

FLAGELLATE SYMBIOTES (PROTOZOA) OF XYLOPHAGOUS TERMITES FROM NORTHERN BIHAR

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INTRODUCTION

Taxonomic studies on the flagellate symbiotes of Indian termites are inadequate and restricted only to a few states of eastern and western parts of the country (*see* Das, 1983). The northern part of India which covers a large area and comprises a large number of states remains almost unexplored excepting one publication of Tiwari (1988) who reported the occurrence of six species of termite flagellates from Uttar Pradesh. However, Simmons (*loc. cit.* Kirby, 1932) studied some 'Behar termites' which as he found were not infected by any protozoa. In view of this the present author undertook several surveys in the districts of Bhagalpur, Chhapra (Saran), Darbhanga, Dumka, Gopalganj, Madhubani, Monghyr, Muzaffarpur, Purnea, Saharsa, Sahibganj, Samastipur, Vaishali, and West Champaran in the northern part of Bihar during 1983-1984 and 1986 and collected 27 species of termite flagellates from 5 species of termite hosts. These flagellates are being dealt with in the present communication.

MATERIAL AND METHODS

During the course of this study large number of termites were examined from different localities. The termites examined were collected from different habitats, specially from the living and dried trees and agricultural plants. Sometimes collection of host termites were also made from timber depots, logs, cemented brick built walls, plywoods and pitch boards. Attempts were made to obtain their different castes, especially the soldiers for proper identification of termites as without soldiers identification of termites is not possible.

To obtain flagellate symbiotes of termites, the entire gut of the worker caste was removed and gut contents were emptied on clean slide containing a drop of 0.5 per cent saline. Generally 67 per cent lock's solution was applied in which the protozoa are less deformed and remain active for a long period. The study is based on the material obtained from living termites. As fixative Schaudinn's fluid was used. The materials so fixed were mostly stained in Heidenhain's iron haematoxylin and some times Eosin was used as a counter stain and mounted in DPX. The dilute Lugol's iodine was occasionally used to detect in the ingested wood particles inside the protozoans specimens examined under microscope. The morphometric measurements of flagellates

on permanent mount were taken with the help of ocular micrometer. The drawings were made with the aid of Camera Lucida (Prism type).

SYSTEMATIC LIST OF FLAGELLATES

Order : OXYMONADIDA

Family : OXYMONADIDAE

1. *Oxymonas bosei* Das
2. *O. grandis* Cleveland

Order : TRICHOMONADIDA

Family : DEVESCOVINIDAE

3. *Caduceia kalshoveni* Kirby
4. *Devescovina glabra* Grassi
5. *D. lemniscata* Kirby
6. *Foaina reflexa* Kirby
7. *F. solita* Kirby
8. *Macrotrichomonas pulchra* Grassi

Family : CALONYMPHIDAE

9. *Stephanonympha minuta* Das and Choudhury
10. *S. pyriformis* Das and Choudhury
11. *S. silvestrii* Janicki

Order : HYPERMASTIGIDA

Family : HOLOMASTIGOTIDAE

12. *Holomastigotoides bengalensis* Chakravarty and Banerjee
13. *H. campanula* (De Mello)
14. *H. emersoni* Das
15. *H. hollandei* Das
16. *H. magnus* Uttangi
17. *H. ogivalis* De Mello
18. *H. ovalis* Uttangi
19. *H. rayi* Karandikar and Vittal

20. *H. reniformis* De Mello
21. *H. sphaeroidalis* De Mello

Family : SPIROTRICHONYMPHIDAE

22. *Spirotrichonympha bhadreshwarensis* Tiwari
23. *S. froilanoi* Karandikar and Vittal
24. *S. roonwali* Das

Family : EUCOMONYMPHIDAE

25. *Pseudotrichonympha cardiformis* Karandikar and Vittal
26. *P. indica* Chakravarty and Banerjee
27. *P. subapicalis* Karandikar and Vittal

HOST—SYMBIOTE LIST

Host	Flagellates
1. <i>Cryptotermis havilandi</i> (Sjosted) :	<ol style="list-style-type: none"> 1. <i>Oxymonas bosei</i> Das 2. <i>O. grandis</i> Cleveland 3. <i>Devescovina glabra</i> Grassi 4. <i>D. lemmiscata</i> Kirby 5. <i>Foaina solita</i> Kirby 6. <i>Stephanonympha minuta</i> Das and Choudhury.
2. <i>Glyptotermes caudomunitus</i> Kemner	<ol style="list-style-type: none"> 1. <i>Macrotrichomonus pulchra</i> Grassi
3. <i>Neotermes bosei</i> Snyder	<ol style="list-style-type: none"> 1. <i>Caduceia kalshoveni</i> Kirby 2. <i>Foaina reflexa</i> Kirby 3. <i>Stephanonympha pyriformis</i> Das and Choudhury
4. <i>Coptotermes heimi</i> (Wasmann)	<ol style="list-style-type: none"> 1. <i>Holomastigotoides bengalensis</i> Chakravarty and Banerjee 2. <i>H. campanula</i> (De Mello) 3. <i>H. emersoni</i> Das 4. <i>H. magnus</i> Uttangi 5. <i>H. ogivalis</i> De Mello

Host	Flagellates
	6. <i>H. reniformis</i> De Mello
	7. <i>H. sphaeroidalis</i> De Mello
	8. <i>Spirotrichonympha bhadreshwarensis</i> Tiwari
	9. <i>S. roonwali</i> Das
5. <i>Heterotermes indicola</i> (Wasmann)	1. <i>Holomastigotoides hollandei</i> Das
	2. <i>H. ovalis</i> Uttangi
	3. <i>H. rayi</i> Karandikar and Vittal
	4. <i>Pseudotrichonympha cardiformis</i> Karandikar and Vittal
	5. <i>Spirotrichonympha froilanai</i> Karandikar and Vittal

Key to families, genera and species

1. Mastigont system with limited flagella	...	...	17
Mastigont system with numerous flagella	...	...	2
2. Flagella arranged in spiral rows	...	...	3
Flagella not arranged in spiral rows		Family Eucomonymphidae (Genus <i>Pseudotrichonympha</i>) ...	15
3. Spiral rows of flagella numerous		Family <i>Holomastigotidae</i> (Genus <i>Holomastigotoides</i>) ...	4
Spiral rows of flagella limited		Family Spirotrichonymphidae (Genus <i>Spirotrichonympha</i>) ...	13
4. Prenuclear zone present	...	...	5
Prenuclear zone absent	...	<i>H. campanula</i>	
5. Prenuclear zone occurs as narrow strip over the nucleus	...	<i>H. magnus</i>	
Prenuclear zone not occurs as narrow strip over the nucleus	...	...	6
6. Body elliptical with nipple like anterior end	...	<i>H. bengalensis</i>	
Body elliptical without nipple like anterior end	...	...	7
7. Non-stereociliac flagella occupying the posterior one fifth of the body	...	<i>H. rayi</i>	
Non-stereociliac flagella not occupying the posterior one fifth of the body	...	...	8

8.	Axostyle present	...	...	9
	Axostyle absent	...	<i>H. ovalis</i>	
9.	Apical pit present	...	<i>H. hollandei</i>	
	Apical pit absent	...	...	10
10.	Nucleus round	...	...	11
	Nucleus not round	...	...	12
11.	Body spherical	...	<i>H. sphaeroidalis</i>	
	Body club-shaped	...	<i>H. emersoni</i>	
12.	Body inverted cup-shaped	...	<i>H. ogivalis</i>	
	Body reniform	...	<i>H. reniformis</i>	
13.	Body cone-shaped	...	<i>S. froilanoi</i>	
	Body not cone-shaped	...	...	14
14.	Posterior extremity drawn out into a cone	...	<i>S. roonwali</i>	
	Posterior extremity not drawn out into a cone	...	<i>S. bhadreshwariensis</i>	
15.	Campanula subapical in position	...	<i>P. subapicalis</i>	
	Campanula not subapical in position	...	...	16
16.	Body heart shaped	...	<i>P. cardiformis</i>	
	Body elongated	...	<i>P. indiana</i>	
17.	Mastigont having two to four flagella always associated with an axostyle, parabasal body present	...	...	18
	No such mastigont system present, parabasal body absent	...	Family : Oxymonadidae (Genus : Oxymonas)...	26
18.	Nucleus single	...	Family : Devescovichidae...	19
	Nucleus multiple	...	Family : Calonymphidae (Genus : Stephanonympha)...	24
19.	Trailing flagellum longer than the body	...	...	20
	Trailing flagellum shorter than the body	...	Genus : <i>Caduceia</i> (<i>C. kalshoveni</i>).	
20.	Cresta very much enlarged with internal membrane	...	Genus : <i>Macrotrichomonas</i> (<i>M. pulchra</i>)	
	Cresta without much enlargement and without internal membrane	...	...	21.
21.	Trailing flagellum 1 – 1½ times of the body length	...	Genus <i>Devescovina</i> ...	22
	Trailing flagellum more than two times of the body length	...	Genus <i>Foaina</i> ...	23

- | | | | |
|-----|---|-----|----------------------|
| 22. | Cytoplasm contains group of deep staining granules posterior to the nucleus, trailing flagellum card-like | ... | <i>D. glabra</i> |
| | Cytoplasm not containing such granules, trailing flagellum band-shaped | ... | <i>D. lemniscata</i> |
| 23. | Parabasal body with U-shaped bend | ... | <i>F. reflexa</i> |
| | Parabasal body without such bend | ... | <i>F. solita</i> |
| 24. | Body pyriform with bluntly pointed anterior end | ... | <i>S. pyriformis</i> |
| | Body not pyriform without bluntly pointed end | ... | ... 25 |
| 25. | Eight to twelve nuclei in a single spiral rows | ... | <i>S. minuta</i> |
| | Numerous nuclei in two to three spiral rows | ... | <i>S. silvestrii</i> |
| 26. | Body broadly ovoidal with stiletto-shaped axostyle | ... | <i>O. bosei</i> |
| | Body ellipsoidal with scimitar-shaped axostyle | ... | <i>O. grandis</i> |

ABBREVIATIONS USED

b=body width, cam=campanula length, cr=cresta length, f_1 =first type of flagella, f_2 =second type of flagella, f_3 =third type of flagella, l=body length, nb=nuclear width, nl=nuclear length, rst=rostrum length, tf=trailing flagellum.

SYSTEMATIC ACCOUNTS

Order : OXYMONADIDA

Family : OXYMONADIDAE

1. *Oxymonas bosei* Das

(Fig. 1)

1974. *Oxymonas bosei* Das, *Acta Protozool.*, 12 : 337.

Material examined : 2 exs, Sonepure, Chhapra Dist., Bihar ; 7.xii.1984, Coll. D. N. Tiwari.

Diagnosis : Body broadly ovoidal, rostellum extending up to 1.5 times length of body ; axostyle stiletto-shaped, projecting slightly below the nucleus and hanging freely in cytoplasm ; blepharoplast two in number and located near shoulder of rostellum ; nucleus elliptical containing one ovoidal karyosome at center and numerous fine granules mostly concentrated to peripheral zone ; endoplasm containing fragments of wood particles.

Measurements : $l=125-172$ (150) μm ; $b=34-45.5$ (41.2) μm ; $nl=8.7-13.6$ (11.9) μm ; $nb=4.6-8.5$ (6.6) μm ; $l : b=2.8-5$ (3.7) ; $l : nl=9.1-17.5$ (13).

Present host : *Cryptotermes havilandi* (Sjöstedt).

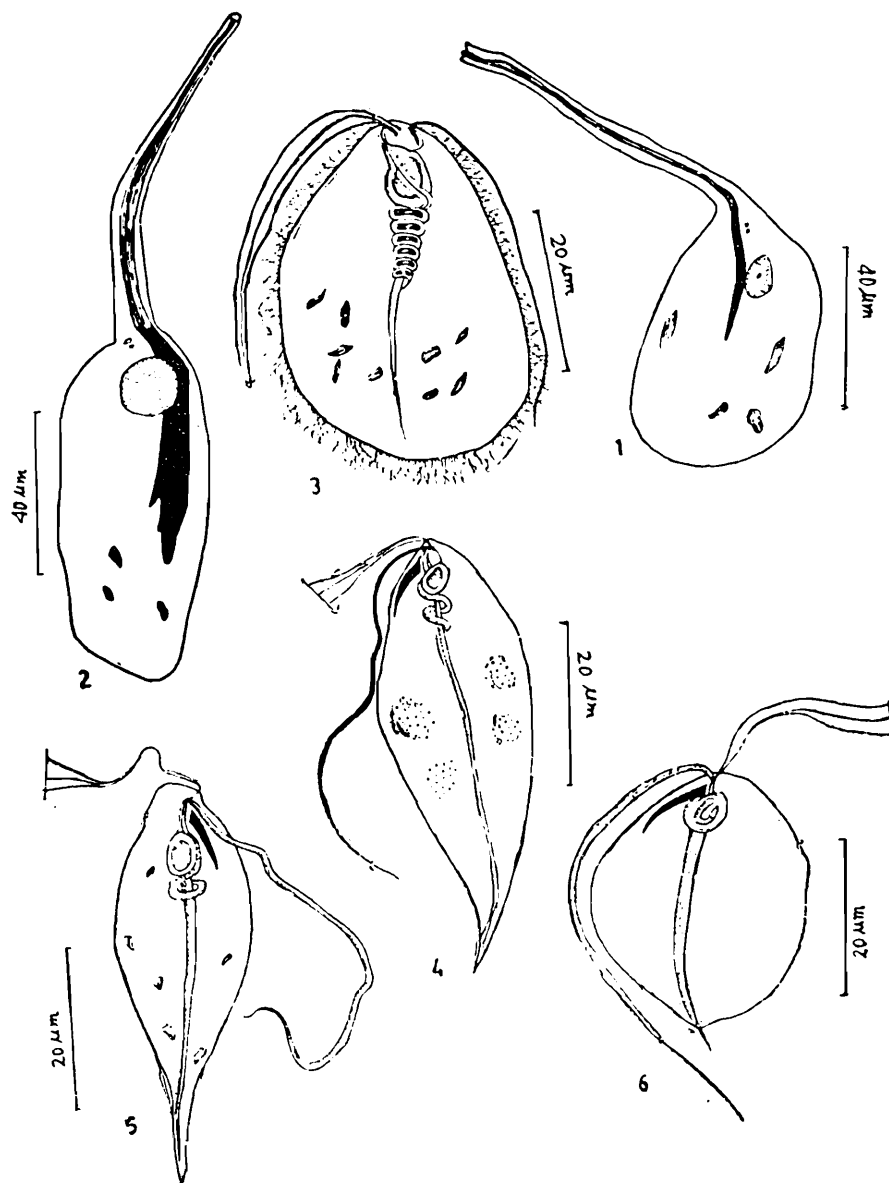
Distribution : India ; Bihar (Present record), West Bengal,

2. *Oxymonas grandis* Cleveland

(Fig. 2)

1935. *Oxymonas grandis* Cleveland, *Biol. Bull.* 69 : 54.

Material examined : 2 exs., Jhanjharpur, Madhubani Dist., Bihar ; 21.i.1986, Coll. D. N. Tiwari.



Figs. 1. *Oxymonas bosei* Das
 2. *Oxymonus grandis* Cleveland
 3. *Caduceia kalshoveni* Kirby
 4. *Devescovina glabra* Grassi
 5. *Devescovina lemniscata* Kirby
 6. *Feaina reflexa* Kirby

Diagnosis : Body ellipsoidal, size of rostellum varies depending upon attaching or motile phase, axostyle scimitar-shaped, nucleus ovoidal, situated posterior to shoulder of axostyle, karyosome absent, chromatin granules of various sizes ; endoplasm containing fragments of wood particles.

Measurements : $l=87.5-224$ (182.8) μm ; $b=38.5-49$ (43.2) μm ; $nl=17.5-24.5$ (20.1) μm ; $nb=10.5-17.5$ (14.8) μm ; $l : b=2.3-5.3$ (4.1) ; $l : nl=5-10.6$ (8.9).

Present host : *Cryptotermes havilandi* Sjöstedt).

Distribution : India : Bihar (present record), West Bengal.

Order : TRICHOMONADIDA

Family : DEVESCOVINIDAE

3. *Caduceia kalshoveni* Kirby

(Fig. 3)

1942. *Caduceia kalshoveni* Kirby, *Univ. Calif. Publ. Zool.*, 45 : 108.

Material examined : 3 exs., Borio, Dumka dist., Bihar ; 23.xi.1983, Coll. D. N. Tiwari.

Diagnosis : Body more or less round ; slender ring present at anterior part of body. Posterior roots of anterior flagella ends with large irregular granules and connected by a fine fibril to blepharoplast group of several closely approximated granules. Cresta, trailing flagellum, parabasal body and anterior flagella connected with blepharoplast. Trailing flagellum long, slender, cord-like and shorter than body. Cresta very small ; parabasal body coiled lightly around the trunk of axostyle ; parabasal turn ranging from 5-9 in number. Chromatin sheild absent ; nucleus oval ; endoplasm containing numerous granules and indigested wood particles ; smaller spirochaetes densely distributed on entire body surface.

Measurements : $l=36-52.5$ (42.6) μm , $b=24-45$ (30.9) μm , $nl=6.7-7.5$ (7.3) μm , $nb=5.2-6$ (5.8) μm , $tf=34.5-45$ (36.3) μm , $l : b=1.1-1.7$ (1.4), $l : nl=4.8-7$ (5.8).

Present host : *Neotermes bosei* Snyder.

Disiribution : India : Bihar (Present record).

Remarks : It is the first record of this species from Indian termite.

4. *Devescovina glabra* Grassi

(Fig. 4)

1917. *Devescovina glabra* Grassi, *Atti Accad. Naz. Lincei Memorie*, Ser, 5, 12 : 334.

Material examined : 4 exs., Jhanjharput, Madhubani Dist., Bihar ; 21.i. 1986, Coll. D. N. Tiwari.

Diagnosis : Body elongated with pointed posterior end. Trailing flagellum cord-shaped. Cresta small measuring 7.2-8 (7.8) μm with posteromedial edge larger than anteromedial edge. Parabasal body takeing two turns round axostyle ; straight with stout aterior and filamentous posterior end. Nucleus oval in shape ; cytoplasm

containing groups of deep staining granules posterior to nucleus which is characteristic of the species.

Measurements : $l=48-64(56.8) \mu\text{m}$, $b=16-25.6(20) \mu\text{m}$, $l : b=2.3-3.5(2.9)$, $nl=4-4.8(4.2) \mu\text{m}$, $nb=2.4-3.2(3) \mu\text{m}$, $tf=60.8-70.4(62.8) \mu\text{m}$.

Present host : *Cryptotermis havilandi* (Sjöstedt).

Distribution : India : Bihar (Present record), West Bengal.

Remarks : *Neotermes bosei* Snyder is new host record for *D. glabra* from the Indian subcontinent.

5. *Devescovina lemniscata* Kirby

(Fig. 5)

1926. *Devescovina lemniscata* Kirby, *Univ. Calif. Publs. Zool.* 29 : 103.

Material examined : 5 exs., Kharagpur, Monghyr Dist., Bihar ; 23.xi.1984, Coll. D. N. Tiwari.

Diagnosis : Body pyriform with pointed posterior end ; trailing flagellum band or ribbon-like. Cresta with broad proximal and pointed distal end ; parabasal body takes $1-1\frac{1}{2}$ turns around the axostyle ; nucleus ellipsoidal ; endoplasm containing smaller wood particles.

Measurements : $l=43.2-51.2(48) \mu\text{m}$, $b=17.6-19.2(18.8) \mu\text{m}$, $l : b=2.5 : 1$; $nl=5.6-7.2(6.2) \mu\text{m}$, $nb=3.2-4.8(4) \mu\text{m}$, $tf=56-72(66.8) \mu\text{m}$, $cr=9.6-12(11.2) \mu\text{m}$.

Present host : *Cryptotermes havilandi* (Sjöstedt).

Distribution : India : Bihar (Present record), West Bengal.

6. *Foaina reflexa* Kirby

(Fig. 6)

1942. *Foaina reflexa* Kirby, *Univ. Calif. Publs. Zool.*, 45 : 206.

Material examined : 4 exs., Borio, Dumka Dist., Bihar, 23.xi.1983, Coll. D. N. Tiwari.

Diagnosis : Species moderate to large ; anterior flagella three in number and equal in length ; trailing flagellum ribbon-like exceeding twice of body length ; cresta long but narrow ; parabasal body with U-shaped bend ; axostyle very stout and projecting out towards posterior end to a short distance ; nucleus more or less oval.

Measurements : $l=24-43.2(33.6) \mu\text{m}$, $b=16-32(24.4) \mu\text{m}$, $l : b=1.2-1.5(1.3)$, $nl=4.8-6.4(5.4) \mu\text{m}$, $nb=4-4.8(4.2) \mu\text{m}$, $tf=60-85(72) \mu\text{m}$, $cr=13.6-16(14.6) \mu\text{m}$.

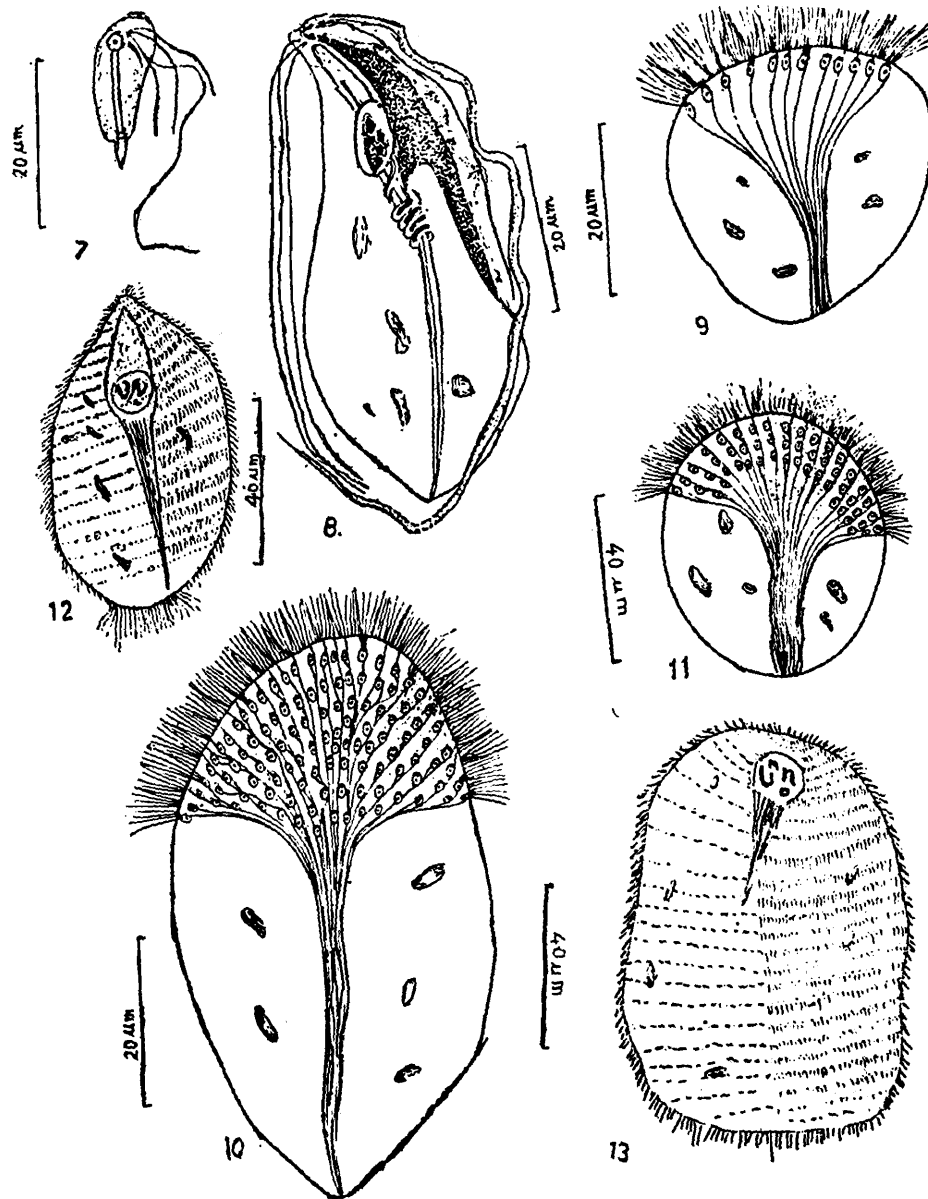
Present host : *Neotermes bosei* Snyder.

Distribution : India : Bihar (Present record), West Bengal.

Remarks : *Neotermes bosei* Snyder is the new host record for *Foaina reflexa* Kirby.

7. *Foaina solita* Kirby

(Fig. 7)

1942. *Foaina solita* Kirby, *Univ. Calif. Publ. Zool.* 45 : 182.*Material examined* : 2 exs, Katra, Muzaffarpur Dist., Bihar, 27.xi.1984, Coll. D. N. Tiwari.

- Figs. 7. *Foaina solita* Kirby
 8. *Macrotrichomonas pulchra* Grassi
 9. *Stephanonympha minuta* Das and Choudhury
 10. *Stephanonympha pyriformis* Das and Choudhury
 11. *Stephanonympha silvestrii* Janicki
 12. *Holomastigotoides bengalensis* Chakrabarty and Banerjee
 13. *Holomastigotoides campanula* (De Mello)

Diagnosis : Anterior flagella three in number, cord-like trailing flagellum with narrow cresta. A conspicuous clear area anterolateral to anterior end of capitulum

which is a prominent feature of *F. nana*, is characteristically absent in present species. Parabasal body short and restricted to dorsal side of nucleus ; axostyle moderately stout without enlarged rounded cusp ; nucleus more or less round.

Measurements : $l=8-16$ (11.1) μm , $b=3.2-8$ (5.4) μm , $l : b=2.-2.5$ (2.1), $nl=1.9-3.2$ (2.6) μm , $nb=1.5-2.4$ (1.9) μm , $tf=19.4-32\mu\text{m}$, $cr=3-4.5$ (3.7) μm .

Present host : *Cryptotermes havilandi* (Sjöstedt).

Distribution : India : Bihar (Present record), West Bengal.

8. *Macrotrichomonas pulchra* Crassi

(Fig. 8)

1917. *Macrotrichomonas pulchra* Grassi, *Atti. Accad. naj. Lincei Memorie Ser. 5*, 12 : 334.

Material examined : 2 exs., Borio, Dumka Dist., Bihar, 23.xi.83, Coll. D. N. Tiwari.

Diagnosis : Body more or less spindle-shaped ; anterior flagella three in number ; trailing flagellum band-shaped ; cresta and trailing flagellum and separately a short distance from central granules. Cresta large and inner part of cresta uniformly dense and outer part undulated. Parabasal body coiled, 4-5 times around axostyle ; parabasal filament extending along a short distance beyond anteromedial edge. Axostyle tapering posteriorly without filamentous end or cusp but with bluntly pointed end and in some specimens projecting out to a short distance. Nucleus elipsoidal with densely distributed chromatin granules. A clear space between nuclear membrane and chromatin granules present ; endoplasm containing wood particles of various sizes ; spirochaetes absent on body surface.

Measurements : $l=57.6-73.6$ (63.3) μm , $b=22.8-33.6$ (31.6) μm , $nl=8.8-10.4$ (9.7) μm , $nb=6-8.8$ (7.2) μm , $cr=27.2-48$ (42.2) μm , $tf=70-115\mu\text{m}$, $l : b=1.8-2.1$ (2), $l : nl=6.1-7$ (6.4).

Present host : *Glyptotermes caudomunitus* Kemner.

Distribution : India : Bihar (Present record).

Remarks : This is the first record of *Macrotrichomonas pulchra* from termite host, *Glyptotermes caudomunitus* from Indian subcontinent.

Family : CALONYMPHIDAE

9. *Stephanonympha minuta* Das and Choudhury

(Fig. 9)

1972. *Stephanonympha minuta* Das and Choudhury, *Proc. zool. Soc. Calcutta*, 25 : 26.

Material examined : 2 exs., Bettiah, West Champaran Dist., Bihar, 23.i.1986, Coll. D. N. Tiwari.

Diagnosis : Body oval with broad anterior and bluntly pointed posterior end ; nuclei in single spiral series, 8-12 in number and oval in shape situated near anterior end of the body ; each nucleus possessing deeply stained chromatin granules and large round blepharoplast. Adjacent to nucleus there is small parabasal body connected with blepharoplast by means of a parabasal thread. An axial filament arising from posterior portion of each blepharoplast and running towards posterior portion of body in form of an axial bundle. Axial bundle reaching up to posterior end of body ; endoplasm containing small pieces of wood particles.

Measurements : $l=36-40 (37.8)\mu\text{m}$, $b=30-36 (32)\mu\text{m}$, $l : b=1.1-1.2 (1.1)$.

Present host : *Cryptotermes havilandi* (Sjöstedt).

Distribution : India : Bihar (Present record), West Bengal.

Remarks : *Stephanonympha minuna* Das and Choudhury is recorded from a new host *Cryptotermes havilandi* (Sjöstedt).

10. *Stephanonympha pyriformis* Das and Choudhury

(Fig. 10)

1972. *Stephanonympha pyriformis* Das and Choudhury, *Proc. zool. Socr. Calcutta*, 25 : 27.

Material examined : 3 exs., Birpur, Saharsa Dist., Bihar, 2.xii.1983, Coll. D. N. Tiwari.

Diagnosis : Body pyriform with bluntly pointed posterior end. Nuclei ovoidal and arranged in 6-8 spiral series, occupying one third portion of anterior end of body ; each nucleus having a round blepharoplast at its anterior end and an ovoidal small parabasal body adjacent to it. Four flagella arising from each blepharoplast ; blepharoplast connected with parabasal body through a fibril and sending an axial filament over nucleus towards posterior end forming an axial bundle ; axial bundle ultimately extending to posterior extremity of body. Endoplasm containing large number of small pieces of wood particles.

Measurements : $l=64-83.2 (73)\mu\text{m}$, $b=38-52.8 (49.6)\mu\text{m}$, $l : b=1.3-1.5 (1.4)$.

Present host : *Neotermes bosei* Snyder.

Distribution : India : Bihar (Present record), West Bengal.

Remarks : *Stephanonympha pyriformis* Das and Choudhury is the new host record from *Neotermes bosei* Snyder,

11. *Stephanonympha silvestrii* Janicki

(Fig. 11)

1911. *Stephanonympha silvestrii* Janicki, *Biol. Zbl.*, 31: 325.

Material examined : 4 exs., Kharagpur, Monghyr Dist., Bihar, 23.xi.1984, Coll. D. N. Tiwari.

Diagnosis : Body more or less round in shape. Nuclei fusiform in shape containing distinct chromatin granules, two to three spiral series of nuclei occupying anterior portion of body. Blepharoplast situated at anterior of nucleus. Parabasal body small and four flagella arising from each blepharoplast. Axial filaments also extending downwards from blepharoplast to form axial bundle like that of *S. pyriformis* and *S. minuta*. Endoplasm containing wood particles.

Measurements : $l=48-80 (61)\mu\text{m}$, $b=36-68 (52)\mu\text{m}$.

Present host : *Cryptotermes havilandi* (Sjöstedt)

Distribution : India : Bihar (Present record), West Bengal.

Order : HYPERMASTIGIDA

Family : HOLOMASTIGOTIDAE

12. *Holomastigotoides bengalensis* Chakravarty and Banerjee

(Fig. 12)

1956. *Holomastigotoides bengalensis* Chakravarty and Banerjee, *Proc. zool. Soc., Calcutta*, 9 : 36.

Material examined : 3 exs., Lalitpur, Saharsa Dist., Bihar, 3.xii.1983, Coll. D. N. Tiwari.

Diagnosis : Body more or less oval but sometimes elliptical with anterior part gradually pointed resembling a nipple while posterior end rounded. Flagella of two types, shorter ones covering major portion of body in dextrotropic manner leaving a posterior portion glabrous and completely devoid of flagellar band; larger flagella occupying posteriormost portion of body. Axostyle narrow, well developed reaching posterior extremity of body. Nucleus lying anteriorly and oval in shape; prenuclear zone granulated with conical area around anterior end of nucleus.

Measurements : $l=67.5-105.2 (69.8)\mu\text{m}$, $b=41.2-70.5 (43.1)\mu\text{m}$, $nl=10.4-13 (12.1)\mu\text{m}$, $nb=8.5-11.5 (9.3)\mu\text{m}$, $l : b=1.5-1.8 (1.6)$, $l : nl=5-9.5 (5.7)$.

Present host : *Coptotermes heimi* (Wasmann).

Distribution : India : Bihar (Present record), Uttar Pradesh, West Bengal.

13. *Holomastigotoides campanula* (De Mello)

(Fig. 13)

1921. *Leidyia campanula* De Mello, *Argu. indo-port. med. Hist. nat.*, 1 : 179.

Material examined : 3 exs., Mirzacheuki, Sahibganj Dist., Bihar, 20.xi.1983, Coll. D. N. Tiwari.

Diagnosis : Body looking typically like bell-jar without apical knob; anterior portion of body usually convex while posterior one may be flat or bulging. Body

covering with two types of flagella, the shorter one arranged all over body in dextrotropic rows while longer ones set thickly on posterior surface. Nucleus more or less oval situated near anterior part of body. Axostyle fibrous. Prenuclear zone absent.

Measurements : $l=36.8-105(73.9)\mu\text{m}$, $b=35.2-80(62.4)\mu\text{m}$, $nl=4.8-9.6(7.6)\mu\text{m}$, $nb=6.4-8(7.2)\mu\text{m}$, $l : b 1.1-1.3(1.2)$; $l : nl=9$.

Present host : *Coptotermes heimi* (Wasmann).

Distribution : India : Bihar (Present record), Diu, West Bengal.

14. *Holomastigotoides emersoni* Das

(Fig. 14)

1976. *Holomastigotoides emersoni* Das, *Acta protozool.* 15 : 105.

Material examined : 2 exs., Pratapganj, Saharsa Dist., Bihar, 5.xii.1983, Coll. D. N. Tiwari.

Diagnosis : Body club-shaped with maximum width in posterior half and considerably elevated at anterior end forming a nipple-like structure ; posterior end of body broadly rounded. Flagella of two types, shorter one distributed all over body dextrotropically while longer ones occupying posterior end of body. Axostyle poorly developed. Prenuclear zone distinct, dense and homogenous.

Measurements : $l=76.5-110.4(93.4)\mu\text{m}$, $b=28.9-47.6(38.2)\mu\text{m}$, $nl=6.8-10.2(8.5)\mu\text{m}$, $nb=6.2-10.2(8.2)\mu\text{m}$, $l : b=1.9-2.5(1.7)$, $l : nl=10.9-15(12.9)$.

Present host : *Coptotermes heimi* (Wasmann).

Distribution : India : Bihar (Present record), West Bengal.

15. *Holomastigotoides hollandei* Das

(Fig. 15)

1976. *Holomastigotoides hollandi* Das, *Acta Protozool.* 15 : 103.

Material examined : 2 exs., Saharsa district town, Sharsa Dist., Bihar, 29.xi.1983, Coll. D. N. Tiwari.

Diagnosis : Body more or less round in shape, finger like elevation at anterior end well developed, bearing an apical pit occasionally. Two types of flagella present, first type smaller and covering whole body while second type nonstereociliac, larger and confined to posterior portion of body. Prenuclear zone clearly visible, nucleus containing chromatin granules in dense patches, dispersed irregularly inside nucleus. Axostyle fibrous and well developed reaching up to posterior part of body. Endoplasm sometimes containing bigger size of wood particles.

Measurements : $l=55-76.8(70.9)\mu\text{m}$, $b=50.2-64(57.1)\mu\text{m}$, $nl=6.8-10.4(8)\mu\text{m}$, $nb=6-9.6(7)\mu\text{m}$, $l : b=1.2-1.3(1.2)$, $l : nl=6.6-8(7.3)$.

Present host : *Heterotermes indicola* (Wasmann).

Distribution : India : Bihar (Present record), West Bengal.

Remarks : *Heterotermes indicola* (Wasmann) is new host record for this flagellate.

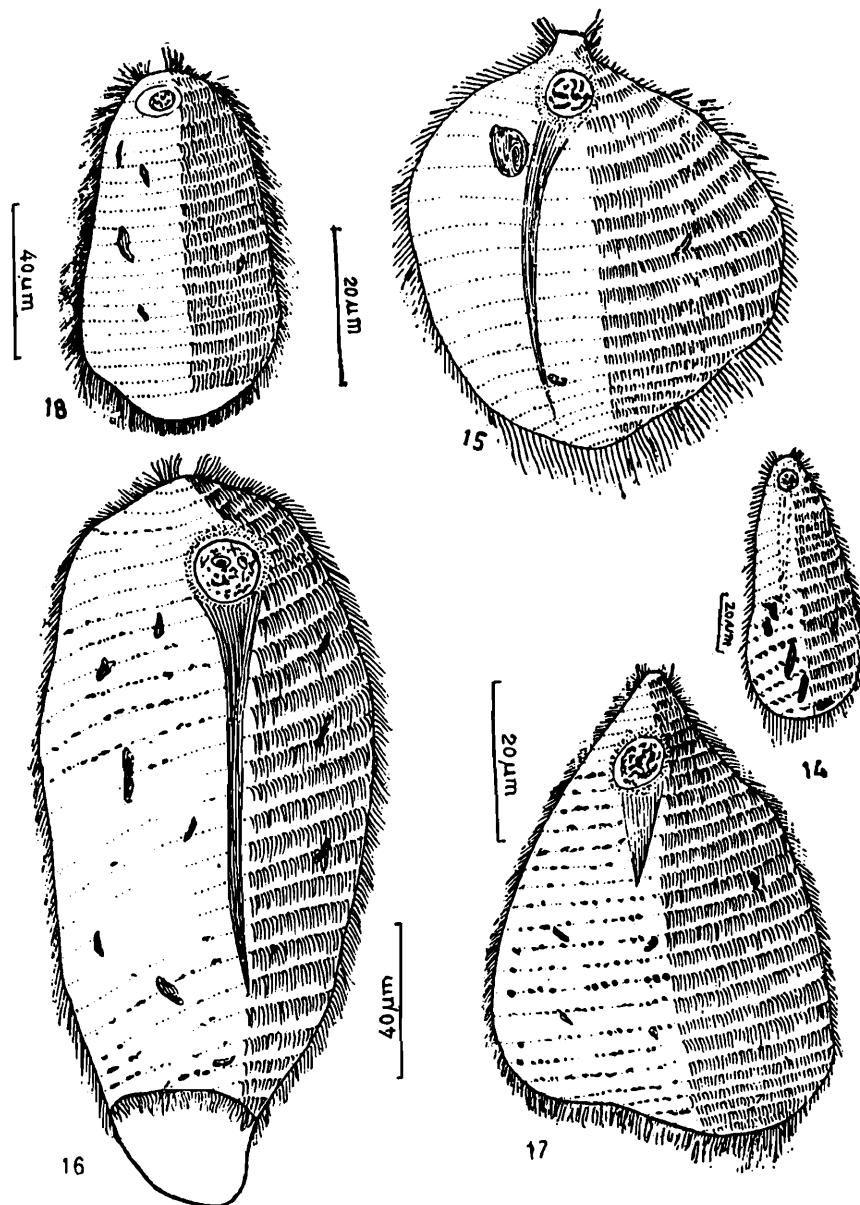
16. *Holomastigotoides magnus* Uttangi

(Fig. 16)

1962. *Holomastigotoides magnus* Uttangi, *J. Karnatak univ.* 7 : 188.

Material examined : 3 exs., Banmankhi, Purnea Dist., Bihar, 30.xi.1983, coll. D. N.

Tiwari.



Figs. 14. *Holomastigotoides emersoni* Das
 15. *Holomastigotoides hollandei* Das
 16. *Holomastigotoides magnus* Uttangi
 17. *Holomastigotoides ogivalis* De Mello
 18. *Holomastigotoides ovalis* Uttangi

Diagnosis : Body ovoidal, broadly rounded anteriorly and blunt towards posterior

end; length of flagella uniform all over the body, but posterior smaller glabrous region completely devoid of any flagella. Nucleus round and situated near anterior end of the body. Chromatin granules deeply stained. Axostyle fibrous, distinct and reaching slightly beyond middle region of body. Narrow striped prenuclear zone, distinct in permanent preparation over the nucleus.

Measurements : $l=176.3-220$ (190.6) μm , $b=94.3-114.8$ (104.5) μm , $nl=16.4-20.5$ (18.9) μm , $l : b=1.7-1.8$ (1.7), $l : nl=8.6-10$ (9.3).

Present host : *Coptotermes heimi* (Wasmann).

Distribution : India : Bihar (Present record), Gujarat, West Bengal.

17. *Holomastigotoides ogivalis* De Mello

(Fig. 17)

1937. *Holomastigotoides ogivalis* De Mello, *C. R. XII Intern. zool. Lisbonne* : 2 : 1373.

Material examined : 4 exs., Hathua, Gopalganj. Dist., Bihar, 31.1.1986, Coll. D. N. Tiwari.

Diagnosis : Body resembles the form of an inverted cup with a blunt finger-like elevation at anterior end. Body covered with two types of flagella, shorter flagella occupying whole of body in dextrotropic rows while longer ones situated densely on posterior surface. Nucleus ovoid and carries a distinct prenuclear zone. Axostyle distinct.

Measurements : $l=60.5-94$ (80.7) μm , $b=40.5-56.2$ (48.3) μm , $nl=8.2-12.7$ (11.6) μm , $nb=6.1-9.5$ (9) μm , $l : b=1.2-1.8$ (1.6), $l : nl$ (6.2-9 (6.9)).

Present host : *Coptotermes heimi* (Wasmann).

Distribution : India : Bihar (Present record), Daman, Uttar Pradesh, West Bengal.

18. *Holomastigotoides ovalis* Uttangi

(Fig. 18)

1962. *Holomastigotoides ovalis* Uttangi, *J. Karnatak univ. Sci.* 7 : 185.

Material examined : 1 exs., Mehrauna, Siwan Dist., Bihar, 12.xii.1984, Coll. D. N. Tiwari.

Diagnosis : Body oval, with anterior end narrowly round and posterior broadly round. Posterior portion of body glabrous and devoid of any flagellar band, Flagella longer arranged in dextrotropic rows and cover whole of body while posterior glabrous portion bearing stereocilia. Nucleus oval situated at anterior pole of body. Chromatin granules homogenous mass surrounded by halo. Prenuclear zone and axostyle absent.

Measurements : $l=102$ μm , $b=63$ μm , $nl=8.2$ μm , $nb=6.5$ μm , $l : b=1.6$, $l : nl=13.5$.

Present host : *Heterotermes indicola* (Wasmann).

Distribution : India : Bihar (Present record), Gujarat, West Bengal.

19. *Holomastigotoides rayi* Karandikar and Vittal

(Fig. 19)

1954. *Holomastigotoides rayi* Karandikar and Vittal, *J. Univ. Bombay*, 23B : 18.

Material examined : 3 exs., Manigachhi, Darbahanga Dist., Bihar, 16.xii.1984, coll. D. N. Tiwari.

Diagnosis : Body oval with apical pit clearly visible at anterior end. Body covered with two types of flagella, smaller flagella covering the whole of body in dexiotropic spirals, longer flagella covering one-fifth of posterior end of body. Present author could not trace any stereocilie at its posterior end. Nucleus ovoidal. Axostyle not distinct and reaching up to middle of body. Prenuclear zone distinct.

Measurements : $l=77-90.2(84.9) \mu\text{m}$, $b=41.5-52.5(49) \mu\text{m}$, $nl=10.5-12.3(11.6) \mu\text{m}$, $nb=8.2-10.5(9.1) \mu\text{m}$, $l : b=1.4-1.8(1.6)$, $l : nl=6.3-8.3(7.3)$.

Present host : *Heterotermes indicola* (Wasmann).

Distribution : India : Bihar (present record), Maharashtra, West Bengal.

Remarks : *Holomastigotoides rayi* is recorded here from a new host *Heterotermes indicola*.

20. *Holomastigotoides reniformis* De Mello

(Fig. 20)

1937. *Holomastigotoides reniformis* De Mello, *C. R. XII Congr. Intern. Zool. Lisbonne*, 2 : 1373.

Material examined : 1 ex., Mehrauna, Siwan Dist., Bihar, 12.xii.1984, Coll. D. N. Tiwari.

Diagnosis : Body reniform, flagella of one type covering whole of body dexiotropically. Nucleus oval. Axostyle short and reaching slightly below nucleus. Prenuclear zone distinct and granular. Endoplasm containing fibres of wood particle.

Measurements : $l=110.2 \mu\text{m}$, $b=36 \mu\text{m}$, $nl=5 \mu\text{m}$, $nb=4.2 \mu\text{m}$, $l : b=3$, $l : nl=22$.

Present host : *Coptotermes heimi* (Wasmann).

Distribution : India : Bihar (Present record), Goa.

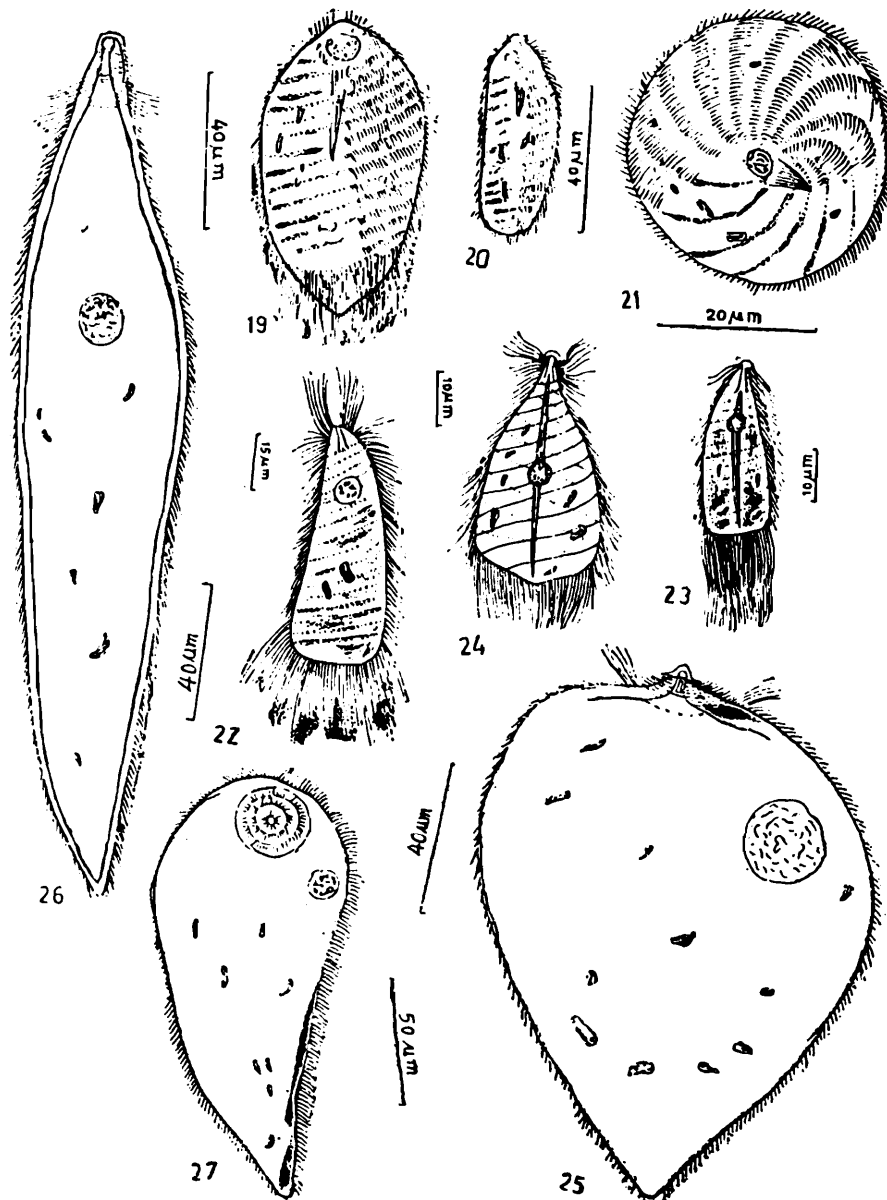
21. *Holomastigotoides sphaeroidalis* De Mello

(Fig. 21)

1937 *Holomastigotoides sphaeroidalis* De Mello, *C. R. XII. Cong, Intern. Zool. Lisbonne*, 2 : 1373.

Material examined : 4 exs., Nathnagar, Bhagalpur Dist., Bihar, 22.xi.1983, Coll. D. N. Tiwari.

Diagnosis : Body spherical as indicated by its name. One type of flagella covering body dextrorotically, Nucleus round situated near anterior end from which flagellar bands seems to derive. Axostyle distinct, broad and abruptly pointed. Prenuclear zone distinct.



- Figs. 19. *Holomastigotoides rayi* Karandikar and Vittal
 20. *Holomastigotoides reniformis* De Mello
 21. *Holomastigotoides sphaeroidalis* De Mello
 22. *Spirotrichonympha bhadreshwarensis* Tiwari
 23. *Spirotrichonympha froilanoi* Karandikar and Vittal
 24. *Spirotrichonympha roonwali* Das
 25. *Pseudotrichonympha cardiformis* Karandikar and Vittal
 26. *Pseudotrichonympha indica* Chakraborty and Banerjee
 27. *Pseudotrichonympha subapicalis* Karandikar and Vittal

Measurements : $1 \times b = 31.8 \mu\text{m} \times 31.8 \mu\text{m}$, $n1 \times nb = 4.5 \mu\text{m} \times 4.5 \mu\text{m}$.

Present host : *Coptotermes heimi* (Wasmann).

Distribution : India : Bihar (present record), Daman, Karnataka, Uttar Pradesh, West Bengal.

Family : SPIROTRICHONYMPHIDAE

22. *Spirotrichonympha bhadreshwarensis* Tiwari

(Fig. 22)

1977. *Spirotrichonympha bhadreshwarensis* Tiwari, *Curr. Sci.*, 46 : 232.

Material examined : 1 ex., Birpur, Saharsa Dist., Bihar, 2.xii.1983, Coll. D. N. Tiwari.

Diagnosis : Body more or less pear-shaped with pointed anterior and slightly compressed posterior end, a short tube originating at anterior end but not reaching to nucleus. Body covered with spiral bands in dextrotropic rows ; a little portion of posterior end of body devoid of flagellar band. Two types of flagella covering the body ; shorter one covering whole of body while longer flagella covering posterior portion. Nucleus spherical with scattered chromatin granules and located in anterior third of body. Axostyle absent.

Measurements ; $l=50.4 \mu\text{m}$, $b=27.3 \mu\text{m}$, $nl=6.7 \mu\text{m}$, $nb=6.7 \mu\text{m}$, $l : b=1.8$, $l : nl=7.7$.

Present host : *Coptotermes heimi* (Wasmann).

Distribution : India : Bihar (present record), West Bengal.

23. *Spirotrichonympha froilanoi* Karandikar & Vittal

(Fig. 23)

1954. *Spirotrichonympha froilanoi* Karandikar & Vittal, *J. Univ. Bombay*, 23B : 20.

Material examined : 4 exs., Dumka district town, Dumka dist., Bihar, 20.xi.1983. Coll. D. N. Tiwari.

Diagnosis : Body cone-shaped with anterior portion narrowed to a blunt end and posterior portion broader, body covered with two types of flagella, shorter ones covering whole body dextrotropically excepting posterior flat portion which is thickly studded with a bunch of very long flagella which appears to come out like a tuft bristles in a brush. Nucleus more or less round and located in anterior third of body. A distinct thick cord-like axostyle present but not protruding outside the posterior end of the body.

Measurements : $l=19.2-51.2(32.5) \mu\text{m}$, $b=14.4-33.6(22.1) \mu\text{m}$, $nl=3.2-6.4(4.8) \mu\text{m}$, $nb=2.4-5.6(4.4) \mu\text{m}$, $l : b=1.3-1.6(1.4)$, $l : nl=4-11.5(7.6)$.

Present host : *Heterotermes indicola* (Wasmann).

Distribution : India : Bihar (present record), Karnataka, Uttar Pradesh, West Bengal.

24. *Spirotrichonympha roonwali* Das

(Fig. 24)

1976. *Spirotrichonympha roonwali* Das, *Acta Protozool*, 15 : 116.

Material examined : 3 exs., Godda, Dumka Dist., Bihar, 20.xi.1983., Coll. D. N. Tiwari.

Diagnosis : Body pyriform and bearing uperculum at anterior end and with broad posterior end drawn out in a cone at its centre. Nucleus more or less round. Prenuclear zone dense and conical. Four flagellar bands arising from centroblepharoplast and turned round body dextrotropically. These bands containing numerous basal granules, giving rise to one type of flagella. Axotyle thin and fibrous and extending beyond middle region of body.

Measurements : $l = 32 - 48(38.4) \mu\text{m}$, $b = 17.6 - 27.2(21.2) \mu\text{m}$, $nl = 4.8 - 5.6(5) \mu\text{m}$, $nb = 3.2 - 4.6(3.6) \mu\text{m}$, $l : b = 1.7 - 2(1.8)$, $l : nl = 5.5 - 8.5(6.8)$.

Present host : *Coptotermes heimi* (Wasmann).

Distribution : India : Bihar (present record), West Bengal.

Family : EUCOMONYMPHIDAE

25. *Pseudotrichonympha cardiformis* Karandikar and Vittal

(Fig. 25)

1954. *Pseudotrichonympha cardiformis* Karandikar and Vittal, *J. Univ. Bombay*, 23B : 2.

Material examined : 3 exs., Birpur, Saharsa, Dist., Bihar, 2.xii.1983, Coll. D. N. Tiwari.

Diagnosis : Body typically heart-shaped, anterior part consisting of campanula and middle portion of campanula known as rostral tube, measuring $8 \mu\text{m}$; tube bearing more or less transparent hemispherical apical cap, campanular surface covered by three types of flagella, distinguishable from one another by their length and location. First type of flagella shortest, immobile and strictly confined to rostral tube; second type of flagella longest and arranged below first one in a thick circular band; third type of flagella arranged in longitudinal rows in a leotropic manner. These flagella covering campanula and rest of body except short glabrous end of posterior extremity of body. Nucleus spherical and situated in the middle region of body. Endoplasm containing fragments wood and sphaerita-like microorganism.

Measurements : $l=105-181.2$ (118.1) μm , $b=82.2-130.3$ (91.8) μm , $nl=22.5-37.5$ (25.6) μm , $nb=20.33.7$ (25.6) μm , $l : b=1.2-2$ (1.2), $l : nl=7-8.5$ (7.8), $cam=14-18.6$ (18) μm , $f_1=6-8\mu\text{m}$, $f_2=17-20\mu\text{m}$, $f_3=8-13.5\mu\text{m}$.

Present host : *Heterotermes indicola* (Wasmann).

Distribution : India : Bihar (Present record), Karnataka, Uttar Pradesh, West Bengal.

26. *Pseudotrichonympha indica* Chakravarty and Banerjee

(Fig. 26)

1956. *Pseudotrichonympha indica* Chakravarty and Banerjee, *Proc. zool. Soc. Calcutta.*, 9 : 42.

Material examined : 5 exs., Pratapganj, Saharsa Dist., Bihar, 5.xii.1983, Coll. D. N. Tiwari.

Diagnosis : Body elongated broader in middle. Rostral tube measuring 3.8-7 μm with apical cap. Campanular surface covered with three types of flagella, distinguishable from another in length and location as described in *P. indicu*. Nucleus more or less circular and located in middle of body. Chromatin granules distributed irregularly. Endoplasm containing fragments of wood.

Measurements : $l=217-301$ (169.9) μm , $b=42-55$ (49) μm , $nl=15.7-21$ (18.8) μm , $nb=14-17.5$ (16.1) μm , $l : b=3.8-7.1$ (5.5), $l : nl=11.3-17.2$ (13.9), $cam=10.5-14$ (11.8) μm , $f_1=8.2-13.3$ μm , $f_2=16.4-20.5$ μm , $f_3=6.1-10.5$ μm .

Present host : *Coptotermes heimi* (Wasmann).

Distribution : India : Bihar (present record), Uttar Pradesh, West Bengal.

27. *Pseudotrichonympha subapicalis* Karandikar and Vittal

(Fig. 27)

1954. *Pseudotrichonympha subapicalis* Karandikar and Vittal, *J. Univ. Bombay*, 23B : 8.

Material examined : 4 exs., Manigachhi, Darbhanga Dist., Bihar, 26.xi.1983, Coll. D. N. Tiwari.

Diagnosis : Body generally rounded and swollen anteriorly and gradually tapering posteriorly to a blunt end. Campanula situated almost in middle towards anterior portion of body in subapical position. Campanular region seen in the form of two circular areas situated one within other ; outer circle representing peripheral margin of campanula, middle circle representing rim along which arranged second series of flagella like eye lashes. Inner circle having tiny aperture in centre. In some specimens campanular region observed in its longitudinal axis. Body entirely covered with third series of flagella excepting a short posterior portion. Nucleus spherical and usually found towards anterior region of the body. Endoplasm containing wood particle of various sizes.

Measurements : $l=172.5-205$ (181) μm , $b=70-90$ (87.5) μm , $nl=15-19.5$ (18.1) μm , $nb=15-19.5$ (18.1) μm , $l : b=2-3.8$ (2), $l : nl=8.6-11.5$ (10), $cam=18.5$ μm , $f1=6-8$ μm , $f2=18-20$ μm , $f3=8-9$ μm .

Present host : *Coptotermes heimi* (Wasmann).

Distribution : India : Bihar (present record), Karnataka, West Bengal.

SUMMARY

1. Twenty seven species of flagellate symbiotes representing six families and nine genera have been reported from Northern Bihar.
2. *Glyptotermes caudomunitus* has been searched for the first time for its flagellate symbiotes from India.
3. All the species of the flagellate symbiotes under the study are new record from Northern Bihar.

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