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STUDIES ON EUGREGARINIDA (APICOMPLEXA : SPOROZOEA : SEPTATINA) OF INDIAN ODONATES (ARTHROPODA : INSECTA : ODONATA). A SYNOPSIS OF THE GENERA AND SPECIES

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INTRODUCTION

Bhatia and Setna (1924) initiated the study on Eugregarinida (Apicomplexa : Septatine) parasitising the midgut of Arthropoda in India. Sarkar and Chakravarty (1969) have first time described *Actinocephalus ceriagrionae*, a septate gregarine from the midgut of the Damselfly *Ceriagrion coromandelianum* (Fabr.) (This host was erroneously written as beetle). Recently, the contributions from Haldar et al. (1985) and Das et al. (1993) have further enhanced the knowledge about the septate gregarines of India. In recent past, Levine (1988) listed various gregarines update a very significant contribution on gregarines. The present study, however, reflects the recent status of 32 species of septate gregarines from 21 species of Indian Odonates.

MATERIAL AND METHODS

Odonates, in most cases, were collected alive, brought back to the laboratory and examined the midguts of the hosts for the septate gregarines. These gregarines were studied in fresh with a drop of Lugol's iodine solution and observed under the microscope after sealing the edges of the coverglass with nail polish or paraffin. The permanent slides were prepared by fixing the smears on glass slides with Schaudinn's fluid and subsequently stained by Heindenhain's Iron-alum Haematoxylin. The cysts obtained from the hindgut as well as faeces of the hosts, were placed in the moist chamber for further development. The sporocysts released from the cysts by simple rupture were observed with a drop of Lugol's iodine under the oil immersion lens of an Olympus microscope. The ratios used here are LP : TL and WP : WD where LP denotes the length of the protomerite, TL the total length, WP the width of the protomerite and WD the width of the deutomerite. All the measurements are given in micrometer (μm). The figures given are not upto the scale. In a few cases, the observations were based on the available literatures.

TAXONOMIC ACCOUNT

Phylum : APICOMPLEXA Levine, 1970

Class : SPOROZOEA Leuckart, 1879

Subclass : GREGARINIA, Dufour, 1828

Order : EUGREGARINIDA Léger, 1900

Suborder : SEPTATINA Lankester, 1885

Family : ACTINOCEPHALIDAE Leger, 1892

Key to the genera

Subfamily : ACANTHOSPORINAE Léger, 1892 emend. Grasse, 1953

1. Epimerite regular, non-appendiculate

2. Epimerite complex, discoid, appendiculate

3(1). Epimerite globular with short or no neck

4(2). Epimerite digitiform with long neck

5(3). Sporocyst with polar and equatorial spines ..... *Acanthospora* Léger 1892

6(4). Sporocyst with polar & meridional spines ..... *Ancyrophora* Léger, 1892

7(6). Epimerite a membranous cup with numerous longitudinal folds ..... *Mukundaella* Sarkar, 1981

8(3). Epimerite with backwardly directed, plate-like longitudinal spines

9(8). Sporocyst biconical with a pair of sharp polar spines ..... *Tetractinospora* Sarkar and Haldar, 1981

10(3). Epimerite a group of upwardly directed conical papillae

11(10). Sporocyst flat, diamond-shaped with a pair of polar and two pairs of mid-lateral spines (one pair on each side) ..... *Tetra-meridionospinispora* Kori & Amoji, 1985

12(2). Epimerite highly complex with ramified spines

13(12). Sporocyst biconical with polar & meridional spines ..... *Ramicephalus* Obata, 1953

Subfamily : MENOSPORINAE Léger, 1892 emed. Grasse, 1953

1. Epimerite complex with short neck

2. Epimerite complex with long neck

3(1). Epimerite cup-like with recurved digitiform processes at the margin

4(2) Epimerite hat-shaped with petaloid spines

5(3) Sporocyst smooth, cylindro-biconical ..... *Menospora* Léger emend. Sarkar, 1995

6(4). Sporocyst smooth, boat-shaped ..... *Odonaticola* Sakar & Haldar, 1981

7(2). Epimerite digitiform, branched ..... bifid & trifid

8(7). Sporocyst smooth, crescentic ..... *Hoplorynchus* Carus, 1863

Subfamily : ACTINOCEPHALINAE Labbe, 1899

1. Epimerite complex with short neck

2(1). Epimerite with hooks or spines

3(2). Sporocyst smooth, ellipsoidal ..... *Actinocephalus* Stein, 1848

Family : DACTYLOPHORIDAE Léger, 1892

1. Epimerite complex with short neck

2(1). Epimerite digitiform, branched (bifid)

3(2). Sporocyst smooth, ellipsoidal with pseudocyst ..... *Dendrorhynchus* Keilin, 1920

SYNOPSIS OF THE GENERA & SPECIES

Family : ACTINOCEPHALIDAE, Léger, 1892

Subfamily : ACANTHOSPORINAE Leger, 1892 emend. Grasse, 1953

Acanthospora Léger, 1892

Epimerite (mucron) regular, non-appendiculate, sessile or stalked, dehiscenece of cyst by simple rupture, sporocyst biconical or spindle-shaped with polar and equatorial spines in both. One species

Acanthospora bengalensis Sarkar & Haldar, 1981

Epimerite globular or bulb-like, 16.90 μm × 21.20 μm, neck short, largest trophozoite 758.0 μm long, largest sporadin 913.70 μm long, LP : TL = 1 :7.0, WP : WD = 1 : 1.0 ; gametocyst spherical, sporocyst spindle-shaped with truncate ends also with polar and equatorial spines ; development intracelluler (Fig. 1 – 4).

Site of infection : Midgut.

Host : *Ceriagrion cerinorubellum* (Brauer).

Locality : Chinsurah, West Bengal, India

Ancyrophora Léger, 1892

Epimerite discoid or globular with 5 – 12 processes (tentacular, recurved digitiform or spinous), sessile or stalked, shape of the gametocys variable, sporocyst biconical with polar and equatorial spines. 2 species.

Key to species

1. Epimerite discoid with digitiform processes
2. Epimerite globular with slightly recurved processes

3(1). Dimension of epimerite 11.0 μm × 12.8 μm

4(2). Dimension of epimerite 27.7 μm × 19.6 μm

5(3). Gametocyst spherical ..... *Ancyrophora ischnurae* Sarkar and Haldar, 1991

6(4). Gametocyst oval ..... *Ancyrophora ovoides* Sarkar & Haldar, 1981

Ancyrophora ischnurae Sarkar and Haldar, 1981

Epimerite discoid with 12 short, recurved, digitiform processes, 11.0 μm × 12.8 μm ; stalked ; largest trophozoite 218.0 μm long ; largest sporadin 748.9 μm long ; LP : TL = 1 : 6.1, WP : WD = 1 : 0.9 ; sporocyst spindle-shaped, hexagonal ; maridional spines longer than polar spines, 6.0 μm × 3.5 μm (Figs. 5 – 8).

Site of infection : Midgut.

Host : *Ischnura senegalensis* (Rambur).

Locality : Hooghly, West Bengal, India.

Ancyrophora ovoides Sarkar and Haldar, 1981

Epimerite globular, 10 – 11 radiating slender digitiform processes. stalked, 22.7 μm × 19.6 μm ; largest trophozoite 542.7 μm long ; largest sporadin 916.8 μm long ; LP : TL = 1 : 5.4, WP : WD = 1 : 1.01 ; gametocyst ovoidal ; sporocyst spindle-shaped, equatorial spines longer than polar spine 6.0 μm × 4.5 μm (Figs. 9 – 12).

Site of infection : Midgut.

Host : *Ischnura aurora aurora* (Brauer).

Locality : Hooghly, West Bengal, India.

Mukundaella Sarkar, 1981

Epimerite a wide cup with numerous vertical undulations on its wall ; neck very short or absent ; gametocyst spherical ; sporocyst diamond-shaped hexagonal, with polar and equatorial spines. 3 species :

Key to species

1. Epimerite a wide cup with vertical undulations
2. Epimerite a bud with vertical undulations

3(1). Broad cup with numerous undulations

4(2). Bud with a few undulations

5(3). No neck between epimerite and protomerite

6(4). Neck very short between epimerite and protomerite

7(5). Epimerite 17.0 μm × 28.4 μm in dimension

8(6). Epimerite 38.5 μm long

9(7). Gametocyst spherical

10(8). Gametocyst spherical to ovate

11(9). Sporocyst diamond-shaped with 2 polar spines ..... *Mukundaella undulatus* Sarkar, 1981

12(10). Sporocyst diamond-shaped with 4 polar spines ..... *Mukundaella agriocnemii* Prema & Janardanan, 1991

13(1). Cup with fewer undulations

14(13). The gregarine from a distantly placed odonate, *Copera* sp. ..... *Mukundaella gurbargaensis* Kori & Amoji, 1984

Mukundaella undulatus Sarkar, 1981

Epimerite a small hemisphere at early stage, wide cup with numerous vertical undulations on its wall when fully differentiated, 17.0 μm × 28.4 μm ; neck almost absent ; largest trophozoite 484.3 μm × 43.4 μm ; largest sporadin 467.6 μm × 83.5 μm ; LP : TL = 1 : 6.36, WP : WD = 1 : 1.2 ; gametocyst spherical ; sporocyst diamond-shaped, hexagonal in polar view, 2 polar and 6 meridional spines, 8.5 μm × 5.0 μm (Figs. 53 – 56).

Site of infection : Midgut.

Host : *Enallagma* sp.

Locality : Hooghly & 24-Parganas(N), West Bengal, India.

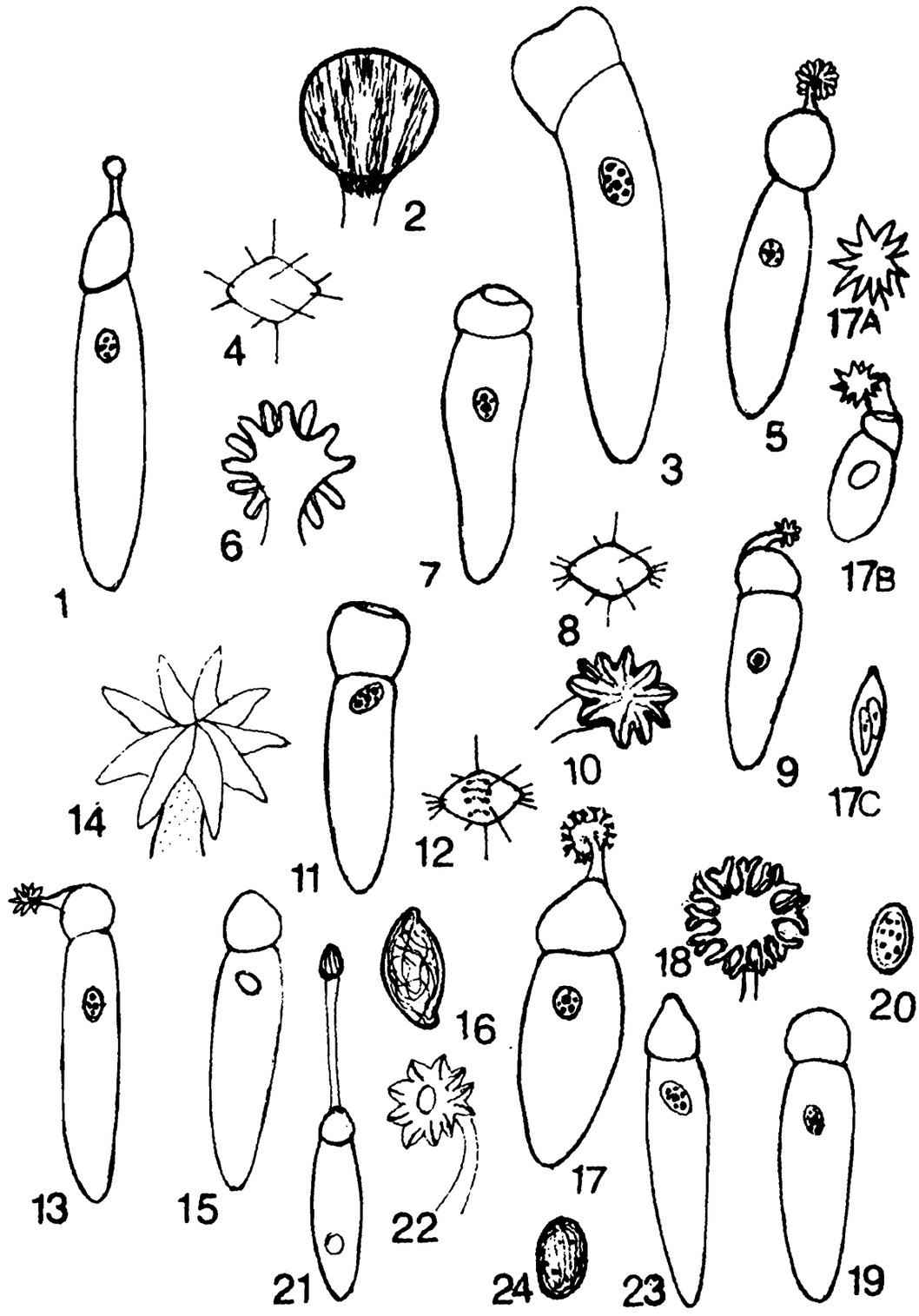
Mukundaella agriocnemii Prema & Janardanan, 1991

Epimerite bud-like with vertical folds to look like a lower, 38.5 μm long, neck very short ; largest trophozoite 1035.4 μm long ; largest sporadine 1108.8 μm long ; gametocyst spherical to ovate ; sporocyst diamond-shaped, hexagonal in polar view, 4 polar and 6 meridioal spines, 6.0 μm – 7.5 μm × 4.5 μm ; LP : TL = 1 : 6.8, WP : WD = 1 : 1.0 ; (Figs. 57 – 59).

Site of infection : Midgut.

Host : *Agriocnemis* sp.

Locality : Calicut University campus, Mallappuram, Kerala, India.



Figs. 1 – 4. *Acanthospora bengalensis*— 1.–Trophozoite, 2.–Epimerite, 3.–Sporadin, 4.–Sporocyst.
Figs. 5 – 8. *Ancyrophora ischnuri*— 5.–Trophozoite, 6.–Epimerite, 7.–Sporadin, 8.–Sporocyst.
Figs. 9 – 12. *Ancyrophora ovoides*— 9.–Trophozoite, 10.–Epimerite, 11.–Sporadin, 12.–Sporocyst.
Figs. 13 – 16. *Actinocephalus ellipsoidus*— 13.–Trophozoite, 14.–Epimerite, 15.–Sporadin, 16.–Sporocyst.
Figs. 17A – 17C. *Actinocephalus ceriagrionae*— 17A.–Epimerite, 17B.–rophozoite, 17C.–Sporocyst.
Figs. 17 – 20. *Dendrorhynchus keilini*— 17.–Trophozoite, 18.–Epimerite, 19.–Sporadin, 20.–sporocyst.
Figs. 21 – 24. *Actinocephalus bradinopygi*— 21.–Trophozoite, 22.–Epimerite, 23.–Sporadin, 24.–Sporocyst.

Remark : It is the only gregarine species where a little variation in the length of the sporocyst is noticed.

Mukundaella gulbargaensis Kori & Amoji, 1984

Epimerite cup or vase-shaped with 12 – 16 vertical undulations or fold on its wall ; very short neck ; largest trophozoite 810.0 μm long ; largest sporadin 1750.0 μm long ; LP : TL = 1 : 3.8 – 8.8, WP : WD = 1 : 0.57 – 1.3 ; gametocyst spherical ; sporocyst diamond-shaped, hexagonal in polar view, 2 polar and 6 maridional spines, 7.5 μm × 5.0 μm (Figs. 60 – 63).

Site of infection : Midgut.

Host : *Copera* sp.

Locality : Gulbarga, Karnataka, India.

Ramicephalus Obata, 1953

Epimerite dish-like, complex with many radially and upwardly directed dendroidal processes ; at the top a cylindrical, longitudinally striated bulb set upon a short neck ; sporocyst diamond-shaped with polar and meridional spines. 1 species :

Ramicephalus olivacus Sarkar and Haldar, 1981

Epimerite complex, cylindro-globular consisting of an upper disc with 15 – 20 ramified spines and lower cylinder with longitudinal striations ; very short neck ; epimerite 28.8 μm × 32.3 μm ; largest trophozoite 411.6 μm long ; largest sporadin 1024.0 μm long ; LP : TL = 1 : 6.1, WP : WD = 1 : 0.96 ; gametocyst spherical with ectocyst ; sporocyst spindle-shaped with shorter polar and longer meridional spines (Figs. 113 – 117).

Site of infection : Midgut.

Host : *Ceriagrion olivaceum* Laidlow.

Locality : Hooghly, West Bengal, India.

*****Tetrameridionospinispora*** Kori and Amoji, 1985

Syn. ***Rodgiella*** Sarkar, 1995

Epimerite a shallow cup, many papilla-like processes on its margin ; sessile ; sporocyst biconical with 2 pairs of polar and 2 pairs of equatorial spines-1 pair on each side at the equatorial region. 1 species :

*****Tetrameridionospinispora ceriagrioni*** (Nazeer Ahamed & Narasimhamurti, 1979) Kori & Amoji, 1985

** cited from Levine (1988)

Syn. ***Ancyrophora ceriagrioni*** Nazeer Ahamed & Narasimhamurti 1979

Rodgiella ceriagrioni Sarkar, 1995

Epimerite a shallow cup ; its margin provided with 17 – 20 papillate processes, sessile ; largest trophozoite 900.0 μm × 200.0 μm ; largest sporadin 825.0 μm × 125.0 μm ; LP : TL = 1 : 9.2, WP : WD = 1 : 0.61 ; gametocyst spherical with an ectocyst of 40.0 μm thick ; sporocyst biconical, 6.5 μm × 5.4 μm, with polar and equatorial spines of equal length, 1 pair on each pole and 1 pair on each side ; each spine 5.0 μm long (Figs. 118 – 121).

Site of infection : Midgut.

Host : *Ceriagrion coromandelianum* (Fabr.).

Locality : Shanti Ashram, Waltair, Andhra Pradesh, India.

Tetractinospora Sarkar & Haldar, 1981

Epimerite globular with several vertical lamellar plates, short neck sporocyst biconical, bent at the middle, with 4 sharp and stout spines a pair at each pole. 1 species :

Tetractinospora victoris Sarkar & Haldar, 1981

Epimerite globular, 16 hyaline plates arranged longitudinally around the globular epimerite, anterior end of each plate round and posterior end sharply truncate, 20.0 μm × 23.2 μm ; short neck ; largest trophozoite 312.5 μm × 54.1 μm ; largest sporadin 466.7 μm × 83.3 μm ; LP : TL = 1 : 5.2, WP : WD = 1 : 0.9 ; gametocyst spherical, dehisces by simple rupture, sporocyst biconical, bent at the middle, a pair of sharply pointed, stout spines a each pole (extention of the sporocyst wall), 9.0 μm × 4.5 μm (excluding the polar spine) ; (Figs. 122 – 125).

Site of infection : Midgut.

Host : *Ceriagrion coromandelianum* (Fabr.).

Locality : Kalyani, West Bengal, India.

Subfamily : MENOSPORINAE Léger, 1892

Menospora Léger, 1892 emend. Sarkar, 1995

Syn. ***Levineia*** Kori & Amoji, 1986

Epimerite cup-like or bell-shaped, bordered with recurved hooks or digitiform processes ; long, slender neck ; gametocyst dehisces by simple rupture ; sporocyst smooth, cylindro-biconical or crescentic ; 4 species :

Key to the species

1. Epimerite cup-like, bordered with digitiform processes.

2. Epimerite bell-shaped with digitiform processes.

3(1). The cup with short neck.

4(2). The bell with long, slender neck.

5(3). Epimerite with more than 30 recurved digitiform processes ... *Menospora enallagmae* Sarkar Haldar, (1980) 1982.

6(5). Sporocyst cylindrobiconical, 10.2 μm × 4.0 μm ..... *Menospora coenagrii* Sarkar & Haldar, (1980) 1982

7(1). Recurved digitiform processes with terminal sucker ..... *Menospora agriocnema* (Kori & Amoji, 1991) Sarkar, 1995

8(3). Sporocyst cylyndrobiconical, 9.0 μm × 3.5 μm ..... *Menospora gulbargaensis* (Amoji & Kori, 1986) Sarkar, 1995

Menospora enallagmae Sarkar & Haldar, (1980) 1982

Epimerite a cup bordered with 32 recurned digitiform processes, long slender neck ; epimerite 21.5 μm in diameter ; largest trophozoite 412.7 μm × 63.7 μm ; largest sporadin 431.0 μm × 68.8 μm ; LP : TL = 1 : 6.1, WP : WD = 1 : 0.9 ; gametocyst spherical ; sporocyst cylindrobiconical, smooth, 10.5 μm × 3.8 μm. (Figs. 36 – 40).

Site of infection : Migut.

Host : *Enallagma parvum* Selys.

Locality : Hooghly, West Bengal, India.

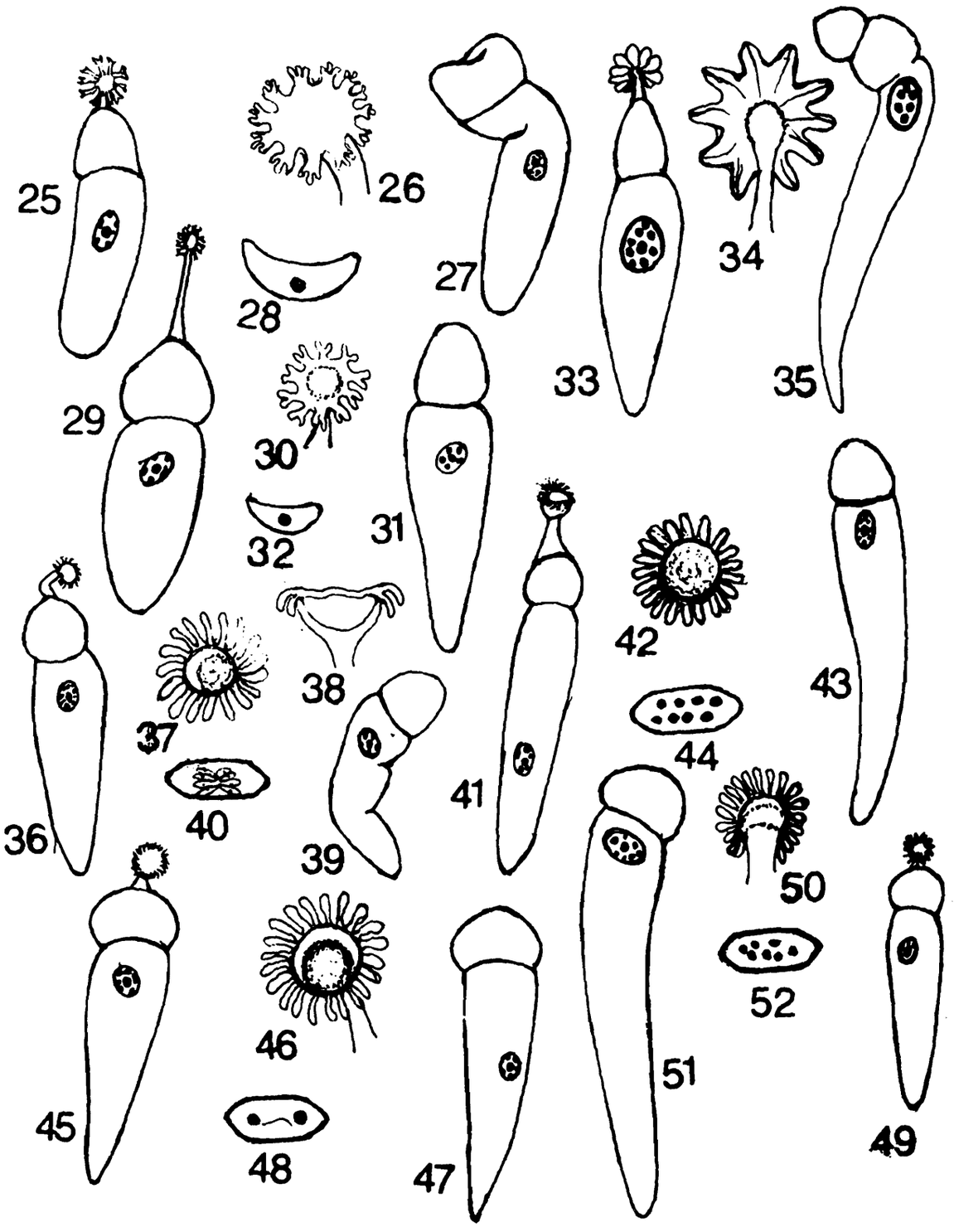
Menospora coenagrii Sarkar & Haldar, (1980) 1982

Epimerite bell-shaped with many recurved digitiform processes, long slender neck, epimerite 24.8 μm × 3.18 μm ; largest trophozoite 350.8 μm × 51.6 μm ; largest sporadin 451.2 μm × 61.2 μm ; LP : TL = 1 : 5.5, WP : WD = 1 : 0.9 ; gametocyst spherical ; sporocyst cylindro-biconical, 9.2 μm × 4.0 μm (Figs. 41 – 44).

Site of infection : Midgut.

Host : *Coenagrion dyeri* Fraster.

Locality : Hooghly, West Bengal, India.



Figs. 25 – 28. *Hoplorhynchus ramidigitus*— 25.–Trophozoite, 26.–Epimerite, 27.–Sporadin, 28.–Sporocyst.
Figs. 29 – 32. *Hoplorhynchus bahamanii*— 29.–Trophozoite, 30.–Epimerite, 31.–Sporadin, 32.–Sporocyst.
Figs. 33 – 35. *Hoplorhynchus carusi*— 33.–Trophozoite, 34.–Epimerite, 35.–Sporadin.
Figs. 36 – 40. *Menospora enallagmae*— 36.–Trophozoite, 37.–Epimerite, 38.–Vertical section through epimerite, 39.–Sporadin, 40.–Sporocyst.
Figs. 41 – 44. *Menospora coenagrii*— 41.–Trophozoite, 42.–Epimerite in frontal view, 43.–Sporadin, 44.–Sporocyst.
Figs. 45 – 48. *Menospora agriocnema*— 45.–Trophozoite, 46.–Epimerite in frontalview, 47.–Sporadin, 48.–Sporocyst.
Figs. 49 – 52. *Menospora gulbargaensis*— 49.–Trophozoite, 50.–Epimerite in side view, 51.–Sporadin, 52.–Sporocyst.

Menospora agriocnema (Kori & Amoji, 1986) Sarkar, 1995

Syn. ***Levineia agriocnema*** Kori & Amoji, 1986

Epimerite a wide cup bordered with 34 – 35 digitiform recurved processes – each with terminal sucker, epimerite 35.0 μm in diameter ; sporadin fusiform ; LP : TL = 1 8.2. WP : WD = 1 : 0.68 – 1.1 ; gametocyst spherical ; sporocyst cylindro-biconical, 10.0 μm × 4.5 μm (Figs. 45 – 48).

Site of infection : Midgut.

Host : *Agriocnemis pygmaea* (Rambur).

Locality : Gulbarga, Karnataka, India.

Menospora gulbargaensis (Amoji & Kori, 1991) Sarkar, 1995

Syn. ***Levinia gulbargaensis*** Amoji & Kori, 1991

Epimerite cup-like, with many digitiform processes ; short, slender neck ; epimertie 12.6 μm long ; largest trophozoite 102.6 μm × 22.3 μm ; largest sporadin 710.0 μm × 160.0 μm ; LP : TL = 1 : 1.3 – 7.8, WP : WD = 1 : 0.4 – 1.1 ; gametocyst spherical ; sporocyst cylindro-biconical, 9.0 μm × 3.5 μm (Figs. 49 – 52).

Site of infection : Midgut.

Host : *Agriocnemis pygmaea* (Rambur).

Locality : Gulbarga, Karnataka, India.

Hoplorhynchus Carus, 1863 emend. Grasse, 1953

Epimerite a flat disc with many digitiform processes at the periphery, processes may be branched or unbranched ; usually a long neck ; gametocyst spherical, dehisces by simple rupture ; sporocyst smooth biconical or crescentic. 3 species :

Key to species

1. Epimerite with long narrow neck
2. Epimerite with short neck

3(1). The disc with radially arranged, unbranched, slightly recurved processes

4(2). The disc with bifid and trifid, short processes

5(3). The processes unbranched, not more than 10 ..... *Hoplorhynchus carasi* Sarkar & Mazumder, 1983

6(4). The processes branched (bifid & trifid) ..... *Hoplorhynchus ramidigitus* Sarkar & Haldar, 1980

7(4). The disc with 10 bifid processes

8(7). Sporocyst largestd, 16.0 μm × 5.0 μm ..... *Hoplorhynchus bahamani* Sailaja & Amoji, 1992

Hoplorhynchus ramidigitus Sarkar & Haldar, 1980

Epimerite a disc with 11 –14 bifid and trifid, stumpy digitiform processes, 16.7 μm in diam., short neck ; largest tropozoite 175.0 μm × 33.3 μm ; Largest sporadin 700.1 μm × 166.7 μm ; LP : TL = 1 : 4.9, WP : WD = 1 : 0.97 ; gametocyst spherical ; sporocyst crescentic, 12.0 μm × 3.5 μm. (Figs. 15 – 28).

Site of infection : Midgut.

Host : *Agriocnemia phygmaea* (Rambur).

Locality Chinsurah, West Bengal, India.

Hoplorhynchus carusi Sarkar & Mazumder, 1983

Epimerite a disc with 10 radially arranged digitiform processes (slightly recurved), long narrow neck ; largest trophozoite 805.0 μm × 60.0 μm ; largest sporadin 650.0 μm × 92.0 μm ; LP : TL = 1 : 9.8, WP : WD = 1 : 1.1 gametocyst and sporocyst unknown (Figs. 33 – 35).

Site of infection : Midgut.

Host : *Pseudagrion decorum* (Rambur).

Locality : Mahananda forest, West Bengal, India.

Hoplorhynchus bahamanii Sailaja & Amoji, 1992

Epimerite disc-like with 10 bifid digitiform processes, 24.5 μm × 13.25 μm long slender neck ; largest trophozoite 210.0 μm × 57.5 μm ; LP : TL = 1 : 3.55, WP : WD = 1 0.95 ; gametocyst spherical ; sporocyst crescentic, 16.0 μm × 5.0 μm (Figs. 29 – 32).

Site of infection : Midgut.

Host Coenagrionid larvae (Odonata).

Locality : Gulbarga, Karnataka, India.

Odonaticola Sarkar & Haldar, 1981

Epimerite hat-shaped with petaloid spines at the margin, long neck ; sporadin solitary ; gametocysts dehisce by simple rupture ; sporocysts boat-shaped, smooth ; development extracellular ; 12 species :

Key to species

1. Epimerite hat-shaped with long neck

2. Epimerite a conical, inverted cup, long neck

3(1). Margin of the hat with with petaloid spines

4(2). Margin of cup with broad spines

5(3). Epimerite with 6 spines ..... *Odonaticola hexacantha* Sarkar & Haldar, 1981

6(4). Epimerite with 7 spines, very long neck ..... *O. longicollara* Sarkar & Haldar, 1981

7(1). Epimerite hat-like, umbrella-shaped margin

8(7). Umbrella-like margin with many sharp spines

9(8). Epimerite 13.7 μm in diameter

10(9). Boat-shaped sporocyst measures 8.5 μm × 3.5 μm ..... *O. orthetri* Sarkar & Haldar, 1981

11(3). Epimerite with 8 petaliod spines

12(11). Epimerite 14.2 μm × 17.4 μm in dimension

13(12). Sporocyst 10.7 μm long ..... *O. rodgii* Sarkar & Haldar, 1981

14(7). Epimerite with many petaloid spines

15(14). Epimerite 12.3 μm × 22.5 μm in dimension ..... *O. brachydiplaxi* Sarkar & Haldar, 1981

16(2). Epimerite with many small recurved spines

17(8). Epimerite 15.8 μm × 20.0 μm in dimension

18(10). Sporocyst 12.0 μm × 5.0 μm in dimension ..... *O. elliptica* Sarkar, 1981

19(2). Epimerite with 9 petaloid spines

20(19). Long slender neck

21(20). Epimerite 24.2 μm × 28.3 μm

22(21). Sporocyst 8.5 μm × 4.5 μm ..... *O. nonacontha* (Devdhar & Despande, 1971) Sarkar, 1981

23(1). Epimerite dome-shaped, 8 downwardly directed petaloid spines

24(23). Gametocyst oval

25(24). Sporocyst boat-like, 13.8 μm × 4.4 μm ..... *O. diplacodi* Kori & Amoji, 1986

26(1). Epimerite hood-shaped, long narrow neck

27(26). Epimerite with several filamentous, curved spines

28(27). Gametocyst oval

28(28). Sporocyst oval, 12.0 μm × 4.0 μm ..... *O. crocothemis* Kori & Amoji, 1983

30(1). Epimerite bell-shaped, long neck

31(30). Epimerite with 8 petaloid spines

32(31). Gametocyst oval

33(32). Sporocyst spindle-like in dorsal view

34(33). Sporocyst 13.0 μm × 5.0 μm ..... *O. haldari* Kori & Amoji, 1984

35(1). Epimerite with 7 – 11 marginal spines

36(35). Epimerite measures 16.0 μm × 6.0 μm

37(36). Gametocyst very large

38(37). Sporoduct cord-like (?)

39(36). Sporocyst small, boat-shaped, 7.5 μm × 4.5 μm ..... *O. pantalae* Prema & Janardanan, 1991

40(1). Epimerite with 6 petaloid spines

41(40). Sporosyst boat-shaped, 9.0 μm × 4.5 μm ..... *O. nurothemisi* Prasadan & Janardanan, 1994

Odonaticola hexacentha Sarkar & Haldar, 1981

Epimerite hat-shaped with 6 petaloid spines at the margin, 9.0 μm × 11.1 μm, long slender neck ; largest trophozoite 273.1 μm long ; largest sporadin 758.5 μm long ; LP : TL = 1: 4.2, WP : WD = 1 : 1.4 ; gametocyst soherical : sporocyst released in the group of three forming a triangle, each one boat-shaped with a very small rectangular projection on each end, 7.5 μm × 3.0 μm. (Figs. 64 – 67).

Site of infection : Midgut.

Host : *Brachythemis contaminata* (Fabr.).

Locality Chinsurah, West Bengal, India.

Odonaticola longicollara Sarkar & Haldar, 1981

Epimerite a conical cup with 7 petaloid spines at its margin, 18.0 μm × 22.9 μm ; very long slender neck ; largest trophozoite 838.1 μm long ; largest sporadin 1467.8 μm long ; LP : TL = 1 : 7.0, WP : WD = 1 : 1.2 ; gametocyst spherical ; sporocyst boat-shaped with short projections on either end, 7.5 μm × 4.1 μm. (Figs. 68 – 71).

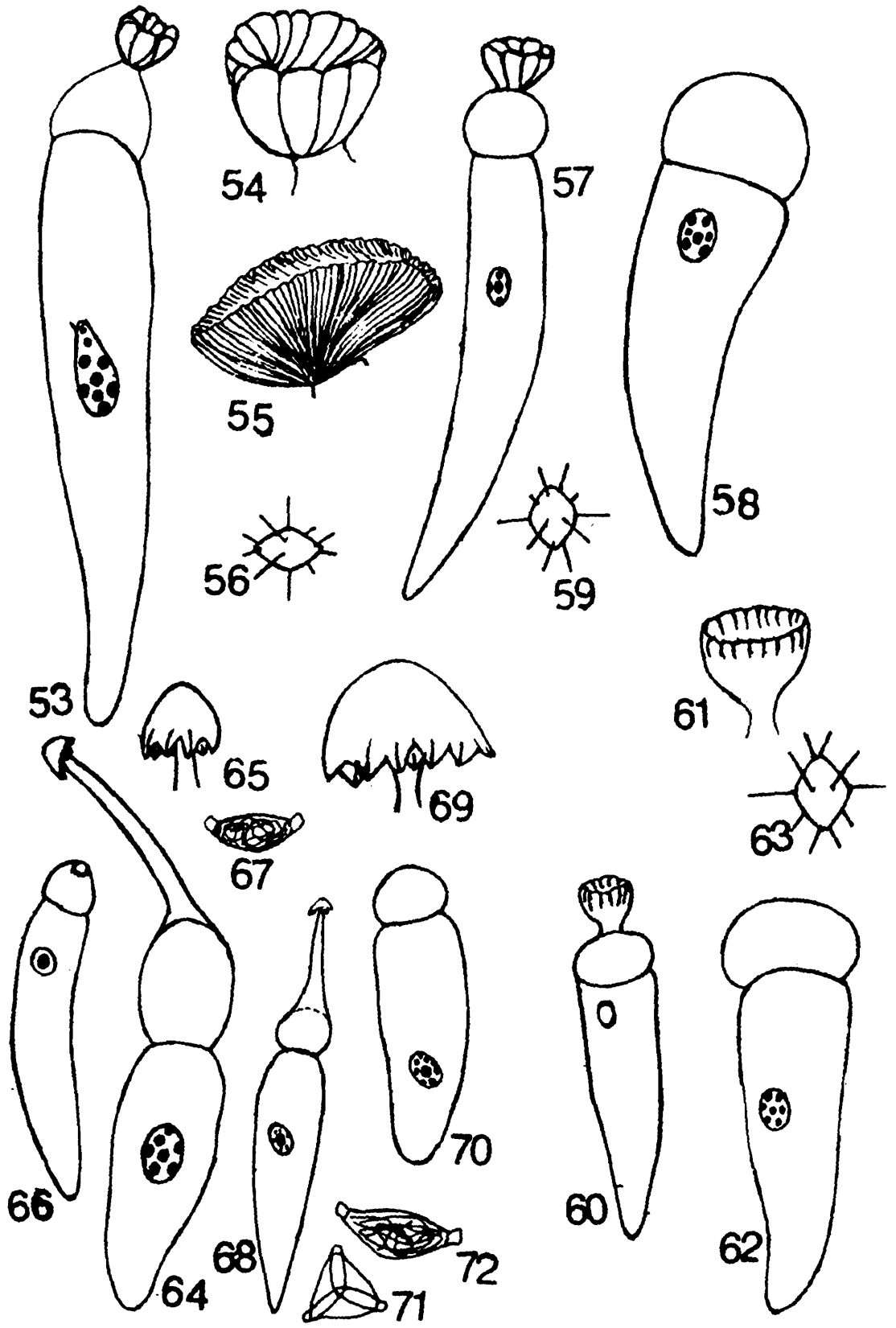
Site of infection : Midgut.

Host : *Diplacodes trivialis* (Rambur).

Locality : Chinsuran, West Bengal, India.

Odonaticola orthetri Sarkar & Haldar, 1981

Epimerite hat-shaped with umbrella-like margin leading to several sharp spines, 13.7 μm in diam. ; moderately long neck ; largest trophozoite 33.70 μm long ; largest sporadin 950.2 μm long ; LP : TL = 1 : 5.4, WP : WD = 1 : 1.3 ; gametocyst spherical ; sporocyst boat-shaped with small rectangular projection on either ends, 8.5 μm × 3.5 μm (Figs. 74 – 77).



Figs. 53 – 56. *Mukunaella undulatus*— 53.–Trophozoite, 54. & 55.–Epimerite, 56.–Sporocyst.
Figs. 57 – 59. *Mukundaella agriocnemii*— 57.–Trophozoite, 58.–Sporadin, 59.–Sporocyst.
Figs. 60 – 63. *Mukandaella gulbargaensis*— 60.–Trophozoite, 61.–Epimerite, 62.–Sporadin, 63.–Sporocyst.
Figs. 64 – 67. *Odonaticola hexacantha*— 64.–Trophozoite, 65.–Epimerite, 66.–Sporadin, 67.–Sporocyst.
Figs. 68 – 72. *Odonaticola longicollara*— 68.–Trophozoite, 69.–Epimerite, 70.–Sporadin, 71.–Aggregation of 3 sporocyst, 72.–Sporocyst.

Site of infection Midgut.

Host *Orthetrum sabina* (Drury).

Locality Chinsurah, West Bengal, India.

Odonaticola rodgii Sarkar & Haldar, 1981

Epimerite hat-shaped with 8 petaloid spines at its margin, 14.2 µm × 17.4 µm ; long slenden neck lartgest trophozoite 268.8 µm × 54.6 µm ; largest sporadin 1624.5 µm long ; LP : TL = 1 : 6.4, WP : WD = 1 : 1.06 ; gametocyst spherical ; sporocyst boat-shaped with small, rectangular, terminal projections, 10.7 µm × 4.0 µm (Figs. 78 – 81).

Site of infection Midgut.

Host *Neurothemis tullia tullia* (Drury).

Locality Kalyani, West Bengal, India.

Odonaticola elliptica Sarkar, 1981

Epimerite conical, umbrella-like with many small curve spines along its margin, 15.8 × 20.0 µm ; very long, slender neck ; largest trophozoite 309.4 µm × 62.5 µm ; largest sporadin 1512.0 µm × 294.6 µm ; PL : TL = 1 : 7.2, WP : WD = 1 : 1.2 ; gametocyst spherical ; sporocyst boat-shaped with a lateral projection on each side, 12.0 µm × 5.0 µm (Figs. 108 – 112).

Site of infection : Midgut.

Host : *Crocothemis servilia servilia* (Drury).

Locality : Chinsurah, West Bengal, India.

Odonaticola nonacontha (Devdhar & Deshpande, 1971) Sarkar, 1981

Syn. : ***Menospora nonacontha*** Devdhar & Deshpande, 1917.

Epimerite conical, umbrella-like with 9 marginal pataloid spines, 24.2 µm × 28.3 µm ; long, slender neck ; LP : TL = 1 : 7.2, WP : WD = 1 : 1.2 ; gametocyst spherical ; sporocyst boat-shaped with lateral projectios, 8.5 µm × 4.5 µm. (Figs. 104 – 107).

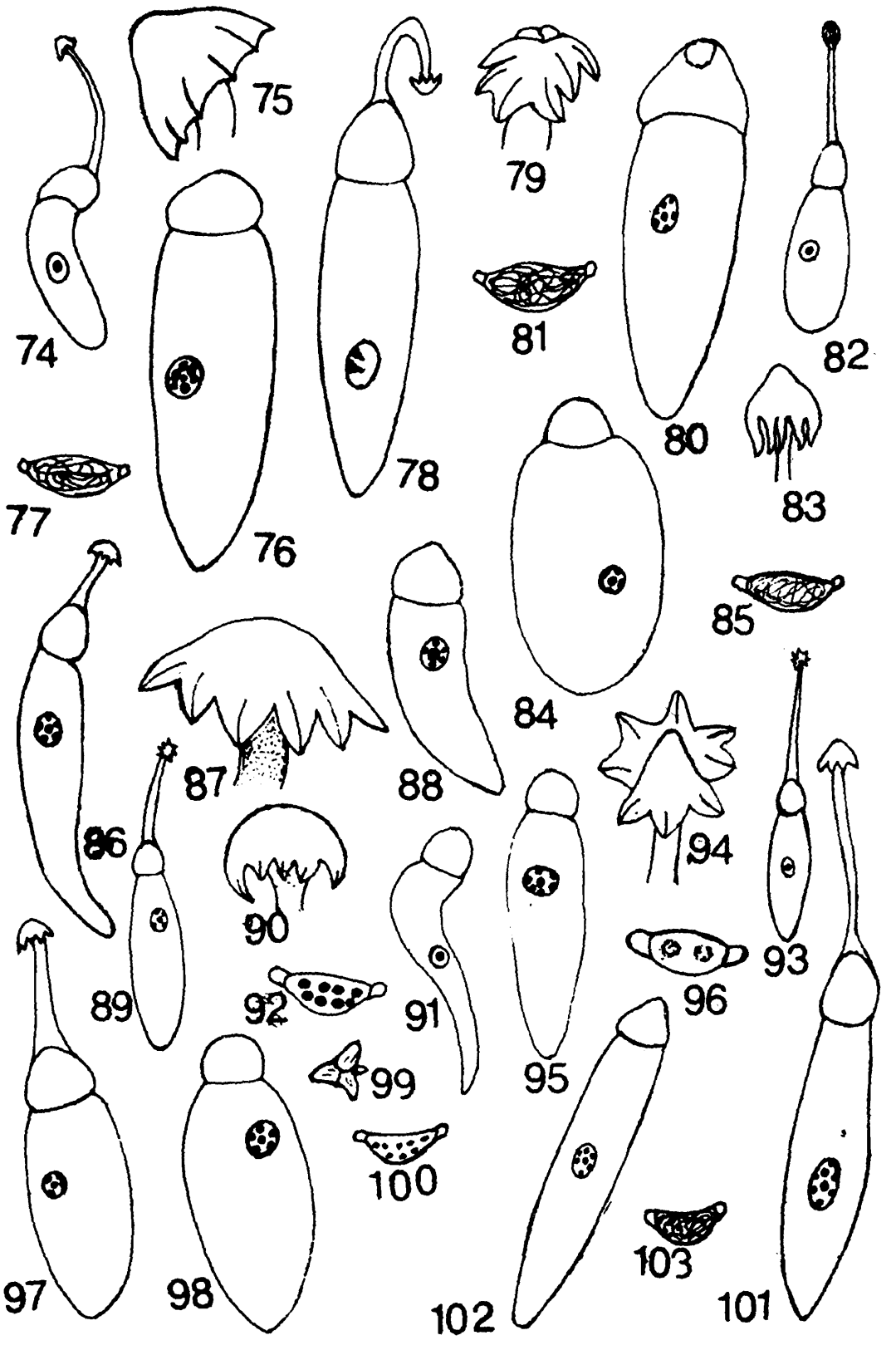
Site of infection : Midgut.

Host : *Urothemis signata signata* (Drury).

Locality Karnataka & West Bengal, India.

Odonaticola brachydiplaxi Sarkar & Mazumder,1983

Epimerite umbrella-shaped with many marginal petaloid spines, 12.5 µm × 22.5 µm ; long neck ; largest trophozoits 382.0 µm × 45.0 µm ; largest sporadin 265.0 µm × 60.0 µm ; LP : TL = 1 : 5.04, WP : WD = 1 : 1.14 ; gametocyst and sporocyst unknown. (Figs. 86 – 88).



Figs. 74 – 77. *Odonaticola orthetri*— 74.–Trophozoite, 75.–Epimerite, 76.–Sporadin, 77.–Sporocyst.
Figs. 78 – 81. *Odonaticola rodgii*— 78.–Trophozoite, 79.–Epimerite, 80.–Sporadin, 81.–Sporocyst.
Figs. 82 – 85. *Odonaticola crocothemis*— 82.–Trophozoite, 83.–Epimerite, 84.–Sporadin, 85.–Sporocyst.
Figs. 86 – 88. *Odonaticila brachydiplaxi*— 86.–Trophozoite, 87.–Epimerite, 88.–Sporadin.
Figs. 89 – 92. *Odonaticola diplacodi*— 89.–Trophozoite, 90.–Epimerite, 91.–Sporadin, 92.–Sporceyst.
Figs. 93 – 96. *Odonaticola haldari*— 93.–Trophozoite, 94.–Epimerite, 95.–Sporadin, 96.–Sporocyst.
Figs. 97 – 100. *Odonaticola pantalae*— 97.–Trophozoite, 98.–Sporadin, 99.–3 sporocyst attached, 100.–Sporocyst.
Figs. 101 – 103. *Odonaticola neurothemisi*— 101.–Trophczoite, 102.–Sporadin, 103.–Sporocyst.

Site of infection : Midgut.

Host : *Brachydiplax farinosa* Kruger.

Locality Mahananda Forest, West Bengal, India.

Odonaticola crocothemis Kori & Amoji, 1983

Epimerite hood-shapped with several filamentous, curved spines ; long neck ; largest trophozoite 540.0 μm long ; largest sporadin 575.0 μm long ; LP : TL = 1 : 5 – 9.5, WP : WD = 1 : 1.8 – 3.6 ; gametocyst oval ; sporocyst boat-shaped with lateral projections, 12.0 μm × 4.0 μm. (Figs. 82 – 85).

Site of infection : Midgut.

Host : *Crocothemis servilia servilia* (Drury).

Locality : Gulbarga, Karnataka, India.

Odonaticola haldari Kori & Amoji, 1984

Epimerite bell-shaped, 8 petaloid spines in the margin ; long neck ; largest trophozoite 770.0 μm long ; largest sporadin 1750.0 μm long ; LP : Tl = 1 : 4.2 – 13.6, WP : WD = 1 : 1.0 – 2.3 ; gametocyst oval ; sporocyst boat-shaped, spindle-like in dorsal view, 13.0 μm × 5.0 μm. (Figs. 93 – 96).

Site of infection : Foregut & Midgut.

Host : *Trithemis aurora* (Burmeister).

Locality : Gulbarga, Karnataka, India.

Odonatocola diplacodi Kori & Amoji, 1986

Epimerite dome-shaped, 8 downwardly directed petaloid spines ; moderately long neck ; largest sporadin 1550.0 μm long ; LP : TL = 1 : 3.5 – 10.75, WP : WD = 1 : 0.6 – 1.75 ; gametocyst oval ; sporocyst boat-shaped, small, terminal projections, 13.8 μm × 4.4 μm. (Figs. 89 – 92).

Site of infection : Midgut.

Host : *Diplacodes trivialis* (Rambur).

Locality : Gulbarga, Karnatak, India.

Odonaticola pantalae Prema & Janardanan, 1991

Epimerite hat-shaped, 7 – 11 petaloid, marginal spines, 16.0 μm × 6.0 μm ; neck long ; lartest trophozoite 880.0 μm long where epimerite is 38.0 μm long ; largest sporadin 1871.0 μm long ; gametocyst spherical ; sporoduct (?) naked ; sporocyst boat-shaped with two short projections at poles, 7.5 μm × 4.5 μm. (Figs. 97 – 100).

Site of infection : Midgut.

Host : *pantala flavescens* (Fabr.).

Locality : Calicut University campus, Kerala, India.

Odonaticola neurothemisi Prasadan & Janardanan, 1994

Epimerite hat-shaped with 6 petaloid spines ; long neck ; largest trophozoite 862.0 μm long ; **largest** sporadin 1778.0 μm long ; gametocyst spherical ; sporocyst released in the form of a naked **sporoduct** (?), sporocyst boat-shaped with a small projection at each pole, 9.0 μm × 4.5 μm. **(Figs.** 101 – 103).

Site of infection : Midgut.

Host : *Neurothemis fulvia* (Drury).

Locality : Calicut University Campus, Kerala, India.

Subfamily : ACTINOCEPHALINAE Labbé, 1899

Actinocphus Stein, 1848

Epimerite with 8 – 10 stout spines or simple digitifor processes ; sessile or with short neck ; **sporocyst** smooth, biconical. 3 species.

Key to species

1. Epimerite a globular crown or a cap
2. Epimerite a discoid plate

3(1). Crown with 16 or more lateral spines

4(2). Disc with 7 to 9 slightly recurved hooks

5(3). Gametocyst spherical

6(4). Gametocyst ellipsoidal

7(5). Sporocyst biconical with rounded ends, 12.40 μm × 4.28 μm .....*Actinocephalus ceriagrionae* Sarkar & Chakravarty, 1969

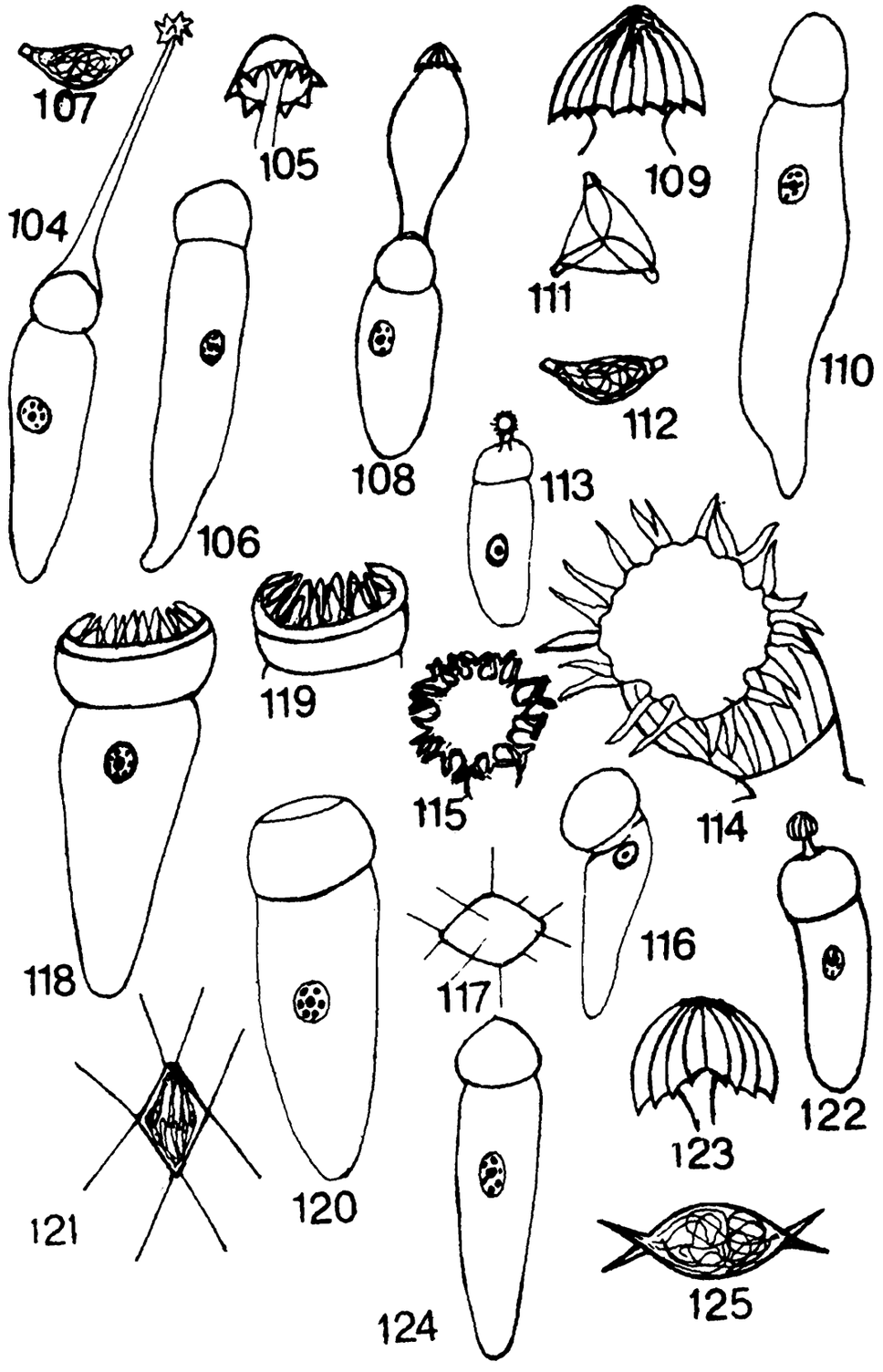
8(6). Sporocyst biconical, 8.0 μm × 4.5 μm .....*Actinocaphalus ellipsoidus* Sarkar & Haldar, 1981.

9(1). Cap with petaloid lobes, long neck

10(9). Gametocyst spherical

11(10). Sporocyst oval, 17.0 μm × 5.0 μm ..... *Actinocephalus bradinopygi* Narasimhamurti & Nazeer Ahamed, 1980

..... *Actinocephalus ceriagrionae* Sarkar & Chakravarty, 1969



Figs. 104 – 107. *Odonaticila nonacontha*— 104.–Trophozoite, 105.–Epimerite, 106.–Sporadin, 107.–Sporocyst.
Figs. 108 – 112. *Odonaticola elliptica*— 108.–Trophozpozoite, 109.–Epimerite, 110.–Sporadin, 111.–Association of 3 sporocyst, 112–Sporocyst.
Figs. 113 – 117. *Ramicephalus olivacus*— 113.–Trophozoite, 114 & 115.–Epimerite, 116.–Sporadin, 117.–Sporocyst.
Figs. 118 – 121. *Tetrameridionospinospora ceriagroni*— 118.–Trophozoite, 119.–Epimerite, 120.–Sporadin, 121.–Sporocyst.
Figs. 122 – 125. *Tetractinospora victoris*— 122.–Trophozoite, 123.–Epimerite, 124.–Sporadin, 125.–Sporocyst.

Epimerite a globular crown with 16 short and stout, lateral, digitiform processes set upon a short, cylindrical neck ; trophozoite (largest) 258.0 μm ; sporadin (largest) 1.0 mm ; LP : TL = 1 : 5.5, WP : WD = 1 : 1.1 ; gametocyst spherical : sporocyst biconical, 12.4 μm × 4.28 μm.

Site of infection : Midgut.

Host : *Ceriagrion coromandelianum* (Fabr.).

Locality : Howrah, West Bengal, India.

Actinocephalus ellipsoidus Sarkar & Haldar, 1981

Epimerite discoid with 7 – 9 slightly recurved, pointed processes, 18.8 μm in diameter ; stalked ; largest trophozoite 458.3 μm long ; largest sporadin 916.8 μm long ; LP : TL = 1 : 7.6, WP : WD = 1 : 1.3 ; Gametocyst ellipsoidal ; Sporocyst biconical, 8.0 μm × 4.5 μm (Figs. 13 – 16).

Site of infection : Midgut.

Host : *Ischnura aurora aurora* (Bramis.).

Locality : Kalyani, West Bengal, India.

Actinocephalus bradinopygi Narasimhamurti & Nazeer Ahamed 1980

Epimerite conical with 9 – 11 petaloid lobes, long neck, largest trophozoite 825.0 μm × 160.0 μm ; largest sporadin 1300.0 μm × 255.0 μm ; Gametocyst spherical ; Sporocyst oval, 17.0 μm × 5.0 μm (Figs. 21 – 24).

Site of infection : Midgut.

Host : *Bradinopyga greminata* Rambur.

Locality : Visakhapatnam, Andhra Pradesh, India.

Remark : The epimarite of this species shows much similarity with that of the *Odonaticola* but its sporocyst does not ; in fact distinctly different from the boat-shaped sporocyst of *Odonaticola*. I, therefore, retain the present status of this species.

Family DACTYLOPHORIDAE

Dendrorhynchus Keilin, 1920 emend. Levine, 1988

Dendrorhynchus Keilin, 1920 emend, Levine, 1988

Epimerite a sucker boardered with ramified lobes (papillae) ; transverse fibrils conspecuous ; gametocyst ellipsoidal ; sporocyst biconical (fusiform). 1 species :

Dendrorhynchus keilini Nazeer Ahmed & Narasimhamurt, 1980

Epimerite a disc (32.0 μm in diam.), the margin produced into 13 – 16 bifid papillae ; very

short neck ; largest trophozoite 400.0 μm long ; largest sporadin 410.0 μm × 156.0 μm ; epicyte with transvrese fibrils in the deutomerite ; gametocyst spherical, dehisces by simple rupture ; sporocyst oval, 12.0 μm × 5.0 μm, sporozoite spindle-like, 7.0 μm × 3.0 μm. LP : TL = 1 : 3.47, WP : WD = 1 : 1.1 (Figs. 17 – 20).

Site of infection : Midgut.

Host : *Ceriagrion coromandelium* (Fabr.).

Locality : Visakhapatnam, Andhra Pradesh, India.

SUMMARY

This study reveals that there are 32 species of Eugregarinida (Apicomplexa : Sporozoea : Septatina) described so far from Indian Odonates (Arthopoda : Insecta : Odonata). These gregarines are referable to 11 genera viz. *Acanthospora* Léger, 1892 ; *Actinocephalus* Stein, 1848 ; *Ancyrophora* Leger, 1892 ; *Dendrorhynchus* Kielin, 1920 ; *Hoplorhynchsu* Carus, 1863 emend. Grasse 1953 ; *Menospora* Léger,1892 ; emend : Sarkar, 1995 ; *Mukundaella* Sarkar, 1981 *Odonaticola* Sarkar & Haldar, 1981 ; *Ramicephalus* Obata, 1953 ; *Tetractinospora* Sarkar & Haldar, 1986 and *Tetrameridionospinispora* Kori & Amoji, 1985. belonging to the family Actinocephalidae Leger, 1892 from 21 species of Odonata.

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