

Eleven New Ciliate Species of the Genus *Triplumaria* (Ciliophora, Entodiniomorphida) from Asian Elephant, *Elephas maximus* and African Elephant, *Loxodonta africana*

OLGA TIMOSHENKO¹ AND SOICHI IMAI²

¹Institute of Zoology, Kiev, Ukraine and ²Department of Parasitology, Nippon Veterinary and Animal Science University, Tokyo, Japan

received 16 January 1996 / Accepted 28 February 1996

Key words; ciliate, Cycloposthiidae, elephant, Entodiniomorphida, *Triplumaria*.

ABSTRACT

Intestinal ciliate compositions in fecal samples from zoo-kept Asian and African elephants were examined. As a result, eleven new species belonging to the genus *Triplumaria* were recognized. Four of the new species possess both honeycomb-like thick skeletal plates and broad linear skeletons, like *T. hamertonii* Hoare, 1937 and *T. selenica* Latteur et al., 1970 known up to this time, and resemble the latter species in anterior location of micronuclei. However, *T. longinucleata* n.sp. and *T. nucleocaudata* n.sp possess long macronuclei, with posterior ends curved ventrally or straight and extending into the tail lobe, respectively; *T. asiatica* n. sp. has two bulb-like and one cylindrical caudalia; and hill-like caudalia of *T. heterofasciculata* n. sp. are clearly characteristic in size. Six new species possess thin light skeletal plate and slender linear skeleton showing vertebra-like structure, respectively; *T.antis* n. sp. is small in body size and has a micronucleus in the center of macronucleus, whereas the other species have micronuclei located anteriorly; *T. doliiformis* n. sp. is characterized by anteriorly hooked macronucleus; *T. acuticaudata* n. sp. has a triangular tail lobe; *T. dvoinosi* n. sp. possesses antero-dorsal and ventral caudalia directed up and downward. Antero-dorsal caudalium of *T. ovina* n. sp. and ventral caudalium of *T. irregularis* n. sp. are shifted upward and to the left, respectively. The other new species, *T. poljanskii* n. sp. is characterized by a combination of heavy honeycomb-like skeletal plate and vertebra-like linear skeleton as well as posterior location of the micronucleus.

INTRODUCTION

Peculiar ciliates belonging to the order Entodiniomorphida including Archistomatina, Blepharocorythina and Entodiniomorphina (Small and Lynn 1985) are known to inhabit the intestinal lumen of various large herbivores, such as ruminants, horses, hippopotamuses, rhinoceroses, tapirs and elephants (Ogimoto and Imai 1981). In Asian and African elephants, 25 species in the several families, such as Buetschliidae, Blepharocorythidae, Cycloposthiidae, Polydiniellidae, Ophryoscolecidae, and Paraisotrichidae, have been described up to this time (Eloff and van Hoven 1980; Kofoid 1935; Latteur 1966, 1967; Latteur and Bousez 1970; Mandal and Choudhury 1983; Wolska 1967, 1968, 1970, 1986).

Two representatives of the cycloposthiid genus *Triplumaria*, *T. hamertonii* Hoare, 1937 and *T. selenica* Latteur et al., 1970, have been reported from African elephants, and the former species is also known from Indian and white rhinos (Hoare 1937, Van Hoven et al. 1987). This paper describes eleven new species of the genus *Triplumaria* found in feces of both Asian, *Elephas maximus*, and African, *Loxodonta africana*, elephants.

MATERIALS AND METHODS

Samples of feces examined were obtained from three Asian elephants kept in Kiev zoo (European studbook No. 7002), Moscow zoo (European studbook No. 8001) and Berlin Tierpark (European studbook No. 8507), and one African elephant kept in Moscow zoo. For the purpose of identification, 10 % (V/V) formalin solution containing 0.06% (W/V) methylgreen and 0.8% (W/V) sodium chloride (Ogimoto and Imai 1981) was added to the same volume of fecal sample. A drop of glycerol was added to a drop of the sample on a glass slide before examination. In some instances slides were put aside for a few hours to make ciliates more lucid. To determine the average body size of new species, 25 cells were measured using a calibrate micrometer. Size is indicated as mean \pm standard deviation, and the range is indicated in parentheses. A part of the formal fixed sample was washed with distilled water and post-fixed with 2% (W/V) osmium tetroxide aqueous solution for 2 hrs under a room temperature, washed with distilled water five times, dehydrated with a series of ethanol, freeze-dried, then coated with gold in a sputter coater and examined with a JSM 6100 SEM (JEOL, Tokyo).

Terminology used is mainly in accordance with that applied by Hsiung (1930) to the other cycloposthiid genera. However, the skeletal structure situated just below the pellicle we called the outer skeletal plate and the inner longitudinally arranged skeletal structure the linear skeleton.

RESULTS

All examined animals were wild-borne and possessed native ciliate faunae, despite the long-term in captivity. Asian elephant from Kiev had only one of the new species, the ones from Moscow and Berlin had five and eight new species, respectively. Two new triplumariids were also found in the African elephant from Moscow zoo. *Triplumaria selenica* was recorded from all animals.

Since the genus identification available so far is based only on the description of *T. hamertonii*, further characteristics of the genus *Triplumaria* is also described followed by new species descriptions.

Genus *Triplumaria* n. charact.

Family Cycloposthiidae. Body elongated, usually rectangular, compressed laterally. Three caudalia located postero-ventrally, postero-dorsally and antero-dorsally, usually angled to the longitudinal axis of the body. Below posterior caudalia body forms a tail lobe. Clear dorsal groove on the left side of the body. Right-dorsal or some additional longitudinal grooves may be present depending on number of sections of the outer skeletal plate, which surrounds the subsurface of the body. Inner linear skeleton lies along the left dorsal groove, in the gap between the margins of skeletal plate, left to macronucleus. Elongated macronucleus on the right side of dorsal caudalia. Contractile vacuoles on longitudinal row located left to macronucleus, between dorsal caudalia.

Type species: *Triplumaria hamertonii* Hoare, 1937.

Triplumaria longinucleata n.sp.

(Figs. 1, 12, 13)

Description: Body rectangular. Body length 90.3 ± 12.0 (72-112) μm , width 36.2 ± 5.3 (30-49) μm , length to width ratio 2.5 ± 0.3 (2.1-3.1). One longitudinal groove left dorsally. Tail lobe rather small and flattened. Outer skeletal plate heavy and thick, with polygonal honeycomb-like structure. Inner linear skeleton extending from the anterior end of the body to postero-dorsal caudalium, tapering posteriorly. Its anterior third relatively broad with honeycomb-like structure. Caudalia are relatively large and similar in shape and size, with bulb-like lips. Posterior end of rod-shaped macronucleus curved ventrally, extending below the postero-dorsal caudalium. Micronucleus located at anterior one-seventh of macronucleus. Three to four contractile vacuoles in a row.

Type host and locality: Asian elephant, *Elephas maximus*, from Berlin Tierpark and Moscow zoo.

Type material: No.IE-4 deposited in the Zoological Institute, Kiev, Ukraine.

Etymology: *Triplumaria longinucleata* is named after its long macronucleus.

NEW *TRIPLUMARIA* SPECIES OF ELEPHANTS

Remarks: The species closely resembles both *T. selenica* and *T. hamertonii* in presence of heavy skeletal plate and honeycomb-like structure of linear skeleton. Like the former species, it possesses anteriorly located micronucleus. However, this new species has a smaller and slender body, and macronucleus in peculiar shape extending below the postero-dorsal caudalium.

Triplumaria nucleocaudata n.sp.

(Figs. 2, 14)

Description: Body rectangular. Body length 174.0 ± 22.5 (135-220) μm , width 92.2 ± 11.6 (71-131) μm , length to width ratio 1.9 ± 0.1 (1.6-2.1). With left dorsal longitudinal groove. Tail lobe broad and short, with flattened end. Heavy skeletal plate with honeycomb-like structure. Linear skeleton from the anterior end of the body to the two-thirds of body length, tapering posteriorly. Its anterior third relatively broad, and has the same structure as the plate. Respective cylindrical caudalia similar in size, with many longitudinal folds. Rod-shaped macronucleus straight, its posterior end extends into the tail lobe. Micronucleus located near to the anterior one-seventh of macronucleus. Four to six contractile vacuoles in a row.

Type host and locality: African elephant, *Loxodonta africana*, in Moscow zoo.

Type material: No. AE-3 deposited in the Zoological Institute, Kiev, Ukraine

Etymology: *Triplumaria nucleocaudata* is named after its macronucleus extending into the tail lobe.

Remarks: This species closely resembles *T. hamertonii*, *T. selenica* and *T. longinucleata* in presence of heavy skeletal plate and honeycomb-like structure of linear skeleton. Straight macronucleus is also similar to those of *T. hamertonii* and *T. selenica*, and the position of micronucleus similar to that in *T. selenica* and *T. longinucleata*. However, new species has broader body, and its macronucleus extends into the tail lobe.

Triplumaria asiatica n.sp.

(Figs. 3, 15)

Description: Body rectangular. Body length 109.1 ± 10.9 (84-134) μm , width 47.2 ± 5.4 (33-56) μm , length to width ratio 2.3 ± 0.2 (2.0-2.6). Longitudinal grooves at the left and right dorsal sides of the body. Tail lobe with rounded end. Heavy skeletal plate and linear skeleton with honeycomb-like structure. The latter runs from the anterior end of the body to the two thirds of body length, tapered posteriorly, with broad anterior third. Antero-dorsal and ventral caudalia are bulb-like, folded transversally. Postero-dorsal caudalium

NEW *TRIPLUMARIA* SPECIES OF ELEPHANTS

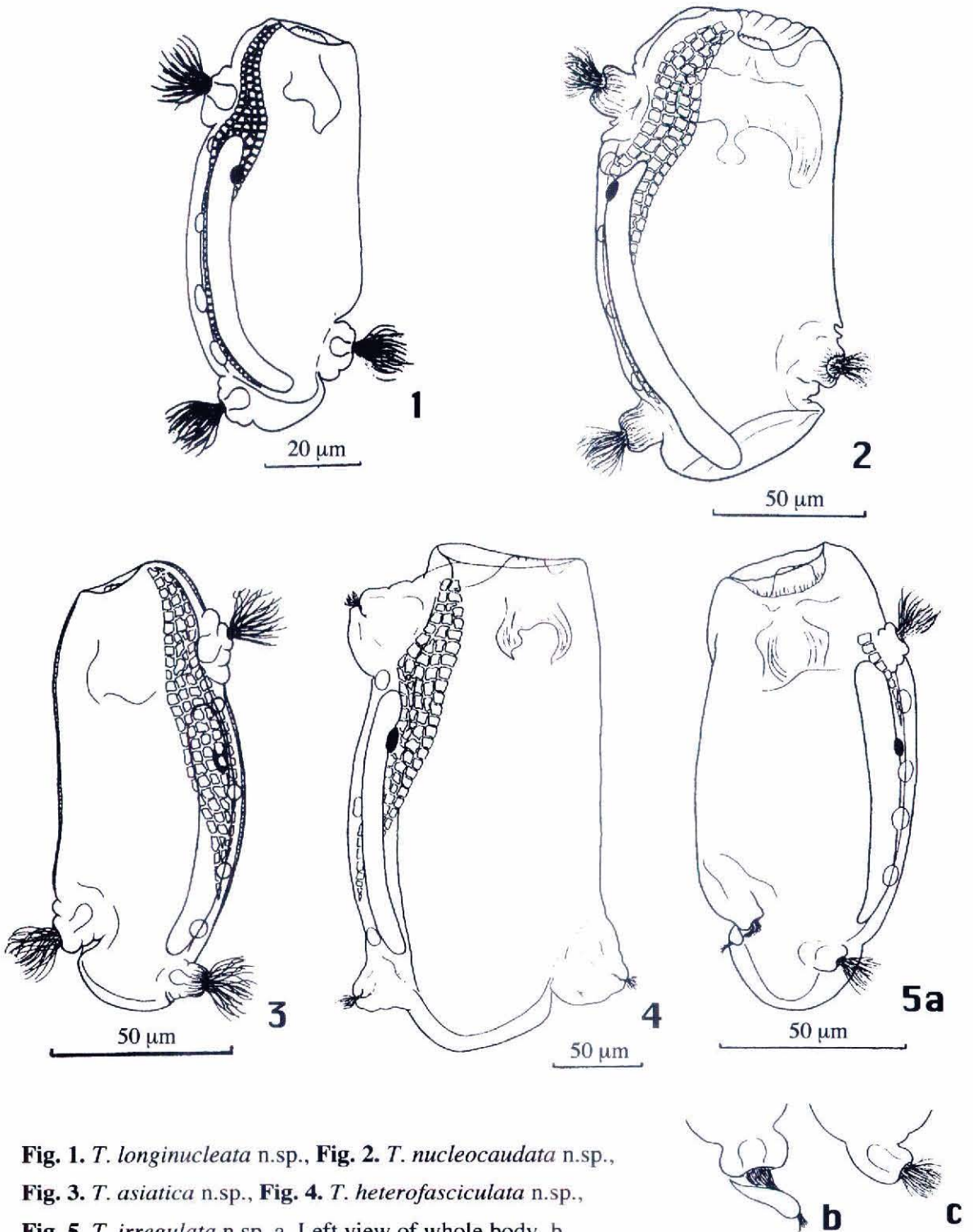


Fig. 1. *T. longinucleata* n.sp., **Fig. 2.** *T. nucleocaudata* n.sp.,
Fig. 3. *T. asiatica* n.sp., **Fig. 4.** *T. heterofasciculata* n.sp.,
Fig. 5. *T. irregulata* n.sp. a. Left view of whole body. b.
 Ventral caudalium. c. Postero-dorsal caudalium.

NEW *TRIPLUMARIA* SPECIES OF ELEPHANTS

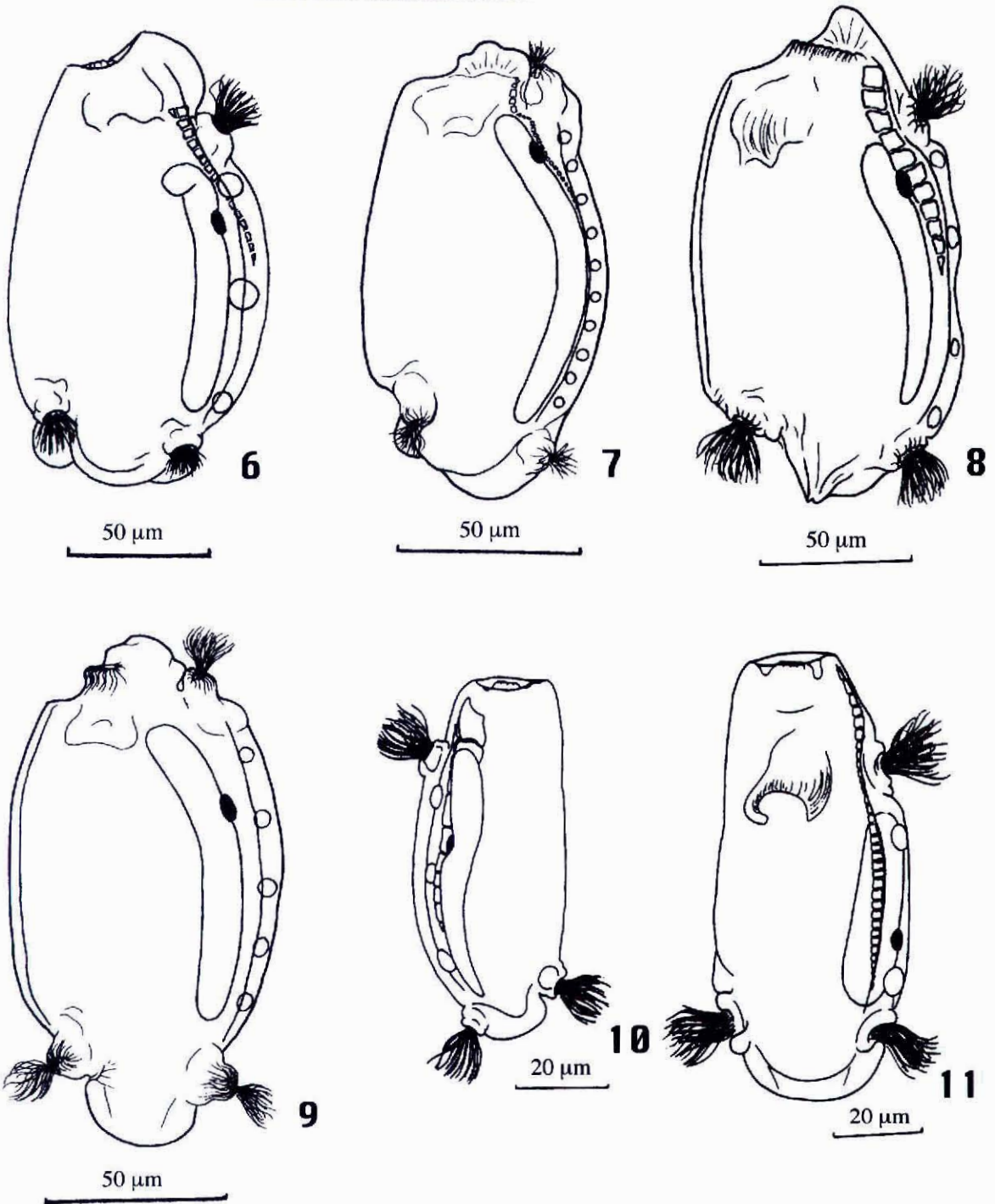


Fig. 6. *T. doliiformis* n.sp., **Fig. 7.** *T. dvoinosi* n.sp., **Fig. 8.** *T. acuticaudata* n.sp.,
Fig. 9. *T. ovina* n.sp., **Fig. 10.** *T. antis* n.sp., **Fig. 11.** *T. poljanskii* n.sp.

NEW *TRIPLUMARIA* SPECIES OF ELEPHANTS

cylindrical in shape with longitudinal folds. Straight rod-shaped macronucleus between dorsal caudalia. Micronucleus located at the anterior one-fifth of macronucleus. Three to four contractile vacuoles in a row.

Type host and locality: Asian elephant, *Elephas maximus*, in Berlin Tierpark.

Type material: No. IE-22 deposited in the Zoological Institute, Kiev, Ukraine.

Etymology: *Triplumaria asiatica* is named after the origin of the host.

Remarks: Like *T. hamertonii*, *T. selenica*, *T. nucleocaudata* and *T. longinucleata*, the species possesses heavy skeletal plate and honeycomb-like structure of linear skeleton. Also it has straight macronucleus between dorsal caudalia, as *T. hamertonii* and *T. selenica*, and anteriorly located micronucleus, as *T. selenica*, *T. nucleocaudata* and *T. longinucleata*. New species resembles *T. selenica* more closely, but differs in its smaller body size and varying shape of the caudalia.

Triplumaria heterofasciculata n.sp.

(Figs. 4, 16, 17)

Description: Body rectangular. Body length 180.4 ± 25.9 (131-249) μm , width 86.2 ± 16.3 (60-126) μm , length to width ratio 2.1 ± 0.2 (1.8-2.6). Longitudinal groove runs left dorsally. Tail lobe broad, but short, with rounded end. Outer skeletal plate heavy and thick, with honeycomb-like structure. Broad linear skeleton having the same structure tapering posteriorly, which length is two-thirds of body length. Massive hill-like caudalia, same in shape and size, at the antero-dorsal and ventral sides of the body, respectively. Postero-dorsal caudalium smaller than those and narrower on the bottom. Straight rod-shaped macronucleus between dorsal caudalia. Micronucleus located at the anterior one-sixth of macronucleus. Three to four contractile vacuoles in a row.

Type host and locality: Asian elephant, *Elephas maximus*, in Berlin Tierpark and Moscow zoo.

Type material: No. IE-4 deposited in the Zoological Institute, Kiev, Ukraine..

Etymology: *Triplumaria heterofasciculata* is named after its clear difference in size of caudalia.

Remarks: New species closely resembles both *T. selenica* and *T. asiatica*. Caudalia of both species do not differ in size, comparing to that of the new species. However, this new species have hill-like shaped caudalia, whereas all caudalia of *T. selenica* and postero-dorsal caudalium of *T. asiatica* are cylindrical in shape, and the other two caudalia of *T. asiatica* are bulb-like.

NEW *TRIPLUMARIA* SPECIES OF ELEPHANTS

Triplumaria irregularis n.sp.

(Figs. 5, 18-20)

Description: Body rectangular, with anterior third slightly curved ventrally. Body length 107.8 ± 12.3 (86-130) μm , width 54.0 ± 5.5 (41-64) μm , length to width ratio 2.0 ± 0.2 (1.6-2.5). Left and right longitudinal grooves on the dorsal side of the body. Relatively large and rounded tail lobe with ventral edge turning left ward. Outer skeletal plate light and thin, with gently large alveolar structure. Vertebra-like slender inner linear skeleton runs from the bottom of antero-dorsal caudalium to the anterior one-third of body, and tapers posteriorly. Caudal lips short cylindrical in shape, folded transversally or longitudinally. Ventral caudalium shifted to the left side of the body and directed downward. Ventral edge of the tail lobe encircles its cilia. Those are stuck out over the surface of the lobe as a little brush. Straight rod-shaped macronucleus between dorsal caudalia. Micronucleus located at the anterior one-fourth of macronucleus. Three to six contractile vacuoles in a row.

Type host and locality: Asian elephant, *Elephas maximus*, in Berlin Tierpark and Kiev zoo.

Type material: No. IE-1 deposited in the Zoological Institute, Kiev, Ukraine.

Etymology: *Triplumaria irregularis* is named after the great shift of the ventral caudalium resulting in its irregular direction.

Remarks: This species differs from *T. hamertonii*, *T. selenica* and all above species in its possession of a light skeletal plate and vertebra-like linear skeleton, as well as irregular direction of ventral caudalium.

Triplumaria doliiformis n.sp.

(Figs. 6, 21)

Description: Body rather ovoid in shape with its anterior end lowered ventrally. Body length 125.6 ± 19.0 (91-159) μm , width 73.7 ± 11.6 (48-95) μm , length to width ratio 1.7 ± 0.2 (1.2-2.0). One longitudinal groove left-dorsally. Tail lobe rounded and short, its margins protruding showing earlobe-like appearance. Outer skeletal plate light and thin, its structure quite indistinct. Slender linear skeleton from the bottom of antero-dorsal caudalium to a half of body length, tapered posteriorly, with vertebra-like structure. Antero-dorsal caudalium bulb-like in shape and seems to lie in a depression, as the upper part of the body protrudes over it. Both posterior caudalia short cylindrical or even rim-like in shape. Those shifted to the left side of the body and directed left-downward, as projected ventral and dorsal edges of the tail lobe restrict them on the right side. Rod-shaped macronucleus between dorsal caudalia, with anterior end hooked to the left. Micronucleus located at the anterior one-fourth of

NEW *TRIPLUMARIA* SPECIES OF ELEPHANTS

macronucleus. Three to six contractile vacuoles in a row.

Type host and locality: Asian elephant, *Elephas maximus*, in Moscow zoo.

Type material: No. IE-4 deposited in the Zoological Institute, Kiev, Ukraine.

Etymology: *Triplumaria doliiformis* named after the shape of its body which looks like a barrel.

Remarks: The species resembles *T. irregularis* in light skeletal plate, vertebra-like linear skeleton and anterior location of micronucleus, but differs in shape of the body, both posterior caudalia shifted to the left side of the body, and anteriorly hooked macronucleus. Some specimens lack tail lobe projections, thus their presence may be a variable characteristic.

Triplumaria dvoinosi n.sp.

(Figs. 7, 22)

Description: Body rather ovoid in shape, with anterior end lowered ventrally. Body length 203.4 ± 23.3 (160-243) μm , width 110.6 ± 13.0 (91-138) μm , length to width ratio 1.8 ± 0.2 (1.5-2.1). Longitudinal dorsal groove on the left side of the body. Some specimens also possess an additional groove left-ventrally. Rounded tail lobe broad and short, occasionally with protrusion on the ventral margin. Light skeletal plate with quite indistinct structure. Slender vertebra-like linear skeleton from anterior end of the body to one-third of its length. Ventral caudalium shifted to the left side of the body and directed downward. Ventral protrusion on the tail lobe restricts it on the right side. Antero-dorsal caudalium directed upward, along the longitudinal axis of the body, whereas the postero-dorsal caudalium is angled to it. Caudal lips, hill-like or high cylindrical in shape, are folded longitudinally. Rod-shaped macronucleus curved anteriorly, between dorsal caudalia. Micronucleus located at the anterior one-sixth of macronucleus. Seven to ten contractile vacuoles in a row.

Type host and locality: Asian elephant, *Elephas maximus*, in Berlin Tierpark.

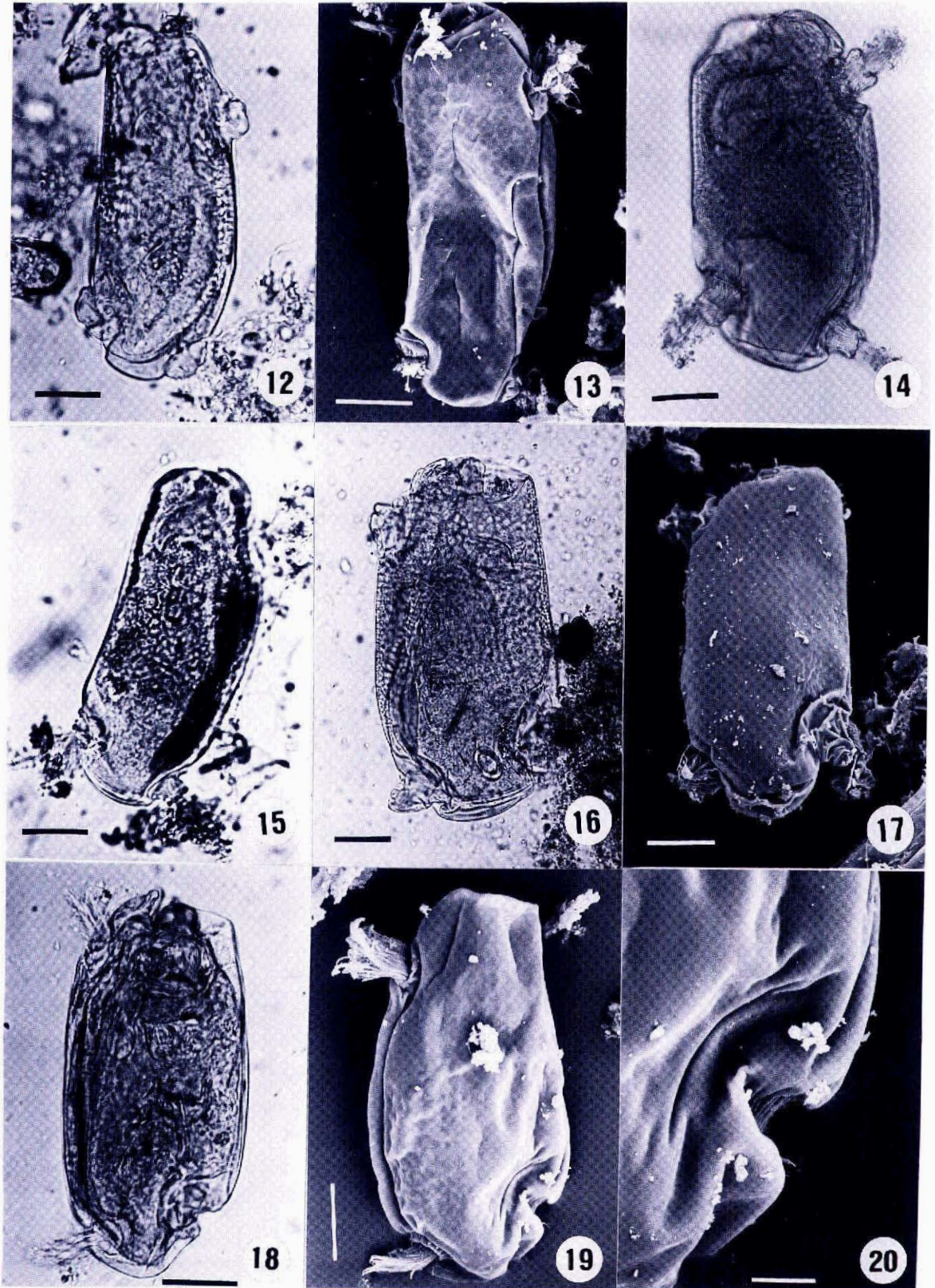
Type material: No. IE-22 deposited in the Zoological Institute, Kiev, Ukraine.

Etymology: *Triplumaria dvoinosi* named after Prof. G.M. Dvoinos, as parasitologist at the Institute of Zoology, Ukraine, who has contributed to parasitological field.

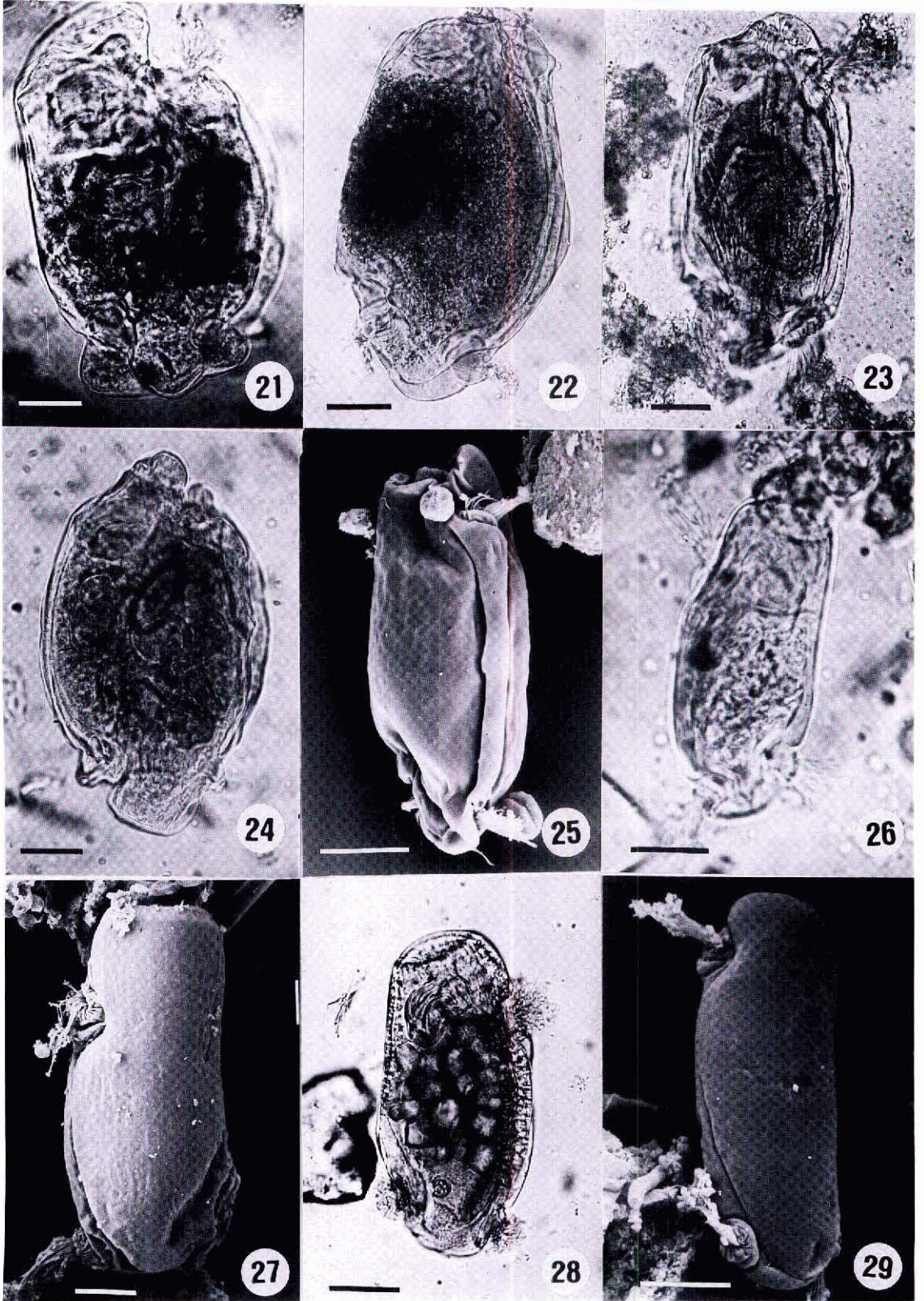
Remarks: The species resembles *T. irregularis* and *T. doliiformis* in possession of light skeletal plate, vertebra-like linear skeleton and anterior location

Fig. 12. *T. longinucleata*. Bar=20 μm . Fig. 13. SEM of *T. longinucleata*. Bar=20 μm . Fig. 14. *T. nucleocaudata*. Bar=30 μm . Fig. 15. *T. asiatica*. Bar=20 μm . Fig. 16. *T. heterofasciculata*. Bar=30 μm . Fig. 17. SEM of *T. heterofasciculata*. Bar=30 μm . Fig. 18. *T. irregulata*. Bar=20 μm . Fig. 19. SEM of *T. irregulata*. Bar=20 μm . Fig. 20. SEM of ventral caudalium of *T. irregulata*. Bar=50 μm .

NEW *TRIPLUMARIA* SPECIES OF ELEPHANTS



NEW *TRIPLUMARIA* SPECIES OF ELEPHANTS



NEW *TRIPLUMARIA* SPECIES OF ELEPHANTS

of micronucleus. However, this new species differs in its larger body size, upward direction of antero-dorsal caudalium and shape of the macronucleus which is curved anteriorly. The presence of ventral and dorsal grooves left longitudinally indicates two sections of skeletal plates in some specimens, this may be a variable characteristic for the species.

Triplumaria acuticaudata n.sp.

(Fig. 8, 23)

Description: Body rectangular. Its anterior end twisted ventrally. Body length 127.3 ± 23.4 (82-173) μm , width 77.1 ± 13.0 (42-104) μm , length to width ratio 1.7 ± 0.2 (1.2-2.1). Two longitudinal grooves on the left side of the body: dorsal and ventral. Tail lobe triangular, tapered posteriorly, with rounded dorsal margin. Light skeletal plate with quite indistinct structure, consists of left and right sections. Slender vertebra-like linear skeleton tapered posteriorly, from the antero-dorsal caudalium to a middle part of body. Caudalia elongated, with short cylindrical lips. Macronucleus located between dorsal caudalia, its anterior end swollen and curved ventrally. Micronucleus at the anterior one-fifth of macronucleus. Four to six contractile vacuoles in a row.

Type host and locality: African elephant, *Loxodonta africana*, in Moscow zoo.

Type material: No. AE-3 deposited in the Zoological Institute, Kiev, Ukraine.

Etymology: *Triplumaria acuticaudata* is named after the shape of the tapered tail lobe.

Remarks: The species can be distinguished from above species by its light skeletal plates and vertebra-like skeletons and the presence of a triangular tail lobe and anteriorly swollen macronucleus.

Triplumaria ovina n.sp.

(Figs. 9, 24, 25)

Description: Body ovoid, with anterior end lowered ventrally. Body length 118.6 ± 20.8 (82-149) μm , width 65.2 ± 13.1 (42-88) μm , length to width ratio 1.8 ± 0.2 (1.5-2.1). Ventral and dorsal grooves on the left side of the body. Right dorsal groove also present. Tail lobe narrow, with rounded margin. Light skeletal plate without visible structure, consists of left and right sections. Linear skeleton quite indistinct. Antero-dorsal caudalium directed upward along the longitudinal

Fig. 21. *T. doliiformis*. Bar=20 μm . Fig. 22. *T. dvoinosi*. Bar=30 μm . Fig. 23. *T. acuticaudata*. Bar=20 μm . Fig. 24. *T. ovina*. Bar=20 μm . Fig. 25. SEM of *T. ovina*. Bar=20 μm . Fig. 26. *T. antis*. Bar=20 μm . Fig. 27. SEM of *T. antis*. Bar=10 μm . Fig. 28. *T. poljanskii*. Bar=20 μm . Fig. 29. SEM of *T. poljanskii*. Bar=20 μm .

NEW *TRIPLUMARIA* SPECIES OF ELEPHANTS

Table 1. Key to the genus *Triplumaria*

1	Micronucleus located near anterior part of macronucleus	2
	Micronucleus located near the middle of macronucleus or dorsally	11
2(1)	Large linear skeleton honeycomb-like structured; heavy skeletal plate	3
	Slender linear skeleton showing vertebra-like structure; light skeletal plate	7
3(2)	Posterior end of macronucleus prolonged below postero-dorsal caudalium	4
	Posterior end of macronucleus does not go below postero-dorsal caudalium	5
4(3)	Posterior end of macronucleus curved ventrally below the caudalium <i>longinucleata</i> Posterior end of macronucleus straight, prolonged into the tail lobe <i>nucleocaudata</i>	
5(3)	Caudalia same in shape and size	<i>selenica</i>
	Caudalia differ in shape and size	6
6(5)	Postero-dorsal caudalium cylindrical in shape, while the other two bulb-like <i>asiatica</i> Massive hill-like caudalia, postero-dorsal caudalium smaller in size than others <i>heterofasciculata</i>	
7(2)	All caudalia angled to the longitudinal axis of the body	8
	One or two caudalia along the longitudinal axis of the body	9
8(7)	Tail lobe tapered posteriorly; anterior end of macronucleus swelling; ventral and dorsal longitudinal grooves on the left side of the body	<i>acuticaudata</i>
	Tail lobe rounded posteriorly; anterior end of macronucleus with small hook; ventral groove in absence	<i>doliiformis</i>
9(7)	Antero-dorsal caudalium directed upward, ventral caudalium downward along longitudinal axis of the body	<i>dvoinosii</i>
	Only one caudalium directed along longitudinal axis of the body	10
10(9)	Antero-dorsal caudalium directed upward; macronucleus curved anteriorly; ventral and dorsal grooves on the left side of the body	<i>ovina</i>
	Ventral caudalium directed downward; macronucleus straight; ventral groove in absence	<i>irregularis</i>
11(1)	Micronucleus located posteriorly, on the two-thirds from anterior end of macronucleus; linear skeleton with vertebra-like structure; heavy skeletal plate <i>poljanskii</i> Micronucleus near to the middle of macronucleus	12
12(11)	Micronucleus located on the two-fifth from anterior end of macronucleus; vertebra-like linear skeleton slender and tapered posteriorly; light skeletal plate <i>antis</i> Micronucleus on the middle of macronucleus; linear skeleton rod-shaped with honeycomb-like structure; heavy skeletal plate	<i>hamertonii</i>

NEW *TRIPLUMARIA* SPECIES OF ELEPHANTS

axis of the body, while both posterior caudalia angled to it. Caudal lips cylindrical in shape, folded longitudinally. Rod-shaped macronucleus located between dorsal caudalia and slightly curved ventrally. Micronucleus located at the anterior one-third of macronucleus. Four to six contractile vacuoles in a row.

Type host and locality: Asian elephant, *Elephas maximus*, in Berlin Tierpark.

Type material: No. IE-22 deposited in the Zoological Institute, Kiev, Ukraine.

Etymology: *Triplumaria ovina* is named after the ovoid shape of the body.

Remarks: New species more closely resembles *T. dvoinosii* and *T. doliiformis* in shape of the body. However, the species differs from the latter in shape and direction of the caudalia, as well as shape of the macronucleus; and from the former species by the smaller size of the body, and direction of ventral caudalium.

Triplumaria antis n.sp.

(Figs. 10, 26, 27)

Description: Body rectangular. Body length 73.1 ± 7.5 (54-87) μm , width 29.0 ± 2.6 (24-33) μm , length to width ratio 2.0 ± 0.2 (1.6-2.5). Dorsal groove on the left side of the body. Tail lobe relatively short and flattened. Outer skeletal plate light and thin, with quite indistinct structure. Slender vertebra-like linear skeleton tapered posteriorly, from the anterior end to the posterior one-third of body. Caudalia with short cylindrical lips, usually folded transversally. Rod-shaped macronucleus straight, located between dorsal caudalia. Micronucleus near the middle of the macronucleus. Three to four contractile vacuoles in a row.

Type host and locality: Asian elephant, *Elephas maximus*, in Moscow zoo.

Type material: No. IE-4 deposited in the Zoological Institute, Kiev, Ukraine.

Etymology: *Triplumaria antis* is named after its graceful shape of the body.

Remarks: Compared to species with light skeletal plates and vertebra-like skeletons, the new species differs in its smaller and slender body, as well as the central location of macronucleus. This new species also resembles *T. hamertonii* in its body shape, but easily discriminated by the structure of both plate and skeleton, and smaller body size.

Triplumaria poljanskii n.sp.

(Figs. 11, 28, 29)

Description: Body rectangular. Body length 99.6 ± 10.3 (84-118) μm , width 40.6 ± 4.7 (30-51) μm , length to width ratio 2.5 ± 0.2 (2.2-3.1). One longitudinal groove left-dorsally. Rounded tail lobe broad dorso-ventrally and short. Skeletal plate heavy, honeycomb-like structured, especially thick on the dorsal side and at the anterior fifth of the ventral side of the body. Vertebra-like slender linear

NEW *TRIPLUMARIA* SPECIES OF ELEPHANTS

Table 2. Comparative characteristics of the species in the genus *Triplumaria*

Species	Length (L) x Width (W) µm	Mean L/W ratio	Skeletal plate	Linear Skeleton	Ventral groove	Shape and location of macronucleus	Micro- nucleus
<i>T. acuticaudata</i> n.sp.	82-173 x 42-104	1.7	light	vertebra-like	+	curved ventrally, between dorsal caudalia	anteriorly
<i>T. antis</i> n.sp.	54-87 x 24-33	2.5	light	vertebra-like	-	straight, between dorsal caudalia	middle
<i>T. asiatica</i> n.sp.	84-134 x 33-56	2.3	heavy	honeycomb- like	-	straight, between dorsal caudalia	anteriorly
<i>T. doliformis</i> n.sp.	91-159 x 48-95	1.7	light	vertebra-like	-	hooked anteriorly, between dorsal caudalia	anteriorly
<i>T. dvoinosi</i> n.sp.	160-243 x 91-138	1.8	light	vertebra-like	±	curved anteriorly, between dorsal caudalia	anteriorly
<i>T. hamertonii</i> Hoare, 1937	120-207 x 64-82*	2.3**	heavy	honeycomb- like	-	straight, between dorsal caudalia	middle
<i>T. heterofasciculata</i> n.sp.	131-249 x 60-126	2.1	heavy	honeycomb- like	-	straight, between dorsal caudalia	anteriorly
<i>T. irregularis</i> n.sp.	86-130 x 41-64	2.0	light	vertebra-like	-	straight, between dorsal caudalia	anteriorly
<i>T. longinucleata</i> n.sp.	72-122 x 30-49	2.5	heavy	honeycomb- like	-	curved ventrally below posterior caudalium	anteriorly
<i>T. ovina</i> n.sp.	82-149 x 42-88	1.8	light	indistinct	+	curved anteriorly, between dorsal caudalia	anteriorly
<i>T. nucleocaudata</i> n.sp.	135-220 x 71-131	1.9	heavy	honeycomb- like	-	straight, prolonged into the tail lobe	anteriorly
<i>T. poljanskii</i> n.sp.	84-118 x 30-51	2.5	heavy	vertebra-like	-	straight, between dorsal caudalia	posteriorly
<i>T. selenica</i> Latteur <i>et al.</i> , 1970	184-243 x 69-111	2.4	heavy	honeycomb- like	-	straight, between dorsal caudalia	anteriorly

*: From the original description.

** : Mean for minimum and maximum values.

NEW *TRIPLUMARIA* SPECIES OF ELEPHANTS

skeleton tapering posteriorly runs from the anterior end to the posterior one-fourth of body. Caudalia stretched from right to left, with short, rim-like lips. Straight rod-shaped macronucleus between dorsal caudalia. Micronucleus located near posterior one-third of macronucleus. Two to four contractile vacuoles in a row.

Type host and locality: Asian elephant, *Elephas maximus*, in Berlin Tierpark and Moscow zoo.

Type material: No. IE-4 deposited in the Zoological Institute, Kiev, Ukraine.

Etymology: *Triplumaria poljanskii* is named after Prof. G. I. Poljansky in recognition of his work on ciliatology.

Remarks: New species can be distinguished from the other species by the combination of honeycomb-like structured skeletal plate and vertebra-like linear skeleton, as well as in posterior location of micronucleus.

Comparative characteristics and criteria of the thirteen known species of the genus *Triplumaria* are shown in Tables 1 and 2.

DISCUSSION

No findings of triplumariid species from Asian elephants have been reported up to this time, whereas both *T. hamertonii* and *T. selenica* are known from African elephant (Eloff & van Hoven 1980; Latteur et al. 1970). In the present study, the former species was not detected in available specimens, but two and ten new species were found in African and Asian elephants, respectively.

Thirteen triplumariid species can be subdivided into two groups: with heavy thick and light thin skeletal plates. The heavy plates have polygonal honeycomb-like structures, whereas the lights show gentle alveolar or even quite indistinct structure. Usually, presence of the heavy plate coincides with the broad honeycomb-like structured linear skeleton, and slender vertebra-like skeleton combines with the light skeletal plate. The only exception to that is *T. poljanskii*, in respects of combination the heavy plate with vertebra-like skeleton. Six other heavy skeletal plate species, *T. hamertonii*, *T. selenica*, *T. heterofasciculata*, *T. asiatica*, *T. longinucleata* and *T. nucleocaudata*, show rectangular shape of the body; single longitudinal groove; large caudalia angled to the long axis of the body, and rod-shaped macronucleus. The most variable characteristics among them are the length and location of macronucleus, as well as size and shape of caudalia. Those characteristics do not vary in the light skeletal plate species, *T. irregularis*, *T. acuticaudata*, *T. ovina*, *T. dvoinosi*, *T. doliiformis* and *T. antis*. But they differ in shape of the bodies; number of longitudinal grooves and, in turn, number of skeletal plate sections; direction of caudalia and shape of macronuclei.

NEW *TRIPLUMARIA* SPECIES OF ELEPHANTS

Four monotype genera in the family Cycloposthiidae related to *Triplumaria* in possession of three caudalia have been reported up to the present: *Trifascicularia* Strelkow, 1931 from zebra, *Tripalmaria* Gassovsky, 1919 from horse, *Tricaudalia* Buisson, 1923 from Black rhino and *Rhabdothorax* Latteur et Bousez, 1970 from Asian elephant (Buisson 1923; Latteur & Bousez 1970; Strelkow 1939). The last two genera, together with *Triplumaria*, are similar to each other in respects of elongated macronucleus along the dorsal surface of the body, contractile vacuoles arranged in a row between dorsal caudalia along macronucleus and possession of inner linear skeleton in addition to an outer skeletal plate. If we suppose that the number of sections of skeletal plate, number of contractile vacuoles and direction of caudalia are unstable characteristics and are not usable to diagnose genera, *Tricaudalia*, *Rhabdothorax* and *Triplumaria* should be classified under the same genus. Thus, the genus would include *Tricaudalia brumptii* Buisson, 1923 with only skeletal plate on the right side of the body and *Rhabdothorax macrostegon* Latteur et Bousez, 1970, in addition to all described triplumariid species. Five skeletal structures of *R. macrostegon* we consider to include linear skeleton right-dorsally, close to the macronucleus, and skeletal plate consisting of four sections: the left-dorsal, left, ventral and right stripes.

The presence of abundant triplumariid species with appearance of *Rhabdothorax* in elephant large intestine may suggest that genus *Triplumaria* originated in that habitat. *Triplumaria hamertonii*, which has been described from both elephants and rhinoceroses, should be confirmed, whether individuals obtained from respective hosts are properly the same species or not.

ACKNOWLEDGMENTS

The authors are greatly indebted to Dr. G. Dvoinos of the Institute of Zoology, Kiev for his helpful suggestion on the research. We also thank keepers in Kiev, Moscow and Berlin zoos, and Prof. K. Odening and Dr. W. Grummt for arrangement of sampling. The research was conducted under the financial support by the International Science Foundation.

REFERENCES

- Buisson, J. 1923. Sur quelques infusoires nouveaux ou peu connus parasites des mammifères. *Ann. Parasitol.* 1: 209-246.
- Eloff, A. & van Hoven, W. 1980. Intestinal Protozoa of the African elephant *Loxodonta africana* (Blumenbach). *S. Afr. J. Zool.* 15: 83-89.
- Gassovsky, G. 1919. On the microfauna of the intestine of the horse. *Trav. Sec. Nat. Petrograd* 49: 20-37, 65-69 (In Russian with English summary).

NEW *TRIPLUMARIA* SPECIES OF ELEPHANTS

- Hoare, C. A. 1937. A new cycloposthiid ciliate (*Triplumaria hamertonii* gen. n., sp. n.) parasitic in Indian rhinoceros. *Parasitology*. 29: 559-569.
- Hsiung, T.-S. 1930. A monograph on the protozoa of the large intestine of the horse. *Iowa State Coll. J. Sci.* 4: 359-423.
- Kofoed, C. A. 1935. On two remarkable ciliate protozoa from the caecum of Indian elephant. *Proc. Nat. Acad. Sci. USA*. 21: 501-506.
- Lateur, B. 1958. Les ciliates Polydiniinae *Thoracodinium vorax* n.gen., n.sp. *Cellule* 59: 271-296.
- Lateur, B. 1966. *Thoracodinium vorax* ciliate du caecum de l'elephant des Indes. *Acta Zool. Pathol. Antverp.* 41: 83-102.
- Lateur, B. 1967. *Helicozoster indicus* n. gen., n. sp. ciliate holotriche du caecum de l'elephant des Indes. *Acta Zool. Pathol. Antverp.* 43: 93-103.
- Lateur, B. & Bousez, M. P. 1970. *Rhabdothorax macrostegon* n. gen., n. sp. cilie cycloposthiide du colon de l'elephant d'Asie. *Ann. Soc. R. Zool. Belg.* 99: 193-214.
- Lateur, B., Tuffray, M. & Wespes, G. 1970. *Triplumaria selenica* n. sp. cilie spirotriche du colon de l'elephant d'Afrique. *Protistologica*. 6: 319-327.
- Mandal, D. & Choudhury, A. 1983. On two new cycloposthiid ciliates from Indian elephant *Elephas maximus* L. *J. Bengal. Natur. Hist. Soc.* 2: 13-18.
- Ogimoto, K. & Imai, S. 1981. Atlas of Rumen Microbiology. Japan Scientific Society Press, Tokyo.
- Small, E. B. & Lynn, D. H. 1985. Phylum Ciliophora Doflein, 1901. In: An Illustrated Guide to the Protozoa. Society of Protozoologists, Kansas, 393-575.
- Strelkow, A. 1939. Parasitological infusoria from the intestine of Ungulata belonging to the family Equidae. *Uchen. Zap., Leningrad Pedagog. Inst. Gert.* 17: 1-262 (in Russian with English summary).
- Van Hoven, W., Gilchrist, F. M. C. & Hamilton-Atwell, V. L. 1987. Intestinal ciliated protozoa of African rhinoceros: two new genera and five new species from the white rhino, *Ceratotherium simum* (Burchell, 1817). *J. Protozool.* 34: 338-342.
- Wolska, M. 1967. Study on the family Blepharocorythidae Hsiung. III. *Raabena bella* gen. n., sp. n. from the intestine of the Indian elephant. *Acta Protozool.* 4: 284-290.
- Wolska, M. 1968. Study on the family Blepharocorythidae Hsiung. IV. *Pararaabena dentata* gen. n., sp. n. from the intestine of the Indian elephant. *Acta Protozool.* 5: 219-224.
- Wolska, M. 1970. *Spirocorys indicus* a ciliate from the intestine of the Indian elephant, its systematic position. *Acta Protozool.* 8: 143-147.
- Wolska, M. 1986. *Pseudoentodinium elephantis* gen. n., sp. n. from the order

NEW *TRIPLUMARIA* SPECIES OF ELEPHANTS

Entodiniomorhida. proposition of the new family Pseudoentodiniidae. *Acta Protozool.* 25: 139-146.