J Parasit Dis (July-Sept 2019) 43(3):487–497
https://doi.org/10.1007/s12639-019-01116-4

ORIGINAL ARTICLE

An annotated list of aseptate gregarine parasites (Protozoa; Apicomplexa; Sporozoa) infecting oligochaete hosts

Beauty Kundu[1] · **Probir K. Bandyopadhyay**[1]

Received: 29 January 2019 / Accepted: 10 April 2019 / Published online: 29 April 2019

Abstract Gregarines are mainly coelozoic parasites belonging to the protozoan phylum Apicomplexa. The present communication deals with 137 species belonging to the genera *Aikinetocystis* Gates, 1926; *Apolocystis* Cognetii de Martiis, 1923; *Dirhynchocystis* Cognetii de Martiis, 1921; *Enterocystis* Tsvetkov, 1926; *Nematocystis* Hesse 1909; *Rhynchocystis* Hesse 1909; and *Zygocystis* Von Stain, 1848. This study was conducted to explore the diversity of gregarine parasites infecting the oligochaete hosts of the world.

Keywords Apicomplexa · Apicoplast · Coelozoic · Endoparasite · Unicellular

Introduction

Gregarines are endoparasites, which solely dependent on their host for completion of their life cycle. Levine (1988) included gregarines under the phylum Apicomlpexa, which are unicellular, spore forming and solely parasites. Most of them possess a unique form of organelle that comprises a type of plastid called an apicoplast and an apical complex structure. The organelle is an adaptation that the apicomplexan applies in penetration of a host cell. Gregarines are of mainly two types aseptate and septate. The aseptate gregarines contain aseptate body, but the septate gregarines bear septum. Both the gregarine parasites possess a hold fast organ for anchoring the host species. Aseptate gregarines are mainly found in oligochaetae hosts. It causes harm to the hosts. Septate gregarines are mainly found in arthropods and mollusc. Grase (1953) recognised the gregarines as a taxon. Currently, under this taxon about 250 genera and 1650 species are known. Gregarines are the earliest lineage of apicomplexan animals and separated from coccidians, haemosporidians and piroplasms. Under this group *Aikinetocystis, Apolocystis, Dirhynchocystis, Enterocystis, Monocystis*, *Nematocystis*, *Rhynchocystis*, *Stomatophora, Zygocystis* genus have so far been established from oligochaetae host throughout the world.

The genus *Aikinetocystis* was erected by Gates (1926) and is characterised by syzygy in pairs, tail to tail by the non-ramified ends in coelom of oligochaetes.

The genus *Apolocystis* was established by Cognetii de Martiis (1923), having solitary and spherical gamonts, biconical oocyst. Later on, many scientists worked on the genus *Apolocystis* and described forty species under the genus (Schimidt 1854; Cognetii de Martiis 1923; Troisi 1933; Tuzet and Loubatieres 1946; Loubatieres 1955; Berlin 1924; Meier 1956; Tuzet and Zuber-Vogeli 1955; Tuzet and Vogeli 1956; Meier 1956; Rees 1963; Bereczky 1967; Ramadan 1969; Segun 1971a, b, 1978; Pradhan and Dasgupta 1983a, b; Frolov 1991; Torista 1933; Bhatia and stena 1926; Loubatieres 1955; Gullo Armeendariz 2002; Bandyopadhyay et al. 2004; Bhowmik et al. 2012; Ramadan et al. 2014, 2015 and Medhat et al. 2018).

Cognetii de martis in 1921 established the genus *Dirhynchocystis* having characterised by rostrum of gamont metabolic, most often elongated into a conical or cylindroconical trunk. Gamont bears projection at both the ends. Subsequently, eight species of *Dirhynchocystis* was established by many researchers (Bhatia and Chatterjee, 1925; Tuzet and Loubatieres 1946; Loubatieres 1955;

✉ Probir K. Bandyopadhyay
prabir0432@hotmail.com

[1] Parasitology Laboratory, Department of Zoology, University of Kalyani, Kalyani 741235, West Bengal, India

Tuzet and Vogeli 1956; Boisson 1957; Ruston 1959 and Bandyopadhyay and Mitra 2006).

The genus *Enterocystis* was erected by Tsvetkov (1926) which is characterised by gamonts are intracellular. Early syzygy, primate enlarging at its base and the satellite remaining more or less cylindrical that the two cells have a sword or dagger shape, gametocysts without sporoducts, opening by simple rupture; oocysts ellipsoidal. Subsequently, fourteen species of *Enterocystis* was described by many researchers (Sarkar and Haldar 1983; Codreanu 1940; Von Frantzius 1848; Desportes 1963; Baudoin and Maillard 1972; Levine 1977a, b; Sarkar et al. 2012b).

Hesse in 1909 established the genus *Nematocystis* which is characterised by having large, solitary and cylindrical gamonts, contains mucron at the anterior ends, oocyst biconical. Then 43 species of *Nematocystis* was established by many workers (Cognetii de Martiis 1918 and 1921; Bhatia and Chatterjee 1925, 1926; Hesse 1909; Bhatia 1929; Sciacchitano 1931; Tuzet and Loubatieres 1946, 1956; Bereczky 1967; Loubatieres 1955; Boisson 1957; Berlin 1924; Segun 1968, 1978; Mohammed and Ramanandan 1972; Georgevitch 1951; Levine 1977a, b; Bandyopadhyay et al. 2005a, b, 2009; Mallik et al. 2011; Sarkar and Bandyopadhyay 2012 and Mallik and Bandyopadhyay 2016).

Hesse in 1909 established the genus *Rhynchocystis,* characterised by having cylindrical trunk, ovoid and spherical gamonts. Later on, ten species of *Rhynchocystis* were established by many workers (Schmidt, 1854; Cognetii de Martiis 1911; Berlin 1924; Bhatia and chatterjee 1925; Bhatia and Setna 1926; Troisi 1933; Loubatieres 1955; Righi 1974; Ruschhaput 1885; Levine 1977a, b; Sarkar and Bandyopadhyay 2012).

The genus *Zygocystis* was established by von Stain in 1848. It is characterised by pyriform gamonts, frontal syzygy; oocyst navicular. After that, nineteen species of *Zygocystis* have been described by many workers (Hesse 1909; Berlin 1924; Troisi 1933; Tuzet and Loubatieres 1946; Loubatieres 1955; Meier 1956; De puytorac and Tourret 1963; Bereezky 1968; Segun 1968, 1978; Janiszewska 1968; Mahammed and Ramadan 1971; Pradhan and Dasgupta 1983a, b; Bandyopadhyay et al. 2004, 2005b).

Till date no efforts have been made to prepare a systematic checklist of the gregarine parasites infecting oligochaetes belonging to the genus *Aikinetocystis, Apolocystis, Dirhynchocystis*, *Enterocystis, Nematocystis*, *Rhynchocystis,* and *Zygocystis.*

Genus ***Aikinetocystis*** Gates, 1926

Aikinetocystis singularis Gates, 1926
Site of infection: Coelom
Type host: *Eutyphaeus foveatus, E. peguanus, E. rarus, E. spinulosus*
Type locality: India

Genus ***Apolocystis*** Cognetii de Martiis, 1923

(1) ***Apolocystis lumbriciolidi*** (Schmidt, 1854) Cognetti de martiis, 1923 emend. Levine, 1977a, b

Site of infection: Seminal vesicles
Type host: *Eisenia foetida, Dendrobaena rubida, D. subrubicunda, D. tenuis*
Type locality: England, France, Germany, Poland

(2) ***Apolocystis michaelseni*** (Hesse, 1909) Cognetti de Martiis, 1923

Site of infection: Coelom
Type of host: *Pheretima hawayana*
Type locality: France

(3) ***Apolocystis villosa*** (Hesse, 1909) Cognetti de Martiis, 1923

Site of infection: Seminal vesicles
Type host: *Octolasium lacteum*
Type locality: France, Germany, Wales

(4) ***Apolocystis pareudrili*** (Cognetti de Maritiis, 1911) Cognetti de Martiis, 1923

Site of infection: Seminal vesicles
Type of host: *Pareudrilus pallidus*
Type locality: Ruwenzori (Africa)

(5) ***Apolocystis catenata*** (Mulsow, 1911) Cognetii de Martiis, 1923

Site of infection: Coelom
Type host: *Lumbricus terrestris*
Type locality: Germany

(6) ***Apolocystis beaufortii*** (Cognetii de Martiis, 1918) Cognetii de Martiis, 1923

Site of infection: Seminal vesicles
Type host: *Pheretima* (*Parapheretima*) *beaufortii*
Type locality: Dutch New Guinea

(7) ***Apolocystis minuta*** Troisi, 1933

Site of infection: Seminal vesicles
Type host: *Lumbricus terrestris. L. castaneus, L. rubellus*
Type locality: England, USA

(8) ***Apolocystis chattoni*** Tuzet and Loubatieres, 1946

Site of infection: Seminal vesicles
Type host: *Allolobophora gigas*
Type locality: France

(9) ***Apolocystis gigas*** Tuzet and Loubtieres, 1946

Site of infection: Seminal vesicles
Type host: *Octolasium complanatum*
Type locality: France

(10) ***Apolocystis granulata*** Tuzet and Loubatieres, 1946

Site of infection: Seminal vesicles
Type host: *Allolobophora gigas, A. chlorotica*
Type locality: France, Hungary

(11) ***Apolocystis pertusa*** Loubatieres, 1955

Site of infection: Seminal vesicles
Type host: *Allolobophora chlorotica, A. gigas, A. rosea*
Type locality: France, Germany

(12) ***Apolocystis vivax*** (Berlin, 1924) Meier, 1956

Site of infection: Seminal vesicles
Type host: *Eiseniella t. tetraedra*
Type locality: Germany, Sweden

(13) ***Apolocystis dichogasteri*** (Tuzet and Zuber-Vogeli, 1955) Tuzet and Vogeli, 1956

Site of infection: Seminal vesicles
Type host: *Dichogaster baeri*
Type locality: France, West Africa

(14) ***Apolocystis herculea*** (Bosanquet, 1894) Meier, 1956

Site of infection: Seminal vesicles and Coelom
Type host: *Lumbricus terrestris*, L. *rubellus*, *L. castaneus*, *Octolasium lacteum*, *O. cyaneum, Allolobophora caliginosa, A. chlorotica, Dendrobaena rubida.*
Type locality: England, France, Germany, Sweden, Wales

(15) ***Apolocystis pilosa*** Meier, 1956

Site of infection: Seminal vesicles
Type host: *Lumbricus terrestris, L. rubbellus. L. festivus, L. castaneus*
Type locality: England, Germany, Hungary

(16) ***Apolocystis stammeri*** Meier, 1956

Site of infection: Coelom
Type host: *Fridericia striats, F. perrieri, F. ratzeli*
Type locality: Germany

(17) ***Apolocystis lavernensis*** Rees, 1963

Site of infection: Seminal vesicles
Type host: *Allolobophora longa*
Type locality: England, Wales

(18) ***Apolocystis perfida*** Rees, 1963

Site of infection: Coelom
Type host: *Allolobophora chlorotica*
Type locality: Wales

(19) ***Apolocystis rotaria*** Rees, 1963

Site of infection: Coelom
Type host: *Octolasium cyaneum*
Type locality: Wales

(20) ***Apolocystis spinosa*** Rees, 1963

Site of infection: Seminal vesicles
Type host: *Allolobophora chlorotica*
Type locality: England, Wales

(21) ***Apolocystis almanili*** Ramadan, 1969

Type host: *Alma nilotica*
Type locality: Nile River banks

(22) ***Apolocystis centrospora*** Ramadan, 1969

Type host: Unidentified species of *Alma* sp.
Type locality: Abole-Rawash

(23) ***Apolocystis dudichi*** Bereczky, 1967

Site of infection: Seminal vesicles
Type host: *Dendrobaena platyura* var. *depressa*
Type locality: Hungary

(24) ***Apolocystis megagranulata***, Segun, 1971a, b

Site of infection: Seminal vesicles
Type host: *Dendrobaena rubida, f. subrubicunda*
Type locality: England

(25) ***Apolocystis iridodrili*** Segun, 1978

Site of infection: Seminal vesicles
Type host: *Iridodrilus preussi, I. roseus*
Type locality: Nigeria

(26) ***Apolocystis libyodrili*** Segun, 1978

Site of infection: Seminal vesicles
Type host: *Libyodrilus violaceus*
Type locality: Nigeria

(27) ***Apolocystis akaryosomiferus*** Pradhan and Dasgupta, 1983a, b

Site of infection: Blood vesseles
Type host: *Pheretima robusta*
Type locality: Darjeeling, West Bengal, India

(28) ***Apolocystis goomtiensis*** Pradhan and Dasgupta, 1983a, b

Site of infection: Coelomic fluid
Type host: *Pheretima diffringens*
Type locality: Darjeeling, West Bengal, India

(29) ***Apolocystis monokaryosomiferus*** Pradhan and Dasgupta, 1983a, b

Site of infection: Blood vessel
Type host: *Pheretima robusta*
Type locality: Darjeeling, West Bengal, India

(30) ***Apolocystis vacuolata*** Pradhan and Dasgupta, 1983a, b

Site of infection: Intestine
Type host: *Pheretima alexandri*
Type locality: Darjeeling, West Bengal, India

(31) ***Apolocystis saigonensis*** Frolov, 1991

Site of infection: seminal vesicles
Type host: *Pheretima peguana*

(32) ***Apolocystis minima*** (Boisson, 1957) Frolov 1991

Site of infection : Seminal vesicles
Type host: *Pheretima posthuma*

(33) ***Apolocystis gigantea*** Torista, 1993

Site of infection: Seminal vesicles
Type host: *Eiseneia foetida, Lumbricus rubellus*
Type locality: U.S.A

(34) ***Apolocystis mattheii*** (Bhatia and Senta, 1926) Loubatieres, 1955

Site of infection: Seminal vesicles
Type host: *Megascolex trilobatus*
Type locality: India

(35) ***Apolocystis janovyi*** Gullo Armeendariz, 2002

Site of infection: Coelom
Type host: *Microscolex dubius*
Type locality: Argentina

(36) ***Apolocystis chotonagpurnsis*** Bandyopadhyay et al., 2004

Site of infection: Seminal vesicles
Type host: *Amynthus robusta*
Type locality: India

(37) ***Apolocystis cognetti*** Bhowmik et al., 2012

Site of infection: Seminal vesicles
Type host: *Amynthus hawayanus*
Type locality: Darjeeling, India

(38) ***Apolocystis perienteron*** Ramadan et al., 2014

Site of infection: Coelom
Type host: *Pheretima californica*
Type locality: Egypt

(39) ***Apolocystis proventus*** Ramadan et al., 2015

Site of infection: Pheringyal gland and Pheringyeal coelom
Type host: *Pheretima californica, pheretima elongata*
Type locality: Egypt

(40) ***Apolocystis nephredii*** (Medhat et al., 2018)

Site of infection: Nephredia
Type host: *Limnodrilus* sp.
Type localities: Maghaga region, Egypt, Abo-Rawash

Genus ***Dirhynchocystis*** Cognetii de Martiis, 1921

(1) ***Dirhynchocystis brasiliensis*** Cognetti de Martiis 1921

Site of infection: Seminal vesicles
Type host: *Fimoscolex inurus*
Type locality: New Guinea

(2) ***Dirhynchocystis globosa*** (Bhatia and Chatterjee, 1925) Tuzet and Loubatiéres, 1946

Site of infection: Seminal vesicles
Type host: *Pheretima heterochaeta*
Type locality: India, France

(3) ***Dirhynchocystis oblonga*** Tuzet and Louhatiéres, 1946

Site of infection: Seminal vesicles
Type host: *Octolasium complanatum*
Type locality: France

(4) ***Dirhynchocystis elongata*** Loubatiéres, 1955

Site of infection: Seminal vesicles
Type host: *Allolobophora rosea, A. chlorotica.*
Type locality: France

(5) ***Dirhynchocystis eudrilii,*** Tuzet and Vogeli, 1956

Site of infection: Seminal vesicles
Type host: *Eudrilus eugeniae*
Type locality: France, West Africa

(6) ***Dirhynchocystis sacciformis*** Boisson, 1957

Site of infection: Seminal vesicles
Type host: *Pheretima peguana*
Type locality: Indo-China

(7) ***Dirhynchocystis minuta*** Ruston, 1959

Site of infection: Seminal vesicles
Type host: *Lumbricus terrestris*
Type locality: USSR

(8) ***Dirhynchocystis indica*** Bandyopadhyay and Mitra, 2006

Site of infection: Seminal vesicles
Type host: *Lampito mauritii*
Type locality: West Bengal, India

Genus *Enterocystis* Tsvetcov, 1926

(1) ***Enterocystis ensis*** Tsvetkov, 1926

Site of infection: Intestine
Type host: *Caenis* sp., nymph and *Baetis rhodani* (Ephemeropterorida)
Type locality: *USSR*

(2) ***Enterocystis bengalensis*** Sarkar and Haldar, 1983

Site of infection: Midgut & Hindgut
Type host: *Psocatropos* sp.
Type locality: West Bengal India

(3) ***Enterocystis fungoides*** M. Codreanu, 1940

Site of infection: Intestine
Type host: *Baetis vernus* nymph and *B. rhodani* (Ephemeropterorida)
Type locality: England

(4) ***Enterocystis palmata*** M. Codreanu, 1940

Site of infection: Intestine
Type host: *Baetis buceratus* nymph (Ephemeropterorida)
Type locality: England

(5) ***Enterocystis racovitza*** M. Codreanu, 1940

Site of infection: Intestine
Type host: *Baetis vernus, B. rhodani* (Ephemeropterorida)
Type locality: England

(6) ***Enterocystis rhithrogenae*** M. Codreanu, 1940

Site of infection: Intestine
Type host: *Rhithrogena semicolorata* nymph (Ephemeropterorida)
Type locality: England

(7) ***Enterocystis ephemerae*** (Von Frantzius, 1848) Desportes, 1963

Site of infection: Intestine
Type host: *Eephemerae vulgate* nymph and *Ephemerella ignite* (Ephemeropterorida)
Type locality: England

(8) ***Enterocystis grassei*** Desportes, 1963

Site of infection: Intestine
Type host: *Baetis vernus*, *Epeorus torrentium*, *Heptagenia flava, Ecdyonurus* sp. nymph. (Ephemeropterorida)
Type locality: Europe

(9) ***Enterocystis hydrophili*** (Foerster, 1938) Baudoin and Maillard, 1972

Site of infection: Intestine
Type host: *Hydrochara* (*Hydrophilus*) *caraboides* (Colepterorida)
Type locality: USSR

(10) ***Enterocystis bullis*** (Noble, 1938), Levine, 1977a, b

Site of infection: U.S.A
Type host: *Urechis caupo* (Annelida)
Type locality: Intestine

(11) ***Enterocystis greeffi*** (Noble, 1938) Levine, 1977a, b

Site of infection: Intestine
Type host: *Echiurus pallasii* (Echiurida)
Type locality: Europe

(12) ***Enterocystis yumushii*** (Iitsuka, 1933) Levine, 1977a, b

Site of infection: Intestine
Type host: *Urechis Unicinctus*
Type locality: USSR

(13) ***Enterocystis elongatum*** Sarkar et al., 2012b

Site of infection: Seminal vesicles
Type host: *Metaphire posthuma*
Type locality: Bangladesh

Genus ***Nematocystis*** Hesse, 1909

(1) ***Nematocystis magna*** (Schmidt, 1854) Hesse, 1909

Site of infection: Testis
Type host: *Lumbricus terrestris*
Type locality: England, France, Germany, Scotland, Sweden

(2) ***Nematocystis anguillula*** Hesse, 1909

Site of infection: Seminal vesicles
Type host: *Pheretima rodericensis*, *P. hawayana*
Type locality: France

(3) ***Nematocystis vermicularis*** Hesse, 1909

Site of infection: Seminal vesicles
Type host: *Allobophora longa*, *Lumbricus terrestris*, *L.rubellus*, and *Pheretima barbadensis*
Type locality: France, Sweden, India

(4) ***Nematocystis cecconii*** Cognetii de Martiis, 1918

Site of infection: Coelom
Type host: *Pheretima* (*parapheretima*) *wendessiania*
Type Locality: New Guinea

(5) ***Nematocystis almae*** Cognetii de Martiis, 1921

Site of Infection: Coelom
Type host: *Almae emini* var. *aloysii-sabaudii*
Type locality: Ruwenzori (Africa)

(6) ***Nematocystis hessei*** Bhtia and Chatterjee, 1925

Site of infection: Seminal vesicles
Type host: *Pheretima heterochaeta*
Type locality: India

(7) ***Nematocyatis plurikaryosomata*** Bhatia and Chatterjee, 1925

Site of infection: Seminal vesicles
Type host: *Eisenia foetida*
Type locality: Punjab, India

(8) ***Nematocystis stephensoni*** Bhatia and Setna, 1926

Site of infection: Seminal vesicles
Type host: *Eutyphoeus incommodus*
Type locality: Punjab (Kasauli), India

(9) ***Nematocystis elmassiani*** (Hesse, 1909) Bhatia, 1929

Site of infection: Seminal vesicles
Type host: *Dendrobaena subrubicunda*, *D. tenuis*, *Lumbricus terrestris*, *L. rubellus*, *Allobophora r.* rosea, *A. longa*, *Eisenia foetida*
Type locality: England, France, Sweden, U.S.A.

(10) ***Nematocystis criodrilii*** Sciacchitano, 1931

Site of infection: Coelom
Type host: *Criodrilus lacuum*
Type locality: Italy

(11) ***Nematocystis variabilis*** Sciacchitano, 1931

Site of infection: Coelom
Type host: *Criodrilus lacuum*
Type locality: Italy

(12) ***Nematocystis pilosa*** Bereczky, 1967

Site of infection: Seminal vesicles
Type host: *Octolasium complanatum*, *O. transpadanu*, *Dichogaster baeri*
Type locality: France, Hungary, Ivory Coast

(13) ***Nematocystis testiculi*** Tuzet and Loubatieres, 1946

Site of infection: Seminal vesicles
Type host: *Octolasium complanatum*
Type locality: France

(14) ***Nematocystis claviformis*** Loubatieres, 1955

Site of infection: Seminal vesicles
Type host: *Allobophora chlorotica*
Type locality: France

(15) ***Nematocystis clipeiformis*** Loubatieres, 1955

Site of infection: Seminal vesicles
Type host: *Octolasium complanatum*
Type locality: France

(16) ***Nematocystis navicula*** Loubatieres, 1955

Site of infection: Seminal vesicles
Type host: *Octolasium complanatum*
Type locality: France

(17) ***Nematocystis pistilliformis*** Loubatieres, 1955

Site of Infection: Seminal vesicles
Type host: *Allolobophora gigas*
Type locality: France

(18) ***Nematocystis sinuosa*** Loubatieres, 1955

Site of infection: Seminal vesicles
Type host: *Allolobophora rosea*
Type locality: France

(19) ***Nematocystis glossoscoli*** Boisson, 1957

Site of infection: Seminal vesicles
Type host: *Glossoscolex corethrurus*
Type locality: France

(20) ***Nematocystis gracilis*** Berlin, 1924 emend. Segun, 1968

Site of infection: Seminal vesicle
Type host: *Lumbricus terrestris, L. rubellus, L. castaneus*
Type locality: Sweden, England

(21) ***Nematocystis dendrobaenae*** Segun, 1968

Site of infection: Seminal vesicles and Coelom
Type host: *Dendrobaena rubida f. subrubicunda, D. mammalis.*

Type locality: England

(22) ***Nematocystis caerenis*** Mohammed and Ramadan, 1972

Site of infection: Seminal vesicles
Type host: *Alma nilotica*
Type locality: Egypt

(23) ***Nematocystis cylindroides*** (Georgevitch, 1951) Levine, 1977a, b

Site of infection: Seminal vesicle
Type host: *Criodrilus ochridensis*
Type locality: Yugosiavia

(24) ***Nematocystis goliatti*** (Georgevitch, 1951) Levine, 1977a, b

Site of infection: Seminal vesicle
Type host: *Criodrilus ochridensis*
Type locality: Yugosiavia

(25) ***Nematocystis tuzetae*** Loubatieres, 1947 emend. Levine, 1977a, b

Site of infection: Testes and Coelom
Type host: *Octolasium complanatum*, *O. transpadanum*
Type locality: France, Hungary

(26) ***Nematocystis meierae*** Levine, 1977a, b

Site of infection: Seminal vesicles
Type host: *Allolobophora longa*
Type locality: England, France, Germany

(27) ***Nematocystis bunmii*** Segun, 1978

Site of infection: Seminal vesicles
Type host: *Heliodrilus lagosensis*
Type locality: Nigeria

(28) ***Nematocystis levinei*** Pradhan and Dasgupta, 1980a, b

Site of infection: Seminal vesicles
Type host: *Eutyphoeus gammiei*
Type locality: India

(29) ***Nematocystis manpooensis*** Pradhan and Dasgupta, 1980a, b

Site of infection: Coelom
Type host: *Eutyphoeus gammiei*
Type locality: West Bengal, India

(30) ***Nematocystis quadrikaryosomata*** Pradhan and Dasgupta, 1980a, b

Site of infection: Coelom
Type host: *Pheretima diffringens*
Type locality: West Bengal, India

(31) ***Nematocystis snechalensis*** Pradhan and Dasgupta, 1980a, b

Site of infection: Coelom
Type host: *Apporectodea trapezoids*
Type locality: West Bengal, India

(32) ***Nematocystis theodoridis*** Pradhan and Dasgupta, 1980a, b

Site of infection: Coelom
Type host: *Pheretima diffringes*
Type locality: West Bengal, India

(33) ***Nematocystis bengalensis*** Roy Chowdhury and Halder, 1984

Site of infection: Seminal vesicles
Type host: *Eutyphoeus incommodus*
Type locality: India

(34) ***Nematocystis mauritii*** Roy Chowdhury and Haldar, 1984

Site of infection: Seminal vesicles
Type host: *Lampitito mauritti*
Type locality: West Bengal, India

(35) ***Nematocystis gardenica*** Bandyopadhyay and Mitra, 2005a, b

Site of infection: Seminal vesicles
Type host: *Amynthas hawayanus*
Type locality: West Bengal, India

(36) ***Nematocystis kalyaniensis*** Bandyopadhyay and Mitra, 2005a

Site of infection: Seminal vesicles
Type host: *Amynthas hawayanus*
Type locality: West Bengal, India

(37) ***Nematocystis indicus*** Bandyopadhyay et al., 2006a

Site of infection: Seminal vesicles
Type host: *Perionyx excavatus*
Type locality: Sundarban, West Bengal, India

(38) ***Nematocystis indica*** Bandyopadhyay et al., 2006b

Site of infection: Seminal vesicles
Type host: *Amynthas diffringes*
Type locality: Midnapore East district, West Bengal, India

(39) ***Nematocystis majumdari*** Bandyopadhyay et al., 2007

Site of infection: Seminal vesicles
Type host: *Eutyphoeus incommodus* (Beddard)
Type locality: West Midnapur, West Bengal, India

(40) ***Nematocystis bayrami*** Mallik and Bandyopadhyay, 2009

Site of infection: Seminal vesicle
Type host: *Eutyphoeus orientalis*
Type locality: Bankura, West Bengal, India

(41) ***Nematocystis vinodae*** Mallik et al., 2011

Site of infection: Seminal vesicle
Type host: *Eutyphoeus orientalis*
Type locality: Bankura, West Bengal, India

(42) ***Nematocystis bangladeshensis*** Sarkar and Bandyopadhyay, 2012

Site of infection: Seminal vesicle
Type host: *Metaphire peguana*
Type locality: Dhaka, Bangladesh.

(43) ***Nematocystis kailasi*** Mallik and Bandyopadhyay, 2016

Site of infection: Seminal vesicles
Type host: *Glyphidrilus tuberosus*
Type locality: Contai, Purba Midnapore, West Bengal

Genus ***Rhynchocystis*** Hesse, 1909

(1) ***Rhynchocystis porrecta*** (Schmidt, 1854) Hesse, 1909

Site of infection: Seminal vesicles
Type host: *Lumbricus terrestris, L. rubellus, L. castaneus, Eisenia foetida Allolobophora calinginosa.*
Type locality: France

(2) ***Rhynchocystis hessei*** Cognetti de Martiis 1911

Site of infection: Seminal vesicles
Type host: *Pareudrilus pallidus, Lumbricus rubellus, L. terrestris*
Type locality: Equader

(3) ***Rhynchocystis piriformis*** Berlin, 1924

Site of infection: Seminal vesicles
Type host: *Lumbricus terrestris, L. rubellus, Eisenia foetida.*
Type locality: France

(4) ***Rhynchocystis cognetti*** Bhatia and Chatterjee, 1925

Site of infection: seminai vesicles
Type host: *Allolobophora caliginosa*
Type locality: India

(5) ***Rhynchocystis awatii*** Bhatia and Setna, 1926

Site of infection: Seminal vesicles
Type host: *Pheretima elongata*
Type locality: India

(6) ***Rhynchocystis mamillata*** Bhatia and Setna, 1926

Site of infection: Seminal vesicles
Type host: *Pheretima elongata*
Type locality: India

(7) ***Rhynchosystis pilosa,*** Troisi, 1933

Site of infection: Seminal vesicles
Type host: *Lumbricus castaneus, L. terrestris, Helodrilus foetidus*
Type locality: England

(8) ***Rhynchocystis ovata*** Loubatiéres, 1955

Site of infection: Seminal vesicles
Type host: *Allolobophora rosea*
Type locality: France

(9) ***Rhynchocystis pessoai,*** Righi, 1974

Site of infection: Seminal vesicles
Type host: *Pristina minuta*
Type locality: Brazil

(10) ***Rhynchocystis cuneiformis*** (Ruschhaupt, 1885) Levine, 1977a, b

Site of infection: Seminal vesicles
Type host: *Lumbricus terrestris L. rubellus, L. castaneus, L. festivus, Eisenia foetida*
Type locality: France

(11) ***Rhynchocystis oculata*** (Berlin, 1924) emend Levine, 1977a, b

Site of infection: Seminal vesicles
Type host: *Lumbricus terreestris*, *L. rubellus*, *L. castaneus*
Type locality: Sweden, France

(12) ***Rhynchocystis silvae*** Sarkar et al., 2012a

Site of infection: Seminal vesicles
Type host: *Metaphire peguana*
Type locality: Bagladesh

Genus ***Zygocystis*** Von stein, 1848

(1) ***Zygocystis cometa*** Von Stein, 1848

Site of infection: Seminal vesicle
Type host: *Lumbricus terrestris*, *Allolobophora longa, A. caliginosa, A. caliginosa* var. *trapezoides*, *A. chloroticum, A. dubiosa*, *Eisenia foetida*
Type locality: England, France, Germany, Sweden, Hungary, Maxico.

(2) ***Zygocystis legeri*** Hesse, 1909

Site of infection: Seminal vesicle
Type host: *Allolobophora chlorotica, pheretima diffringens*
Type locality: France

(3) ***Zygocystis pilosa*** Hesse, 1909

Site of infection: Seminal vesicle
Type host: *Allolobophavg longa*
Type locality: France

(4) ***Zygocystis suecia*** Berlin, 1924

Site of infection: Seminal vesicles
Type host: *Eisenia foetida*
Type locality: Poland, Sweden

(5) ***Zygocystis wenrichi*** Troisi, 1933

Site of infection: Seminal vesicle
Type host: *Lumbricus rubellus, Helodrilus foetidus*
Type locality: Europe

(6) ***Zygocystis pagesi*** Tuzet and Loubatiéres, 1946

Site of infection: Seminal vesicles
Type host: *Allolobophara gigas*
Type locality: France

(7) ***Zygocystis cordiformis*** Loubatiéres, 1955

Site of infection: Seminal vesicles
Type host: *Allolobophora gigas*
Type locality: USSR

(8) ***Zygocystis eiseniae*** Loubatiéres, 1955

Site of infection: Seminal vesicles
Type host: *Eisenia foetida*
Type locality: France

(9) ***Zygocystis grassei*** Loubatiéres 1955

Site of infection: Amebocytes
Type host: *Allolobophora caliginosa*
Type locality: France

(10) ***Zygocystis henleae*** Meier, 1956

Site of infection: Coelom
Type host: *Henlea ventriculosa*
Type locality: England

(11) ***Zygocystis pheretimae*** de Puytorac and Tourret, 1963

Site of infection: Coelom
Type host: *Pheretima schmardae, P. houlleti, Pheretima* sp.
Type locality: Germany

(12) ***Zygocystis aster*** Bereczky, 1968

Site of infection: Coelom
Type host: *Allolobophora dubiosa*
Type locality: Hungary

(13) ***Zygocystis ictericae*** Segun, 1968

Site of infection: Seminal vesicles
Type host: *Allolobophora icterica f. typica*
Type locality: Nigeria

(14) ***Zygocystis limnodrili*** Janiszewska, 1968

Site of infection: Seminal vesicles
Type host: *Limnodrilus hoffmeisteri*
Type locality: USSR

(15) ***Zygocystis aegyptica*** Mahammed and Ramadan, 1971

Site of infection: Seminal vesicles
Type host: *Pheretima californica, P. hawayana*
Type locality: Egypt

(16) ***Zygocystis violacea*** Segun, 1978

Site of infection: Coelom
Type host: *Libyodrilus violaceus*
Type locality: Nigeria

(17) ***Zygocystis indicus*** Pradhan and Dasgupta, 1983a, b

Site of infection: Seminal vesicles
Type host: (*Metaphire*) *Pheretima californica*
Type locality: Darjeeling, West Bengal, India

(18) ***Zygocystis levinei*** Bandyopadhyay and Mitra, 2004

Site of infection: Seminal vesicles
Type host: *Amynthas nicholsoni*
Type locality: Sundarban, West Bengal, India

(19) ***Zygocystis perionyxae*** Bandyopadhyay and Mitra, 2005b

Site of infection: Coelomic fluid
Type host: *Perionyx graveleyi*
Type locality: Canning, West Bengal, India

Discussion

This checklist summarizes information on the aseptate gregarine parasites of oligochetae hosts of the world. It is expected that this checklist will be helpful for future research in this field.

Acknowledgements One of the authors (BK) is thankful to the University of Kalyani, Kalyani for providing research scholarship to carry out the work.

Author's Contribution All authors had participated in the study design. Manuscript writing was done by first author. Corresponding author participated planning and supervision of the work. All authors had critically read and approved of the final manuscript.

Compliance with ethical standards

Confilct of interest The authors declare that they have no conflict of interest.

Ethical approval It has been informed that as per CPCSEA instructions protocol that there is no need of taking approval from the ethical committee to carry out the research work on this animal.

References

Bandyopadhyay PK, Mitra AK (2004) Description of a new species *Zygocystis levinei* sp. n. (Eugregarinida, Zygocystidae), from the earthworm *Amynthas nicholsoni* (Oligochaeta) from West Bengal, India. Protistology 3(4):227–231

Bandyopadhyay PK, Mitra AK (2005a) Observation on two new species of *Nematocystis* Hesse, 1909 (Protozoa; Monocystidae) from earthworms (Annelida: Oligochaeta) of West Bengal, India. Animal Biol 55:133–139

Bandyopadhyay PK, Mitra AK (2005b) Description of a new gregarine species, *Zygocystis perionyxae* sp. n. (Protozoa: Zygocystidae), from the earthworm *Perionyx gravelleyi* (Annelida: Oligochaeta) from West Bengal, India. Protistology 4(2):91–95

Bandyopadhyay PK, Mitra AK (2006) *Dirhynchocystis indica (*Apicomplexa, Rhynchocystinae*),* a new gregarine species from the earthworm *Lampito mauritii* (Annelida, Oligochaetae) in India. Parasitology 4(3):201–207

Bandyopadhyay PK, Roychudhuri US, Biswas G (2004) Descriptions of two new species of acephaline gregarines (Protozoa: Apicomplexa: Eugregarinida), *Apolocystis chotonagpurensis* sp. n. and *Stomatophora janovyi* sp. n. from Earthworms (Annelida: Oligochaeta) of India. Acta Protozoologica 43:275–279

Bandyopadhyay PK, Mitra AK, Bhowmik B (2006a) *Nematocystis indicus* sp.nov. (Apicomplexa: Monocystidae) from an Indian earthworm (Annelida: Oligochaeta) *Perionyx excavatus* (Perrier). Zootaxa 1296:63–68

Bandyopadhyay PK, Mallik P, Mitra AK (2006b) *Nematocystis indica* sp. n. (Protozoa: Apicomplexa: Eugregarinida). An endoparasitic monocystid gregarine from the seminal vesicles of an Indian earthworm *Amynthas diffriengens* Baird (Annelida: Oligochaeta) in India. Parasitology 4(3):357–360

Bandyopadhyay PK, Mallik P, Mitra AK (2007) Observations on *Monocystis arabindae* n. sp. and *Nematocystis majumdari* n. sp. (Protozoa: Apicompleaxa:Monocystidae) from Seminal Vesicles of an Earthworm *Eutyphoeus incommodus* (Beddard) from West Bengal, India. Acta Protozoologica 46:147–155

Baudoin J, Maillard Y (1972) Recherches sur les gregarines des coleopteres hydrophilides. Protistologica 8:53–63

Bereczky MC (1967) Txonomische Untersuchungen über die parasitiernden Monocystideen (Protozoa) bei Regenwürmern (Lumbricidae). Opusc Zool Budap 7(1):55–69

Bereezky MC (1968) Observation on the development of *Allolobophora duboisa* (Orley) 1880 and its parasite Zygocystis aster n. sp. Ann Unin Sc, Budapest, Rolando Eotvos (Sect Biol) 9:65–70

Berlin H (1924) Üntersuchngen uber Monocystideen in den vesiculae seminalies der schwedischen oligochaeten. Archives fur Protistenkunde 48:1–124

Bhatia BL (1929) On the distribution of gregarines in oligochates. Parasitology 2:120–131

Bhatia BL, Chatterjee CB (1925) On some gregarine parasites of Indian earthworms. Archives fur protistenkunde 52:189–206

Bhatia BL, Setna SB (1926) On some gregarine parasites of Indian earthworms. Archiv fur Protistenkunde 53:361–377

Bhowmik B, Bandyopadhyay PK, Mitra AK (2012) *Apolocystis cognetti* sp. nov. (Apicomplexa: Monocystinae) a new aseptate gregarine species from the earthworm *Amynthas hawayanus* (Annelida: Oligochaeta) from West Bengal. J Parasit Dis 36:203–206

Boisson C (1957) Monocystidae parasites d'oligochates d' Indochine. Ann des Sci Nat Zool 19:71–90

Bosanquet WC (1894) Notes on a gregarine of the earthworm (*Lumbricus herculeus*). Q J Microsc Sci Arch 39:421–433

Codreanu M (1940) Sur quatre gregarines nouvelles du genre Enterocy-stis, parasites des Ephemeres torrenticoles. Arch Zool Exp Generale, (Notes et Revue) 81:113–122

Cognetti de Maritiis L (1918) Nuove gregarine monocistidae (nota prel.). Monitore Zoologico Italiano 29:147–149

Cognetti de Martiis L (1911) Contributa alla conoscenza delle Monocystidae e deil loro fenomeni reproducttivi. Archives fur protistenkunde 23:205–246

Cognetti de Martiis L (1921) Nuevo contribute alla conoscenza delle gregarine monocistidae. Monitore Zoologico Italiano 31:149–155

Cognetti de Martiis L (1923) Sul genera monocystis. Monitore Zoologica Italiano 34:250–253

De Puytorac P, Tourret M (1963) Etude de kystes d'originc parasitaire (microsporides ou gregarines) sur la paroi interne du crops des vers megascoleccidae. Ann de Parasitologie 38:861–874

Desportes I (1963) Quelques gregarines parasites d'insectes aquatiques de France. Annales de Parasitologie Humaine et Comparée 38:341–377

Foerster H (1938) Gregarinen in schlesischen Insekten. I: II: Z. Parasitenk 10:157–209

Frolov AD (1991) The world fauna of gregarines, Family Monocystidae. Trudy Zoologicheskogo Instituta Akademii Nauk SSSR., No. 229, p 125

Gates GE (1926) Preliminary note on a new protozoan parasite of earthworms of the genus *Eutyphoeus*. Biol Bull 51:400–401

Georgevitch J (1951) Contribution a la connaissance desregarines du lac d' ochrid. Acad Serb Bull Sci Aled 3:15–21

Grasse PP (1953) Classe des gregarinomorphes (Gregarinomorpha n. nov.; Gregarinae Haekel, 1866; gregarinidea Lankester, 1885). Trait de Zoologie 1(2):550–690

Gullo BS, Armendáriz LC (2002) New species of *Apolocystis* (Aseptatorina: Monocystidae) from the coelom of *Microscolex dubius* (Oligochaeta: Acantodrillidae) in Los Talas, Buenos Aires, Argentina. Acta Protozoologica 41(4):407–413

Hesse E (1909) Contribution a l'edude des monocystidees des oligochetes. Archives de Zoologie Experimentale et Generale 5:127–301

Janiszewska J (1968) Life cycle of *Zygocystis limnodrili* sp. n. (Gregarinomorpha, Monocysticlac) from the seminal vesicles of *Limnodrilus hoffmeisteri (*clapared). Zoologica Poloniae 18:61–68

Levine ND (1977a) Revision and check-list of the species of the aseptate gregarine family Mono-cystidae. Folia Parasitologica 24:1–24

Levine ND (1977b) Check-list of the species of the aseptate gregarinefamilies Aikinetocystidae, Diplocystidae, Allantocystidae, Schaudinnellidae, Ganymidae and Enterocystidae. J Invertebr Pathol 29:175–181

Levine ND (1988) The protozoan phylum Apicomplexa, vol I. CRC Press Inc., Boca Raton

Loubatieres R (1955) Contribution a 1'etude des gregarinomorphes monocystidae parasites des oligochates du Languedoc-Roussillon. Ann Sci Natl Zool 17(2):73–201

Mallik P, Bandyopadhyay PK (2009) *Nematocystis bayrami* sp.n. (Protozoa, Apicomplexa, Eugregarinida) monocystid gregarine from *Eutyphoeus orientalis* Beddard (Annelida, Oligochaeta). N-West J Zool 5(2):420–423

Mallik P, Bandyopadhyay PK (2016) Observation on *Nematocystis kailashi* sp. nov. (Apicomplexa: Eugregarinida) from an Indian earthworm *Glyphidrilus tuberosus* Stepheson (Annilida: Oligochaeta). Ann Parasitol 62(4):315–320

Mallik P, Bandyopadhyay PK, Gocmen B (2011) *Nematocystis vinodae* n. sp. (Protozoa, Apicomplexa, Eugregarinida), a monocystid gregarine from *Eutyphoeus nicholsoni* (Beddard). Turkiye Parazitoloji Dergisi 35(1):27–29

Medhat A, Ramadan N, Fawzy S, Nigm A (2018) *Apolocystis nephredii* (Apicomplexa: Monocystinae) a new aseptate gregarine species from nephredia of *Limnodrilus sp.* (Annelida: Oligochaeta) from Egypt. Egypt Acad J Biol Sci 10(2):39–48

Meier M (1956) Die Monocystideent'auna der oligochawn von Earlangen und umgebung. Archives fur protistenkunde 101:335–400

Mohammed AH, Ramdan NF (1971) Zygocystis aegyptiaca n. sp., a common cephaline gregarine in egyptian Oligochaetes of the genus *Pheretima*. Zool Soc Egyp Bull 23:29–38

Mohammed AH, Ramdan NF (1972) *Nematocystis caerenis* n. sp. an acephaline gregarine of *Alma nilotica* (Grube). Zool Soc Egyp Bull 24:5–14

Mulsow K (1911) Über Fortpflanzungserscheinungen bei *Monocystis rostrata* n. sp. Archives fur protistenkunde 22:20–55

Nobel ER (1938) A new gregarine from *Urechis caupo*. Trans Am Microbio Soc 57:142–146

Pradhan D, Dasgupta B (1980a) Records of Some new gregarines in earthworms from the hill areas of Darjeeling district-I. N Bengal Univ Rev (Sci Technol) 1(2):135–139

Pradhan D, Dasgupta B (1980b) Records of Some new gregarines in earthworms from the hill areas of Darjeeling district-II. N Bengal Univ Rev (Sci Technol) 1(2):141–143

Pradhan D, Dasgupta B (1983a) New acephaline gregarines (*Apolocystis*) in earthworm of the hill areas of Darjeeling district. J Bengal Nat Hist Soc (N Ser) 2(2):5–12

Pradhan D, Dasgupta B (1983b) Life history and morphology of *Zygocystis indicus* n.sp. J Bengal Nat Hist Soc (N Ser) 2(2):17–23

Ramadan NF (1969) Acephaline gregarines in Egyptian oligochaetes. M.Sc., Faculty of Science, Ain Shams University, Egypt

Ramadan N, Fawzy S, Ali M, Nigm A (2014) *Apolocystis perienteron* sp. nov. (Apicomplexa: Monocystinae) a new aseptate gregarine from *Pheretima californica* (Annelida: Oligochaeta) from Egypt. Parasitology 8(4):172–177

Ramadan N, Fawzy S, Ali M, Nigm A (2015) *Apolocystis proventus* sp. nov. (Apicomplexa: Monocystinae) a New Species of Aseptate Gregarine from Egyptian Earthworms: *Pheretima californica* and *Pheretima elongata* (Annelida: Oligochaeta). Acta Protozool 54:233–240

Rees B (1963) Studies on monocystid gregarines Six *Apolocystis* species including four new species *A. lavernensis*, *A. perfida*, A. rotaria and A. Spinosa. Parasitology 53:491–500

Righi G (1974) Alguns sporozoa (Gregarinida a haplosporida) de oligochaeta (Naididae en Enchytracidae) *Brasilciros*. Papies Avulsos de Zoologia Sao. Paulo 28(1):85–195

Roychoudhury US, Haldar DP (1984) Studies in aseptate gregarines from earthworms of West Bengal, two new species of *Nematocystis* and one new species of *Stomatophora*. J Bengal Nat Hist Soc (N Ser) 3(2):17–27

Ruchhaput G (1885) Beitrag zur Entwicklungesgeschichte der monocystiden gregarine aus dem testiculus des *Lumbriculus agricola*. Jenaische Zeitschrift Fur Naturwissenschaft 18:713–750

Ruston J (1959) Dirhynchocystis minuta n. sp. gregarine from the seminal vesicles of *Lumbricus terrestris* with a note on the association of *Rhynchocystis porrecta* (Schmidt). J Parasitol 45:259–262

Sarkar S, Bandyopadhyay PK (2012) Studies on the biodiversity of aseptate gregarine parasite from the oligochaete host of Bangladesh. Bangladesh J Zool 40(1):51–58

Sarkar NK, Haldar DP (1983) *Enterocystis bengalensis* n.sp. (Apicomplexa: Enterocystidae) from *Psocatropos* sp. (Psocoptera) of West Bengal, India. Curr Sci 52(8):372–373

Sarkar S, Bandyopadhyay PK, Göçmen B (2012a) Description of *Rhynchocystis silvae* sp. nov (Apicomplexa: Eugregarinida) from Metaphire peguana Rosa (1890) of Dhaka, Bangladesh. Turkiye Parazitoloji Dergisi 36:178–181

Sarkar S, Bandyopadhyay PK, Mitra AK (2012b) On the occurrence of a gregarine parasite (Apicomplexa: Eugregarinorida) from the seminal vesicles of earthworms (Annelida: Oligochaeta) of Bangladesh. J Parasit Dis 36(1):44–48

Sciacchitano I (1931) Su alcune gregarine parasite des Criodrihis lacuum Hoffm. Bollettino di Zoologia Napoli 2:175–195

Segun AO (1968) Studies of acephaline gregarines in British earthworms, their systematic, occurrance and possible mode of transmission. Ph.D. Thesis. University of London, p 318

Segun AO (1971a) Acephaline gregarines of british earthworms- their possible host specificity. Parasitology 62(3):389–396

Segun AO (1971b) further additions to the British records of acephaline gregarines of earthworms. Parasitology 62(3):397–407

Segun AO (1978) Monocystid gregarine parasites of Nigerian earthworms. J Protozool 25:157–162

Stein Von (1848) Beitragc Zur kenntniss niederer thiere. Zeitschrift fur Wissenschaftliche Zoologie 1:1–37

Troisi RA (1933) Studies on the acephalines of some oligochaete annelids. Trans Am Microbio Soc 52:326–352

Tsvetkov BN (1926) Eine neue Gregarinengattung Enterocystis ensis, aus den Larven einer Eintags- fliege. Vorlaufige Mitteilung. Rusk Arkh Protist 5:45–54

Tuzet O, Loubattieres R (1946) Notes sur les monocystidees. Archives de Zoologie Experimentale et Generale 84:132–141

Tuzet O, Zuber-Vogeli M (1955) Gregarines et cities parasites des vesicules serninales de Dichogaster inermis Michaelson oligochete de Man (A.O.F.). Bull Inst France Afr 17:369–376

Tuzet O, Zuber-Vogeli M (1956) Deuxieme contribution a 1'etude des monocystidae parasites des oligochetes Africains Millsonia anomaly Omodeo, 1954 et Dichogaster baeri Sciacchitano. Oligochaetes de Gagrnoa (A.O.F.). BuIl Inst France Afr 11(8):410–417