New records of suctorians (Ciliophora: Suctoria) as epibionts of aquatic true bugs (Hemiptera: Prosorrhyncha: Nepomorpha) from two regions: Mexico and Eastern Europe

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Abstract

Here, we provide new records of suctorians (Ciliophora: Suctoria), epibionts of aquatic true bugs (Hemiptera: Prosorrhyncha: Nepomorpha) collected in Ukraine, Belarus and Mexico. The worldwide distribution of the 16 species we found is updated, from which, 15 species are new records as epibionts of 15 species of aquatic true bugs. Only for the suctorian Discophrya gessneri Matthes, we confirm the previous record (epibiont of Aphelocheirus aestivalis Fabricius). We conclude that the relationship between the suctorians and aquatic true bugs is poorly studied and some suctorian genera (Discophrya Lachmann and Periacineta Collin) inhabit as nepomorphans as other aquatic insects (Coleoptera). However the high degree of specificity at the species level of these genera is evident, for which we provide some possible explanations according to the group of basibiont.

Key words: Suctorian, nepid, epibiosis, epibiont-basibiont system, Mexico, Ukraine, Belarus

Introduction

There are approximately 8,000 species of ciliated protozoa (Lynn, 2008), and some of them are symbionts of other organisms. Epibiotic suctorian ciliates of aquatic insects (such as hemipterans) are poorly understood worldwide, and few studies have been done for the genera Corixa Geoffroy, Sigara Fabricius, Notonecta Linnaeus, Plea Leach, Nepa Linnaeus, Naucoris Geoffroy and Aphelocheirus Westwood (Matthes et al. 1988). Recently in Mexico, Mariño-Pérez & Mayén-Estrada (2009) recorded Discophrya elongata (Claparède et Lachmann) and Acineta tuberosa Ehrenberg as epibionts of the water boatman Corisella edulis (Champion). In the Ukraine, Dovgal (1987, 1991) reported Discophrya lichtensteini (Claparède et Lachmann) (under synonym name D. wrzesniowskii) as an epibiont of the water scorpion Ranatra linearis (Linnaeus), D. ochthebii Matthes as an epibiont of the pygmy backswimmer Plea leachi McGregor & Kirkaldy, D. gessneri as an epibiont of Aphelocheirus aestivalis, Periacineta buckei (Kent) (under name P. nepae) on the water scorpion Nepa cinerea Linnaeus, and Ranatra linearis and Periacineta notonectae (Claparède et Lachmann) as epibionts of the water boatman Corixa sp. Only two of these suctorians, Discophrya lichtensteini and Periacineta buckei were recorded on Nepa cinerea, from Lake Khotin, high-water bed of river Desna, near village Timanovka, Sumy region (Dovgal, 1987). Also, Dovgal (1987, 1991) reported for the first time D. lichtensteini and D. ochthebii as epibionts of true bugs.

The aims of the present study are to update and compare the records and distribution of epibiont suctorian attached to some aquatic insects, from two biogeographical areas.
Material and methods

Between the years 1983–2010, several aquatic insects (hemipterans) were collected at certain localities in Ukraine, Belarus, and Mexico. The insects were collected with a 0.5 mm mesh net or by manual sampling and then, fixed and preserved with 70% alcohol or 4% formalin. For microscopical observation, the suctorian ciliates were recorded and identified, fixed with Bouin’s fixative for 5 min. and stained with either Heidenhain’s or Boehmer’s haematoxylin, or fixed with 70% alcohol and stained with Harris’ haematoxylin. According to Lynn (2008) the taxonomic status for each species of suctorian is presented. Here, we provide the aquatic true bugs species that carries the epibionts, the country and for some localities the geo-reference. Additional data such as altitude are given in meters above sea level (m.a.s.l.). We include for each species of suctorian ciliate, a diagnosis and morphometrical data. We also compiled the available data about epibiont suctorians providing the previous records of the species and also previous measurements.

Results

We obtained 16 species of suctorians representing three subclasses, five orders, 10 families, and 11 genera. These protozoans were found attached to 15 species of aquatic true bugs representing 11 genera and seven families: Nepidae (Ranatra linearis, Nepa cinerea, Ranatra spp. Fabricius); Belostomatidae (Belostoma spp. Latreille, Lethocerus sp. Mayr); Naucoridae ([Naucoris cimicoides (Linnaeus), Ambrus spp. Stål]); Pleidae (Plea leachi); Corixidae ([Hesperocorixa laevigata (Uhler), Corixa sp.]); Aphelocheiridae (Aphelocheirus aestivalis) and Notonectidae (Notonecta unifasciata Guerin-Meneville).

For Ukraine and Belarus, we found nine species as new records, and for Mexico we observed only three new records. Four species of suctorians were found distributed in all three countries (Ukraine, Belarus, and Mexico) as new records. The suctorian Periacineta buckei was found in ten species of aquatic true bugs, and Discophrya elongata was found in seven basibiont species. The nepomorphs which harboured the highest species richness, were the nepids Ranatra linearis (5 species), and Nepa cinerea (4 species).

Systematics

Species taxonomy (Lynn, 2008).

Class PHYLLOPHARYNGEA de Puytorac et al., 1974
Subclass Suctoria Claparède et Lachmann, 1858
Order Exogenida Collin, 1912
   Family Podophryidae Bützchli, 1889
   Genus Podophrya Ehrenberg, 1834
      Species Podophrya fixa (O.F. Müller, 1786)
   Family Metacinetidae Bützchli, 1889
   Genus Metacineta Bützchli, 1889
      Species Metacineta longipes (Mereschkowsky, 1877)
   Family Manuelophryidae Dovgal, 2002
      Genus Manuelophrya Matthes, 1988
      Species Manuelophrya hannae (Guhl, 1985)
Order Endogenida Collin, 1912
   Family Acinetidae Ehrenberg, 1838
      Genus Acineta Ehrenberg, 1834
      Species Acineta flaviatilis Stokes, 1885
   Family Tokophryidae Jankowski, 1978
      Genus Tokophrya Bützchli, 1889
      Species Tokophrya quadripartita (Claparède et Lachmann, 1859)
         Tokophrya lemnarum (Stein, 1859)
      Family Dendrosomatidae Bützchli, 1889

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EPIBIOTIC SUCTORIANS OF NEPOMORPHANS

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Genus *Dendrosoma* Ehrenberg, 1838  
Species *Dendrosoma radians* Ehrenberg, 1838  
Family Pseudogemmidae Jankowski, 1978  
Genus *Pseudogemma* Collin, 1912  
Species *Pseudogemma pachystyla* Collin, 1912  
Order Evaginogenida Jankowski, 1978  
Family Discophryidae Collin, 1912  
Genus *Discophrya* Lachmann, 1859  
Species *Discophrya elongata* (Claparède et Lachmann, 1859)  
*Discophrya gessneri* Matthes, 1954  
*Discophrya lichteinsteinii* (Claparède et Lachmann, 1859)  
*Discophrya ochthebii* Matthes, 1954  
Family Periacinetidae Jankowski, 1978  
Genus *Periacineta* Collin, 1909  
Species *Periacineta buckei* (Kent, 1882)  
*Periacineta notonectae* (Claparède et Lachmann, 1859)  
Genus *Kormosia* Dovgal, 2002  
Species *Kormosia linguifera* (Claparède et Lachmann, 1859)  
Family Heliophryidae Corliss, 1979  
Genus *Cyclophrya* Gonnert, 1935  
Species *Cyclophrya magna* Gonnert, 1935  

Suctorian species records

**Family Podophryidae Bütschli**

*Podophrya fixa* (O.F. Müller, 1786)  
Fig. 3c.

The cell is spherical, stalk long, thin, slightly bent. Numerous capitate tentacles, variable in length, equally spaced over the body surface. There is one centrally located, spherical macronucleus, and one contractile vacuole. Reproduction by pseudo-scissiparity producing a bud that is approximately a same size as a mother cell with about 12 longitudinal rows of cilia and several rudimentary tentacles (Curds, 1986). The stalked oviform cyst with four transversal ribs is characteristic for this species.

Dimensions (in μm): body diameter 10–40; length of stalk 80–100; stalk diameter 4–5; macronucleus diameter 11–15; length of tentacles 12–25. Previous measurements: body diameter 25–70; length of stalk 35–140; length of tentacles until 120.

**Material examined.** Found as epibiont of: *Plea leachi*. **Ukraine.** Small lake in high-water bed of Desna river near village Kladk’kovka, Chernigov region, 12.07.1984.


**Family Metacinetidae Bütschli**

*Metacineteta longipes* (Mereshchkowsky, 1877)  
Fig. 3e.

The cell is spherical or somewhat elongate, covered by stylotheca with very long stalk-like protuberance. Macronucleus is ovoid, centrally located. Cell body clamped to the stylotheca near the apical aperture. The apical aperture of stylotheca has 6 or 7 edges. Tentacles are long, clavate and arranged in 6 or 7 radial rows placed between edges.

Dimensions: body diameter 25–37; diameter of macronucleus 10–15; length of tentacles 30–50; stylotheca length 175–185; stylotheca width 40–50; stalk-like protuberance length 130–200. Previous measurements: body diameter 246; length (with stalk) 2,040.

**Material examined.** Found as epibiont of: *Nepa cinerea*. **Belarus.** River Ubor’ near village Borovoe, 13.08.1983.


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**FIGURE 1.** Some epibiotic suctorians of nepomorphans. **a.** *Manuelophrya hannaeh* parasite of peritrich epibiont of *Lethocerus* sp. (Mexico). **b.** *Pseudogemma pachystyla* parasite of *Periacineta buckei* attached to *Ranaatra* sp. (Mexico). **c.** *Discophrya elongata* on *Ranaatra* sp. (Mexico). **d.** *Discophrya gessneri* epibiont of *Aphelocheirus aestivalis* (Ukraine); the insert shows the shape of the stalk. **e.** *Discophrya lichteinsteinii* found on *Ambrysus* sp. (Mexico). **f.** Empty loricaes of *Periacineta notonentae* from *Corixa* sp. (Ukraine). **g-i.** *Periacineta buckei* from *Ranaatra* sp., *Belostoma* sp. and *Lethocerus* sp., respectively (Mexico).

Family Manuelophryidae Dovgal

*Manuelophrya hannaë* (Guhl, 1985)

Fig. 1a.

Cell is spherical with single, short, thick, rod-like tentacle by which this parasite of the peritrichs attaches to the host body. Lorica absent. Macronucleus spherical, centrally located. There are two contractile vacuoles, placed near the opposite site of the tentacular region of body. Reproduction by semi-circumvaginative budding.


Additional records. Ectoparasite of peritrich Haplocaulus walteri Precht (Matthes et al. 1988).


Family Acinetidae Ehrenberg

Acineta fluviatilis Stokes, 1885

Medium sized, freshwater, loricate species that is pyriform to triangular in outline, strongly compressed laterally. The apical aperture is slit-like through which the two fascicle born upon lobe-like actinophores protrude. Actinophores independently contractile. Stalk of variable length, joining with lorica without any collar or cup-like region.
With centrally located spherical macronucleus and apical contractile vacuole. Reproduction by monogenmic endogenous budding (Curds, 1985a).

Dimensions: width of lorica 24–60; length of stalk 58–68; stalk diameter 5–7; macronucleus 10–14 x 15–45; length of the tentacles 18–30, diameter of contractile vacuole 6–8. Previous measurements: length 65; length of stalk 20–90.


Family Tokophryidae Jankowski

Tokophrya quadripartita (Claparède et Lachmann, 1859)

Fig. 3b.

Species medium to large, freshwater whose body shape is pyramidal and approximately square in cross section. There are 4 lobe-like prominent actinophores, one at each corner of the apical surface, each bearing a fascicle of capitates tentacles. Lorica absent. Stalk of variable length present. Number of contractile vacuoles varies from 1 to 3. Macronucleus spherical to ovoid, centrally placed. There is one contractile vacuole. Endogenous budding results in an ovoid larval form with variable numbers of ciliary rows and formations (Curds, 1985b).

Dimensions: body length 50–138; body width 20–70; macronucleus 7–16 x 28–58; length of tentacles 20–50; length of stalk 80–220; stalk diameter 4–7. Previous measurements: body length 60–175, body width 18–75, length of tentacles until 90.


Tokophrya lemnarum (Stein, 1859)

Fig. 2c.

Freshwater species whose body shape is piryform to pyramidal. Lorica absent. Fascicles of capitates tentacles mounted on 2 actinophores. Stalk longitudinally striated, of variable length, but usually at least as long as body. There are usually 2 anterior-lateral contractile vacuoles. Macronucleus ovoid to elongate with several micronuclei. Reproduction by endogenous budding producing buds with 4 ciliary girdles (Curds, 1985b).

Dimensions: body length 30–48; body width 24–35; length of the tentacles 35–50; macronucleus diameter 9–12; stalk length 60–250; stalk diameter 3–7. Previous measurements: body length 18–127; body width 12–82; stalk length 54–170.


Additional records. On Lemna (Curds, 1985b); on aquatic plants, Asellus aquaticus (Linnaeus), Astacus leptodactylus, gammarids from Baikal lake (Curds, 1985b; Matthes et al. 1988 ); on Gammarus Fabricius, Astacus leptodactylus (Morado & Small, 1995); on Cordylophora caspia Pallas (Aladro-Lubel et al. 2006).
Family Dendrosomatidae Bütschli

Dendrosoma radians Ehrenberg, 1838

Fig. 2a.

Suctorian ciliate with very large (up to 5 mm) branched body. Several fascicles of tentacles placed at the numerous actinophores which are elevated over the substrate. Single macronucleus branched reaching the actinophores. Micronuclei are numerous. The shape of body is extremely variable depending on the type of substrate. Thus at the more or less flat substrates the individuals (especially young), have irregularly shaped flattened body with short, unramified actinophores, whereas on complex surfaces, i.e. aquatic invertebrates, the body might be dendritic with long branched actinophores. Reproduction by multiple endogenous budding.


Family Pseudogenmidae Jankowski

Pseudogemma pachystyla Collin, 1912

Fig 1b.

Ectoparasitic species with sacciform loricate body. There is single, short, thick, rod-like tentacle by which the parasite attaches to the apical part of the host (suctorian ciliates) body. The tentacle as a rule completely dipped into host cell body. Reproduction by endogenous budding.


Additional records. Brackish water from Béziers and the channel of the port of Cette; ectoparasite of Acineta tuberosa (Matthes et al. 1988).

Family Discophryidae Collin

Discophrya elongata (Claparède et Lachmann, 1859)

Fig. 1c.

Freshwater species whose body shape is elongate and flattened. Clavate tentacles are arranged in apical fascicle; with or without 2–5 lateral fascicles, or solitary lateral tentacles. Macronucleus varies from spherical to elongate. Stalk often longitudinal or transversal striated, and occasionally with apical cup-like broadening. There are from 3 to 6 contractile vacuoles. Reproduction by inversogemmic budding.


**Discophrya gessneri** Matthes, 1954

Fig. 1d.

Freshwater species with flattened asymmetrical body. Stalk short, cup-like apically covering about a quarter of body. Clavate tentacles not arranged in fascicles, evenly distributed over apical body surface and each one beginning from small projections of the cortex. Macronucleus spherical, centrally located. Reproduction has not been observed.

Dimensions: body length 20–42; width 17–36; length of the tentacles about 60. Previous measurements: body length 18–38; body width 18–38; length of tentacles until 60.


**Discophrya lichteinsteinii** (Claparède et Lachmann, 1859)

Fig. 1e.

Suctorian ciliate with flattened, disc-shaped or elongate body. Macronucleus ovoid, centrally located. Contractile clavate tentacles evenly distributed over all edge of body, but in some cases only at apical part. Stalk cup-shaped or elongate, with different length (Dovgal & Kochin, 1997), uniformly expanding upwards, with transversal folds. There are up to three contractile vacuoles. Reproduction by inversogemmic budding.


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**Discophrya ochthebii** Matthes, 1954

Fig. 3a.

Suctorian ciliate with flattened disk-like body, and cone-shaped short stalk with transversal ridges. Numerous long, clavate, contractile tentacles distributed over edge of body. Macronucleus spherical or ovoid, centrally located. A group (12–29) of contractile vacuoles placed near edges of body, or (when their number is greatest) thorough the body is characteristic. Reproduction by inversogemmic budding.

Dimensions: body length 26–50; body width 43–69; macronucleus 4–9 x 21–32; contractile vacuole diameter 3–4; length of tentacles 23–26; width of apical part of stalk 26–31. Previous measurements: body length 40–91; body width 43–124; length of stalk 9–45.


**Additional records.** On aquatic coleopteran *Ochthebius* sp. Thomson (Matthes et al. 1988).

**Family Periacinetidae Jankowski**

**Periacineta buckei** (Kent, 1882)

Figs. 1g–i.

Polymorphic suctorian with trapeziform, flattened, loricate body. Lorica smooth, without transversal ribbons, and with slit-like aperture, the stalk is short. Macronucleus spheroidal or elongate. Tentacles are clavate, and capable to contract into body, and are arranged in two apical fascicles. Actinophores absent. There are from 1 to 4 contractile vacuoles. Reproduction by inversogemmic budding.

Dimensions: body length 16–120; width 19–59; macronucleus 13–38 x 4–7; contractile vacuoles diameter 2–4; length of the tentacles 8–75; stalk length 6–24; stalk diameter 3–10. Previous measurements: body length 24–450; body width 13–121; length of tentacles until 88.


Periacineta notonectae (Claparède et Lachmann, 1859)
Fig. 1f.


Kormosia linguifera (Claparède et Lachmann, 1859)
Fig. 3d.

Suctorian with triangular flattened body, with stylotheta provided by short stalk-like protuberance. There are two apical fascicles of contractile clavate tentacles. Macronucleus central and elongated. From 1 to 4 contractile vacuoles. Body attached to the lorica edges near aperture. Reproduction by inversogemmic budding.

Dimensions: lorica length 95–118; width 35–118; body length 67–84; macronucleus 13–17 x 31–38; length of tentacles 6–22. Previous measurements: body length 50–245; body width 40–130.


Family Heliophryidae Corliss

Cyclophrya magna Gonnert, 1935
Fig. 2b.

Suctorian with large, flattened disc-shaped body. Macronucleus ribbon-like, convoluted, ramified. There are four (rarely five) bundles of long, contractile, clavate tentacles near the edge of body. There are from 4 to 8 contractile vacuoles. Reproduction by inversogemmic budding.
Dimensions: diameter of body 90–108; length of tentacles 14–40. Previous measurements: diameter of body until 190; length of tentacles until 500.

**Material examined.** Found as epibiont of: *Nepa cinerea*. **Ukraine.** Snov river near village Gorsk, Chernigov region. 14.06.1991.

**Additional records.** Flowing water, slides (Matthes *et al.* 1988).

**Discussion**

The epibiotic relationship between suctorians and aquatic true bugs is poorly understood. There is little evidence of the degree of specificity in the epibiont-basibiont system. According to Hebsgaard *et al.* (2004), members of the infraorder Nepomorpha are well supported as a monophyletic group, with the Nepoidea (Belostomatidae and Nepidae) placed as the first branch clade. The next node corresponds to Corixidae as sister group of Tripartita (the rest of the families), whose relationship differs according to the analysis employed (morphological, molecular, combined) (Hebsgaard *et al.* 2004). According to previous and present data, the members of the superfamily Nepoidea present a higher diversity of epibiotic suctorians, with 11 species, nevertheless all the species of suctorians recorded in this subfamily have been previously found in substrates other than nepomorphans (i.e. aquatic coleopterans, crustaceans, and aquatic plants).

In contrast, in the most derived branches (Corixidae and Tripartita), the suctorian *Discophyra gessneri* has been recorded only as epibiont of *Aphelocheirus aestivalis*, and *Periacineta notonectae* has been found only as epibiont of members of the family Corixidae (*Hesperocorixa laevigata, Sigara* and *Corixa* sp.), and from only one genus of notonectid (*Notonecta*) (Claparède et Lachmann, 1859). However, after careful revision through years of thousands of specimens of notonectids and corixids, we observed *P. notonectae* only in corixids, for which we consider this last record as a misidentification of the host. For these reasons we can catalogue this suctorian with a high specificity degree to corixids. Recently Mariño-Pérez *et al.* (2010) found a high specific suctorian (*Periacineta mexicana* Mariño-Pérez, Mayén-Estrada & Dovgal) on species of the genus *Buenoa* Kirkaldy (Notonectidae). Nevertheless, we also recorded several species of non specific suctorians (i.e. *P. buckei* and *D. elongata*) in Corixidae and Tripartita.

Certain morphological and physiological features of the aquatic true bugs could rule the presence, specific richness, and or degree of specificity of epibionts over their body surface. For example, within the Nepoidea (Belostomatidae and Nepidae) there is a siphon for breathing air. Individuals are greater in comparison to the members of other families, but we do not find epibiotic ciliates species-specific (Schuh & Slater, 1995). Species belonging to the family Notonectidae usually control their buoyancy capacity and use their abdominal setae to collect an air bubble; these actions reduce their movements through water column until they surface to obtain oxygen (Schuh & Slater, 1995). Members of two families of aquatic true bugs, Naucoridae and Aphelocheiridae could use the plastron for oxygen uptake, so they can spend all the time submerged (Schuh & Slater, 1995). In both cases, these actions probably favor the attachment of epibionts. Species of the family Corixidae are detritivorous and depend of active migrations through water column, for oxygen and food uptake. The rest of the families limit their displacement to prey capture due to predator habits. These behavior patterns could explain the high degree of specificity of *Discophyra gessneri* to be found upon *Aphelocheirus aestivalis*, *Periacineta notonectae* on corixids, and *Periacineta mexicana* on *Buenoa* spp. (Notonectidae).

**Acknowledgments**

We give thanks for the agreement between Universidad Nacional Autónoma de México and Schmalhausen Institute of Zoology, Ukraine, for a short term visit to Ukraine, and to CONACyT (Consejo Nacional de Ciencia y Tecnología) for providing scholarship # 1875. The Posgrado en Ciencias Biológicas and Secretaría de Intercambio Académico, Facultad de Ciencias, UNAM, supported Dr. I. Dovgal for a short stay at UNAM, Mexico. We also want to thank Paul Tinerella (Illinois Natural History Survey), for his help in some nepomorphans identification. We also thank to M. C. Violeta Romero (Instituto de Geología, UNAM), for English improvement, to Biól. Itzel Sigala-Regalado (Facultad de Ciencias, UNAM) who provided some specimens of nepomorphans and to Silvia
Hansen Bernal for the line drawings of figure 3. The comments of three anonymous referees substantially improved the final version of the manuscript.

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