* from Gujarat. In Indian perspective very little effort has been given to study the role of fly pollinators to increase the crop productivity. Sharma *et al.*, (1998) had shown an easy and quick method of breeding flies for pollination of mango blossoms. This study may be the first in the field of applied pollination by flies in India.

In the recent past, medicinal plants constitute a group of industrially important crops, which are of great value for domestic use and for export. In contrast to the large number of publications on the general problems of pollination and outstanding specialization in certain groups such as orchids, orchard trees, garden plants, oilseeds and other selected economically important species, very little attention seems to have been paid to the medicinal plants.

Recently Mitra *et al.*, (2002, 2003, 2004 & 2005) reported 38 dipteran pollinator species of medicinal plants from India (Table 1).

THREATS AND CONSERVATION

Pollinators face a large variety of threats of anthropogenic origin, including habitat fragmentation, a variety of effects of agriculture, pesticides, herbicides, and the introduction of both exotic pollinators and plants (Inouye, 2001).

The recent global concern over conservation and management of such a paradise of diversity has necessitated an immediate and thorough understanding of the factors contributing to their stability and maintenance. Pollination, a crucial link in the survival of ecosystems, is one such factor that needs to be well understood to develop appropriate strategies for conservation of the Indian biodiversity. Flies may never have the charisma of birds and mammals, but habitat conservation and urban planning can help maintain an interesting and diverse group of fly pollinators who render the free services to the human beings for their food security.

DISCUSSION

The role of pollinators in agriculture and horticulture has been acknowledged by workers in developed countries way back in the 1960's. The stress to identify alternatives to bee-pollination began during a 'pollinator-crisis' in the USA, after several local population of bees were wiped out, as a long term effect of introduction of African bees as pollinators, leading to a severe loss of productivity. In India, however, harnessing natural pollinators to increase productivity has been initiated with the launching of a crash programme for development of sunflower cultivation in the country. Like elsewhere in the world, the process has been largely bee-biased and stray reports on dipteran pollinators have come up from the study aimed mainly at bee-pollination.

Majority of the flies are enemies (as carriers of diseases) and causing harm (as crop pests) to the human beings. But there is another dimension to these tiny insects, where they play an important role to maintain the ecosystem healthy by their friendly activities to the human beings. However, in the recent past the importance of flies as pollinators in India have been acknowledged and as many as 38 families of Diptera have been clearly identified as pollinators. The present review is a short communication of the available literature and our preliminary findings of a continuing study on dipteran pollinators. This is the first step in the long process of inventorisation of the fly pollinators (from India) and discerning their importance in providing food security and in maintenance of biodiversity.

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Table 1. : List of Fly pollinators and their visited plant species in India

	NAME	FAMILY	PLANT SPECIES
1.	<i>Adoxomyia heminopla</i> Wiedmann	STRATIOMYIDAE	<i>Nerium indicum</i> , <i>Zizyphus</i> sp.
2.	<i>Argyramoeba duvaucelli</i> (Macquart)	BOMBYLIIDAE	<i>Cassia tora</i>
3.	<i>Asarkina (Asarkina) ericetorum</i> (Fabricius)	SYRPHIDAE	<i>Amaranthus spinosus</i> , <i>Sida acuta</i> , <i>Polygonum chinensis</i> , <i>Cassia tora</i> , <i>Solanum nigrum</i>
4.	<i>Bactrocera (Zeugodacus) cucurbitae</i> Coquillett	TEPHRITIDAE	<i>Cucurbita maxima</i>
5.	<i>Bombylius maculatus</i> (Fabricius)	BOMBYLIIDAE	<i>Sorghum vulgare</i>
6.	<i>Campiglossa cribellata</i> Bezzi	TEPHRITIDAE	<i>Polygonum chinensis</i>
7.	<i>Chrysotoxum baphyrus</i> (Walker)	SYRPHIDAE	<i>Ipomea</i> sp.
8.	<i>Chrysops dispar</i> (Fabricius)	TABANIDAE	<i>Allium cepa</i> , <i>Daucus carota</i>
9.	<i>Chrysomya megacephala</i> (Fabricius)	CALLIPHORIDAE	<i>Zizyphus mauritiana</i> , <i>Althaea rosea</i> , <i>Holarrhena antidysenterica</i>
10.	<i>Chrysomya bezziana</i> Villeneuve	CALLIPHORIDAE	<i>Allium cepa</i> , <i>Daucus carota</i>
11.	<i>Culex</i> sp.	CULICIDAE	<i>Polygonum chinensis</i>
12.	<i>Episyrphus balteatus</i> (De Geer)	SYRPHIDAE	<i>Wedelia calendulaceae</i> , <i>Coriandrum sativum</i> , <i>Nicotiana glauca</i> , <i>Nicotiana glauca</i> , <i>Cannabis</i> sp., <i>Foeniculum vulgare</i> , <i>Trifolium repens</i> , <i>Rubus ellipticus</i> , <i>Solanum nigrum</i> , <i>Malus domestica</i> , <i>Brassica campestris</i> v. <i>sarson</i> , <i>Solanum melongena</i> , <i>Capsicum frutescens</i>
13.	<i>Eristalinus (Eristalinus) arvorum</i> (Fabricius)	SYRPHIDAE	<i>Tagetes patula</i> , <i>Santalum album</i> , <i>Mangifera indica</i> , <i>Zizyphus mauritiana</i> , <i>Polygonum chinensis</i> , <i>Brassica campestris</i> v. <i>sarson</i>
14.	<i>Eristalis (Eoseristalis) cerealis</i> (Fabricius)	SYRPHIDAE	<i>Tagetes patula</i> , <i>Chrysanthemum</i> sp., <i>Helianthus</i> sp., <i>Xanthium strumarium</i> , <i>Ricinus communis</i> , <i>Melilotus alba</i>
15.	<i>Eristalis (Eoseristalis) arbustum</i> (Linnaeus)	SYRPHIDAE	<i>Sida rhombifolia</i> , <i>Tagetes patula</i> , <i>Chrysanthemum</i> sp., <i>Melilotus alba</i>
16.	<i>Eristalinus laetus</i> (Wiedemann)	SYRPHIDAE	<i>Tagetes Patula</i>

Table 1. : (Cont'd.).

	NAME	FAMILY	PLANT SPECIES
17.	<i>Eristalinus (Eristalinus) obscuritarsis</i> (de Meijere)	SYRPHIDAE	<i>Tagetes patula</i> , <i>Aegle marmelos</i>
18.	<i>Eristalinus quinquestriatus</i> (Fabricius)	SYRPHIDAE	<i>Tagetes patula</i>
19.	<i>Eristalinus aenus v. taphicus</i> (Wiedemann)	SYRPHIDAE	<i>Tagetes patula</i>
20.	<i>Eristalis (Eristalodes) paria</i> (Bigot)	SYRPHIDAE	<i>Helianthus</i> sp.
21.	<i>Eristalis (Eristalis) tenax</i> (Linnaeus)	SYRPHIDAE	<i>Tagetes patula</i> , <i>Chrysanthemum</i> sp., <i>Helianthus</i> sp., <i>Pyrus communis</i> , <i>Brassica campestris</i> v. <i>sarson</i>
22.	<i>Eristalis angustimarginalis</i> Brunetti	SYRPHIDAE	<i>Brassica campestris</i> v. <i>sarson</i>
23.	<i>Exhyalanthrax absalon</i> (Wiedemann)	BOMBYLIIDAE	<i>Solanum melongena</i> , <i>Cassia tora</i> , <i>Capsicum frutescens</i> , <i>Lycopersicon esculentum</i>
24.	<i>Graptomyza brevirostris</i> (Wiedemann)	SYRPHIDAE	<i>Herpestis</i> sp.
25.	<i>Gasterophilus</i> sp.	GASTEROPHILIDAE	<i>Allium cepa</i> , <i>Daucus carota</i> , <i>Brassica oleracea</i> v. <i>botrytis</i>
26.	<i>Heteralonia (Isotamia) insulata</i> (Walker)	BOMBYLIIDAE	<i>Solanum melongena</i> , <i>Cassia tora</i> , <i>Capsicum frutescens</i> , <i>Lycopersicon esculentum</i> , <i>Ipomea</i> sp.
27.	<i>Hybomitra hirta</i> Walker	TABANIDAE	<i>Anacardium occidentale</i> , <i>Sorghum vulgare</i> , <i>Coriandrum sativum</i>
28.	<i>Hemipyrellia liguirriens</i> (Wiedemann)	CALLIPHORIDAE	<i>Polygonum chinensis</i>
29.	<i>Hemipyrellia pulchra</i> (Wiedemann)	CALLIPHORIDAE	<i>Santalum album</i> , <i>Psidium guajava</i>
30.	<i>Ischyrosyrphus</i> sp.	SYRPHIDAE	<i>Cannabis sativa</i>
31.	<i>Ischiodon scutellaris</i> (Fabricius)	SYRPHIDAE	<i>Anogeissus pendula</i> , <i>Cassia tora</i> , <i>Panicum</i> sp., <i>Tagetes patula</i> , <i>Solanum melongena</i> , <i>Capsicum frutescens</i> , <i>Brassica campestris</i> v. <i>sarson</i>
32.	<i>Isomyia viridaurea</i> (Wiedemann)	CALLIPHORIDAE	<i>Catharanthus roseus</i>
33.	<i>Litorhynchus lar</i> (Fabricius)	BOMBYLIIDAE	<i>Solanum melongena</i> , <i>Capsicum frutescens</i>

Table 1. : (Cont'd.).

	NAME	FAMILY	PLANT SPECIES
34.	<i>Lucilia porphyrina</i> (Walker)	CALLIPHORIDAE	<i>Scaevola sericea</i>
35.	<i>Melanostoma</i> sp.	SYRPHIDAE	<i>Solanum nigrum</i> , <i>Eleusine indica</i> , <i>Cannabis sativa</i> , <i>Chrysanthemum</i> sp.
36.	<i>Melanostoma orientale</i> (Wiedemann)	SYRPHIDAE	<i>Solanum nigrum</i> , <i>Canabis sativa</i> , <i>Sida</i> sp., <i>Rubus elipticus</i>
37.	<i>Melanostoma univittatum</i> (Wiedemann)	SYRPHIDAE	<i>Brassica campestris</i> v.sarson
38.	<i>Mesembrius bengalensis</i> (Wiedemann)	SYRPHIDAE	<i>Sida acuta</i> , <i>Wedelia calendulaceae</i> , <i>Tagetes patula</i> , <i>Polygonum chinensis</i> , <i>Spilanthes acmella</i>
39.	<i>Mesembrius quadrivittatus</i> (Wiedemann)	SYRPHIDAE	<i>Wedelia calendulaceae</i> , <i>Aegle marmelos</i> , <i>Rauvolfia serpentina</i> , <i>Polygonum chinensis</i> , <i>Spilanthes acmella</i>
40.	<i>Metasyrphus corollae</i> (Fabricius)	SYRPHIDAE	<i>Brassica campestris</i> v.sarson
41.	<i>Metasyrphus (Metasyrphus) latifasciatus</i> (Macquart)	SYRPHIDAE	<i>Cannabis sativa</i>
42.	<i>Microchrysa flaviventris</i> (Wiedemann)	SYRPHIDAE	<i>Tagetes patula</i>
43.	<i>Musca (s.str.) domestica</i> Linnaeus	MUSCIDAE	<i>Zizyphus mauritiana</i> , <i>Brassica oleracea</i> v. <i>botrytis</i> , <i>Daucus carota</i> , <i>Allium cepa</i> , <i>Wedelia calendulaceae</i>
44.	<i>Musca (Philaematomyia) crassirostris</i> Stein	MUSCIDAE	<i>Allium cepa</i>
45.	<i>Musca (Byomya) ventrosa</i> (Wiedemann)	MUSCIDAE	<i>Polianthes tuberosa</i>
46.	<i>Musca</i> sp.	MUSCIDAE	<i>Brassica campestris</i> v. sarson
47.	<i>Orthellia timorensis</i> (Robineau-Desvoidy)	MUSCIDAE	<i>Scaevola sericea</i> , <i>Althaea rosea</i>
48.	<i>Orthellia viridis</i> (Wiedemann)	MUSCIDAE	<i>Castanea sativa</i> , <i>Aesculus indica</i>
49.	<i>Orthellia</i> sp.	MUSCIDAE	<i>Brassica campestris</i> v. sarson
50.	<i>Oplodontha rubrithorax</i> (Macquart)	STRATIOMYIDAE	<i>Tagetes patula</i>
51.	<i>Paragus serratus</i> (Fabricius)	SYRPHIDAE	<i>Solanum nigrum</i> , <i>Ageratum conyzoides</i> , <i>Wedelia calendulaceae</i>
52.	<i>Paragus (Pandasyophthalmus) atratus</i> de Meijere	SYRPHIDAE	<i>Solanum nigrum</i>

Table 1. : (Cont'd.).

	NAME	FAMILY	PLANT SPECIES
53.	<i>Paragus (Pandasyophthalmus) tibialis</i> (Fallén)	SYRPHIDAE	<i>Solanum nigrum</i> , <i>Amaranthus spinosus</i>
54.	<i>Paragus (Pandasyophthalmus) rufiventris</i> (Brunetti)	SYRPHIDAE	<i>Solanum nigrum</i>
55.	<i>Petrorossia albofulva</i> (Walker)	BOMBYLIIDAE	<i>Solanum melongena</i> , <i>Capsicum frutescens</i> , <i>Lycopersicon esculentum</i>
56.	<i>Petrorossia nigrofemorata</i> (Brunetti)	BOMBYLIIDAE	<i>Coriandrum sativum</i>
57.	<i>Phaenicia sericata</i> (Meigen)	CALLIPHORIDAE	<i>Ficus carica</i>
58.	<i>Sphaerophoria</i> sp.	SYRPHIDAE	<i>Eleusine indica</i>
59.	<i>Sphaerophoria indiana</i> Bigot	SYRPHIDAE	<i>Brassica campestris</i> v. <i>sarson</i>
60.	<i>Sphaerophoria scripta</i> (Linnaeus)	SYRPHIDAE	<i>Panicum</i> sp., <i>Eleusine indica</i> , <i>Eleusine</i> sp., <i>Sida</i> sp., <i>Solanum nigrum</i> , <i>Cannabis sativa</i> , <i>Cannabis</i> sp., <i>Chrysanthemum</i> sp., <i>Nicotiana plumbaginifolia</i> , <i>Foeniculum vulgare</i> , <i>Chenopodium ambrosoides</i>
61.	<i>Syrphus latifasciatus</i> (Macquart)	SYRPHIDAE	<i>Cannabis sativa</i>
62.	<i>Syritta orientalis</i> (Macquart)	SYRPHIDAE	<i>Ephedra gerardiana</i>
63.	<i>Syritta indica</i> (Wiedemann)	SYRPHIDAE	<i>Polygonum chinensis</i>
64.	<i>Syritta pipiens</i> (Linnaeus)	SYRPHIDAE	<i>Eleusine</i> sp., <i>Eleusine indica</i> , <i>Cannabis sativa</i> , <i>Nicotiana plumbaginifolia</i> , <i>Amaranthus spinosus</i> , <i>Panicum</i> sp., <i>Solanum nigrum</i> , <i>Anthemis cotula</i>
65.	<i>Scaeva latimaculata</i> Brunetti	SYRPHIDAE	<i>Brassica campestris</i> v. <i>sarson</i> , <i>Melilotus officinalis</i>
66.	<i>Sargus metallinus</i> (Fabricius)	STRATIOMYIDAE	<i>Bauhinia variegata</i> v. <i>candida</i>
67.	<i>Stomorphina discolor</i> (Fabricius)	CALLIPHORIDAE	<i>Tagetes patula</i> , <i>Anogeissus pendula</i> , <i>Zizyphus</i> sp., <i>Syzygium jambos</i> , <i>Callistemon citrinus</i> , <i>Taraxacum officinalis</i> , <i>Zizyphus mauritiana</i> , <i>Polygonum chinensis</i>
68.	<i>Sarcophaga</i> sp.	SARCOPHAGIDAE	<i>Brassica oleracea</i> v. <i>botrytis</i> , <i>Allium cepa</i> , <i>Daucus carota</i>
69.	<i>Villa aureohirta</i> Brunetti	BOMBYLIIDAE	<i>Scaevola sericea</i>
70.	<i>Villa panisca</i> (Rossi)	BOMBYLIIDAE	<i>Scaevola sericea</i> , <i>Tagetes patula</i>

Table 2. : List of Agricultural, Horticultural and Medicinal plants and their fly Pollinators in India

	NAME	FAMILY	POLLINATORS
1.	<i>Ageratum conyzoides</i> Linnaeus	ASTERACEAE	<i>Paragus serratus</i>
2.	<i>Anogeissus pendula</i> Wall	COMBRETACEAE	<i>Ischiodon scutellaris</i> , <i>Stomorphina discolor</i>
3.	<i>Allium cepa</i> Linnaeus	LILIACEAE	<i>Chrysops dispar</i> , <i>Musca (M) domestica</i> , <i>Musca (Philaematomyia) crassirostris</i> , <i>Chrysomya bezziana</i> , <i>Gasterophilus</i> sp., <i>Sarcophaga</i> sp.
4.	<i>Aesculus indica</i> Colebr. ex. Comb.	HIPPOCASTANACEAE	<i>Orthellia viridis</i>
5.	<i>Amaranthus spinosus</i> Linnaeus	AMARANTHACEAE	<i>Asarkina (Asarkina) ericetorum</i> , <i>Paragus (Pandasyophthalmus) tibialis</i> , <i>Syrirta pipiens</i>
6.	<i>Anthemis cotula</i> Linnaeus	ASTERACEAE	<i>Syrirta pipiens</i>
7.	<i>Althaea rosea</i> Cav.,	MALVACEAE	<i>Chrysomya megacephala</i> , <i>Orthellia timorensis</i>
8.	<i>Anacardium occidentale</i> Linnaeus	ANACARDIACEAE	<i>Hybomitra hirta</i>
9.	<i>Aegle marmelos</i> Corr.	RUTACEAE	<i>Mesembrius quadrivittatus</i> , <i>Eristalinus (Eristalinus) obscuritarsis</i>
10.	<i>Brassica oleracea</i> Linn. v. <i>botrytis</i> Linn.	BRASSICACEAE	<i>Gasterophilus</i> sp., <i>Musca (M) domestica</i> , <i>Sarcophaga</i> sp.
11.	<i>Brassica campestris</i> v. <i>sarson</i> Linn.	BRASSICACEAE	<i>Eristalinus (Eristalinus) arvorum</i> , <i>Episyrphus balteatus</i> , <i>Eristalis (Eristalis) tenax</i> , <i>Eristalis angustimarginalis</i> , <i>Eristalis polymacharus</i> , <i>Ischiodon scutellaris</i> , <i>Melanostoma univittatum</i> , <i>Spherophoria indica</i> , <i>Scaeva latimaculata</i> , <i>Metasyrphus corollae</i> , <i>Musca</i> sp., <i>Orthellia</i> sp.
12.	<i>Bauhinia variegata</i> v. <i>candida</i> Linnaeus	LEGUMINOSAE	<i>Sargus metallinus</i>
13.	<i>Castania sativa</i> Mill	FAGACEAE	<i>Orthellia viridis</i>
14.	<i>Cassia tora</i> Linnaeus	FABACEAE	<i>Asarkina (Asarkina) ericetorum</i> , <i>Ischiodon scutellaris</i> , <i>Exhyalanthrax absalon</i> , <i>Hetaralonia (Isotamia) insulata</i> , <i>Argyramoeba duvaucelli</i>

Table 2. : (Cont'd.).

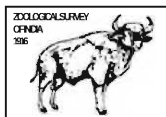
	NAME	FAMILY	POLLINATORS
15.	Chrysanthemum sp.	ASTERACEAE	<i>Sphaerophoria scripta</i> , <i>Melanostoma</i> sp., <i>Eristalis</i> (E) <i>tenax</i> , <i>Eristalis</i> (E) <i>arbustorum</i> , <i>Eristalis</i> (E) <i>cerealis</i>
16.	Chenopodium ambrosoides Linnaeus	CHENOPODIACEAE	<i>Sphaerophoria scripta</i>
17.	Coriandrum sativum Linnaeus	UMBELLIFERAE	<i>Hybomitra hirta</i> , <i>Petrorossia nigrofemorata</i>
18.	Cannabis sativa Linnaeus	CANNABINACEAE	<i>Episyrphus balteatus</i> , <i>Sphaerophoria scripta</i> , <i>Metasyrphus latifasciatus</i> , <i>Melanostoma orientale</i> , <i>Melanostoma</i> sp., <i>Syrirta pipiens</i> , <i>Ischyrosyrphus</i> sp.
19.	Callistemon citrinus (Curtis)	MYRTACEAE	<i>Baccha</i> (A) <i>ampithoe</i> , <i>Stomorphina discolor</i>
20.	Capsicum frutescens Linnaeus	SOLANACEAE	<i>Petrorossia albofulva</i> , <i>Exhylanthrax absalon</i> , <i>Hetaralonia (Isotamia) insulata</i> , <i>Litorhynchus lar</i> , <i>Ischiodon scutellaris</i> , <i>Episyrphus balteatus</i>
21.	Cucurbita maxima Duchesne	CUCURBITACEAE	<i>Bactrocera</i> (<i>Zeugodacus</i>) <i>cucurbitae</i>
22.	Catharanthus roseus Linnaeus	APOCYANACEAE	<i>Isomyia viridaurea</i>
23.	Daucus carota Linnaeus	UMBELLIFERAE	<i>Gasterophilus</i> sp., <i>Sarcophaga</i> sp., <i>Chrysomya bezziana</i> , <i>Musca domestica</i> , <i>Chrysops dispar</i>
24.	Digitalis purpurea Linnaeus	SCROPHULARIACEAE	<i>Melanostoma orientale</i>
25.	Eleusine indica Gaertn.	GRAMINAE	<i>Syrirta pipiens</i> , <i>Sphaerophoria scripta</i> , <i>Spaerophoria</i> sp., <i>Melanostoma</i> sp.
26.	Eleusine sp.	GRAMINAE	<i>Syrirta pipiens</i> , <i>Sphaerophoria scripta</i>
27.	Ephedra gerardiana Adans	EPHEDRACEAE	<i>Syrirta orientalis</i>
28.	Foeniculum vulgare Gaertn.	UMBELLIFERAE	<i>Episyrphus balteatus</i> , <i>Sphaerophoria scripta</i>
29.	Ficus carica Linnaeus	MORACEAE	<i>Phaenicia sericata</i>
30.	Holarrhena antidysenterica Flem.	APOCYANACEAE	<i>Chrysomya megacephala</i>

Table 2. : (Cont'd.).

	NAME	FAMILY	POLLINATORS
31.	Helianthus sp.	ASTERACEAE	<i>Eristalis tenax</i> , <i>Eristalis (Eristalodes) paria</i> , <i>Eristalis (Eoseristalis) cerealis</i>
32.	Ipomea sp.	CONVOLVULACEAE	<i>Chrysotoxum baphyrus</i> , <i>Heterolonia (Isotamia) insulata</i>
33.	Lycopersicon esculentum Mill	SOLANACEAE	<i>Exhyalanthrax absalon</i> , <i>Petrorossia albofulva</i> , <i>Heterolonia (Isotamia) insulata</i>
34.	Mangifera indica Linnaeus	ANACARDIACEAE	<i>Eristalinus (Eristalinus) arvorum</i>
35.	Malus domestica Mill	ROSACEAE	<i>Episyrphus balteatus</i>
36.	Melilotus officinalis Linnaeus	LEGUMINOSAE	<i>Scaeva latimaculata</i> , <i>Eristalis (Eoseristalis) cerealis</i>
37.	Melilotus alba Lamk	LEGUMINOSAE	<i>Eristalis (Eoseristalis) cerealis</i> , <i>Eristalis (Eoseristalis) arbustorum</i>
38.	Nerium indicum Linnaeus	APOCYANACEAE	<i>Adoxomyia heminopla</i>
39.	Nicotiana plumbaginifolia Viv.	SOLANACEAE	<i>Episyrphus balteatus</i> , <i>Spherophoria scripta</i> , <i>Syrirta pipiens</i>
40.	Panicum sp.	GRAMINAE	<i>Syrirta pipiens</i> , <i>Spherophoria scripta</i> , <i>Ischiodon scutellaris</i>
41.	Pyrus communis Linnaeus	ROSACEAE	<i>Eristalis (s.str.) tenax</i>
42.	Polygonum chinensis Linnaeus	POLYGONIACEAE	<i>Culex sp.</i> , <i>Asarkina (Asarkina) ericetorum</i> , <i>Eristalinus (Eristalinus) arvorum</i> , <i>Mesembrius bengalensis</i> , <i>Mesembrius quadrivittatus</i> , <i>Syrirta indica</i> , <i>Hemipyrellia liguiriens</i>
43.	Psidium guajava Linnaeus	MYRTACEAE	<i>Hemipyrellia pulchra</i> , <i>Thelaira macropus</i>
44.	Polyanthes tuberosa Linn.	AMARYLIDACEAE	<i>Musca (Byomya) ventrosa</i>
45.	Ricinus communis Linnaeus	EUPHORBIACEAE	<i>Eristalis (Eoseristalis) cerealis</i>
46.	Rubus ellipticus J.E. Smith	ROSACEAE	<i>Episyrphus balteatus</i> , <i>Melanostoma orientale</i>
47.	Rubus sp.	ROSACEAE	<i>Melanostoma orientale</i>
48.	Santalum album Linnaeus	SANTALACEAE	<i>Hemipyrellia pulchra</i> , <i>Eristalinus (Eristalinus) arvorum</i>
49.	Scaevola sericea Vahl.	GOODENIACEAE	<i>Orthellia timorensis</i> , <i>Lucilia porphyryna</i> , <i>Villa aureohirta</i> , <i>Villa panisca</i>

Table 2. : (Cont'd.).

	NAME	FAMILY	POLLINATORS
50.	<i>Sida acuta</i> Burm	MALVACEAE	<i>Mesembrius bengalensis</i> , <i>Asarkina</i> (A) <i>ericetorum</i>
51.	<i>Sida rhombifolia</i> Linnaeus	MALVACEAE	<i>Eristalis</i> (<i>Eoseristalis</i>) <i>arbustorum</i>
52.	<i>Sida</i> sp.	MALVACEAE	<i>Melanostoma orientale</i>
53.	<i>Solanum melongena</i> Linnaeus	SOLANACEAE	<i>Petrorossia albofulva</i> , <i>Exhyalanthrax absalon</i> , <i>Exoprosopa insulata</i> , <i>Litorhynchus lar</i> , <i>Episyrphus balteatus</i> , <i>Ischiodon scutellaris</i>
54.	<i>Spilanthes acmella</i> Linnaeus	ASTERACEAE	<i>Mesembrius bengalensis</i> , <i>Mesembrius quadrivittatus</i>
55.	<i>Syzygium jambos</i> Alston.	MYRTACEAE	<i>Stomorhina discolor</i> , <i>Baccha</i> (<i>Allo-baccha</i>) <i>amphithoe</i>
56.	<i>Sorghum vulgare</i> Pears	GRAMINAE	<i>Bombylius maculatus</i> , <i>Hybomitra hirta</i>
57.	<i>Tagetes patula</i> Linnaeus	ASTERACEAE	<i>Stomorhina discolor</i> , <i>Eristalinus aenus</i> v. <i>taphicus</i> , <i>Eristalinus</i> (<i>Eristalinus</i>) <i>arvorum</i> , <i>Eristalinus laetus</i> , <i>Eristalinus</i> (<i>Eristalinus</i>) <i>obscuritarsis</i> , <i>Eristalinus quinquestriatus</i> , <i>Eristalis</i> (<i>Eristalis</i>) <i>tenax</i> , <i>Eristalis</i> (<i>Eoseristalis</i>) <i>arbustorum</i> , <i>Eristalis</i> (<i>Eoseristalis</i>) <i>cerealis</i> , <i>Microchrysa flaviventris</i> , <i>Oplodontha rubrithorax</i> , <i>Mesembrius bengalensis</i> , <i>Ischiodon scutellaris</i>
58.	<i>Taraxacum officinale</i> Wigg.	ASTERACEAE	<i>Stomorhina discolor</i>
59.	<i>Trifolium repens</i> Linnaeus	UMBELLIFERAE	<i>Episyrphus balteatus</i>
60.	<i>Wedelia calendulacea</i> Less	ASTERACEAE	<i>Mesembrius bengalensis</i> , <i>Mesembrius quadrivittatus</i> , <i>Paragus serratus</i> , <i>Musca</i> (M) <i>domestica</i>
61.	<i>Xanthium strumarium</i> Linnaeus	ASTERACEAE	<i>Eristalis</i> (<i>Eoseristalis</i>) <i>cerealis</i>
62.	<i>Zizyphus mauritiana</i> Lamk	RHAMNACEAE	<i>Stomorhina discolor</i> , <i>Chrysomya megacephala</i>
63.	<i>Zizyphus</i> sp.	RHAMNACEAE	<i>Adoxomyia heminopla</i> , <i>Stomorhina discolor</i>



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SCORPION FAUNA (ARACHNIDA : SCORPIONIDA) OF PARAMABIKULAM WILD LIFE SANCTUARY, KERALA, INDIA

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INTRODUCTION

Scorpions (Arachnida : Scorpionida) are venomous arachnids which occupy a wide range of habitats in the terrestrial ecosystem. They are found in the burrows of the soil, rock crevices, barks of trees, surface debris, and also in deep caves. Order scorpionida is composed of 9 living families of which five are represented in the Indian subcontinent (Buthidae, Chaerilidae, Euscorpiidae, Ischnuridae and Scorpionidae). It is estimated that there are about 1500 described species of scorpions belonging to 112 genera are presently known from the world (Williams 1987). Pocock (1900) reported 60 species and 20 subspecies within five families from India, Sri Lanka and Myanmar. Tikader & Bastawade (1983) provided detailed systematic account of 99 species of scorpions under 18 genera and five families from India. Later, 3 new species of scorpions were described from India (Bastawade, 1986a, b, 1992) and currently there are more than 110 known species of scorpions from India.

When compared to the other parts of India, scorpion fauna of the Deccan region is well known and represents 27 species. The state Kerala is so far known to comprise 16 species of Scorpions belonging to 7 genera under three families (Tikader and Bastawade, 1983, Indra, 2001, and Bastawade *et. al.*, 2003). The present paper is based on a collection of scorpions from Parambikulam Wild Life Sanctuary, an important conservation area in Kerala. An account of 6 species belonging to 4 genera under 3 families is provided here with diagnostic characters and details of collection. The scorpion fauna of Parambikulam wild life sanctuary is practically unknown and the present account will form a basis for further investigations on the group from the area.

Parambikulam wild life sancturay located in Palakkad district of Kerala lies in a valley between Anaimalai and Nelliampathy hills. It lies between 10°20'–10°32' N latitude and 76°35'–76°50' E longitudes. It is contiguous with the Anamalai wild life sanctuary of Tamil Nadu in the east. The area is characterised by tropical evergreen and semi evergreen forests along the western part besides South Indian moist deciduous forest, riparian forests and teak plantations. Collections were made from different environs within the sanctuary during the year 1995-1996. All the specimens studied are deposited in the faunal holdings of the Zoological Survey of India, Calicut.

SYSTEMATIC ACCOUNT

Class ARACHNIDA

Order SCORPIONIDA

Family BUTHIDAE

Subfamily BUTHINAE

1. *Lychas (Endotrichus) tricarinatus* Simon

(Photo 1)

1884. *Lychas tricarinatus* Simon, *Ann. Mus. civ. sto. nat. Genova*, **20** : 371.

Material examined : 1 female, India : Kerala : Parambikulam Wildlife Sanctuary, Pulikkal, 1.xi.1995, coll. (Reg. No. 8480); 1 female, Padippara, 28.x.1995, (Reg. No. 8529); 2 females, 2 males, Muthalakayam, 6.xi.1995 (Reg. No. 8455); 1 female, Venkoil, 27.x.1995 (Reg. No. 8457); 3 females, 1 male, 9 female yound ones, Kamathalchi, 30.x.1995 (Reg. No. 8456); 1 female, Anchupoolai, 3.xi.1995 (Reg. No. 8451); 1 female, Thunakkadavu, 2.xi.1995 (Reg. No. 8452); coll. P. M. Sureshan; 1 female, Peruvaripallam, 25.i.1997 (Reg. No. 9874); 1 female, 1 male, Venkoli, 23.i.1995 (Reg. No. 9875), coll. K. C. Gopi.

Diagnostic characters : Size medium to large; colour brownish yellow; entire surface of carapace coarsely granular; anterior margin very weakly invaginated in the middle; pedipalp with femur shorter than carapace and carinated; hand smooth; trichobothria *eb* and *esb* placed closer to the base of the immovable finger of pedipalp; pectines well developed, 5x longer than wide, teeth 23/23 in number; genital operculum with two sclerites pointed on latero median portion, united in the middle; mesosomal tergites II-IV with three carinae; cauda five times as long as carapace, basal segment slightly wider than long; telson shorter than last caudal segment.

Distribution : INDIA : Madhya Pradesh, Maharashtra, Karnataka, Kerala, Andhra Pradesh, Tamil Nadu.

Remarks : Most common species of *Lychas* in south, south western and central India; normally found under the bark of large to medium sized trees; female gives birth to 10–15 young ones which are carried on the back until the initial four instars are completed; feeds on small insects.

2. *Lychas (Endotrichus) albimanus* Henderson

(Photo 2)

1919. *Lychas albimanus* Henderson, *Rec. Indian Mus.*, **16**(5) : 379-381.

Material examined : 1 male, Parambikulam, 24.iii.1997 (Reg. No. 10,664); 1 female, Pezhakunnu, 27.iii.1997 (Reg. No. 10,075), coll. K. C. Gopi.

Diagnostic characters : Medium sized; coloured brownish, variegated with yellow patches; carapace entirely and sparsely weakly granular, no carinae developed; anterior margin slightly invaginated in the middle; pedipalp slender, blackish brown except manus yellow; femur as long as carapace, carinae weakly developed; pectines well developed and 4x as long as wide; fulcra not distinguished; teeth 21/21 in number, genital operculum sclerites weak, not well sclerotised, fused in the middle; mesosomal tergites I-VI yellowish brown with a pair of yellow elliptical spots in the middle portion and with >>---<< shaped marks; tergite I without carinae; II-IV with a median granular carina developed only on posterior portion, VII with two pairs of weakly granular carina; cauda more than 5x as long as carapace; sub aculear teeth of vesicle furnished with a pair of minute teeth just near the tip.

Distribution : INDIA : Kerala, Uttar Pradesh, Orissa, Himachal Pradesh.

Remarks : Not common, mostly restricted to forested areas, prefers to stay under bark, no information available on biological aspects.

Subfamily CENTRURINAE

3. *Isometrus (Reddyanus) brachycentrus* Pocock

(Photo 3)

1899. *Isometrus brachycentrus* Pocock, *J. Bombay nat. Hist. Soc.*, **12** : 263.

Material examined : 1 male, 1 female, Kamathalachi, 30.x.1995, (Reg. No. 8456); 1 male, 1 female, Kariyanchola, 22.i.1997 (Reg. No. 9891), coll. P. M. Sureshan.

Diagnostic characters : Moderately sized; coloured dark brown, dark black on metasoma; ventral surface pale brown; pectines yellowish brown; entire surface of carapace finely and almost closely granular without carinae; five pairs of lateral eyes; pedipalp with femur flat and as long as carapace; trichobothria *db* placed always proximal to *et* but distal to *est* on immovable finger of manus; tarsomere I provided with a pair of pedal spurs; pectines 3.5 times longer than wide, teeth 12/12 in number; genital operculum wider than long; mesosomal tergite I without carina; II-IV with only single median carina; cauda thin long and almost six times as long as carapace; basal segment always longer than wide; telson with subaculear spine provided with three pairs of small denticulate granules on inner margin.

Distribution : INDIA : Karnataka, Kerala.

Remarks : Endemic to Peninsular India. No information available on biological aspects.

4. *Isometrus (Isometrus) sankeriensis* (Tikader & Bastawade)

(Photo 4)

1983. *Isometrus (Closotrichus) sankeriensis* Tikader & Bastawade. Fauna India. Scorpions. III. 311.

Material examined : 1 male, Pulickal, 27.i.1997 (Reg. No. 9861), coll. P. M. Sureshan.

Diagnostic characters : Small in size, slender and delicate bodied, colour yellowish white; body variegated with black to brown bands and spots. Entire surface of carapace coarsely granular, anterior margin nearly straight; five lateral eyes; pedipalp slender, long, variegated with dark colour; both fingers of manus longer than carapace; trichobothria *db* placed always distal to *et* on immovable finger of manus; pectines well developed, teeth elongated 15/16 in number in male; mesosomal tergites coarsely and finely granular with single median carina; cauda more than six times as long as carapace; telson with vesicle globular, as wide as caudal segment V, aculeus curved.

Distribution : INDIA : Karnataka, Kerala.

Remarks : Rare and endemic to peninsular India, prefers to inhabit forested areas, lives under barks of large trees, no other biological details known.

Family SCORPIONIDAE

Subfamily SCORPIONINAE

5. *Heterometrus (Chersonesometrus) kanarensis* (Pocock)

(Photo 5)

1900. *Palamnaeus scaber kanaraensis* Pocock, Fauna Brit. India Arachn., 93.

1981. *Heterometrus (Chersonesometrus) phipsoni kanaraensis*, Couzijn. Zool. Verln., **184** : 151.

Material examined : 1 male, Parambikulam, 24.iii.1997, 1 male, Pezhakunnu, 27.iii.1997, coll. K. C. Oopi (Reg. No. 10664 & 10075); 5 young ones, Kamathalachi, 30.x.1995, 1 female, 1 male, Anchupoolai, 3.ii.1995, 1 female, 1 male, Pulikical, 1.xi.1995, 3 young ones, Sirkaipathi, 29.x.1995, 1 female, Venkoli, 27.x.1995, coll. P. M. Sureshan (Reg. Nos. 8450, 8451, 8454, 8456, 8457).

Diagnostic characters : Large sized; colour dark blackish brown or brown; carapace weakly granular on anterior portion, otherwise smooth; anterior margin with deep notch; lateral ocular tubercle much elevated with three contiguous eyes; pedipalp stout, strong, convex on manus; femur always longer than carapace; tarsomere I provided with a pedal spur, pectines well developed, teeth not much tapering, 11/11 in number in male and 9/9 in female; mesosomal tergites smooth, without carinae; cauda slightly less than four times as long as carapace; basal segment longer than wide; telson with vesicle almost as long as caudal segment II.

Distribution : INDIA : Karnataka, Maharashtra, Kerala.

Remarks : The species is represented by a good number in the collection. In Kerala, this species is reported only from the forested tracts of Parambikulam wild life sanctuary. Burrowing in habit

and prefers to live in deep burrows under large boulders or logs lying in forested areas. Heavy rains make them to shift to some protections such as stones and crevices. Feeds on medium to large insects, sometimes smaller mammals; found in the vicinity of burrows in about 1–2 meters radius. Female gives birth to 12–20 young ones; young ones of 1-2 generations share the same burrow.

Family ISCHNURIDAE

6. *Liocheles laeviceps laeviceps* (Pocock)

(Photo 6)

1890. *Iomachus laeviceps laeviceps* Pocock, *Ann. Mag. nat. Hist.*, 5(6) : 242.

Material examined : 1 male, Parambikulam, 24.iii.1997 (Reg. No. 10664); 1 female, Muthuvarachal 5.xi.1995 (Reg. No. 8453), coll. P. M. Sureshan.

Diagnostic characters : Medium to large sized; colour brownish with slight yellowish tint on tergites; telson with clear and conspicuous yellow vesicle; carapace entirely smooth, anterior margin invaginated; pedipalp stout and dorsoventrally flattened, femur and patella longer than carapace; Trichobothria *est1* placed distal to *est2* and *est3* on patella; two trichobothria *dsb* and *dst* on dorsal surface of immovable finger of manus; pectines moderately developed, teeth small, 6/6 in number; genital operculum narrowed posteriorly and without a median suture; mesosomal tergites smooth and finely punctate; cauda weak and slightly longer than two and half times as long as carapace.

Distribution : INDIA : Kerala, Tamil Nadu, Andhra Pradesh, Gujrat, Rajasthan, Bihar.

Remarks : Burrowing in habit and makes the burrows quiet deep in soft soil, feeds around the burrow; gives birth to 8–12 young ones.

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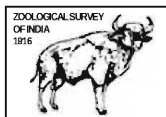
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PLATE I



Fig 1 : Scorpion fauna of Parambikulam Wildlife Sanctuary

1. *Lychas (Endotrichus) tricarinatus*, 2. *Lychas albimanus*,
3. *Isometrus (Reddyanus) brachycentrus*, 4. *Isometrus (Closotrichus) sankeriensis*,
5. *Heterometrus (Chersonesometrus) kanarensis*, 6. *Liocheles laeviceps laeviceps*.



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ZOOPLANKTON INVESTIGATIONS FROM A PADDY FIELD IN TAMIL NADU

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INTRODUCTION

Paddy fields are widespread and are integral parts of the landscape of India. Although biological cycles are interrupted by cultivation, colonization in the aquatic phase can be rapid by zooplankton, benthos and nektonic animals along with phytoplankton and macrophytes. There is a rapid buildup of diversity of aquatic organisms after the planting of rice (Fernando, 1995). Hence a study on the zooplankton composition of a paddy field in Tamil Nadu was undertaken.

MATERIAL AND METHODS

From April 1998 to March 2000, regular monthly collections were made from a paddy field near Chennai in Singaperumalkoil. Though the studies were carried out in an area of 4.5 ha of paddy field behind Singaperumalkoil railway station, yet they were confined mostly to an easily accessible plot of 100 m². Plankton samples were collected by using plankton net of 30 cm diameter with a mesh size of 100 μ . Samples were preserved in 5% formalin.

ZOOPLANKTON

A group wise account of various species of Rotifera, Cladocera, Ostracoda and Copepoda collected/identified is as under (Table 1).

Class ROTIFERA Subclass EUROTATORIA Superorder MONOGONONTA Order PLOIMIDA	Family BRACHIONIDAE 1. <i>Brachionus calyciflorus f. borgerti</i> (Apstein) 2. <i>Brachionus rubens</i> Ehrenberg 3. <i>Brachionus falcatus</i> Zacharias
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4. <i>Keratella quadrata</i> (O.F. Muller)	Family DAPHNIIDAE
5. <i>Keratella tropica</i> (Apstein)	11. <i>Ceriodaphnia cornuta</i> Sars
Order GINESIOTROCHA	12. <i>Daphnia carinata</i> King
Family TESTUDINELLIDAE	Family MOINIDAE
6. <i>Testudinella patina</i> (Hermann)	13. <i>Moina micrura</i> Kurz
Family FILINIDAE	Family MACROTHRICIDAE
7. <i>Filinia longiseta</i> (Ehrenberg)	14. <i>Macrothrix spinosa</i> King
Phylum ARTHROPODA	Family CHYDORIDAE
Subphylum CRUSTACEA	15. <i>Chydorus parvus</i> (Daday)
Subclass OSTRACODA	16. <i>Chydorus reticulatus</i> Daday
8. <i>Strandesia indica</i> Hartmann	Subclass COPEPODA
9. <i>Stenocypris major</i> (Baird)	Order CALANOIDA
Subclass BRANCHIOPODA	17. <i>Heliodiaptomus viduus</i> Gurney
Order CLADOCERA	18. <i>Sinodiaptomus (Rhinediaptomus) indicus</i>
Family SIDIDAE	Kiefer
10. <i>Diaphanosoma excisum</i> Sars	

Further a brief taxonomic group wise profile of various species is as follows.

ROTIFERA

1. *Brachionus calyciflorus f. borgerti* (Apstein, 1907)

1907. *Brachionus ampiceros borgerti* Apstein, Zool. Jb. Abt. Syst., **25** : 211, Figs. G. 11.

1998. *Brachionus calyciflorus f. borgerti* (Apstein), Zool. Surv. India, State Fauna Series 3, Fauna of West Bengal, Part **11** : 358.

Material examined : 5 exx., iv.1998; 5 exx., v.1998; 5 exx., vi.1998; iii.1999.

Remarks : Median occipital spines longer than laterals.

2. *Brachionus rubens* Ehrenberg, 1838

1838. *Brachionus rubens* Ehrenberg, Ein Blick in das tiefere organize Leben der Natur. Leipzig : p. 513, Lxiii, fig. 4.

1998. *Brachionus rubens* (Ehrenberg), Zool. Surv. India, State Fauna Series 3, Fauna of West Bengal, Part **11** : 365.

Material examined : 5 exx., vii.1998; iii.1999.

Remarks : Lorica oval, firm and compressed dorsoventrally, anterior margin with six occipital spines.

Distribution : Assam, Haryana, Orissa, Punjab, Rajasthan and West Bengal.

3. ***Brachionus falcatus*** Zacharias, 1893

1898. *Brachionus falcatus* Zacharias, *Forschungsber Biol. Stn. Zu Plön*. VI p. 45, tab. iv, Fig. 4.

1998. *Brachionus falcatus* (Zacharias), *Zool. Surv. India, State Fauna Series 3, Fauna of West Bengal*, Part **11** : 361.

Material examined : 5 exx., vii.1998; 5 exx., ii.1999.

Remarks : Lorica rigid and compressed dorsoventrally, occipital margin with six spines.

Distribution : Andhra Pradesh, Assam, Bihar, Gujarat, Haryana, Kerala, Orissa, Punjab and Rajasthan.

4. ***Keratella quadrata*** (O.F. Muller, 1786)

1786. *Brachionus quadratus* Muller, *Havniae*, I-L VI p. 354, pl. 49; figs. 12, 13.

1998. *Brachionus quadratus* (Muller), *Zool. Surv. India, State Fauna Series 3, Fauna of West Bengal*, Part **11** : 368-369.

Material examined : 5 exx., ii.1999; 5 exx., iii.1999.

Remarks : Lorica rectangular with six occipital spines.

Distribution : Assam, Kashmir, Kerala, Tamil Nadu and West Bengal.

5. ***Keratella tropica*** (Apstein, 1907)

1907. *Ansurea valga f. tropica* Apstein, *Zool. Jb. Abt. Syst.*, **25** : p. 210, Fig. f.

1998. *Keratella tropica* (Apstein), *Zool. Surv. India, State Fauna Series 3, Fauna of West Bengal*, Part **11** : 369-370.

Material examined : 5 exx., iv.1999.

Remarks : Lorica elongate oboval and with six anterior occipital spines.

Distribution : Andhra Pradesh, Assam, Bihar, Gujarat, Haryana, Kashmir, Kerala, Madhya Pradesh, Orissa, Punjab and West Bengal.

6. ***Testudinella patina*** (Hermann, 1783)

1783. *Brachionus patina* Hermann, *Naturforscher Halle*. **19** : p. 48, Tab. 2, Fig. 10.

2000. *Testudinella patina* (Hermann), Taxonomic notes on Rotifer from India. *Indian Association of Aquatic Biologists*, p. 93.

Material examined : 5 exx., vii.1998.

Remarks : Lorica transparent, circular and dorsoventrally flattened.

Distribution : Andhra Pradesh, Assam, Gujarat, Kashmir, Orissa, Punjab and West Bengal.

7. *Filinia longiseta* (Ehrenberg, 1834)

1834. *Triarthra longiseta* Ehrenberg, *Folio, Berlin* : p. 222, pl. viii, fig. 1.

2000. *Filinia longiseta* (Ehrenberg), Taxonomic notes on Rotifer from India. *Indian Association of Aquatic Biologists*, p. 91.

Material examined : 5 exx., vi. 1998.

Remarks : Body thin, barrel shaped, with two long movable antero-lateral seta and one long immobile posterior setae.

Distribution : Assam, Gujarat, Haryana, Madhya Pradesh, Orissa, Punjab and West Bengal.

OSTRACODA

8. *Strandesia indica* Hartmann, 1964

1964. *Strandesia indica* Hartmann, *Int. Rev. gesamen. Hydrobiol. Syst. Beih.*, **3** : 101.

1979. *Strandesia indica* Hartmann, *Rec. zool. Surv. India*, **74**(2) : 169-171.

Material examined : 5 exx., vii.1998; 5 exx., ii.1999.

Remarks : Left valve overlaps right valve, entire margin of the valve hairy except dorsally, claws pectinate, maxillary spine smooth.

Distribution : Gujarat, Kerala, Pondicherry, Tamil Nadu and West Bengal.

9. *Stenocypris major* (Baird, 1859)

1859. *Cypris cylindrica major* Baird, *Proc. Zool. Soc. Lond.*, **389** : 233, Fig. 1, 1a-f.

1979. *Stenocypris major* (Baird), *Rec. zool. Surv. India*, **74**(2) : 193-197.

Material examined : 5 exx., ix.1998; 5 exx., x.1998.

Remarks : Left and right valves are of same size, valves margin hairy except dorsally, claws pectinate, maxillary spines toothed.

Distribution : Andhra Pradesh, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Tamil Nadu and West Bengal.

CLADOCERA

10. *Diaphanosoma excisum* Sars, 1885

1885. *Diaphanosoma excisum* Sars, *Norske Videnst. Selsk. Forhandl. Christianin*, **8** : p. 13-18, pl. 2, Figs. 1-3.

1988. *Diaphanosoma excisum*, Michael and Sharma, *Fauna of India : Indian Cladocera*, p. 46-48.

Material examined : 5 exx., vii.1998; 5 exx., ix.1998.

Remarks : Carapace oblong in outline, posterior end truncate.

Distribution : Bihar, Rajasthan, West Bengal and Tamil Nadu.

11. *Ceriodaphnia cornuta* Sars, 1885

1885. *Ceriodaphnia cornuta* Sars, *Nrske Videnst Selsk Forhandl Christianin*, **8** : p. 26-28, pl. 5, Figs. 1-3.

1988. *Ceriodaphnia cornuta* Sars, *Fauna of India : Indian Cladocera*, p. 51-53.

Material examined : 5 exx., viii.1998; 5 exx., ix.1998; 5 exx., x.1998.

Remarks : Valves distinctly reticulate, head small depressed and separated from body by a distinct ocular depression.

Distribution : Bihar, Kerala, Meghalaya, Rajasthan, Tamil Nadu and West Bengal.

12. *Daphnia carinata* King

1853. *Daphnia carinata* form a, King, p. 246.

1988. *Daphnia carinata* form a, King, *Fauna of India : Indian Cladocera*, p. 59-62.

Material examined : 5 exx., xii.1998; 5 exx., i.1999.

Remarks : Carapace oblong and reticulated dorsal margin evenly arched and forming a slight concavity in anterior margin, posterior spine rather elongated and slightly upturned.

Distribution : Bihar, Gujarat, Karnataka, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal.

13. *Moina micrura* Kurz, 1820

1820. *Monaculus rectirostris* Jurine, p. 134-145, pl. 13, Figs. 3-4.

1988. *Moina micrura* Kurz, *Zool. Surv. India. Fauna of India : Indian Cladocera*, p. 86-89.

Material examined : 5 exx., vii.1999; 5 exx., vii.1999; 5 exx., ix.1999.

Remarks : Head large, extended in anteroventral direction and with well developed supraocular depression.

Distribution : Bihar, Kerala, Punjab, Tamil Nadu, Rajasthan and West Bengal.

14. *Macrothrix spinosa* King

1853. *Macrothrix spinosa* King, p. 256, pl. vi F.

1988. *Macrothrix spinosa* King, *Zool. Surv. India. Fauna of India : Indian Cladocera*, p. 102-104.

Material examined : 5 exx., ix.1998; 5 exx., x.1998.

Remarks : Head moderately large, subtriangular and with slightly prominent rostral projection.

Distribution : Rajasthan and Tamil Nadu.

15. ***Chydorus parvus*** (Daday, 1898)

1898. *Chydorus sphaericus variparvus* Daday, p. 25-26, Fig. 7.

1988. *Chydorus parvus* (Daday), Zool. Surv. India. Fauna of India : Indian Cladocera, p. 142-144.

Material examined : 5 exx., i.1999.

Remarks : Body rounded in outline, posterodorsal corner of valves rounded.

Distribution : Kerala, Tamil Nadu and Andhra Pradesh.

16. ***Chydorus reticulatus*** Daday, 1898

1898. *Chydorus reticulatus* Daday, p. 27, Fig. 9.

1988. *Chydorus reticulatus* Daday, Zool. Surv. India. Fauna of India : Indian Cladocera, p. 153-154.

Material examined : 5 exx., ix.1998; 5 exx., viii.1999.

Remarks : Body spherical, posterodorsal corner of valves well marked posteroventral corner rounded.

Distribution : Kerala and Tamil Nadu.

COPEPODA

17. ***Heliodiaptomus viduus*** (Gurney, 1916)

1916. *Diptomus viduus* Gurney, Proc. Zool. Soc. Lond., 1 : 338-339.

1994. *Heliodiaptomus viduus* (Gurney), Guide Identification of Micro invertebrates of Continental waters of World. 5 : 7-9.

Material examined : 5 exx., xii.1998; 5 exx., i.1999.

Remarks : Antennule overreaching caudal rami by last 3 or 4 segments and genital somite asymmetrical in females, left coxal spine stouter than right in leg 5 of female, right antennule with spine on each of segments 8th and 10-16 in males.

Distribution : Most common in South India.

18. ***Sinodiaptomus (Rhinediaptomus) indicus*** Kiefer, 1936

1936. *Sinodiaptomus indicus* Kiefer, Zool. Anz., 113 : 226-229.

1953. *Rhinediaptomus indicus* Brehm, Ost. Zol. Z., 4 : 283-286.

1994. *Sinodiaptomus (Rhinediaptomus) indicus* Kiefer, Guide Identification of Micro invertebrates of Continental waters of World. 5 : 202-207.

Material examined : 5 exx., vi.1998.

Remarks : Genital somite distinctly longer than the rest of the urosome and antennules extending to the end of the caudal rami in females, coxal spine strong in leg 5 of females, right antennule with spine on segments 8 and 10-16 in males.

Distribution : Common in South India.

SUMMARY

For the first time an attempt has been made to study a paddy field in Tamil Nadu to reveal the faunal diversity during aquatic and semiaquatic phases. During the study period, in general, plankton population was very much restricted and was represented by 18 species. Interestingly *Moina oryzae*, a new species described from the paddy fields near Chennai could not be collected.

Plankton samples collected during the 24-month study indicated the presence of the following groups namely Rotifera, Cladocera and Copepoda. During the first part of the study, from April 1998 to July 1998, the samples contained only Rotifera. Cladocerans were observed in the samples from August 1998 to January 1999. Again the samples contained only Rotifera during February 1999 to May 1999. After this, both Cladocerans and copepods represented samples. Calanoid copepods were recorded only in November 1999.

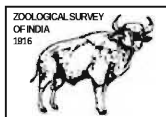
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STUDIES ON LIFE HISTORY OF *HEMIPYRELLIA LIGURRIENS* (WIEDEMANN) (DIPTERA : CALLIPHORIDAE) IN SUNDARBANS BIOSPHERE RESERVE, WEST BENGAL, INDIA

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INTRODUCTION

This scavenger species are found abundantly in seashore, fishing port, dry fish processing centers, human faeces and market areas in Sundarbans Biosphere Reserve. They are very important in medical and veterinary sciences. The adults are suspected as the most potential vectors of different enteric pathogens. Roy and Dasgupta (1971) reported that the larvae of *Hemipyrellia ligurriens* could able to lead parasitic mode of live and they also showed that with experiment on live specimens the flies deposit eggs on the body and the larvae penetrate inside the body of earthworm, fish, toad, frog, wall lizard, pigeon and shrew. First, second and third instars larvae of this species have been described by Kano and Sato (1952) from Japan after rearing on raw fish in the laboratory conditions. Later on, Ishijima (1967) described only the third stage larvae from Japan and reported that the larvae breed in dead animals, garbage, human faeces and animal dung especially dog and cat dung. But nothing was reported regarding the life history and larval characters of this species from India. Abbreviations used in the adult figures are after Kano and Shinonaga (1968) and in the larval figures are after Ishijima (1967).

MATERIAL AND METHODS

A mating pair was collected from fish processing center at Ganga Sagar of Sundarbans Biosphere Reserve and brought to the laboratory in live condition. The male specimen was killed and identified as *Hemipyrellia ligurriens* (Wiedemann) and the live female fly was kept in a glass jar covering the mouth of the jar with silken cloth for rearing in the laboratory conditions. About 50 gm of raw coastal fish of *P. microdon* was supplied regularly to the female for deposition of eggs. After few days, the gravid female fly started for laying eggs on this raw fish. Later on, when the larvae

hatched out from eggs then some of them were taken out from the jar and placed in another glass jar (10 × 8 cm) providing 100 gm of above mentioned raw fish daily as their food. Here the mouth of the jar was also covered with double silken cloth so that the other flies cannot contaminate the culture medium. Moist sand was kept at the bottom of the glass jar to provide mature larvae a humid condition for pupation. The flies emerged out from this culture medium. After that a male and a female fly from this pure stock were taken out and kept in a jar of earlier size to study the different larval stages of this species in laboratory conditions of temperature $24 \pm 4^\circ\text{C}$ and at relative humidity of $66 \pm 4\%$. The mouth of the jar was also covered with double silken cloth. Sugar solution soaked in cotton was given above the silken cloth of the jar four times daily so that the adult flies get continuous food supply. For oviposition, 50 gm of above-mentioned raw fresh fish was supplied to the female regularly. Their mating was observed and the female fly deposited eggs on the fish after fifth day of mating. After hatching from eggs, four to five first stage larvae were taken out from the culture medium and collections of larvae were repeated every six hours up to the formation of pupae to study the exact duration of each instars. The collected larvae were killed by dropping them into slightly boiled water and preserved them in 70% alcohol for future study. To study the larval characters, they were boiled in 10% KOH solutions for 1–3 minutes and washed them in water to remove the excess KOH particles. To study the entire larvae, the internal debris was removed by making a puncture at one point and cleaned them with distilled water. The larvae were then dehydrated through alcoholic grades and finally to absolute alcohol. After proper dehydration, the larvae were cleaned with clove oil and mounted on slides with Canada balsam. For studying the anterior and posterior spiracles and cephalopharyngeal sclerite, these parts were dissected out with fine forceps putting them in cavity block and processed as earlier. The figures of different parts were drawn with the help of camera lucida before mounting them on slides with Canada balsam. For studying the male genitalia and female ovipositor, the posterior portion of the abdomen was dissected out with fine scissor. The dissected portions were boiled in a test tube immersed in 10% KOH solutions for 1–2 minutes. Then the genitalia portion and ovipositor were placed in separate cavity block and different parts of genitalia and ovipositor were dissected under stereoscopic binocular microscope with fine needles and later on washed the dissected parts with distilled water to remove excess KOH. They were then transferred to 30% alcohol and different parts of genitalia and ovipositor were observed under same binocular microscope. After proper study the different parts of genitalia and ovipositor, they were processed through alcoholic grades for dehydration and finally to phenol and the figures of different parts were drawn with the help of camera lucida before mounting them on slides with Canada balsam.

OBSERVATION

The flies started mating from the fourth day of emergence up to seventh day. During mating, a male fly suddenly jumps over the female fly and grasps the female body with its prothoracic and

metathoracic legs. The duration of the mating was for 2–7 minutes. A female fly mated more than once with different males. On the twelfth day of emergence, the gravid female fly started to lay eggs. A total of 583 eggs were laid in seven batches and completed on thirty ninth day of emergence with highest number on twenty fourth day. Total numbers of eggs deposited by a female fly in laboratory conditions are shown in chart 1. Among the total eggs deposited by a female fly, 86% of the eggs hatched out and 61% of the larvae were survived up to pupation. Longevity of the male and female flies with food and without food was noted. Average longevity of male and female was about 33 to 51 days respectively. Females survived more than males feeding on dilute sugar solution. The flies could survive 4–5 days without food after emergence. Sex ratio of male and female was 1 : 1.

Chart 1. : Number of eggs deposited by a female fly.

Batches	Days of emergence	Number of eggs
1 st batch	12 th	71
2 nd batch	16 th	91
3 rd batch	24 th	117
4 th batch	29 th	99
5 th batch	32 nd	74
6 th batch	34 th	67
7 th batch	39 th	64
		Total : 583

DESCRIPTION OF DIFFERENT STAGES

Immature Stages (Figs. 1-13)

Egg (Fig. 1) : White in colour. Its length varied from 1 to 1.2 mm and its diameter varied from 0.3 to 0.5 mm. It is almost oblong and posterior end is much wider than anterior end.

Eggs are hatched after 9 to 15 hours of oviposition.

Larvae : There are three larval instars. All have a clearly defined anterior cephalopharyngeal sclerite, three thoracic segments and eight abdominal segments.

First instar larva (Fig. 2) : White in colour. Its length varied from 2.5 to 3 mm and its diameter varied from 0.5 to 0.8 mm. Spine bands on segments weakly developed. Complete anterior spine bands present on segments 2 to 6. Spines present on dorsal surface of 6 segment. Posterior spine bands present on ventral surface of segments 5 to 10. Segment 11 with complete posterior band.

Cephalopharyngeal sclerite (Fig. 3) : Small, incompletely developed and not uniformly sclerotised. Oral hook part strong. Dorsal cornu deeply pigmented, long, pointed and slightly curved. Sinus wide and tubercles prominent.

Spiracles : No anterior spiracles. Posterior spiracles (Fig. 4) light brown with two slits. Spiracular slits not completely developed, which are attached ventrally and separated dorsally.

First instar larva is transformed into second instar larva after 5 to 6 hours of hatching.

Second instar larva (Fig. 5) : White in colour. Its length varied from 4 to 6 mm and its diameter varied from 0.9 to 1.1 mm. Anterior spine band on segment 6 is wide. Other spine bands are similar in position as in earlier instar. Dorsal tubercles reduced but ventral tubercles prominent.

Cephalopharyngeal sclerite (Fig. 6) : Uniformly pigmented. Anterior end of hook part more curved ventrally. Posterodorsal process projected upward. Parastomal sclerite long. Dorsal cornu pointed and long and it is structurally similar to first instar larva but with increased size. Ventral cornu shorter than the dorsal cornu which is with prominent window.

Spiracles : Anterior spiracles (Fig. 7) yellow, flower-like and each with 6–7 branches. Posterior spiracles (Fig. 8) deep brown, with two spiracular slits and the slits are separated completely.

Second instar larva is transformed into third instar larva after 12 to 14 hours.

Third instar larva (Fig. 9) : White to yellow in colour. Its length varied from 10 to 12 mm and its diameter varied from 1.5 to 2 mm. Segments 2 to 9 with complete anterior spine bands. Segment 11 with complete posterior spine band. Anterior spine bands of segment 10, 11 and 12 confined to ventral and lateral surfaces. Dorsal and ventral tubercles equal in length.

Cephalopharyngeal sclerite (Fig. 10) : Deeply pigmented. Hook part strong. Dental sclerite comma-shaped and prominent. Parastomal sclerite about the same length that of second instar. Dorsal cornu reduced and uniform in width. Sinus reduced. Window in ventral cornu reduced in size in comparison to second instar. Ventral cornu equal in length to dorsal cornu.

Spiracles : Anterior spiracles (Fig. 11) yellowish and each with 6 to 9 branches. Lobes are not arranged in a straight line but in a circle. Posterior spiracles (Fig. 12) heavily pigmented. It is twice in size than that of the second instar. Peritreme complete. Button present. Ventral arch short. Inner, dorsal and outer arch almost equal in length.

Third instar larva is transformed into pupal stage after 103 to 104 hours.

Puparium (Fig. 13) : Brown in colour. Its length varied from 6 to 7 mm and its diameter varied from 2 to 2.5 mm.

Pupal stage lasted for an average of 183–186 hours.

Total time required for completing the life history of this species from egg to adult is about 13 to 14 days.

Mature Stage (Figs. 14-20)

Diagnosis : Eyes holoptic; frontal vitta dark brown; upper part of parafacial black with silvery pollen; face yellowish brown; metacephalon blackish green with silvery pollen and numerous black

hairs; second antennal segment dark brown, third reddish to dark brown; thorax green to copper with white pollen; acrostichal bristles 2 + 2 and dorsocentral bristles 3 + 3; upper part of propleura and prosternum hairy; numerous black hairs present on supraspiracular convexity; wings hyaline; R_1 bare and R_{4+5} with a row of short setae on dorsal and ventral surfaces; upper squama with yellowish white cilia and lower squama with light brown cilia : legs black; hind tibia with 2 anteroventral bristles; abdomen metallic green to copper with faint whitish pollen; third and fourth tergites with distinct marginal bands, second indigo-blue, purple to dark green, third and fourth with indigo to bluish bands on the posterior margin, fifth with long bristles entirely : first sternite with brownish hairs, second with numerous long hairs, third and fourth with numerous black hairs laterally, fifth sternite v-shaped with numerous long black hairs terminally (Fig. 14).

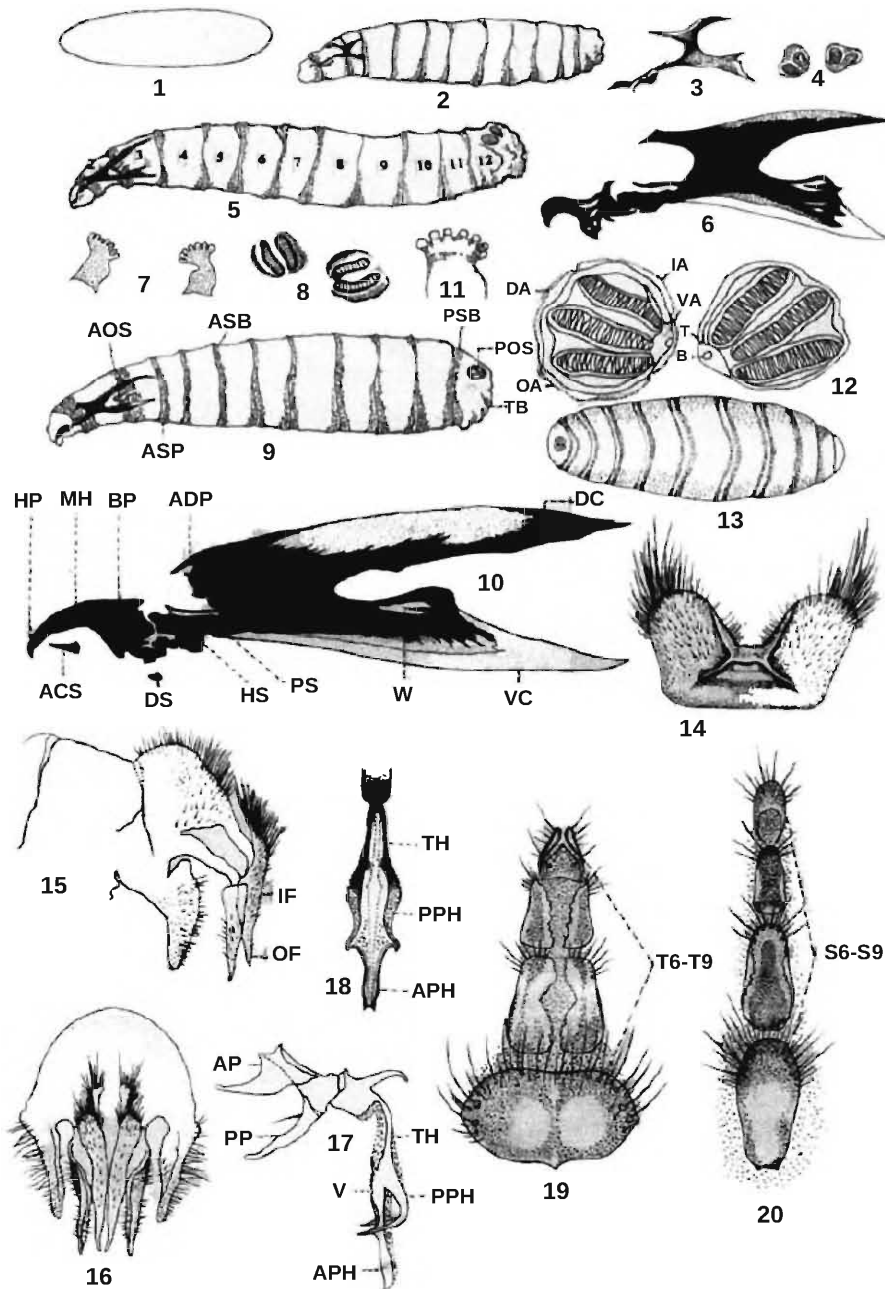
Male genitalia : First genital tergite metallic green, second dark green with grayish pollen and with a pair of brown lobes ventrally; inner forceps dark brown, slender and with diverge for a long distance, outer forceps brown and slender with pointed end (Figs. 15-16); anterior paramere wide at middle and pointed terminally, posterior paramere slender with one hair basally; paraphallus longer than acrophallus and acrophallus slightly blunt at end (Figs. 17-18).

Female ovipositor : First tergite of ovipositor wide and with numerous hairs terminally, sixth large, seventh and eighth elongated and inner margin of seventh tergite concave, ninth wide and shorter than seventh; cerci elongated with few hairs; seventh sternite shorter than sixth, ninth horse-shoe shaped (Figs. 19-20).

Distribution : Palaearctic region : China, Japan, and Korea; Oriental region : India (Assam, Bihar, Sikkim, Tamil Nadu, West Bengal), Indonesia (Java, Sumatra, Sulawesi), Malaysia, Nepal, Philippines, Sri Lanka, S. China, Taiwan and Thailand; Australian and Oceanian regions : Australia, Indonesia (Maluku, Irian Jaya), Japan (Bonin Islands), New Zealand and Papua New Guinea.

DISCUSSION

The larvae of this species are generally found in carcasses of animals, human and other animal faeces, garbage and other decaying materials and the larvae breed therein. The adult flies are mostly available in all seasons and their abundance in Sundarbans Biosphere Reserve is more in the months of November to February when the fishing and fish processing are done in coastal area. This fly breeds not only on *P. microdon* but also on other fishes. A large number of netted fish is processed and dried for future use during this time in different coastal areas of this Biosphere Reserve, which offer a potential breeding media of different fly species. The larvae of different dipteran species cause a substantial loss of dried fishes (Sinha and Nandi, 2003) in this area because the larvae breed in and feed on maximum fleshy portion of these fishes. No report has yet been available regarding the life history of this species and the percentage of loss caused by the larvae of this species on this and other coastal fishes, which are used in dry fish processing centers.



Figs. 1-20. : 1. Dorsal view of egg, 2. First instar larva, 3. Cephalopharyngeal sclerite of first instar larva, 4. Posterior spiracle of first instar larva, 5. Second instar larva, 6. Cephalopharyngeal sclerite of second instar larva, 7. Anterior spiracle of second instar larva, 8. Posterior spiracle of second instar larva, 9. Third instar larva, 10. Cephalopharyngeal sclerite of third instar larva, 11. Anterior spiracle of third instar larva, 12. Posterior spiracle of third instar larva, 13. Puparium (dorsal view), 14. Fifth sternite of male, 15. Inner and outer forceps (lateral view), 16. Inner and outer forceps (ventral view), 17. Penis (lateral view), 18. Penis (ventral view), 19. Ovipositor (dorsal view), 20. Ovipositor (ventral view).

The study of loss caused by the larvae of this species is still waiting for future observation. Association of this adult flies with different micro-pathogens is not known and it is expected that this fly might be a carrier of different micro-pathogens due to its filthy habit. So, there is a great scope to study the percentage of loss caused by the larvae of species on different dried fishes and the association of the adult flies with different micro-pathogens.

The present study shows some differences in larval structures given by Kano and Sato (1952) and Ishijima (1967). Dorsal cornu of cephalopharyngeal sclerite of second instar larva is longer here and the ventral cornu of first instar larva much wider here.

SUMMARY

Life history of *Hemipyrellia ligurriens* (Wiedemann) on Bhola fish, *Panna microdon* (Bleeker) in laboratory conditions from India along with descriptions and figures of egg, three larval instars, puparium have been given. Mating was observed from the 4th–7th day after emergence of the adult flies from pupal case. This species deposited a total of 583 eggs in seven batches with highest number on 24th day after 12th day of emergence of the adult. First instar larval development period varied from 5–6 hours, second instar varied from 12–14 hours, third instar varied from 103–104 hours and pupal stage varied from 183–186 hours at $24 \pm 4^\circ\text{C}$ and relative humidity of $66 \pm 4\%$. The sex ratio of the emerged flies was 1 : 1. Longevity of male and female flies with food ranged from 33 and 51 days respectively and without food 4 days. Short diagnostic characters of the adult flies along with figures of male genitalia and female ovipositor have also been included. Distributional records of the species from India and rest of the world are also reported.

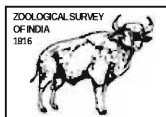
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Abbreviations used in the figures : ACS-Accessory sclerite, ADP-Anterodorsal process, AOS-Anterior spiracle, AP-Anterior paramere, APH-Acrophallus, ASB-Anterior spinose band, ASP-Anterior spiracular plate, B-Bitton, BP-Basal piece, DA-Dorsal arch, DC-Dorsal cornu, DS-Dental sclerite, HP-Hook part, HS-Hypostomal sclerite, IA-Inner arch, IF-Inner forceps, MH-Mouth hook, OA-Outer arch, OF-Outer forceps, PP-Posterior paramere, PPH-Paraphallus, POS-Posterior spiracle, PS-Parastomal sclerite, PSB-Posterior spinose band, S6–S9-Stermites 6th to 9th of female, T-Tail, TB-Tubercles, TH-Theca, T6–T9-Tergites 6th to 9th of female, V-Ventralia, VA-Ventral arch, VC-Ventral cornu, W-Window, 2-12- Body segments.

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ON A COLLECTION OF FISHES FROM THE MALVAN MARINE SANCTUARY, MALVAN, MAHARASHTRA, INDIA

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INTRODUCTION

The Malvan coastal belt of Maharashtra has been declared as Malvan Marine Sanctuary only recently. This sanctuary is rich in marine flora and fauna especially the coral life and mangroves. A perusal of the existing literature shows that the ichthyofaunal resources of this sanctuary has not documented yet. Hence, an attempt was made to evaluate the fish resources of this sanctuary. Two faunistic surveys were undertaken for the assessment of the Marine fish faunal resources of the Malvan sanctuary in the months of September 2004 and October 2005. These surveys have resulted in enlisting 108 species of fishes belonging to 48 families and 13 orders. This study has also revealed the occurrence of 4 vulnerable and 2 near threat species in this Malvan Marine Sanctuary. Common English names of the species have been provided along with the scientific names of the species.

STUDY AREA

The Malvan Marine Sanctuary is located in Malvan Taluka of Sindhudurg district in Konkan Region along the Maharashtra coast between 16°15'–16°50' N latitude and 73°27'–73°31' E longitude. It covers an area of 29.22 sq km. This coastal line is indented with creeks and bays. Kolam, Kalabati and Karli and the prominent creeks of this sanctuary. This region is free from pollution and harbours a wide variety of flora and fauna. The flora components of this region are mainly mangroves and sea grasses. Several species of marine algae are found in this region. Sand dune vegetation is also found very rich here. Mangrove species like *Rhizophora mucronata*, *Avicennia officinalis* and *Excoecaria* sp. flourish well here. It has been observed that among its faunal composition several species of sponges, sea fans, soft and hard corals, sea anemones thrive well in this sanctuary. Live pearl oyster and red coral are also found here. The sanctuary also includes turtle nesting grounds. The Malvan Marine sanctuary and its surrounding area support a

commercial trawl fishery. The Sindhurg fort, built by Shivaji Maharaj is situated in this sanctuary and is considered as one of the main attraction of Malvan. It is one of the very few relatively undisturbed locations along the western coast of India. The nearest major city is Mumbai, about 400 kilometers away.

LIST OF THE FISHES OF THE MALVAN SANCTUARY

Class CHONDRICHTHYES

Order 1. ORECTOLOBIFORMES

Family 1. HEMISCYLLIIDAE
(Bamboo sharks)

1. *Chiloscyllium griseum* Muller & Henle (Grey bamboo shark) (**Near threatened**)

Order 2. CARCHARHINIFORMES

Family 2. CARCHARHINIDAE
(Requiem sharks)

2. *Scoliodon laticaudus* (Muller & Henle) (Spade nose shark) (**Near threatened**)

Class OSTEICHTHYES

Order 3. ANGUILLIFORMES

Family 3. OPHICHTHIDAE
(Snake eels)

3. *Neenchelys buitendijki* (Weber and deBeaufort) (Fintail serpent eel)
4. *Ophichthus apicalis* (Bennett) (Bluntnose snake-eel)

Family 4. MURAENESOCIDAE
(Pike congers)

5. *Congresox talabonoides* (Bleeker) (Indian pike conger) (**Vulnerable species**)
6. *Muraenesox cinereus* (Forsskal) (Daggertooth pike conger) (**Vulnerable species**)

Order 4. CLUPEIFORMES

Family 5. CLUPEIDAE
(Herrings, shads, sardines)

7. *Amblygaster clupeioides* Bleeker (Bleeker's smooth belly sardinella)
8. *Hilsa kelee* (Cuvier) (Kelee shad)
9. *Nematolosa nasus* (Bloch) (Bloch's gizzard shad)
10. *Pellona ditchella* Valenciennes (Indian pellona)
11. *Sardinella melaneura* (Cuvier) (Black tip sardinella)
12. *S. longiceps* Valenciennes (Indian oil sardine)
13. *Tenuulosa ilisha* (Hamilton) (Hilsa shad) (**Vulnerable species**)

Family 6. PRISTIGASTERIDAE
(Pristigasterids)

14. *Opisthopterus tardoore* (Cuvier) (Tardoore)
15. *Ilisha melastoma* (Bloch & Schneider) (Indian ilisha)

Family 7. ENGRAULIDIDAE
(Anchovies)

16. *Stolephorus indicus* (van Hasselt) (Indian anchovy)
17. *Thryssa hamiltonii* (Gray) (Hamilton's thryssa)
18. *Thryssa dussumieri* (Valenciennes) (Dussumier's thryssa)
19. *T. malabarica* Bloch (Malabara thryssa)
20. *Thryssa mystax* (Hamilton) (Moustached thryssa)
21. *T. setirostris* (Broussonet) (Longjaw thryssa)

Family 8. CHIROCENTRIDAE
(Wolf herrings)

22. *Chirocentrus dorab* (Forsskal) (Dorab wolf-herring)

Order 5. SILURIFORMES

Family 9. BAGRIDAE
(Bagrid catfishes)

23. *Mystus gulio* (Hamilton) (Long-whiskered catfish)

Family 10. ARIIDAE
(Sea catfishes)

24. *Arius maculatus* (Thunberg) (Spotted catfish)
25. *A. platystomus* Day (Flatmouth sea catfish)
26. *A. thalassinus* (Ruppell) (Giant sea catfish) (**Vulnerable species**)

Family 11. PLOTOSIDAE
(Eeltail catfishes)

27. *Plotosus canius* (Grey eel-catfish)

Order 6. AULOPIFORMES

Family 12. HARPADONTIDAE
(Bombay duck)

28. *Harpadon nehereus* (Hamilton) (Bombay duck)

Family 13. SYNODIDAE
(Lizardfishes)

29. *Saurida tumbil* (Bloch) (Greater lizardfish)

Order 7. GADIFORMES

Family 14. BREGMACEROTIDAE
(Codlets)

30. *Bregmaceros mccllellandii* Thompson (Spotted codlet)

Order 8. MUGILIFORMES

Family 15. MUGILIDAE
(Mulletts)

31. *Liza tade* (Forsskal) (Tade mullet)
32. *Mugil cephalus* Linnaeus (Flathead mullet)

Order 9. BELONIFORMES

Family 16. HEMIRAMPHIDAE
(Halfbeaks)

33. *Hemiramphus archipelagicus* Collette (Jumping halfbeak)
34. *H. far* (Forsskal) (Blackbarred halfbeak)
35. *H. lutkei* (Valenciennes) (Lutke's halfbeak)

Order 10. SCORPAENIFORMES

Family 17. PLATYCEPHALIDAE
(Flatheads)

36. *Platycephalus indicus* (Linnaeus) (Bartail flathead)

Order 11. PERCIFORMES

Family 18. CENTROPOMIDAE
(Snooks)

37. *Lates calcarifer* (Bloch) (Barramundi)

Family 19. SERRANIDAE
(Groupers)

38. *Epinephelus bleekeri* (Forskall) (Dusky tail grouper)

Family 20. TERAPONIDAE
(Terapons)

39. *Terapon jarbua* (Forsskal) (Jerbua terapon)
40. *T. theraps* Cuvier (Largescaled terapon)

Family 21. APOGONIDAE
(Cardinalfishes)

41. *Apogon thermalis* Cuvier (Half-barred cardinal)

Family 22. SILLAGINIDAE
(Smelt-whitings)

42. *Sillago sihama* (Forsskal) (Silver sillago)

Family 23. CARANGIDAE
(Jacks, Kingfishes and pompanos)

43. *Alepes ciliaris* (Bloch) (African pompano)
44. *A. djedaba* (Forsskal) (Shrimp scad)
45. *A. kleinii* (Bloch) (Razor belly scad)
46. *Atropus atropus* (Schneider) (Cleftbelly trevally)
47. *Caranx carangus* (Bloch) (Crevalle jack)
48. *C. ignobilis* (Forsskal) (Giant trevally)
49. *C. sexfasciatus* Quoy & Gaimard (Bigeye trevally)
50. *Decapterus russelli* (Ruppell) (Indian scad)
51. *Gnathonodon speciosus* (Forsskal) (Golden trevally)
52. *Megalaspis cordyla* (Linnaeus) (Torpedo scad)
53. *Naucrates ductor* Linnaeus (Pilotfish)
54. *Parastrumus niger* (Bloch) (Black pomfret)
55. *Scomberoides lysan* (Forsskal) (Double-spotted queenfish)
56. *S. tol* (Cuvier) (Needle scaled queenfish)
57. *Trachinotus blochii* (Lacepede) (Largespotted dart)

Family 24. CORYPHAENIDAE
(Dolphin fish)

58. *Coryphaena hippurus* (Common dolphin fish)

Family 25. LEIOGNATHIDAE
(Slipmouths or ponyfishes)

59. *Gazza minuta* (Bloch) (Toothpony)
60. *Leiognathus bindus* (Valenciennes) (Orangefin ponyfish)
61. *L. brevirostris* (Valenciennes) (Shortnose ponyfish)
62. *L. daura* (Cuvier) (Goldstripe ponyfish)
63. *L. equulus* (Forsskal) (Common ponyfish)
64. *Secutor insidiator* (Bloch) (Pugnose ponyfish)

Family 26. LUTJANIDAE
(Snappers)

65. *Lutjanus argentimaculatus* (Forsskal) (River snapper)
66. *L. johnii* (Bloch) (John's snapper)
67. *L. russellii* Bleeker (Red snapper)

Family 27. GERREIDAE
(Mojarras)

68. *Gerres erythrourus* (Bloch) (Deep bodied mojarras)
69. *G. limbatus* Cuvier (Saddleback silver-biddy)
70. *G. macracanthus* Bleeker (Long rayed mojarra)

Family 28. HAEMULIDAE
(Grunts)

71. *Pomadasys kaakan* (Cuvier) (Javelin grunter)
72. *P. maculatus* (Bloch) (Saddle grunt)

Family 29. NEMIPTERIDAE
(Threadfin breams, Whiptail breams)

73. *Nemipterus japonicus* (Bloch) (Japanese threadfin bream)

Family 30. SCIAENIDAE
(Drums or croakers)

74. *Chrysochir aureus* (Richardson) (Reeve's croaker)
75. *Jahnius carutta* (Bloch) (Karut croaker)
76. *Otolithes rubber* (Schneider) (Tiger-toothed croaker)

Family 31. MULLIDAE
(Goatfishes)

77. *Upeneus vittatus* (Forsskal) (Yellowstriped goatfish)

Family 32. MONODACTYLIDAE
(Moonyfishes or fingerfishes)

78. *Monodactylus argenteus* (Linnaeus) (Silvery moony)

Family 33. PEMPHERIDIDAE
(Sweepers)

79. *Pempheris vanicolensis* Cuvier (Vanikoro sweeper)

Family 34. SCATOPHAGIDAE
(Spotted scat)

80. *Scatophagus argus* (Bloch) (Spotted scat)

Family 35. CICHLIDAE
(Cichlids)

81. *Etroplus suratensis* (Bloch) (Green chromide)

Family 36. SPHYRAENIDAE
(Barracuda)

82. *Sphyaena jella* Cuvier (Pickhandle barracuda)

Family 37. POLYNYMIDAE
(Threadfins)

- 83. *Eleutheronema tatradyctylum* (Shaw) (Fourfinger threadfin)
- 84. *Filimanus xanthonema* (Valenciennes) (Yellowthread threadfin)
- 85. *Polydactylus mullani* (Hora) (Spotted Sevenfinger threadfin)

Family 38. GOBIIDAE
(Gobies)

- 86. *Caragobius urolepis* (Bleeker) (Scaleless worm goby)
- 87. *Odontamblyopus rubicundus* (Hamilton) (Rubicundus eelgoby)

Family 39. TRYPAUCHENIDAE
(Burrowing goby)

- 88. *Trypauchen vagina* (Bloch) (Burrowing goby)

Family 40. SIGANIDAE
(Rabbitfishes)

- 89. *Siganus canaliculatus* (Park) (White-spotted spinefoot)

Family 41. TRICHIURIDAE
(Cutlassfishes)

- 90. *Lepturacanthus pantului* (Gupta) (Coromandal ribbonfish)

Family 42. SCOMBRIDAE
(Mackerels, tunas, bonitos)

- 91. *Auxis thazard* (Lacepede) (Frigate tuna)
- 92. *Rastrelliger kanagurta* (Cuvier) (Indian mackerel)
- 93. *Scomberomorus commerson* (Lacepede) (Narrow-barred Spanish mackerel)
- 94. *S. guttatus* (Bloch & Schneider) (Indo-Pacific king mackerel)
- 95. *Scomberoides tol* (Cuvier) (Needlescaled queenfish)
- 96. *Thunnus albacares* (Bonnaterre) (Yellowfin tuna)
- 97. *T. tonggol* (Bleeker) (Longtail tuna)

Family 43. STROMATEIDAE
(Pomfret)

- 98. *Pampus argenteus* (Euphrasen) (Silver pomfret)
- 99. *P. chinensis* (Euphrasen) (Chinese silver pomfret)

Order 12. PLEURONECTIFORMES

Family 44. PARALICHTHYIDAE
(Large-tooth flounders)

- 100. *Pseudorhombus javanicus* (Bleeker) (Javan flounder)
- 101. *P. triocellatus* (Schneider) (Three spotted flounder)

Family 45. CYNOGLOSSIDAE
(Tonguefishes)

102. *Cynoglossus puncticeps* (Richardson) (Speckled tongesole)

Family 46. SOLEIDAE
(Soles)

103. *Solea ovata* Richardson (Ovate sole)
104. *Synaptura albomaculata* Kaup (Kaup's sole)

Order 13. TETRAODONTIFORMES

Family 47. TETRAODONTIDAE
(Puffers)

105. *Lagocephalus inermis* (Schneider) (Smooth-backed blowfish)
106. *Torquigener hypselogenion* (Bleeker) (Orange-spotted toadfish)

Family 48. DIODONTIDAE
(Porcupinefishes)

107. *Diodon hystrix* Lacepede (Spot-fin porcupinefish)
108. *D. holocanthus* Lacepede (Long spine porcupinefish)

DISCUSSIONS

The present study has recorded 108 species belonging to 48 families in 13 orders in Malvan Marine Sanctuary.

Analysis of these 108 species shows that it contains 4 vulnerable species viz. *Congresox talabonoides*, *Muraenesox cinereus*, *Tenualosa ilisha* and *Arius thalassinus* and two near threatened species viz. *Chiloscyllium griseum* and *Scalioton laticaudus*. It also contains some important commercial food fishes. The fishes of the family Carangidae form the dominating group consisting of 15 species among the important food fishes. The fishes of the family Scombridae and Clupeidae represented by 7 species each followed by Leiognathidae and Engraulidae represented by 6 species each.

Malvan Marine Sanctuary is the only Marine Sanctuary in Maharashtra. The sanctuary is rich in coral and marine life in addition to the mangroves. The creation of Marine Biosphere Reserves has increased due to the natural changes and human depredation in many coastal area. Several ecologically important species of plant and animal have been extinct and whatever remains, urgently need for conservation measures. This has necessitated for the declaration of the sanctuaries for the conservation and protection of the marine wild life. Since Malvan Marine Sanctuary contains four vulnerable fish species and two near threatened species in addition to the coral life and mangroves

the declaration of the Malvan coast as Marine Sanctuary recently is justified and it needs urgent legal protection.

SUMMARY

The samples of fishes collected during the surveys conducted during September 2004 and October 2005 have been examined and determined with the help of standard literature (Collette, B.B. and Neun, C.E. 1983, Day, 1875-78; de Bruin *et al.*, 1995; Fischer and Bianchi, 1984; Talwar, 1995; Talwar and Jhingran, 1991; Talwar and Kacker, 1984; Whitehead, P.J.P., 1985; Whitehead, P.J.P., Nelson, J. and Wongratana, T., 1988). In all, 110 species belonging to 48 families under 13 orders have been recorded from this sanctuary and the same is enlisted here under.

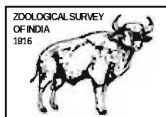
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ANALYSIS OF THE MORPHOMETRIC AND MERISTIC CHARACTERS OF THE FISH *NANDUS NANDUS* (HAMILTON) FROM THE NEW ALLUVIAL ZONE OF WEST BENGAL

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INTRODUCTION

Nandus nandus is also known as the Gangetic leaf fish. It inhabits fresh and brakish waters of India, Nepal, Pakistan, Bangladesh, Burma, Thailand and Malaysia. It occurs in ditches and inundated fields and is common in summer months when it is collected from dired-up beds of tanks, beels, bheries *etc.* and attains a length of 20 cm. It is a high-prized fish and had great demand in the market due to its taste and once used to fetch good price. But now it is rarely available in the market since its population has declined to an alarming extent in this region of West Bengal. This fish has been catergorised as critically endangered by Das and De, 2002.

Morphological variation in fish have been cited by various authors for different species of fishes but no report is available on the morphometric and meristic analysis of *Nandus nandus*. It is very much essential to record the morphological and meristic characters of different species of fishes for solving the race problem. With this aim the present work on the morphometric and meristic characters of *Nandus nandus* has been undertaken from the New Alluvial Zone of West Bengal.

MATERIALS AND METHODS

The materials of the present study pertains to the specimens of *Nandus nandus* collected from Mogra beel, situated at Birohi in the Nadia district of the New Alluvial Zone of West Bengal (Latitude 21.5–24.5° North and Longitude 86–89° East) during the period August 2001 to July 2003.

Collections were made mostly at fortnightly intervals. The study is based on the examination of 158 specimens of *Nandus nandus* in the size range of 20.0 mm to 160.0 mm.

Divider and measuring board, having graduation in millimeter have been used for various measurements. A total of 23 morphometric parameters have been undertaken according to Lowe Mc Connell (1971).

Biometric Index :

The number of times each character went into the reference length of the fish was considered as the Biometric Index (Tobor, 1974). Biometric study was done for 10 morphometric characters. For each character, a mean index for each 1 mm length group has been calculated to see whether it is constant or varying with the increase in total length and head length.

Meristic Characters :

Seven meristic characters were taken up for study following Lowe Mc Connell (1971).

All the measurements and counts were made on the left side of the fish. The specimens of *N. nandus* taken up for the present study were grouped into 1 mm length groups for convenience sake by pooling the data together, viz., Group I : 20.0–30.0 mm, Group II : 30.0–40.0 mm and so on. In this way 14 groups of *N. nandus* could be made.

The regression method has been applied in various morphometric parameters with the formula :

$$Y = a + bX$$

where 'Y' is the variable character such as total length, head length etc., 'a' is the constant value to be determined, 'b' is the regression coefficient and 'X' is the standard length or head length. The values of 'a' and 'b' were determined by the formula :

$$b = \frac{XY - N\bar{X}\bar{Y}}{X - N\bar{X}}, \quad a = Y - bX$$

where, N = total number of length groups, X = mean of 'X' and Y = mean of 'Y'.

All linear measurements were made to the nearest 0.1 mm then converted to a percentage of the standard length and head length. Mean, range and 'b' values were tabulated and compared.

RESULTS AND DISCUSSION

The morphometric characters showed a proportional positive increase with increase in length of the fish. The mean and range of these values have been presented in Table 1. Among the meristic characters the number of pectoral, ventral and caudal fin rays were constant. The number of dorsal, anal lateral line scales and lateral line transverse scales showed variations without any relation to length of the fish. The average values and the range of variations of the variable meristic characters are shown in Table 2.

The regression coefficient 'b' (Table 3) of different variable characters (Y) on total length (X) indicates that the rate of growth in respect to total length is highest in case of anal length

Table 1. : Morphometric analysis of *Nandus nandus*.

Parameters	% Total length	
	Mean	Range
Head length	35.72	34.45 – 37.06
Predorsal length	37.71	35.73 – 40.80
Anal length	59.31	58.45 – 66.30
Girth length	68.24	65.78 – 74.64
Body depth	28.20	25.00 – 32.43
Head depth	22.54	20.68 – 23.63
Dorsal fin height	13.32	12.20 – 14.94
Dorsal fin base	40.85	38.79 – 42.99
Pectoral fin length	13.38	12.50 – 14.66
Pectoral fin base	05.17	04.82 – 05.74
Anal fin length	14.06	11.28 – 17.52
Anal fin base	11.52	10.74 – 13.21
Ventral fin length	14.60	13.53 – 16.66
Ventral fin base	04.75	03.95 – 06.32
Length of caudal peduncle	11.01	10.52 – 11.78
Least height of caudal peduncle	10.32	09.51 – 10.92
Parameters	% Head length	
	Mean	Range
Pre-orbital length	33.85	31.11 – 36.43
Inter-orbital length	18.86	17.66 – 21.70
Post-orbital length	47.41	40.31 – 50.77
Eye diameter	21.07	17.73 – 24.80
Upper jaw length	33.53	30.72 – 39.53
Lower jaw length	30.53	27.27 – 35.65
Gape width	31.97	28.57 – 35.32

Table 2. : Meristic characters of *Nandus nandus*.

Parameters	Mean	Range
No. of dorsal fin rays	13 / 12	12–14 / 11–13
No. of pectoral fin rays	–	16 (constant)
No. of ventral fin rays	–	1 / 5 (constant)
No. of anal fin rays	3 / 7	3 / 7–9
No. of caudal fin rays	–	15 (constant)
No. of lateral line scales	52.5	46–59
No. of lateral line transverse scales	5.75 / 13.5	5.5–6 / 7–20

Table 3. : Regression equation of morphometric parameters of *Nandus nandus*.

Parameters	Regression equation	Correlation coefficient 'r'
Predorsal length (Y) on total length (X)	$Y = 2.5372 + 0.3417 X$	0.9988
Head length (Y) on total length (X)	$Y = 1.1074 + 0.3410 X$	0.9986
Eye diameter (Y) on total length (X)	$Y = 1.6951 + 0.0523 X$	0.9942
Pre-orbital length (Y) on total length (X)	$Y = 0.7635 + 0.1111 X$	0.9824
Inter-orbital distance (Y) on total length (X)	$Y = 0.2260 + 0.0635 X$	0.9921
Post-orbital length (Y) on total length (X)	$Y = -0.6348 + 0.1809 X$	0.9971
Gape (Y) on total length (X)	$Y = -0.1008 + 0.1141 X$	0.9743
Length of upper jaw (Y) on total length (X)	$Y = 1.9282 + 0.0918 X$	0.9907
Length of lower jaw (Y) on total length (X)	$Y = 1.6966 + 0.0839 X$	0.9827
Head depth (Y) on total length (X)	$Y = -0.6887 + 0.2348 X$	0.9902
Body depth (Y) on total length (X)	$Y = -3.9099 + 0.3354 X$	0.9967
Anal length (Y) on total length (X)	$Y = 0.2197 + 0.5961 X$	0.9965
Girth (Y) on total length (X)	$Y = -5.7919 + 0.7607 X$	0.9945
Dorsal fin height (Y) on total length (X)	$Y = 1.4615 + 0.9952 X$	0.9952
Dorsal fin base (Y) on total length (X)	$Y = -1.5252 + 0.4305 X$	0.9970
Pectoral fin height (Y) on total length (X)	$Y = 0.3946 + 0.1284 X$	0.9902
Pectoral fin base (Y) on total length (X)	$Y = 0.3740 + 0.0471 X$	0.9924
Anal fin length (Y) on total length (X)	$Y = 3.9829 + 0.0884 X$	0.9333
Anal fin base (Y) on total length (X)	$Y = -0.1691 + 0.1180 X$	0.9912
Ventral fin height (Y) on total length (X)	$Y = 1.7138 + 0.1223 X$	0.9948
Ventral fin base (Y) on total length (X)	$Y = 0.9250 + 0.0361 X$	0.9627
Length of caudal peduncle (Y) on total length (X)	$Y = 0.3430 + 0.1056 X$	0.9968
Least height of caudal peduncle (Y) on total length (X)	$Y = -0.3300 + 0.1091 X$	0.9957
Eye diameter (Y) on head length (X)	$Y = 1.5371 + 0.1530 X$	0.9926
Pre-orbital length (Y) on head length (X)	$Y = 0.0617 + 0.1849 X$	0.9867
Inter-orbital distance (Y) on head length (X)	$Y = 0.3521 + 0.3274 X$	0.9886
Post-orbital length (Y) on head length (X)	$Y = -1.2000 + 0.5298 X$	0.9969
Length of upper jaw (Y) on head length (X)	$Y = 1.6399 + 0.2689 X$	0.9913
Length of lower jaw (Y) on head length (X)	$Y = 1.4159 + 0.2463 X$	0.9846
Gape (Y) on head length (X)	$Y = -0.5253 + 0.3363 X$	0.9803

Table 4. : Mean Biometric indices of *Nandus nandus* at different length groups.

Mean parameters in total length	Length Groups						
	Gr-I	Gr-II	Gr-III	Gr-IV	Gr-V	Gr-VI	Gr-VII
TL / HL	2.69	2.74	2.76	2.87	2.81	2.80	2.90
TL / HD	4.83	4.70	4.44	4.37	4.23	4.28	4.23
TL / BD	4.00	3.82	3.67	3.55	3.44	3.37	3.08
TL / Girth	1.51	1.52	1.48	1.50	1.45	1.44	1.33
TL / Gape	8.28	9.50	9.69	8.93	7.96	8.36	8.82
HL / ED	4.03	4.09	4.66	4.71	5.06	5.63	5.49
HL / POL i	2.74	3.21	2.96	2.99	2.76	2.94	3.09
HL / IOL	4.60	5.45	5.60	5.27	5.66	5.56	5.11
HL / POL ii	2.48	2.16	2.06	2.05	2.11	1.96	1.98
HL / Gape	3.07	3.46	3.50	3.11	2.83	2.98	3.04

Note : TL = Total length, HL = Head length, HD = Head depth, BD = Body depth, ED = Eye diameter, POL i = Pre-orbital length, IOL = Inter-orbital length, POL ii = Post-orbital length

Table 5. : Morphometric analysis of males and females of *Nandus nandus*.

Parameters	% Total length (mean values)	
	Males	Females
Head length	35.39	35.22
Pre-dorsal length	37.38	37.38
Anal length	57.28	58.91
Girth length	67.22	67.25
Body depth	28.29	29.04
Head depth	23.30	23.34
Dorsal fin height	13.51	12.87
Dorsal fin base	40.10	42.22
Pectoral fin length	15.29	13.08
Pectoral fin base	05.34	03.35
Anal fin length	14.03	13.70
Anal fin base	11.94	11.12
Ventral fin length	15.29	14.00
Ventral fin base	04.71	05.04
Length of caudal peduncle	10.78	10.50
Least height of caudal peduncle	10.78	10.40

Table 5. : (Cont'd.).

Parameters	% Total length (mean values)	
	Males	Females
Pre-orbital length	34.91	33.04
Inter-orbital length	17.78	17.54
Post-orbital length	47.04	47.95
Eye diameter	21.00	21.93
Upper jaw length	32.84	34.50
Lower jaw length	29.58	33.04
Gape width	40.23	31.28

($b = 0.5961$) and lowest in case of ventral fin base ($b = 0.036$). High values of correlation coefficient, 'r' (Table 3) obtained indicates a high degree of positive correlation between the different morphometric parameters with the reference length (total length).

Biometric Index of *N. nandus* indicates that the indices of head length and girth in relation to total length are almost constant (Fig. 1). According to Bayagbona (1963), a constant index in any of the biometric characters in relation to its reference length is isometric. Similar observations has been reported by Dasgupta (1989) in *Acrossocheilus hexagonolepis*. The indices of body depth and head depth increase in relation to total length (Fig. 1). The eye diameter becomes progressively smaller in relation to head length (Fig. 1) and showed negative allometry. A similar case has been reported by Tobor (1974) in *Lates niloticus* and Dasgupta (1989) in *Acrossocheilus hexagonolepis*. The growth of inter-orbital length and gape in relation to head length was found to be allometric and showed variations. Dasgupta (1990) also reported allometric growth of inter-orbital distance in relation to head length in *Tor tor*.

The use of 'r' statistic thus indicates that predorsal length is the most significantly correlated ($r = 0.9988$) body part of the fish in relation to total length. The least significantly correlated ($r = 0.9333$) body part is the anal fin length. The head length is the second highly correlated ($r = 0.9986$) body part. Nautiyal and Lal (1988) showed predorsal length as the most significantly correlated variable in the Garhwal Himalayan Mahseer while Johal *et al.*, (1994) and Bhatt (1997) found the standard length as the most correlated body part in *Tor putitora* from Gobind sagar reservoir and in the river Ganga between Rishikesh and Hardwar.

In the present case of study of the fish, high degree of positive correlation was also found among the different head parts with the head length as indicated by high values of correlation coefficient 'r' (Table 3). The post orbital length is the most significantly correlated ($r = 0.9969$) head part of the fish in relation to head length, and gape width the least correlated ($r = 0.9803$) variable. Bhatt (1997) reported the eye diameter to be the least correlated variable in *Tor putitora* from the river Ganga between Rishikesh and Haridwar.

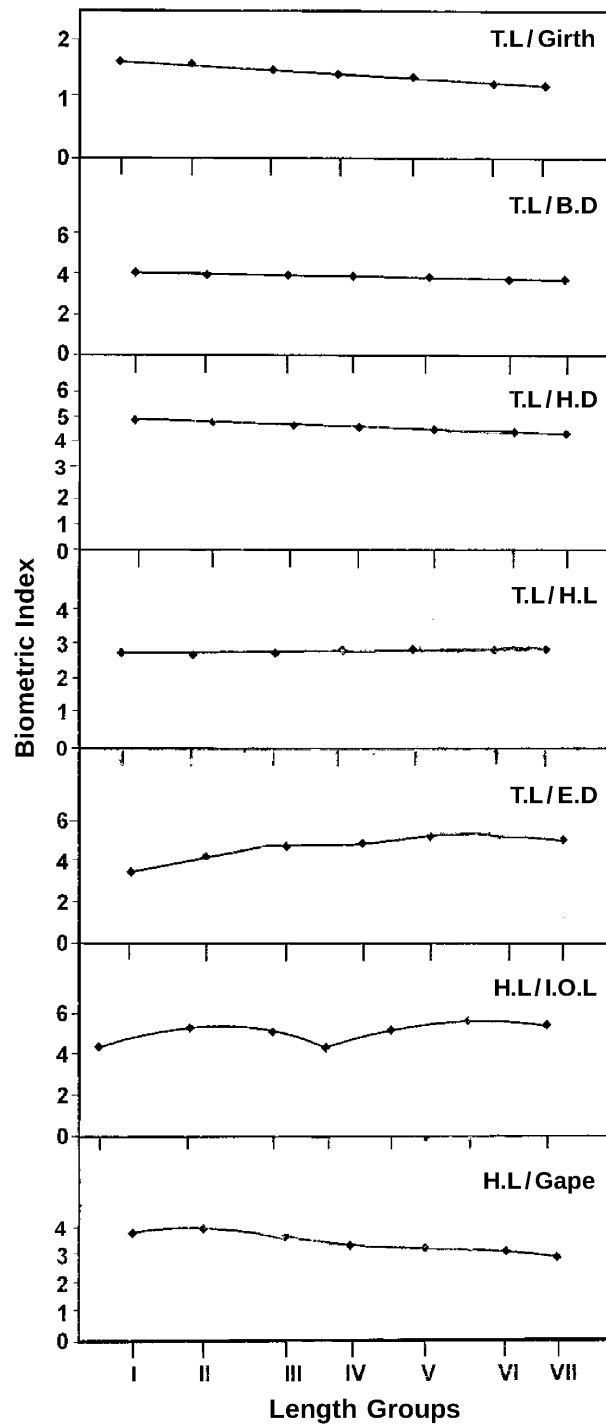


Fig. 1. : Biometric indices of *Nandus nandus* at different length groups

In the fish-sample lot of *N. nandus* under study, considerable difference in the morphometric characters has been observed between males and females (Table 5). The males were found to have greater height of dorsal, pectoral, anal, ventral fins and greater length of caudal peduncle than those of the females. On the other hand the females had greater eye diameter, upper and lower jaw length, body depth and head depth. Similar cases have been reported by Dasgupta (1989 and 1990) in *A. hexagonolepis* and *Tor tor*. Nikolsky (1963) has stated that males and females often differ in the length and shape of the fins. According to him, in the males of many cyprinoids, both the paired and the unpaired fins are slightly larger than those of the females, as has been observed in the present study too. He cited examples of some species where males were found to differ in length and shape of fins. For example, in the males of certain Lake Baikal sculpins, *Cotio comephorus* spp., the thoracic fins were found to be significantly larger. He further stated that in *Xiphophorus* (Fam. Poeciliidae) there is a long outgrowth of the caudal fin whereas in the males of many pleuronectes of the family Bothidae, the rays of the dorsal fin are elongated, and so on. In majority of cases the difference in the structure of the fins between males and females is connected with the peculiarities of reproduction. As for example, the dorsal fin of the grayling, *Thymallus*, which is larger in the male than in the female and increases still further towards the time of spawning, creates a turbulence close to the spawning fish during the spawning process, and delays the dispersal of the sperm by fast currents (Brown, 1938). The larger size of the pelvic fins of the male *Tinch* facilitates a more successful fertilization of the eggs and their attachment to plant stalks (Nikolsky, 1963). Hence such a difference in the morphometric characters of males and females may be represented as sexually dimorphic characters in *Nandus nandus* also.

According to Gould (1966), ratios between morphological characters of fish will not necessarily be constant for the organisms of the same species due to variation resulting from differences in sex, race and nutrition and/or other environmental factors.

Various authors have shown that morphometric characters of fish can vary under the influence of the environment and, in particular, the thermal factor during the period of incubation and the beginning of larval life (Schmidt, 1921; Barlow, 1961). According to Hubbs (1922) and Tanning (1944) variation occurs in the number of rays in the unpaired fins in several species which is also related to an adaptation to movement of water of various density.

Variation in the body proportions in the same species, according to hydrographic conditions, have also been reported by various authors (Hubbs, 1922; Barlow, 1961). They associated these variations with the effect of the duration of periods of growth and of the relating differentiations which determine the number of vertebrae and of segments.

Many authors (Schmidt, 1921; Vladykov, 1934; Tanning, 1944; Lindsay, 1954; Barlow, 1961) have reported that meristic characters, exhibit plasticity under the influence of environmental factors.

Zupanovic (1968) stated, "as it is essential to distinguish between different species, so it is essential to distinguish between the self perpetuating sub-groups within the species. These sub-groups may be equivalent to what taxonomists calls sub-species, but they may be generally of lesser rank. In the fishery literature, they are often called races or populations". This study will be helpful in comparing the morphological and meristic data with populations of *Nandus nandus* from geographical regions.

SUMMARY

A study on the morphometric and meristic characters of *Nandus nandus* was conducted from the New Alluvial Zone of West Bengal. A total of 23 morphometric characters and a total of 7 meristic characters were analysed. The morphometric characters of the species showed proportional positive growth with the increasing length of the fish and a high degree of positive correlation with the reference length. Some of the meristic characters were found to be constant while some varied. The biometric index indicated that the growth of head length, head depth, body depth and girth in relation to total length is isometric while the growth of inter-orbital length and gape in relation to head length is allometric. The eye diameter becomes progressively smaller in relation to head length. Some difference has been observed between male and female of the species.

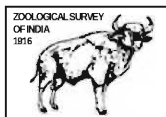
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STATUS OF HOOVED MAMMALS IN THE CONSERVATION AREAS OF RAIPUR DISTRICT, CHHATTISGARH, INDIA

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INTRODUCTION

Chhattisgarh state, located in Central India, has been carved out of Madhya Pradesh state. It is surrounded by Andhra Pradesh in south, Jharkhand and Orissa in east, Madhya Pradesh and Maharashtra in west and Uttar Pradesh and Jharkhand in the north.

The state is very rich in natural resources, mainly minerals, power and forest products. A large amount of revenue comes from mining (mainly bauxite, limestone, coal and iron ore) and forest products. The well known Bailadila mines are in this state. The steel plant of Bhilai and cement factories generate sizeable revenue for the state.

The total recorded forest area of the state is 59285 sq. km. and is one of the most forested states of India. 44% of the state's geographical area is under forest cover which is about 7.7% of the country's forest area (MOEF 2001).

Forest Survey of India in its report of 2001 has mentioned that in the state 40.4% is reserve forest, 52.5% is protected forest and 7.1% is unclassified forest. The dense forest is about 28.0%, open forest 13.7% and non-forest land 58.2% (MOEF 2001).

The state is having three National Parks and 11 Wildlife Sanctuaries of which 3 Wildlife Sanctuaries are located in Raipur district.

Detailed report on the status of different hoofed species of mammals present within these sanctuaries is not available except for a few scattered publications (Ranjitsinh *et al.*, 2004; Kotwal *et al.*, 2002, 2004).

As a result, Zoological Survey of India, took up this project as a part of the studies on the status of different species of mammals in conservation areas of the country and conducted one field survey during November–December, 2000 and all the sanctuaries were surveyed for six consecutive days.

During this survey attempts were made to identify the existing population trend and factors affecting them. For this purpose, in addition to systematic field observations, necessary discussion were held with local people as well as management authorities. Status of different hoofed mammal species found within the sanctuaries of Raipur district has been discussed along with ecological conditions in this paper.

PHYSICAL FEATURES

The state falls under the Deccan Biogeographical Zone of Rodgers *et al.*, (2000). Of its forests, 11.0% are under the Protected Area Network.

There are four major forest types, viz. Tropical Moist Deciduous, Tropical Dry Deciduous, Tropical Thorn and Subtropical Broadleaf Hill forest. Forests are mainly distributed in the north and in the southern parts of the state.

There are three seasons, namely monsoon (July to October), winter (November to February) and summer (March to June). The annual temperature ranges from 4° to 45°C and the annual rainfall varies between 800 mm and 1800 mm.

WILDLIFE SANCTUARIES OF RAIPUR DISTRICT

The district Raipur is situated in the fertile plains of Chhattisgarh. It is surrounded by Bilaspur district in the north, Bastar district and part of Orissa in the south, Raigarh district in the east and the district of Durg in the west. The total geographical area of the district is 1344500 ha.

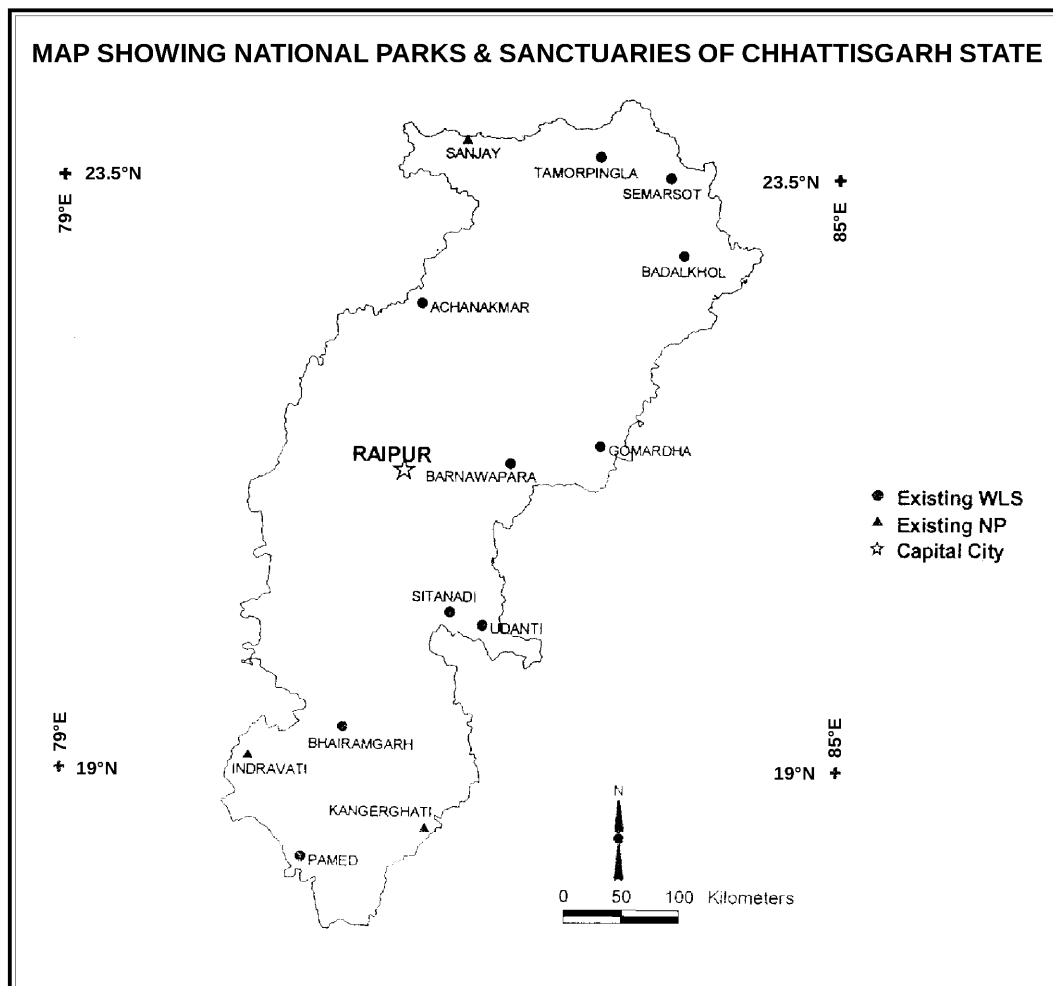
The district has three Wildlife Sanctuaries as detailed below :

1. BARNAWAPARA WILDLIFE SANCTUARY

Established in July, 1976 the sanctuary with an area of 24466 ha lies between 21°25'16" N latitude and 82°26'36" E longitude. The sanctuary falls within the Biogeographic Zone of Deccan Peninsula with Tropical Dry Deciduous Forests.

The name Barnawapara has been derived from Bar and Nawapara forest villages which are close to each other and situated in the middle of the sanctuary. It falls under Raipur Forest Division and includes reserve forests of Lawan and Sonakhan Forest Ranges. It is situated 15 km north of block headquarters Pithora on National Highway 6, 100 km from Raipur town, and is approachable in all seasons.

The terrain is generally flat, with some hills varying between 265 & 400 m in altitudes. There are numerous perennial and seasonal streams which are all tributaries of Mahanadi River. Most of these streams dry out during summer. Forest Department has constructed number of waterholes, where most of the wildlife concentrate during summer.



According to Champion and Seth (1968) the forest can be classified as Dry Teak, Dry Sal and South Indian Dry Deciduous Mixed Forest. Teak occurs mainly in Schistose Rock and in alluvial banks around rivers and streams, the important area being Tenduchua hills. Sal is found mainly around village Gidpuri. Mixed forest areas harbour Bamboo, *Terminalia* sp. and other species.

2. GOMARDA WILDLIFE SANCTUARY

Established in August 1975, the sanctuary with an area of 27791 ha lies between 21°30'24" N latitude and 83°06'47" E longitude. The sanctuary falls within Biogeographic zone of Deccan Peninsula having Tropical Dry Deciduous Forest.

The name Gomarda has been derived from the village Gomarda in Saranath tehsil of Raipur district. The sanctuary is 15 km south of Saranath on Raigarh–Saranath–Saraipali State Highway

which bisects the sanctuary. The terrain is gently undulating, with numerous boulders and rocks, unfit for cultivation, hence naturally protected. The main water source is the perennial Lath Nullah, a natural stream and two medium sized tanks.

The vegetation of the sanctuary is typical Tropical Dry Deciduous Forest with predominance of Teak, Bamboo (*Dendrocalamus strictus*) and *Terminalia* sp.

3. UDANTI SANCTUARY

Established in March 1983, the sanctuary with an area of 24760 ha lies between 19°55'30"–20°11'15" N latitude and 82°11'10"–82°24'10" E longitude. The sanctuary falls within the Biogeographic zone of Deccan Peninsula having Tropical Dry Deciduous Forest.

The name Udanti has been derived from the river Udanti which flow through the sanctuary. The sanctuary is located in the Brindanawagarh tehsil of Raipur district and 210 km southeast of Raipur. The eastern boundary of the sanctuary is the interstate boundary between Chhattisgarh and Orissa.

The habitat of the sanctuary is representative of Mixed Dry Deciduous Forest (Champion and Seth 1968). The dominant plant species are Sal mixed with species *Terminalia*, *Anogeissus*, *Pterocarpus* and bamboo. Teak has been introduced by State Forest Department. The main water source is the Udanti River and its tributaries. The river is not perennial but small pools always retain water even in summer.

METHODOLOGY

Observations were made while moving on foot and in vehicle, visiting different places in the early morning, at noon and in the evening. All possible areas of ungulate habitats were surveyed. Observations were also made from temporary observation towers built on trees at selected places near drinking, feeding and resting places. The animals were observed with the help of 7 × 50 binoculars. For estimating the population dung density and hoof marks were also taken into consideration.

STATUS OF HOOFED MAMMALS IN DIFFERENT SANCTUARIES

Order ARTIODACTYLA

Family SUIDAE

Subfamily SUINAE

1. *Sus scrofa* Linnaeus, 1758

1758. *Sus scrofa* Linnaeus, *Syst. Nat.*, 10th ed., 1 : 49.

Common names : Wild Boar (Eng.); Suar, Barba, Bad Janwar, Bura Janwar (Hin.).

Remarks : In Barnawapara 50 animals were seen in three herds; in Gomarda 40 animals were seen in four herds and in Udanti 45 animals were seen in three herds. From the above observation it is quite evident that this species is most common and the sanctuaries maintain a good population.

Family CERVIDAE

Subfamily CERVINAE

2. *Axis axis* (Erxleben, 1777)

1777. *Cervus axis* Erxleben, *Syst. Regn. Anim.*, 1 : 312.

Common names : Spotted Deer, Axis Deer (Eng.); Chital, Chitra, Jhank (Hin.).

Remarks : In Barnawapara 15 animals were seen in three herds, in Gomarda 8 animals were seen in two herds and in Udanti 12 animals were seen in three herds. Though this animal was seen in less number but from hoof marks and dung density found at different places it can be concluded that all the sanctuaries are having good population of this deer.

3. *Cervus unicolor* Kerr, 1792

1792. *Cervus unicolor* Kerr, *In. Linnaeus, Anim. Kingdom*, p. 300.

Common names : Sambar (Eng.); Sambhar, Samar (Hin.).

Remarks : In Barnawapara 18 animals were seen in four herds, in Gomarda 12 animals were seen in two herds and in Udanti 15 animals were seen in five herds. From actual sighting, hoof marks and dung density found at different places it can be concluded that a good population of this deer exists in the three sanctuaries.

Subfamily MONTIACINAE

4. *Muntiacus muntjak* (Zimmermann, 1780)

1780. *Cervus muntjak* Zimmermann, *Geogr. Gesch. Mensch. Vierf. Thiere.*, 2 : 131.

Common names : Indian Muntjak, Barking Deer, Rib-faced Deer (Eng.); Kakar (Hin.).

Remarks : In Barnawapara 10 animals were seen in total, in Gomarda 9 animals were seen in total and in Udanti 12 animals were seen in total. From actual sighting of animals and also from dung density and hoof marks found at different places it appeared that the population of this deer species is less in comparison to viz. Spotted Deer and Sambar populations found in these three sanctuaries.

Family BOVIDAE
Subfamily ANTILOPINAE

5. **Gazella bennettii** (Sykes, 1831)

1831. *Anilope bennettii* Sykes, *Proc. Zool. Soc. London*, **1830-31** : 104 (1831).

Common names : Indian Gazelle, Chinkara (Eng.); Chinkara, Kal Punch (Hin.).

Remarks : In Barnawapara 3 animals were seen in total, in Gomarda not a single specimen were seen and in Udanti only two animals could be seen. From actual sighting and also from hoof marks and dung density found at different places it appeared that the population of this bovid species in Barnawapara and Udanti is very meagre. In Gomarda existence of this bovid species could not be established.

Subfamily BOVINAE

6. **Tetracerus quadricornis** (Blainville, 1816)

1816. *Cerophorus quadricornis* Blainville, *Bull. Sci. Soc. Philom*, p. 75.

Common names : Four-horned Antelope (Eng.); Chausingha, Chowka, Doda (Hin.).

Remarks : In Barnawapara 6 animals were seen in total, in Gomarda 4 animals were seen in total and in Udanti 5 animals were seen in total. From actual sighting of animals and also from hoof marks and dung density found at different places it appeared that the three sanctuaries maintain a thin population of this bovid species.

7. **Boselaphus tragocamelus** (Pallas, 1766)

1766. *Antilope tragocamelus* Pallas, *Misc. Zoo/.*, p. 5.

Common names : Blue Bull (Eng.); Nilgai, Nil, Rojh, Roz, Rozra (Hin.).

Remarks : In Barnawapara 6 animals were seen in two herds, in Gomarda 4 animals were seen in a single herd and in Udanti 16 animals were seen in three herds. From actual sighting and also from hoof marks and dung density found at different places it appeared that the three sanctuaries maintain a good population of this animal, the maximum concentration being found at Udanti followed by a lesser concentration at Barnawapara; but a very thin population at Gomarda.

8. **Bos frontalis** Lambert, 1804

1758. *Bos frontalis* Lambert, *Tram. Linn. Soc. London*, **7** : 57.

Common names : Indian Bison (Eng.); Gaur, Gaur Gai (Hin.).

Remarks : In Barnawapara 38 animals were seen in three herds and 4 animals in a single herd at Gomarda. At Udanti we could not see any animal. From actual sighting and also from hoof

marks and dung density found at different places it appeared that Barnawapara sanctuary maintains a very viable population of this animal followed by a very thin population at Gomarda sanctuary. Existence of this animal at Udanti sanctuary could not be established.

9. *Bubalus bubalis* (Linnaeus, 1758)

1758. *Bos bubalis* Linnaeus, *Syst. Nat.*, 10th ed., 1 : 72.

Common names : Water Buffalo, Indian Buffalo (Eng.); Arna [Male], Arni [Female] (Hin.).

Remarks : Only in Udanti sanctuary we could see 50 animals in four herds. Not a single animal could be seen in rest of the sanctuaries. According to the records of the Udanti Forest Department 78 animals exist in the sanctuary. Kotwal *et al.*, (2002) have reported to have seen 27 animals in 6 herds. Ranjitsinh *et al.*, (2004) have assessed about 42-44 buffaloes while Kotwal *et al.*, (2004) have assessed 35-40 buffaloes in the sanctuary. Sitanadi Sanctuary of Dhamtari district is located at a distance of about 30 km from Udanti Sanctuary having a corridor of good forest cover. Both these sanctuaries form a compact forest for free movement of wildlife, particularly the buffaloes which is the State mammal. This may be the prime cause for difference in estimation of this animal by different workers. To have a correct estimation of the population of this animal these two sanctuaries are to be surveyed together for the purpose during a particular period.

DISCUSSION

The survey conducted revealed that a very good population of *Sus scrofa* Linnaeus, *Axis axis* (Erxleben) and *Cervus unicolor* Kerr exists followed by a comparatively lesser population of *Muntiacus muntjak* (Zimmermann). A very thin population of *Gazella bennettii* (Sykes) was observed in Barnawapara and Udanti only. *Tetracerus quadricornis* (Blainville) is represented there by a very thin population. *Boselaphus tragocamelus* (Pallas) is represented by a good population in Udanti followed by a lesser population in Barnawapara and Gomarda. *Bos frontalis* Lambert is represented by a good population in Barnawapara followed by a thin population in Gomarda but found absent in Udanti. *Bubalus bubalis* (Linnaeus) is represented by a good population only in Udanti.

THREATS

The sanctuaries of the district were found to have different kind of problems which pose threat to the existence of the wild animals. The same is discussed below separately for the individual sanctuary.

a) Barnawapara Wildlife Sanctuary :

The sanctuary was found to have 25 forest villages inside with a human population of about 7000 (Tiwari 1997) and livestock population of about 8500. These livestock share the forest and

its products with wildlife resulting in disturbance to the natural ecosystems. Man-animal conflict was found to be very common involving Sloth Bear and Leopard. The site being a major attraction for tourists and pilgrims its natural habitat was found to be deteriorating progressively.

Man-made forest fires also found to pose a threat to the site. These fires are started to facilitate the collection of Mahua flowers and Tendu leaves, for which the local inhabitants are allowed and they were found to collect these from all over the sanctuary. Unfortunately, the time of their collection coincides with the breeding season of certain ungulates and causes disturbance.

b) Gomarda Wildlife Sanctuary :

The area was found to have 6 villages well within and 24 villages around it with total human populations of about 7000 and more than 10000 cattle. These cattle were found to compete with the wildlife to share the limited forest resources.

Villagers are allowed to collect forest products like Tendu leaves, honey, fallen timber, grass, etc. The head loads of wood which are allowed to be collected to be used as fuel were found to land up in the market. Villagers start fires to facilitate collection of forest produce, unfortunately, coincides with the main breeding time for certain ungulates. Crop damage by ungulates is quite common, especially in forest villages.

Poaching of ungulates was found still to be a problem at the periphery of the sanctuary, which was completely surrounded by human habitations. The wild ungulates were found to fall into traps and snares when they were going out in search of food.

c) Udanti Sanctuary :

The sanctuary was constituted mainly to protect the remnant population of Wild Buffalo. But about 50 villages with more than 16000 human population and more than 10000 cattle still live within the sanctuary (Kotwal *et al.*, 2002). Since they are totally dependent on the sanctuary for fuel wood, timber, *etc.*, several conflicts were found to occur between locals and the wild ungulates. Many villages were found to be located in the prime wild buffalo habitat where the people were found to move continuously.

The plain area where grasses can grow were found to be encroached by local villagers for agriculture and as a result due to paucity of grasses, the wild ungulates sometimes found to be grazing on agriculture land. While trying to save the crops people at times were found to injure the wild ungulates.

Water was found to be a limiting factor and as a result sharing of water holes by livestock and wild ungulates was found to be a cause of conflicts and conveyance of diseases. According to the local Forest Officials the common diseases reported from the area are rinderpest, foot and mouth disease and some bacterial diseases. It was found that the diseased domestic cattle graze in the

grassland where wild ungulates also graze and thus the contagious diseases are transferred from one to other. Besides it also poses a problem of genetic swarming.

However, the long-term and irreversible threat comes from the plans for diamond mining. B. Vijaykumar Chhattisgarh Exploration Co. has already dug out samples from the sanctuary, and has also set up its own Kimberlite Sample Processing Laboratory near Mainpur Village.

Finally, Man-made forest fire is also causing a serious problem and resulting in habitat destruction.

RECOMMENDATIONS

1. An updated management plan has to be prepared for all the sanctuaries.
2. Wild ungulates need large tract of undisturbed forest with grassy opening preferably with moist and marshy patches and perennial water. This need be ensured in all management applications and disturbance factors should not be ignored.
3. The possibility of shifting forest villages from the sanctuary need be explored as it will be good for wild ungulates.
4. There should be restriction on the number of livestock and these should be fed rather than allowed to graze freely in the forest.
5. The water tanks that have been made for wild ungulates must be kept free from human and livestock disturbances.
6. Cultivation of fodder in the wasteland may be initiated to minimize the grazing pressure.
7. All the domestic cattle around the sanctuary must be inoculated every year to minimize spreading of contagious diseases.
8. Eco-development programme should be taken up in the buffer area of the sanctuaries to reduce the biotic pressure and shifting of the inhabitants by providing alternatives.
9. Forest corridor around the sanctuaries need to be strengthened.
10. The interface conflicts within the sanctuary need be monitored regularly.
11. The local inhabitants should be involved in several management activities of the sanctuary leading towards conservation of nature.
12. Man-made forest fire during summer has been reported to be a common feature. Due to lack of proper antifire measures, lot of habitat is getting destroyed. Proper measures may be initiated to protect the habitat for better survival of the wild ungulates.

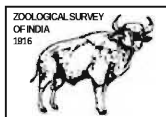
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ON SOME FRESHWATER BRYOZOA PRESENT IN THE UNNAMED COLLECTION OF ZOOLOGICAL SURVEY OF INDIA FROM UTTAR PRADESH

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INTRODUCTION

Freshwater bryozoa belongs to smaller coelomate groups comprising five families of the phylum bryozoa with relatively simple body organization. They live in the aquatic environment of ponds, reservoirs, lakes, streams and adhering to the surface of the substratum *i.e.*, aquatic weeds, logs, stones, bricks etc. They live together in the form a colony, usually yellowish-brown, pinkish-brown, dark-brown, reddish-brown, green or black in colour. Approximately 5000 living species of bryozoa exist today of which between 45 and 50 occur in freshwater. The majority of these belong to the class Phylactolaemata.

Work on Freshwater bryozoa in India initiated by Annandale (1911) followed by Roonwal (1969), Rao (1972, 1976, 1991), Rao *et al.*, (1962, 1978, 1979, 1985), Srivastava (1981, 1985), Agarwal *et al.*, (1981) and Chaubey *et al.*, (1985) from different localities. As a result twenty species have so far been recorded from India, out of which only five species are reported from Uttar Pradesh. The present author has dealt with nine species from West Bengal, five from Meghalaya, four from Tripura, four from Sikkim and six species from Andhra Pradesh.

The present work is based on the study of the Freshwater bryozoa collected from the four districts of Uttar Pradesh. The material was collected through field surveys from Basti, Deoria and Gorakhpur districts during June, 1989 and from Kheri district during April 1990. The material so far collected is represented by five species under four genera and three families, none of them is new to science but all the species show new locality records. The present paper deals with the synonymy (original and latest ones) and distribution of five species.

SYSTEMATIC ACCOUNT

A. Class GYMNOLAEMATA

Order CTENOSTOMATA

I. Family HISLOPIIDAE

1. Genus *Hislopia* Carter

1. *Hislopia lacustris* Carter, 1858

B. Class PHYLACTOLAEMATA

II. Family FREDERICELLIDAE

2. Genus *Fredericella* Gervais

2. *Fredericella sultana* (Blumenbach, 1779)

III. Family PLUMATELLIDAE

3. Genus *Plumatella* Lamarck

3. *Plumatella diffusa* Leidy, 1852

4. *Plumatella fruticosa* Allman, 1844

4. Genus *Hyalinella* Jullien

5. *Hyalinella punctata* (Hancock, 1850)

A. Class GYMNOLAEMATA

Order CTENOSTOMATA

I. Family HISLOPIIDAE

1. Genus *Hislopia* Carter

1. *Hislopia lacustris* Carter, 1858

1858. *Hislopia lacustris* Carter, *Ann. Mag. Nat. Hist.*, (3)1 : 169.

1880. *Norodonia combodgiensis* Jullien, *Bull. Soc. Zool. France*, 5 : 77.

1976. *Hislopia lacustris* Rao, *Rec. zool. Surv. India*, 69 : 331.

Material : (1) Kheri Dist. – 10 colonies, Gola (South), 25.iv.1990; 10 colonies, Gola (east), 27.iv.1990, coll. Dr. L.K. Ghosh & party.

Distribution : Uttar Pradesh : As above and in other places.

Elsewhere : India : Kolkata, Bulandshahr, Rewa, Indore, Mumbai, Malwatal, Chilka Lake, Chennai, Andhra Pradesh, West Bengal and Meghalaya.

Out side India : Africa; Europe, West Germany, Russia; Japan; Burma; America.

Remarks : The material conforms in general with the specimens identified and recorded by Annandale (1911) from Kolkata. Overgrowth of colonies was observed in the material studied as well as reported by Rao (1976) but Annandale (1911) reported "one zooecium, however never grows over another" Present investigation indicates that *Hislopia lacustris* is the first time recorded from this area.

B. Class PHYLACTOLAEMATA

II. Family FREDERICELLIDAE

2. Genus *Fredericella* Gervais

2. *Fredericella sultana* (Blumenbach, 1779)

1779. *Tubularia sultana* Blumenbach, *Ann. Nat. Hist.*, **13** : 330.

1909. *Fredericella indica* Annandale, *Rec. Indian Mus.*, **3** : 373.

1976. *Fredericella sultana* Rao, *Rec. zool. Surv. India*, **69** : 334.

Material : Gorakhpur District. – 24 colonies, Ramgarh Lake, 6.vi.1989, coll. H.C. Ghosh & party.

Distribution : Uttar Pradesh (as above) and in other places.

Elsewhere : India : Kashmir, Madhya Pradesh, Orissa and Punjab.

Outside India : Europe; America; Asia and Africa.

Remarks : The paipoblasts are larger and often ornamented in the present material. The kidney-shaped paipoblasts described by Annandale (1911) could not be observed. Present investigation indicates that *Fredericella sultana* is recorded for the first time from this area.

III. Family PLUMATELLIDAE

3. Genus *Plumatella* Lamarck

3. *Plumatella diffusa* Leidy, 1852

1852. *Plumatella diffusa* Leidy, *P. Ac. Philad.*, **5** : 261.

1911. *Plumatella diffusa* Annandale, *The Fauna British India*, p. 223.

Material : (1) Basti dist. – 10 colonies, Kuano river, 16.vi.1989, coll. Sri. H.C. Ghosh & party.

(2) Deoria dist. – 2 colonies, Deoria, 27.vi.1989, coll. Sri. H.C. Ghosh & party.

(3) Kheri dist. – 10 colonies, Gola, 29.iv.1990, coll. Dr. L.K. Ghosh & party.

Distribution : Uttar Pradesh : As above.

Elsewhere : India : Bengal, Kolkata and neighbourhood, E. Himalayas, Gangtok, Native Sikkim and Punjab.

Outside India : North America; Europe; Bangladesh, Pakistan.

Remarks : *P. diffusa* in lower Bengal is a cold-weather species. It is remarkable for the enormous number of gemmules it produces and is usually found either on floating objects such as the stems of certain water plants or on stones or bricks at the edge of ponds. Present investigation indicates that *Plumatella diffusa* is the first time recorded from this area.

4. *Plumatella fruticosa* Allman, 1844

1844. *Plumatella fruticosa* Allman, *Ann. Mag. Nat. Hist. Ser. 1*, **13** : 328.

1976. *Plumatella fruticosa* Rao, *Rec. zool. Surv. India*, **69** : 338.

Material : (1) Basti dist. – 10 colonies, Bakhira Tal Lake, 21.vi.1989, coll. Sri H.C. Ghosh & party.

(2) Deoria dist. – 1 colony, Deoria, 27.vi.1989, coll. Sri H.C. Ghosh & party.

(3) Gorakhpur dist. – 5 colonies, Rajghat, 9.vi.1989, coll. Sri H.C. Ghosh & party.

(4) Kheri dist. – 12 colonies, Gola, 23.iv.1990, coll. Dr. L.K. Ghosh & party.

Distribution : Uttar Pradesh : As above.

Elsewhere : India : Kolkata, Chilka Lake, Travancore, Mumbai, Ganges delta and the Himalayan region.

Outside India : Europe, North America, Bangladesh, Africa, Pakistan.

Remarks : *Plumatella fruticosa* is well distributed in Uttar Pradesh. The colonies were observed profusely grown and shrubby. The floatoblasts are long and elliptical with a smooth capsule. The sessoblasts are large and elongated with markings on the surface. Present investigation indicates that *Plumatella fruticosa* is the first time recorded from this area.

Genus *Hyalinella* Jullien

5. *Hyalinella punctata* (Hancock, 1850)

1850. *Plumatella punctata* Hancock, *Ann. Mag. Nat. Hist. Ser. 11*, **5** : 173.

1976. *Plumatella punctata* Rao, *Rec. zool. Surv. India*, **69** : 340.

Material : (1) Basti dist. – 10 colonies, Bakhira Tal (Lake), 21.vi.1989; 10 colonies, Kuanoriver (Gandhinagar), 16.vi.1989, coll. Sri H.C. Ghosh & party.

(2) Deoria dist. – 10 colonies, Kunnanala, 28.vi.1989; 12 colonies, Deoria, 30.vi.1989; 10 colonies, Hanuman Temple, 27.vi.1989, coll. Sri H.C. Ghosh & party.

(3) Gorakhpur dist. – 10 colonies, Raighat, 9.vi.1989, coll. Sri H.C. Ghosh & party.

(4) Kheri dist. – 10 colonies, Gola, 23.iv.1990; 8 colonies, Gola, 22.iv.1990, coll. Dr. L.K. Ghosh & party.

Distribution : Uttar Pradesh : As above, elsewhere India : Kolkata, Rajasthan, Rewa, Indore.

Outside India : Europe; North America.

Remarks : In Uttar Pradesh *H. punctata* flourishes both during the “rains” and in winter. Floatoblasts are rounded or oval with a large capsule and agree in general with the earlier descriptions. This is first time recorded from Uttar Pradesh.

SUMMARY

The paper deals with a systematic account of 5 species of fresh water Bryozoa hitherto known from the 4 (four) districts of Uttar Pradesh. Each of the species is provided with a synonymy (original and latest ones) and distribution.

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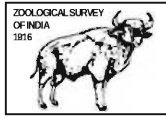
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A POPULATION SURVEY OF HANUMAN LANGURS IN THE DISTRICT OF BIRBHUM, WEST BENGAL, INDIA

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INTRODUCTION

Birbhum is the 10th and last district that has been taken up for population survey of non-human primates in West Bengal. The states of West Bengal comprised of 19 districts of which three districts (Kolkata, North and South Dinajpur) are devoid of monkeys. Selecting some districts, surveys were done in the north, south, east, west and central part based on different ecological niches except swamps of Sunderbans (Fig. 1). The other districts so far surveyed were Darjeeling, Jalpaiguri, Coochbehar in the north; East and West Midnapore in the south; North 24 parganas in the east; Purulia and Birbhum in the west, Howrah and Hugli are more or less situated in the central part of the West Bengal. Southwick *et al.* (1964), Mukherjee *et al.* (1986), Mandal (1964), Bhiunya *et al.* (1993) carried out field studies on non-human primates of West Bengal. The Hanuman langurs occur through out India except in northeastern states. The primates species found in the West Bengal are Rhesus macaque (*Macaca mulatta*), Assamese macaque (*Macaca assamensis*) and Hanuman langur (*Semnopithecus entellus*). The northern districts viz. Darjeeling, Jalpaiguri and Coochbehar are devoid of Hanuman langurs. The Assamese macaque is restricted only in Darjeeling district (Mukherjee *et al.* 1995, Murmu *et al.* 2004), the rhesus is found in the northern district of West Bengal and Ajodhya hill of Purulia district (Chaudhuri *et al.* 2004). This report deals with the distribution, abundance, and social composition of Hanuman langur in Birbhum district.

STUDY AREA

Birbhum district is located in the western part of West Bengal between 23°32'–24°3' N latitude and 87°05'–88°0' E longitude. It covers an area of 4545 sq. km. The configuration of general slope is from west to east. Ajoy and Mayurakshi are the main rivers. There is a hot sulphur spring on the bank of river Bakreswar. Laterite soil is the predominant soil group. Alluvial soil occupies considerable area in the southeastern part.

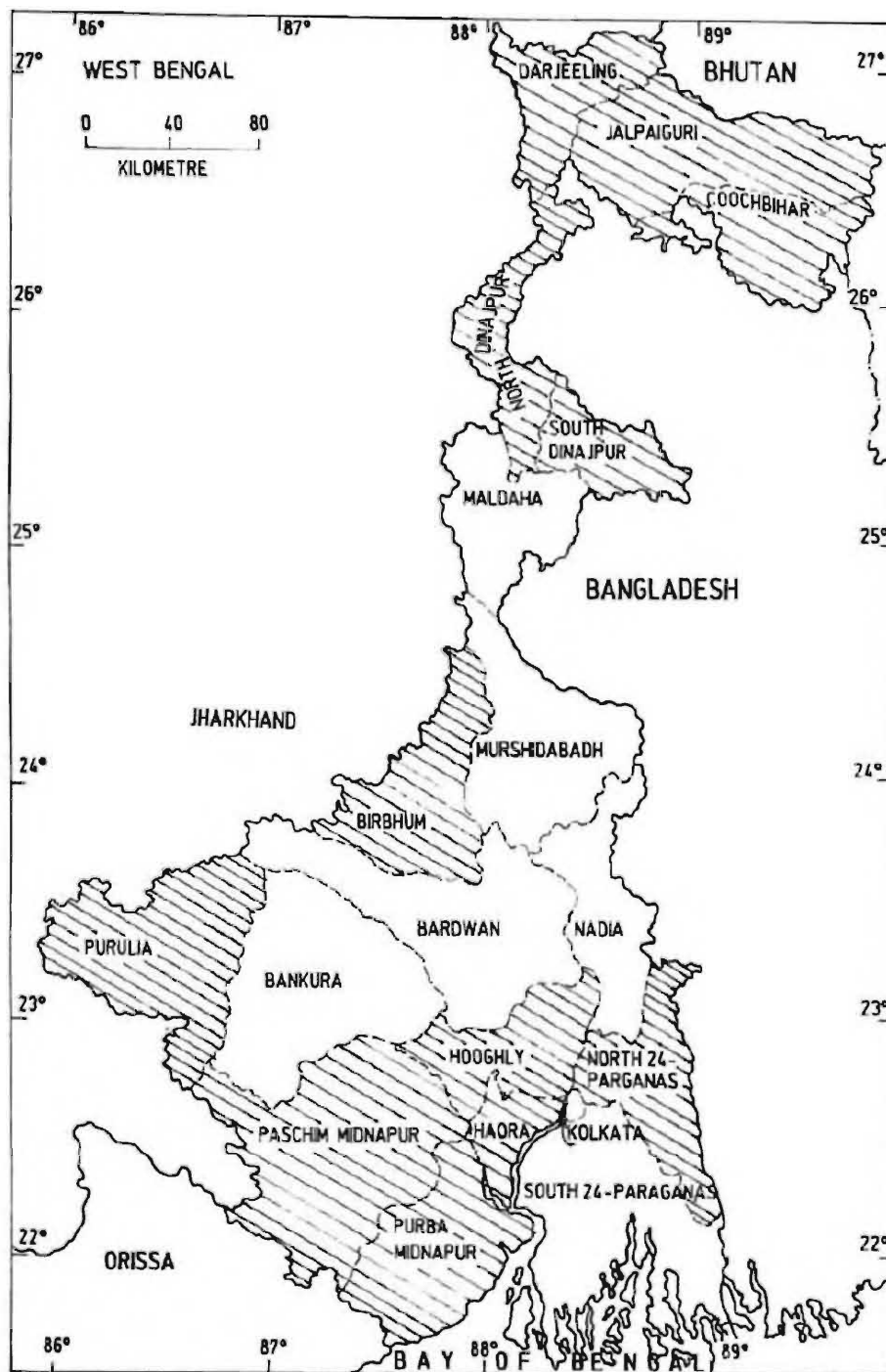


Fig. 1. : Map of West Bengal showing surveyed districts.



The district with its head quarters at Suri has five municipal towns namely Suri, Rampurhat, Bolpur and Nalhati and Dubrajpur. The district is fairly densely populated with 560 people per sq.km, and the population is predominantly rural, 80% land is under agricultural. Above 50% of irrigated land is served by canals and Mayurakshi is the major irrigation project. Rice is the main crop followed by wheat, pulses and oil seeds. Forest occupies small areas of 15.82 thousand-hectare and it composed of only 3.5% of the total geographical area of the district. The trees are mainly eucalyptus, akashmoni and few Sal plantations in the protected areas. Lac and Tasar are the main forest products.

METHODS

The survey methods adopted in this district was by using a slow moving vehicle at an average speed of 20 km per hour with 4 observers for locating langurs. The entire district is well connected by motorable roads. So, it was possible to approach all the villages. Survey was carried out at phases from 0700–1130 hours and again from 1500–1800 hours. The data represented in this report is based on survey during April 2005, when the district was resurveyed. A total of 2000 km² area was surveyed which was about 44% of the total geographical area of the district covering villages, towns, temples, canal banks, markets, agricultural fields and roadside trees. Total count and sweep sampling methods were used to estimate the population of langurs. A total of 200 hours was spent for census work. On locating the groups their social composition and habitats were recorded. The langurs were classified into four broad categories as adult males > 4 years old; adult females > 3 years; juveniles > 18–24 months and individuals upto 18 months old were classified as infants.

RESULTS

In this district nearly 2000² km was surveyed and 87 groups of Hanuman Langur were sighted. Out of this 79 groups were bisexual and 8 were all male bands. These 87 groups contained 1256 langurs, of which 186 were adults males, 598 were adult females, 244 were juveniles and 228 infants. The distribution of Hanuman Langurs in Birbhum district is shown in Fig. 2. This provides a population estimate of 0.04 groups/km² comprising of 0.60 langur/km². The group size varied from 4 to 56.

The 8 all male band contained 28 langurs, 2 were town groups and 6 were village groups. The all-male village groups inhabited close to the social groups. Thus the remaining 79 groups were social groups of which mostly habouring in the villages. These 79 bisexual group contained 1228 langurs consisting of 158 adult males, 598 adult females, 244 juveniles and 228 infants; with a mean group size of 15.54 ± 0.10 individuals (Table 1). The adult male to adult female ratio was 1 : 3.7 and adult female to sub-adult ratio was 1 : 0.75. About 38.1% females were having infants.

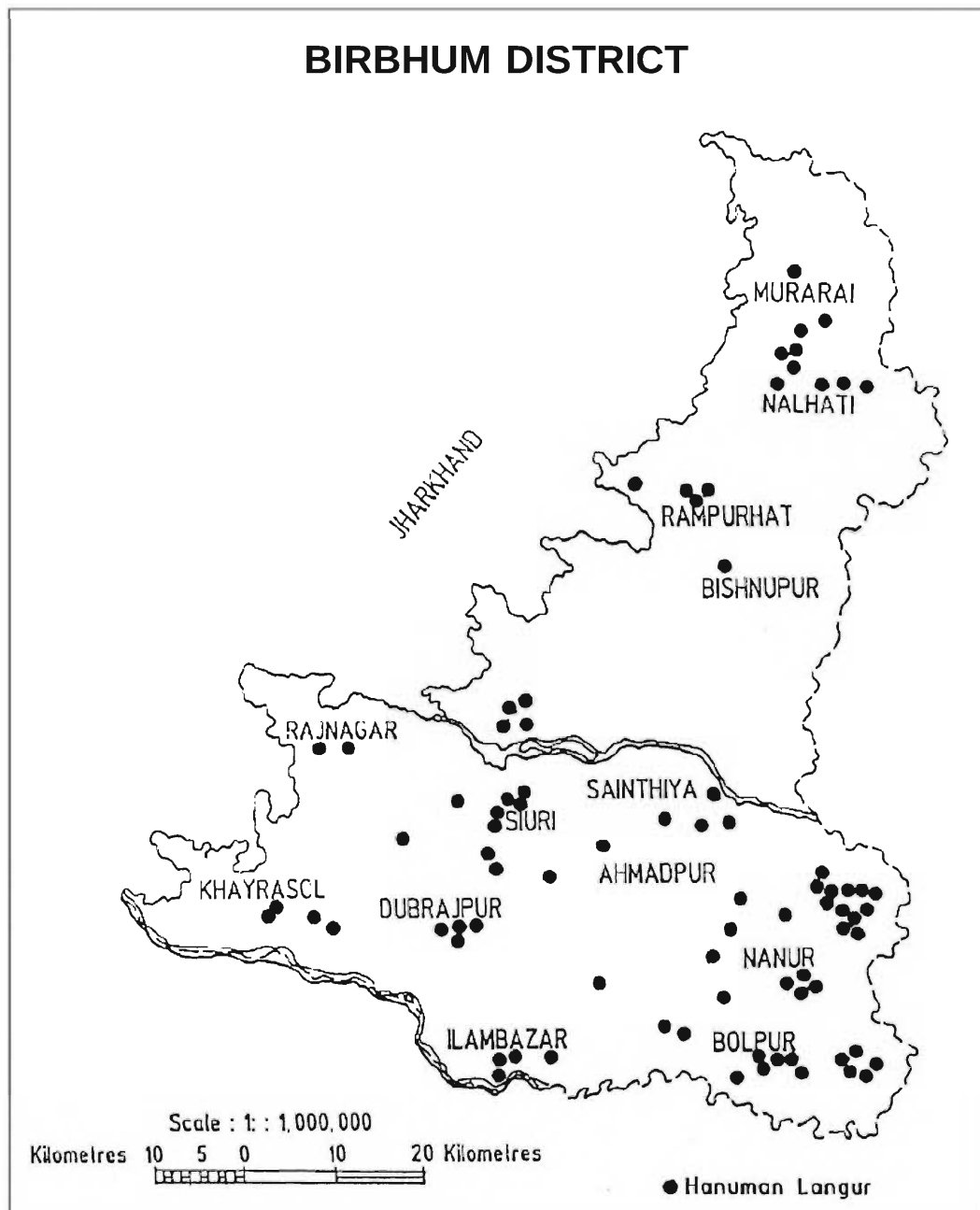


Fig. 2. : Distribution of Hanuman Langur Groups.

Table 1 : Group size and distribution of bisexual Hanuman Langurs in Birbhum.

Sl. No.	Locality	Habitat	Total	Ad. Male	Ad. Female	Juvenile	Infant
1	Kharidhya	BDV	11	1	5	3	2
2	Laujhar	BDV	17	2	9	3	3
3	Padampur	BDV		1	5	2	2
4	Padampur	BDV	6	1	3	1	1
5	Padampur	BDV	9	1	4	2	2
6	Rajnagar	BDV	12	1	7	2	2
7	Mohammad Bazar	BDV	14	2	8	2	2
8	Lambodharpur	BDV	7	1	3	1	2
9	Ayash	BDV	24	4	12	3	5
10	Chatra	BDV	15	2	8	2	3
11	Paikar	BDV	13	2	6	2	3
12	Sheharakuri	BDV	10	2	4	1	3
13	Patel Nagar	BDV	11	2	6	3	0
14	Sekhorda-Hatkhole	BDV	20	2	8	4	6
15	Indus, Prantik-Lavour Rd.	BDV	4	1	2	0	1
16	Mahutar	BDV	26	3	14	4	5
17	Bakul	BDV	16	2	7	3	4
18	Lavour, Hatkhola	BDV	17	2	8	3	4
19	Lavpur, Sripally	BDV	15	2	7	3	3
20	Dhaldanga	BDV	7	1	4	0	2
21	Lohanda	BDV	7	1	4	2	0
22	Sierbandh	BDV	12	2	6	1	3
23	Lohanda, Makaipur	BDV	22	2	9	5	6
24	Motipur	BDV	7	1	3	3	0
25	Kirnahargram	BDV	19	1	8	5	5
26	Kirnahar.Babugram	BDV	14	1	9	4	0
27	Nannur	BDV	12	1	5	2	4
28	Baliguni	BDV	13	1	6	3	3
29	Maithinis	BDV	25	2	12	5	6
30	Uskaran	BDV	31	3	14	8	6
31	Saota	BDV	18	2	8	4	4
32	Patsimulia	BDV	25	4	16	3	2
33	Baram	BDV	35	4	16	8	7

Table 1 : (Cont'd.).

Sl.No.	Locality	Habitat	Total	Ad. Male	Ad. Female	Juvenile	Infant
34	Hatinagar	BDV	4	1	3	0	0
35	Mayurakshi Canal Office	BDV	56	8	29	8	11
36	Kakas	BDV	4	1	2	0	2
37	Kachuighata	BDV	9	1	5	2	1
38	Bikrampur	BDV	17	2	9	3	3
39	Lattu	BDV	17	2	9	3	3
40	Pasui	BDV	7	1	4	2	0
41	Fatehpur	BDV	9	1	5	1	2
42	Bishnupur	BDV	4	1	20	1	
43	Paharpur	BDV	11	1	7	1	2
44	Nawpara	BDV	17	2	9	4	2
45	Batkar	BDV	35	4	15	8	8
46	Muluk	BDV	10	1	5	2	2
47	Bangachatra	BDV	35	4	16	10	5
48	Naoda	BDV	9	1	4	2	2
49	Sarisha	BDV	16	2	8	5	1
50	Singhi	BDV	22	4	11	3	4
51	Kurumbha	BDV	16	3	7	4	2
52	Nachamshah	BDV	11	1	6	1	3
53	Supur	BDV	17	2	8	5	2
54	Payeer	BDV	7	1	4	2	0
55	Mana	BDV	31	5	11	7	8
56	Dumbu	BDV	14	2	7	5	0
57	Gokarul	BDV	11	1	5	5	0
58	Chandipur	BDV	17	2	8	3	4
59	Khayrasol	BDV	18	3	10	2	3
60	Kartikdanga	BDV	5	1	4	0	0
61	Suri	BDT	8	1	3	2	2
62	Suri, PHE Bunglow	BDT	8	1	3	2	2
63	Suri, Lambodharpour	BDT	13	2	6	2	3
64	Rampurhat	BDT	5	3	0	2	0
65	Rampurhat	BDT	18	2	9	3	3
66	Nalhati	BDT	8	1	4	2	1

Table 1 : (Cont'd.).

Sl.No.	Locality	Habitat	Total	Ad. Male	Ad. Female	Juvenile	Infant
67	Murarai	BDT	11	2	6	0	3
68	Bolpur	BDT	19	2	8	5	4
69	Santinekatan	BDT	14	2	8	2	2
70	Bolpur Rly. Stn.	BDT	20	2	8	6	4
71	Abanpally, Santiniketan	BDT	26	2	14	3	6
72	Dubrajpur	BDT	23	2	12	5	3
73	Dubrajpur	BDT	17	2	7	4	4
74	Dubrajpur	BDT	23	2	9	7	5
75	Santiniketan, Goyalpara	BDT	20	3	10	3	4
76	Illambazar	BDT	10	1	5	3	1
77	Bakreswar	BDM	11	2	6	2	1
78	Tarapith	BDM	26	3	13	4	6
79	Fullara, Lavpur	BDM	15	2	8	2	3
	Total	V+T+M	1228	158	598	244	228
	Mean		15.54 ± 0.1	2.0 ± 0.13	7.56 ± 0.48	3.08 ± 0.23	2.88 ± 0.24

V = Village, T = Town, M = Temple, BD = Birbhum district

The entire langur population of Birbhum district is distributed in three main category habitats-village, town and temple. The mean density of social groups of Hanuman langurs is shown in Fig. 3. The habitat wise distribution of langurs is given in Table 2.

Village : The 60 bisexual village groups contained 933 langurs with a mean group size of 15.55 ± 1.22 individuals. The social composition consisted of 118 adult males, 459 adult females, 185 juveniles and 171 infants (Fig. 3). The percentage composition in the population consisted of 12.65% adult males, 49.2% adult females, 19.82% juveniles and 18.33% infants, (Fig. 4). 37.25% females were having infants. The adult male to adult female ratio was 1 : 0.37.

Table 2 : Habitat wise distribution of Hanuman Langur in Birbhum.

Habitat	Total	Adult Male	Adult Female	Juvenile	Infant
Town	243	33	112	51	47
Village	933	118	459	185	171
Temple	52	7	27	8	10
Total	1228	158	598	244	228

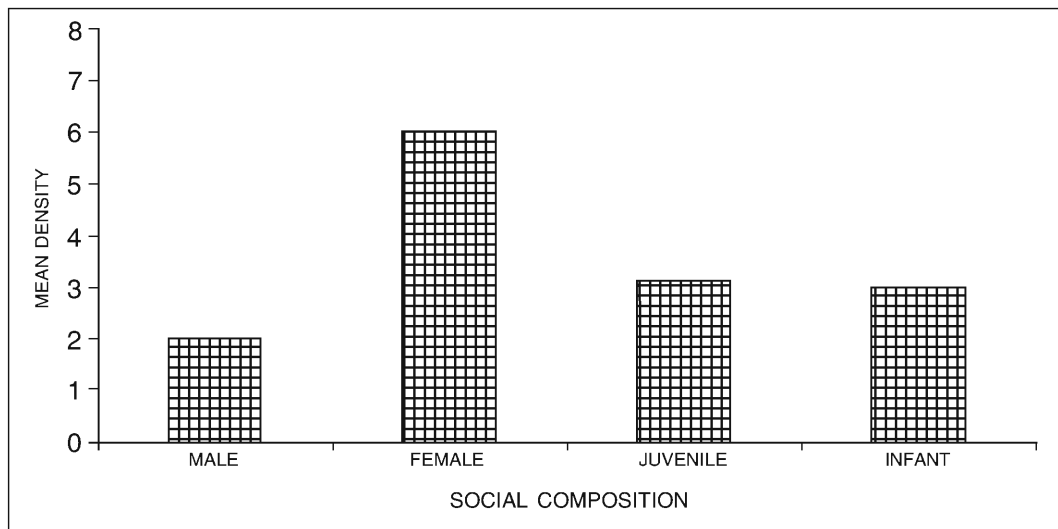


Fig. 3. : Hanuman langur population of Birbhum district.

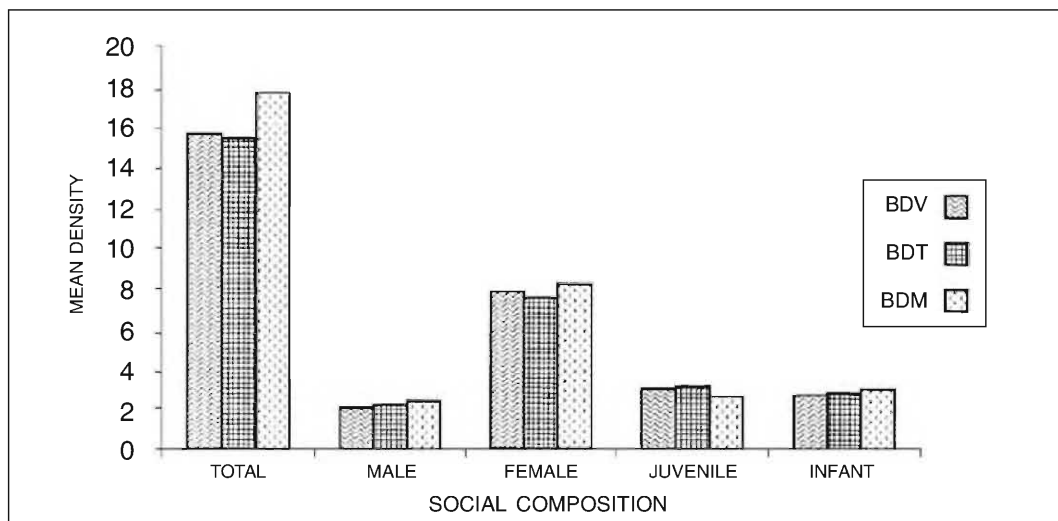


Fig. 4. : Mean density of Hnuman langur in Birbhum district.

Town : The 16 town groups contained 243 langurs with a mean group size of 15.18 ± 1.6 . These 243 langurs composed of 33 adult males, 112 adult females, 57 juveniles and 47 infants. The group size varied from 5 to 26 individuals. The adult male to adult female ratio was 1 : 3.4 and adult female to juvenile and infant ratios were 1 : 0.5 and 1 : 0.4 respectively. Out of 243 town langurs the percentage composition were 13.58% adult males; 46.1% adult females; 20.95% juveniles and 19.34% infants. 42% females having infants. (Fig. 4).

Temple : The 3 temple groups composed of 52 langurs of which 7 were adult males, 27 were adult females, 8 were juveniles and 10 infants. The adult male to adult female ratio was 1 : 3.14 and adult female to juvenile and infant ratios were 1 : 0.3 and 1 : 0.37 respectively. The temple groups were well represented by sub-adult population of 34.6%. The mean density of temple groups is shown in Fig. 4.

DISCUSSION

Purulia, the other western district of West Bengal, was surveyed where 56 groups with 839 langurs sighted in 1200 sq.km. area. The estimated langur distribution was 0. 046 groups/sq.km., with 0.70 individuals/sq.km. which were almost same as that of Birbhum. In Purulia, a sizeable population of langurs was seen in the roadside trees, but in this district the langurs were observed in the villages. The recruitment was more in Purulia, 42% females having infants whereas in Birbhum it was 37% (Chauduri *et al.* 2004).

The present survey revealed that Hanuman langurs are more or less widely distributed in Birbhum. Almost all towns are having langurs beside temples and villages. As the district is predominantly rural in nature the langurs are concentrated more in the villages. The village provides the food and shelter of those langurs. The district has only 3.5% forest cover that unsuitable for langur habitat. In the study areas it was noticed that the villagers no longer tolerate the langurs due to extensive crop depredations. These langurs also damaged the household properly, mainly while jumping from tree to tree or from one house to another breaking the earthen roof tiles. These had become serious concern of the inhabitants of the villages and they often chased and harassed the langurs. So, these were constant man-monkey interactions in the villages. The majority of the villages, where the survey was undertaken, it was found that the villagers want the removal of langurs from their villages. Though killing of langurs were not recorded at Birbhum district, but the sacred image of the langurs which was enjoyed by this animal in the past, was eroded. The town and temple langurs were not faced this type of attitude from the people. The town groups wander in a large area, the local people, shopkeepers were seen to offer foodstuff to them. The temples groups were almost provisioned monkeys, and largely depend on pilgrims.

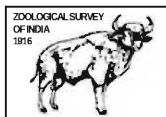
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LIFE HISTORY OF THE COMMON INDIAN CROW *EUPLOEA CORE* (CRAMER) (NYMPHALIDAE : LEPIDOPTERA : INSECTA)

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INTRODUCTION

The genus *Euploea* Fabricius is represented by eighteen species in India and *E. core* Cramer is one of them commonly available in North-West India (Varshney, 1993). Wynter-Blyth (1957), Sevastopulo (1973), Palot and Radhakrishnan (2001), and Palot *et al.* (2005) reported *Streblus asper*, *Ficus banghalensis*, *Ficus racemosa*, *Ficus arnittiana*, *Ficus elastica*, *Ficus religiosa* (Moraceae); *Holarrhena pubescens*, *Nerium odorum*, *Nerium oleander*, *Ichnocarpus frutescens* (Apocynaceae); *Hemidesmes indicus*, *Cryptolepis elegans*, *Cryptolepis buchanani* (Asclepiadaceae) and *Ichnocarpus frutescens* (Linnaeus) (Apocynaceae) as its food plants. The life history and behavioural aspects of this species have not been described in detail by any. During the course of the present study, the life history of the species *Euploea core* was recorded on *Ichnocarpus frutescens* (Linnaeus) (Apocynaceae) in Shiwalik area of North-West India. *Ageratum conyzoides* Linnaeus, *Tagetes erecta* (Linnaeus) (Asteraceae) and *Alstonia scholaris* (Linnaeus) (Apocynaceae) have been recorded as the nectar food plants of *E. core*. The detailed account of various life history stages and their behaviour is as below :

Methodology : The survey tours were conducted in different localities of the Shiwalik area around Chandigarh from 1999–2001 to collect immature stages of *Euploea core* (Cramer). The eggs and different larval instars brought from field were kept in circular transparent containers, each measuring (10 cm in diameter and 4.5 cm deep). Subsequently, the later instars were shifted to relatively larger transparent containers (12 × 7 cm, 15 × 20 cm and 18 × 23 cm) furnished with fresh clippings of the food plants. The mature larvae nearing pupation were then shifted to still bigger rearing containers (18.5 cm in diameter and 12.5 cm deep) for pupation. The freshly emerged adults were transferred to the insect breeding cages of varied sizes or to insectary (180 × 180 × 180 cm) furnished with an artificial diet consisting of 10% sugar solution to record their longevity.

The rearing boxes were carefully examined twice a day in order to make observations on different life history aspects. The rearing boxes were cleaned at regular intervals by removing the faecal matter, dead insect stages and waste host food plant clippings etc. for keeping proper hygienic conditions. The fresh host plant cuttings were provided to the larvae for their proper development and also to minimize the mortality rate due to starvation *etc.* The gross morphology, colouration and measurements of the egg, different larval instars and the pupae were recorded with the help of oculometer, taking a mean of 05 specimens of each stage.

OBSERVATIONS

Egg : Incubation period : 2.16 ± 0.76 days.

Height 1.50 ± 0.14 mm, width 1.00 ± 0.14 mm; laid singly; melon-shaped, broader in middle, narrower on either pole; off-white in colour, turns grayish one day before hatching; chorion furnished with polygonal pits, ribs very low; eggs firmly glued to unopened flower buds of the inflorescence of the host plant on which it is laid.

Larva : Number of instars : 5.

Larval duration : 14.65 ± 2.70 days.

First instar : Duration : 2.33 ± 0.57 days.

Head : Width 0.63 ± 0.05 mm; hypognathus, black; epicranial suture black, clear; primary setae present.

Body : Length 4.33 ± 1.75 mm, width 0.86 ± 0.11 mm; newly hatched larva creamy white, later changes to dirty yellow colour; body well segmented, each segment further divided into annuli, but latter not very distinct; legs and anal segment blackish brown; mesothorax, second and eighth abdominal segments with a pair of rudimentary filaments, the latter black and somewhat fleshy, present ad-dorsally.

Second instar : Duration : 2.33 ± 0.57 days.

Head : Width : 1.03 ± 0.05 mm; other features same as explained above.

Body : Length 7.83 ± 1.89 mm, width 1.93 ± 0.11 mm; yellowish brown, thoracic segments with purplish tinge; four pairs of fleshy filaments (explained above) become longer; thoracic shield gets divided into two lobes; white transverse bands representing annuli appear on each segment.

Third instar : Duration : 2.00 ± 1.00 days.

Head : Width 1.55 ± 0.13 mm; black; vertex with a white band, the latter extending downwards, running through the parietals, ending at genal area; antennae, clypeus and labrum white.

Body : Length 15.00 ± 1.00 mm, width 2.53 ± 0.05 mm; orange brown; each segment with five transverse bands, the latter white in colour; spiracles and legs black; prothoracic and last abdominal

segment orange, anal shield black; but for the prothorax and the tenth abdominal segment, lateral line present on each side; body below completely brown.

Fourth instar : Duration : 2.16 ± 0.28 days.

Head : Width 2.23 ± 0.05 mm; other features same as in the third instar.

Body : Length 22.33 ± 2.51 mm, width 3.33 ± 0.57 mm; brownish black, white transverse bands very prominent, alternating with black bands, prothorax and anal segment orangish yellow; lateral bands yellow, distinct, decorated with prominent, black, oval spiracles; subspiracular band white, conspicuous, extends from mesothorax to ninth abdominal segment on either side; base of prolegs lined yellow; fleshy filaments very large, brownish maroon, mesothorax with the longest pair, eighth abdominal segment with the shortest pair, metathorax and second abdominal segment with equal sized pairs.

Fifth instar (Fig. 1) : Duration : 5.83 ± 0.28 days.

Head : Width 3.45 ± 0.05 mm, other features same as in the third instar.

Body : Length 35.00 ± 5.00 mm, width 4.16 ± 0.28 mm; other features same as in the fourth instar.

Pupa : Duration : 7.33 ± 1.52 days.

Length 16.50 ± 0.70 mm, width 8.50 ± 0.70 mm; attached at anal end by cremaster, with head suspended downwards; somewhat pot-shaped, constricted in the metathoracic region; mesothorax and second abdominal segment very long; the abdominal segments caudad of wings taper abruptly towards caudal end forming a hemispherical structure; cremaster black, narrow, broad at base; body shows a spectrum of dazzling and reflective colours. The freshly formed pupa very soft, grayish pink, flesh-like in appearance; after 2–3 hours becomes harder, glossy and glistening silver bands with golden tinge appear subsequently. A middorsal silver band extends from first to last abdominal segment but missing on second abdominal segment, subdorsal silver band present in mesothorax, and then in third abdominal segment extending up to last abdominal segment, in mesothorax this band bears three black spots while in abdominal segments it possesses a pair of black spots, in third abdominal segment these spots raised on tubercles; ocular region, base, costa, termen and dorsum of wing cases silver patched with reflective golden tinge (Fig. 2). The colour of pupa changes drastically and dramatically a day before eclosion, the abdominal segments become brownish, wooden-coloured and non-reflective, the remaining pupal body becomes blackish but reveals a mixture of variety of colours when rotated, the thorax reflects green colour, the ocular region blue, and the alar region violet shaded (Fig. 3). The advanced pupa turns more blackish and spectrum of colours go on shrinking with passage of time until it reduces into small spots in middle of wing cases; before eclosion the pupa becomes totally black but for the abdominal segments; white spots on wing of imago visible through the pupal case.

Oviposition behaviour : The oviposition sequences of *E. core* have been studied in the field at Nalagarh, Morni Hills (Chandigarh), Kalka and Parwanoo areas falling in Shiwalik range of North-West India on the host plant *Ichnocarpus frutescens* (Fig. 4), a climber. Oviposition occurs during the months of September and October between 11-30 am and 2-00 pm in good sunshine. Prior to egg laying, the female with slow flapping of wings sails for long distances in search of the appropriate host plant. In case of *Ichnocarpus frutescens*, the unopened buds of an inflorescence are preferred for oviposition. On locating the appropriate inflorescence as an egg laying substratum, the female alights on the same by holding the peduncle with her legs, and immediately curls her abdomen downwards to deposit an egg on an unopened bud. In rare instances, it has also been observed that a female may lay an egg on undersurface of the leaf.

Larval behaviour : The newly hatched larva depends upon egg chorion as first food. After consuming it completely, it takes rest for a while before switching to feed on the same very flower bud on which the egg was deposited. As an external feeder, the larva initiates feeding on the bud at its apex, proceeding slowly downwards, eating the whole flower except its thalamus, thereafter switching over to the next bud. Different instars follow the same feeding pattern. However, the fourth and fifth instar larvae may occasionally feed on the leaves of the host plant as well. In some cases, especially when there is scarcity of unopened buds, the earlier instars have also been observed to feed on tender leaves instead of blooming flowers. The first instar is highly cryptic in appearance with the flower buds.

Remarks : The species under reference, *Euploea core* is quite abundant during the months from August to November. The adults of *E. core* (Fig. 5) acting as model for the nymphalid species, *Hypolimnas bolina* (Linnaeus) is an example for Batesian mimicry (Wynter-Blyth, 1957; Eliot, 1992). The adults are slow flyers and congregate in large numbers on *Ageratum conyzoides*. The males also indulge in mud-puddling in ploughed and watered fields as observed in Sukhna lake at 12-30 pm and Morni hills, near Chandigarh at 11-30 am. The males assemble in numbers of 3-8 on these puddles.

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