Systematic Parasitology **28**: 187–196, 1994.

Five new species of Trichostomatida (ciliated protozoa) from the colon of wild African rhinoceroses

F.M.C. Gilchrist[1], W. van Hoven[1] and M.O. Stenson[2]
[1]*Centre for Wildlife Research, University of Pretoria, Pretoria 0002, South Africa*
[2]*Helminthology Section, Onderstepoort Veterinary Institute, Onderstepoort, 0110, South Africa*

Accepted for publication 5th February, 1993

Abstract

Five new species of *Charonina* Strand, 1928 were revealed, in addition to 41 species of 20 other apparent genera, in a survey of ciliated intestinal protozoan endocommensals of both black and white wild African rhinoceroses. *Charonina* species infected the ventral and dorsal region of the ascending colon, where the average total protozoan populations ($\times 10^3$/ml digesta fluid) were 100 and 80, respectively, in the white and 270 and 260, respectively, in the black rhinoceroses. *Charonina* species constituted up to 50% in the ventral and 25% in the dorsal populations. Measurements in micrometres and specific characteristics of the five species are: *C. odontophora* n. sp. length 70 ± 5.7, width 32 ± 7.2, dorso-ventral thickness 7 ± 1.1, slender ovate-lanceolate-shaped body with frontal lobe and prong-like protrusion in oral-opening; *C. tortuosa* n. sp. length 87 ± 9.3, width 42 ± 5.3, dorso-ventral thickness 15 ± 2.7, body-shape ovate-lanceolate without frontal lobe, oral-opening with longitudinal ridge, cytopharyngeal canal with sharp bend after emerging from oral-opening; *C. dicerotis* n. sp. length 67 ± 8.6, width 37 ± 4.0, dorso-ventral thickness 12 ± 2.2, body-shape ovate-lanceolate without frontal lobe, oral-opening without ridge, cytopharyngeal canal curved without sharp bend; *C. tenuis* n. sp. length 56 ± 10.0, width 16 ± 4.1 at anterior end and 10 ± 2.7 at posterior end, dorso-ventral thickness 7 ± 1.2 at anterior end and 5 ± 1.1 at posterior end, body-shape cone-like with longitudinal striations and frontal lobe; *C. tetragona* n. sp. length 58 ± 4.7, width 26 ± 3.2, dorso-ventral thickness 12 ± 1.8, body-shape rectangular with frontal lobe and caudal flaps. The length, width and dorso-ventral thickness of the five species are on average in the approximate ratio of 6:3:1, thus showing them to be dorso-ventrally compressed. The body conformation of *C. tetragona* n. sp. closely resembles that of *Didesmis quadrata* Fiorentini, 1980, but is distinguished from the latter by the absence of a concrement vacuole and the presence of an elongate cytopharyngeal canal.

Introduction

A new protozoan of the family Blepharocorythidae was described by Jameson (1925) under the name *Charon ventriculi* from the rumen of cattle and sheep. Dogiel (1926) described a similar protozoan under the name of *Blepharocorys bovis* from the rumen of cattle. Strand (1928) changed the name *Charon*, as a *nomen praeoccupatum*, to *Charonina*. Strelkow (1939) transferred *Charonina ventriculi* to the genus *Blepharocorys* on the grounds that the two posterior ciliary tufts were only a secondary partition of the single tuft characteristic of *Blepharocorys* spp. Wolska (1967) used silver impregnation to show that the two posterior tufts of *Charonina* were indeed formed independently of each other, and that only one ciliary zone occupied the mouth-opening and

cytopharyngeal canal in *Charonina*, instead of two zones as in *Bleparocorys* spp. On this basis she confirmed the name *Charonina ventriculi* Strand, 1928.

The early naming of *Charonina* species also went through a period of systematic changes: *Charon equi* Hsiung, 1930 with three anterior ciliary tufts from the large intestine of horses (Hsiung, 1930) and rumen of cattle (Clarke, 1964) was transferred to *Charonnotes* by Strelkow (1939), who also removed from the family Blepharocorythidae *Charon nuda* Hsiung, 1932, a species lacking caudal cilia and from the rumen of Chinese cattle. Thereafter the name *Charonina* Strand, 1928 (syn. *Charon* Jameson, 1925) became established; *C. hippotami* Thurston & Grain, 1971 from the stomach of the hippopotamus was subsequently added to the genus.

To date 18 species of ciliated protozoa belonging to different families and genera have been identified systematically in the rhinoceros hindgut and faeces by Buisson (1923), Hoare (1937) and van Hoven, Gilchrist & Hamilton-Atwell (1987, 1988). Anaerobic fungi have been isolated from the faeces of black and Indian rhinoceroses (Teunissen *et al.*, 1991). Flagellates and an enormous population of anaerobic bacteria are known to occur in the hindgut and faeces of rhinoceroses, as is usual in the gut of herbivorous mammals (Dehority, 1986). The five new species of *Charonina* presented in this report, together with eleven other new species and 18 known species yet to be identified, increase the number of species of ciliated protozoa recovered from the hindgut and faeces of rhinoceroses from six (Dehority, 1986) to forty-six.

Hunting of rhinoceroses is rigorously controlled by South African conservation authorities. Hunting of black rhinoceroses has been prohibited since 1975. A very limited number of white rhinoceroses become available annually at an excessively high cost. Thus the acquisition of intestinal protozoan specimens depends on the goodwill of legal hunters active in far-flung terrain, which precludes use of sophisticated apparatus for immediate study of live specimens. Thus the descriptions presented here appertain to preserved specimens obtained from four wild African rhinoceroses.

Materials and methods

Gastro-intestinal tracts were excised while the carcasses were still warm, between one and two hours after each of the four rhinoceroses were shot. Sets of six samples from the stomach, small intestine, caecum, right ventral ascending colon, right dorsal ascending colon and descending colon were collected. A slit was made in the wall of the gastro-intestinal tract at the sampling point, and the digesta mixed by hand. Using a beaker, digesta was bailed out and strained through a 4 mm mesh wire sieve. The strained fluid containing the protozoa was collected. For light microscopy, 25 ml of fluid was added immediately to 25 ml of formalin (14% aq.). Clumping of the protozoa was obviated by shaking vigorously for 30 sec on addition of the preservative.

On reaching the laboratory, formalinized samples were diluted with mineral solutlon (Bryant & Burkey, 1953) and finally with equal parts of glycerine as a stabilising agent (Van Hoven, 1983). Total counts were made at ×90 magnification with a 0.50 mm Nageotte counting chamber (W. Schreck, Hofheim, Germany). The different ciliate species, in wet unstained, permanently sealed slide preparations, were counted at ×400 magnification and converted to a percentage of the total, which was in excess of 200 individuals per host (Van Hoven *et al.*, 1987). Detailed anatomy was studied at ×1,000 magnification using an oil immersion objective. Light microphotography was carried out with either an Olympus BH2 microscope with a PM-10AD photomicrographic system or a Reichert Polyvar photomicroscope, each provided with Nomarski-type equipment for differential interference contrast. An AGFA PAN 25 ASA film was employed in order to obtain clear image enlargements.

Since intestinal ciliated protozoa are strictly anaerobic and active only at about 39°C, specimens had to be preserved at the site of the kill with instantaneous-acting fixatives incompatible with

techniques for study of subpellicular systems. Thus the descriptions presented here exclude subpellicular ciliary morphology.

Size was measured in micrometres. Lubinsky's terminology (1957, 1958) was used for the description and orientation of the species.

Results

No protozoa were found in the stomach or small intestine of either white or black rhinoceroses examined. The average total protozoan numbers $\times 10^3$/ml digesta fluid in the caecum, ventral and dorsal ascending colon, and distal colon were 180, 100, 80 and 0 (smears negative), respectively, in the white rhinoceros, and 360, 270, 260 and 30, respectively, in the black rhinoceros. The greater number in the black rhinoceros is most likely a reflection of the more nutritious and plentiful diet of "spekboom" *Portulacaria afra* found in the stomach.

A preliminary survey in the hindgut of the rhinoceroses revealed bacteria, fungal sporangia, flagellates and 46 ciliated protozoan species, 28 of which were new species. Table I summarises the orders and apparent genera to which the species belong. Of the new species listed: Van Hoven, Gilchrist & Hamilton-Atwell (1987) created two new genera, *Arachnodinium* and *Phalodinium* for two species, and added three species to *Monoposthium* Thurston & Noirot-Timothée, 1973; van Hoven *et al.* (1988) created a new family, Rhinozetidae, and a new genus, *Rhinozeta*, for seven species; the present publication deals with five species belonging to *Charonina* Strand, 1928; and work is in progress to characterise and classify the remaining eleven.

Genus *Charonina* Strand, 1928

Amended diagnosis

Blepharocorythidae Hsiung, 1929. Body asymmetrical, dorso-ventrally compressed. Prominent frontal lobe may be present. Irregular-shaped oral opening in anterior part of body, narrowing to become prominent deeply penetrating cytopharyngeal canal. Oral ciliature composed of one ciliary zone covering both oral-opening and cytopharyngeal canal. Somatic ciliature reduced to two anterior and two posterior tufts. Position and shape of macronucleus variable. Position of oval micronucleus variable. One or more contractile vacuoles, with central pore to body surface, usually situated in posterior half of body. Cytopyge posteriorly terminal. Intestinal inhabitants of ruminants, hippopotami and rhinoceroses.
Type-species: *Charonina ventriculi* Jameson, 1925.

The above-mentioned characteristics constitute the major features used to place the isolates into the genus *Charonina*.

Charonina dicerotis n. sp. (Figs 1, 6, 7)

Description ($n = 34$)

Body ovate-lanceolate without frontal lobe (Figs 1, 6); length 67 ± 8.6; width 37 ± 4.0; dorso-ventral thickness 12 ± 2.2. Oral opening funnel-shaped, approx. 14 wide (Fig. 6A), at anterior end of body leading to cytopharyngeal canal. Preserved specimens with granular endoplasm confined to central column over length of body (Fig. 6B), bordered by clear ectoplasm (Fig. 6C,D). Usual oral ciliature present. Anterior somatic ciliary tufts on either side of posterior end of body. Contractile vacuoles occur in anterior half of body. Elongate macronucleus 32(28–38), along right side of cytopharyngeal canal and oral-opening. Micronucleus in depression on right side of macronucleus. Multiplication by binary division (Fig. 7).

Type-host: Diceros bicornis (Linnaeus, 1758), black rhinoceros. Other hosts unknown.
Type-locality: Addo Elephant National Park, eastern Cape Province, South Africa (33°–34°S; 25°–26°E).
Site of infection: Dorsal ascending colon.
Prevalence: 1×10^4/ml digesta fluid.

Table I. Preliminary survey of orders, apparent genera and number of species of ciliated protozoa in the colon of free-living white and/or black African rinoceroses.

Orders	Genera	No. of species Known	New
Entodiniomorphida Reichenow, 1929	*Arachnodinium* Van Hoven, Gilchrist & Hamilton Atwell, 1987		1
	Cycloposthium Bundle, 1895	1	1
	Diplolophus Hollande & Batisse, 1959	1	1
	Endoralium Eloff & van Hoven, 1980	1	
	Lavierella Buisson, 1923	1	
	Monoposthium Thurston & Noirot-Timothée, 1973		4
	Phalodinium Van Hoven, Gilchrist & Hamilton-Atwell, 1987		1
	Proptotapirella da Cunha, 1919		1
	Rhinozeta Van Hoven, Gilchrist & Hamilton-Atwell, 1988		7
	Telamodinium Latteur & Dufey, 1967		1
	Triadinium Fiorentini, 1890	2	
	Triplumaria Hoare, 1937	1	
Trichostomatida Bütshcli, 1889	*Charonina* Strand, 1928		5
	Paraisotricha Fiorentini, 1890	2	2
Prostomatida Schewiakoff, 1896	*Alloiozona* Hsiung, 1930	1	
	Blepharoconus Gassovsky, 1919	1	1
	Blepharospaera Bundle, 1895	2	1
	Didesmis Fiorentini, 1890		1
	Holophryoides Gassovsky, 1919	1	
	Polymorphella Corliss, 1960	1	
Suchtorida Claparède & Lachmann, 1858	*Allantosoma* Gassovsky, 1919	3	1
	Totals	18	28

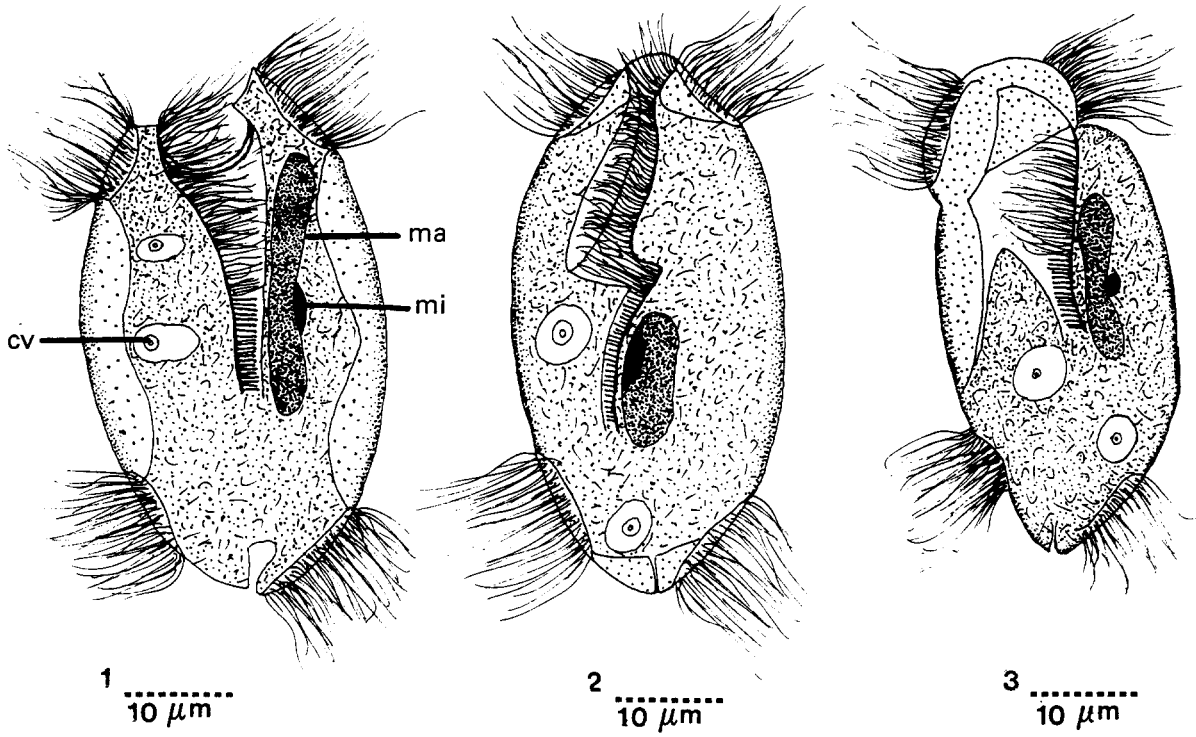
Etymology: Specific name refers to genitive of generic name of host.
Type-material: Accession No. 2240485 deposited in Intestinal Protozoa Collection of Centre for Wildlife Research, University of Pretoria, Pretoria 0002, South Africa.

***Charonina tortuosa* n. sp.** (Figs 2, 8–11)

Description ($n = 33$)

Body slender ovate-lanceolate without frontal lobe (Figs 2, 8); length 87 ± 9.3; width 42 ± 5.3; dorso ventral thickness 15 ± 2. 7. Oral opening oblong (14 wide, 25 long) with longitudinal ridge (Fig. 9), at anterior end of body. Narrow cytopharyngeal canal connects with right side of posterior end of oral opening and veers first right then sharply left before curving right again (Fig. 10A). Oral cilia present (Fig. 10B) [their flexibility in the oral opening (Fig. 10C) is demonstrated by the wave-like position in which they become arrested above the ridge in the oral opening on exposure to formalin]. Anterior somatic ciliary tufts on either side of anterior tip of body; posterior tufts on either side of posterior end of body (Fig. 11). One or more contractile vacuoles in posterior half of body. Elongate macronucleus (19–31) on right side of cytopharyngeal canal Micronucleus in depression in macronucleus in no fixed position.

Type-host: Diceros bicornis (Linnaeus, 1758), black rhinoceros. Other hosts unknown.
Type-locality: Addo Elephant National Park, eastern Cape Province, South Africa (33°–34°S; 25°–26°E).
Site of infection: Dorsal ascending colon.
Prevalence: 1×10^4/ml digesta fluid.
Etymology: Specific name refers to sharp bend in cytopharyngeal canal.
Type-material: Accession No. 2240485 deposited in Intestinal Protozoa Collection of Centre for Wildlife Research, University of Pretoria, Pretoria 0002, South Africa.



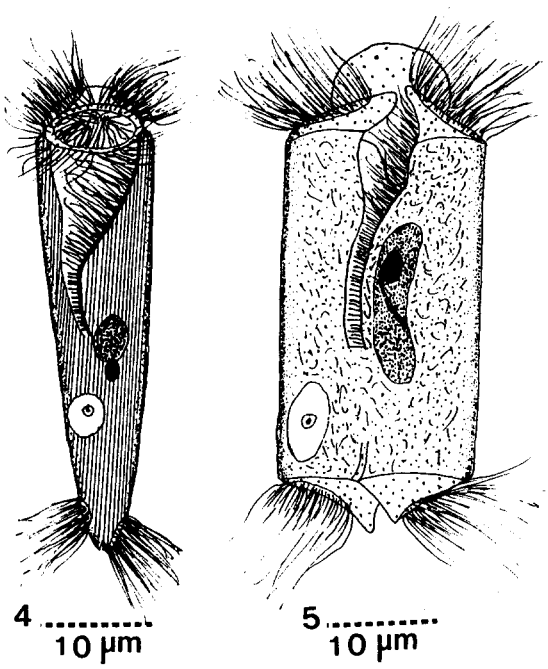
Figs 1–3. 1. *Charonina dicerotis* n. sp. 2. *C. tortuosa* n. sp. 3. *C. odontophora* n. sp. *Abbreviations:* cv, contractile vacuole; ma, macronucleus; mi, micronucleus.

***Charonina odontophora* n. sp.** (Figs 3, 12)

Description (n = 34)

Body slender ovate-lanceolate, with frontal lobe and marked indentation on left side, one quarter body-length from posterior end (Figs 3, 12); length 70 ± 5.7; width 32 ± 7.2; dorso-ventral thickness 7 + 1.1. Rectangular oral opening (15 wide, 42 long) at anterior end of body. Prominent prong-like structure (Fig. 12A) protrudes anteriorly into oral opening from middle region of body at one-third the distance from posterior end, thus forming left side of cytopharyngeal canal. Thin ectoplasmic membrane covers last 7–12 of anterior end of oral-opening as well as frontal lobe and extends posteriorly halfway down left side of body. Oral ciliature shown in cytopharyngeal canal (Fig. 12B) and oral opening (Fig. 12C). Anterior somatic ciliary tufts on left dorsal and right ventral side at base of frontal lobe; posterior ciliary tufts on ventral side of body at level of body indentation, and on right dorsal side of posterior end of body. One or 2 contractile vacuoles in posterior half of body. Elongate macronucleus (12–21) along right side of cytopharyngeal canal at level of prong-like structure. Micronucleus in depression on right side of macronucleus.

Type-host: Ceratotherium simum (Burchell, 1817), white rhinoceros. Other hosts unknown.
Type-locality: Ellisras district, Transvaal, South Africa (23°–24°S; 27°–28°E).
Other locality: Pilanesberg Game Reserve, Bophuthatswana, South Africa (25°–26°S; 27°–28°E).
Site of infection: Dorsal and ventral ascending colon.
Prevalence: 1×10^4/ml of digesta fluid.
Etymology: Specific name refers to prong-like structure projecting into oral-opening.
Type material: Accession Nos 3010585 (Ellisras)



Figs 4–5. 4. *Charonina tenuis* n. sp. 5. *C. tetragona* n. sp.

and 4220585 (Pilanesberg) deposited in Intestinal Protozoa Collection of Centre for Wildlife Research, University of Pretoria, Pretoria 0002, South Africa.

***Charonina tenuis* n. sp.** (Figs 4, 13, 14)

Description ($n = 30$)

Body cone-shaped dorso-ventrally compressed with frontal lobe (Figs 4, 13); length 56 ± 10.0; width at anterior end 16 ± 4.1, at posterior end 10 ± 2.7; dorso-ventral thickness at anterior end 7 ± 1. 2, at posterior end 5 ± 1.1. Widest part of body at level of oral opening in anterior part of body, tapering to narrow rounded posterior end (Fig. 13). Body surface with fine, longitudinal striations (Fig. 14). Funnel-shaped oral opening (6 wide, 9 long). Oral ciliature includes cilia on both inner edge and outer edges of lip surrounding oral opening. Those on inner edge upwardly directed and also inwardly directed toward centre of opening. Those on outer edge directed away from body. Anterior somatic ciliary tufts on either side of base of frontal lobe joined by cilia from outer edge of lip of oral opening and distinguished only by compactness; posterior tufts on either side of posterior end of body. One or 2 contractile vacuoles in posterior half of body. Oval macronucleus (length 9, diameter 6) near end of cytopharyngeal canal. Micronucleus either in depression in macronucleus in no fixed position, or short distance from it.

Type-host: Ceratotherium simum (Burchell, 1817), white rhinoceros. Other hosts unknown.
Type-locality: Ellisras district, Transvaal, South Africa (23°–24°S; 27°–28°E).
Site of infection: Dorsal and ventral ascending colon.
Prevalence: Digesta fluid of: dorsal colon 2×10^4/ml; ventral colon 1×10^4/ml.
Etymology: Specific name refers to slender body.
Type-material: Accession No. 3010585 deposited in Intestinal Protozoa Collection of Centre for Wildlife Research, University of Pretoria, Pretoria 0002, South Africa.

***Charonina tetragona* n. sp.** (Figs 5, 15–18)

Description ($n = 30$)

Body rectangular with frontal lobe and 2 caudal flaps (Figs 5, 15); length 58 ± 4.7; width 26 ± 3.2; dorso-ventral thickness 12 ± 1.8. Funnel-shaped oral opening approximately 10 wide at base of frontal lobe (Figs 15A, 17A) between 2 ectoplasmic lips (Figs 15B,C, 17B,C) leads into cytopharyngeal canal (Fig. 16). Usual oral ciliature. Anterior somatic ciliary tufts appear to rise from ectoplasmic lips on either side of oral opening; posterior ciliary tufts on either side of caudal flaps. Prominent twisted macronucleus (length 16–28) on right side of cytopharyngeal canal. Micronucleus in depression in neighbourhood of twist of macronucleus.

Type-host: Diceros bicornis (Lunnaeus, 1758), black rhinoceros. Other hosts unknown.
Type-locality: Addo Elephant National Park, eastern Cape Province, South Africa (33°–34°S; 25°–26°E).
Site of infection: Dorsal and ventral ascending colon.
Prevalence: Digesta fluid of: dorsal colon 2×10^4/ml; ventral colon 1×10^4/ml.
Etymology: Specific name refers to rectangular body-shape.
Type-material: Accession No. 2240485 deposited in Intestinal Protozoa Collection of Centre for Wildlife Research, University of Pretoria, Pretoria 0002, South Africa.

Key to species of *Charonina*

The following key is based on consistent specific characteristics of existing *Charonina* species: body-shape; presence or absence of frontal lobe; peculiarities of oral-opening; and shape of cytopharyngeal canal.

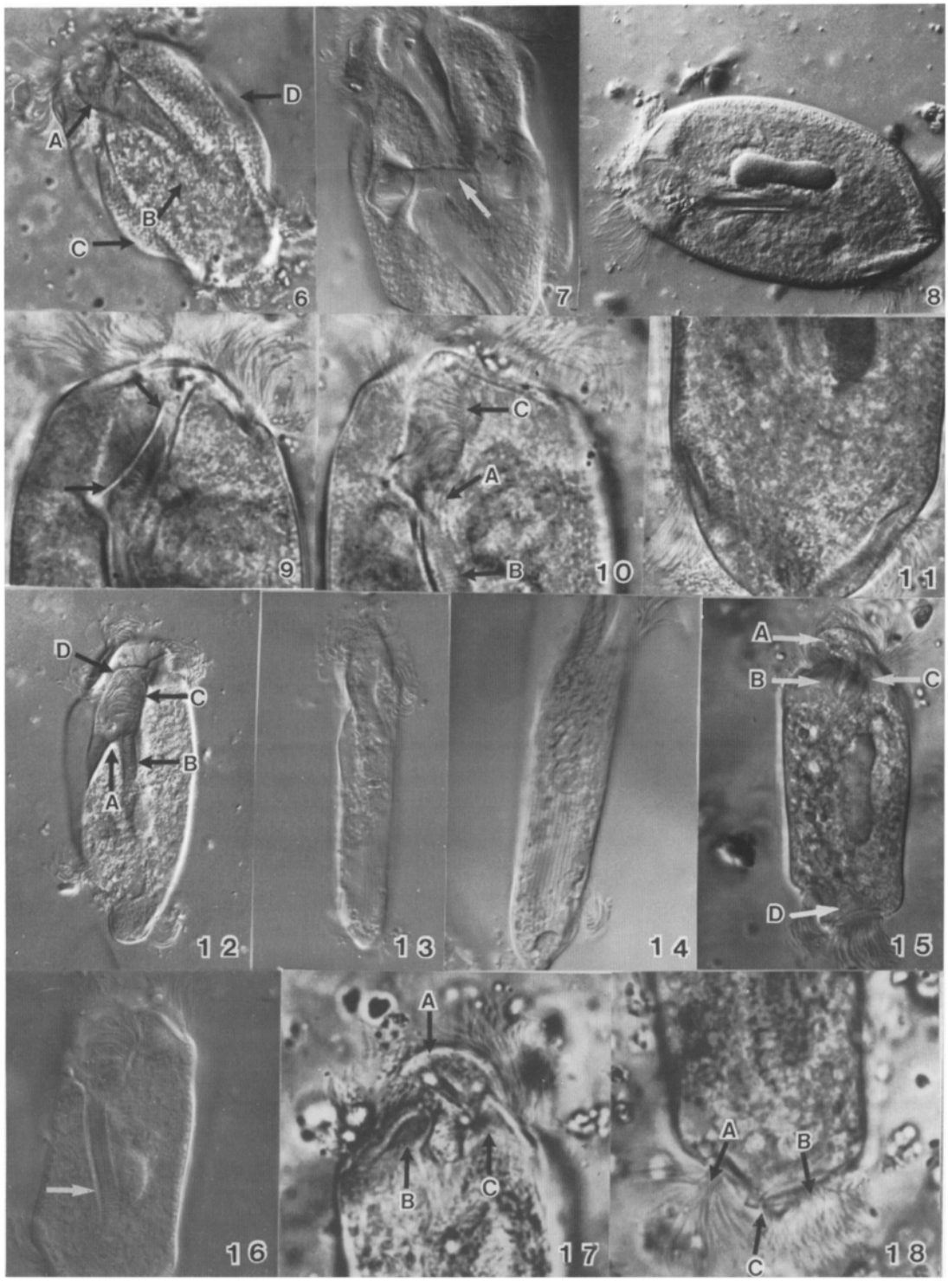
1 Body-shape ovate-lanceolate 2
– Body-shape not ovate-lanceolate 6
2 Frontal lobe present 3
– Frontal lobe absent 5
3 Prong-like protrusion in oral opening ..... *C. odontophora* n. sp.
– No prong-like protrusion in oral opening ... 4
4 Oral opening apical ..... *C. ventriculi* (Jameson, 1925)
– Oral opening lateral ..... *C. hippopotami* Thurston & Grain, 1971
5 Cytopharyngeal canal with bend; oral opening with longitudinal ridge ..... *C. tortuosa* n.sp.
– Cytopharyngeal canal without bend; oral opening without ridge ..... *C. dicerotis* n. sp.
6 Body-shape conical with longitudinal striations ..... *C. tenuis* n. sp.
– Body-shape rectangular with caudal flaps and no striations ..... *C. tetragona* n. sp.

Discussion

Body measurements of the length, width and dorso-ventral thickness of the five newly described species of the genus *Charonina* are on average in the approximate ratio of 6:3:1, thus showing them to be unequivably dorso-ventrally compressed. This is in line with the original description of the genus, as *Charon* and the type-species, *C. ventriculi*, by Jameson (1925), who gave similar measurements and stated that this protozoon was very much dorso-ventrally compressed. This was confirmed in the diagnosis of the genus by Hsiung (1930), who stated that the body was not bi-laterally flattened, which is a contradiction to the statement by Wolska (1971) that the genus *Charonina* is characterised by a laterally flattened body. Although the direction of the flattening of the body has proven to be an important distinguishing feature in the family, it was unfortunately not taken into account by Corliss (1979) in his diagnoses of the genera.

The average length, width and dorso-ventral thickness of the five new *Charonina* species is 68, 39 and 11 respectively, and thus greater than that 30, 14 and 3 respectively of the type-species *C. ventriculi* measured by Jameson (1925). Each of the new species exhibits one or more characteristics, which taken singly or together make it unique. *C. dicerotis* n. sp. lacks a frontal lobe; *C. tortuosa* n. sp. not only lacks a frontal lobe, but also has a longitudinal ridge in the oral opening and a sharp bend in the cytopharyngeal canal; *C. odontophora* n. sp. has a frontal lobe and a prominent prong-like structure protruding anteriorly into the oral opening from the middle region of the body; conical and rectangular the body-shapes of *C. tenuis* n. sp. and *C. tetragona* n. sp., respectively, make them immediately recognisable from each other and from the ovate-lanceolate body-shapes of the other species.

Charonina hippopotami was described by Thurston & Grain (1971) from the stomach of *Hippopotamus amphibius* (Linnaeus, 1758). It differs conspicuously from *C. ventriculi* and the five new species described here in having the oral opening


A
B
C
D
6
7
8
9
10
11
12
13
14
15
16
17
18

on the left antero-lateral side in contrast to its apical position in the latter six species.

The body conformation of *C. tetragona* n. sp. closely resembles that of *Didesmis quadrata* Fiorentini, 1980, but is distinguished from the latter by the absence of a concrement vacuole and the presence of a prominent deeply penetrating cytopharyngeal canal. This provides further evidence in support of the observation of Thurston & Grain (1971), gained from the study of the infraciliature of *C. hippopotami*, that the Blepharocorythidae (Trichostomatida) have some resemblance to certain members of the Buetschliidae (Gymnostomatida), such as *Didesmis*.

Acknowledgements

Thanks are due to Dr J.H. Oosthuizen, Department of Zoology, University of Pretoria, for his constructive criticism of the draft manuscript.

References

Bryant, M.P. & Burkey, L.A. (1953) Cultural methods and some characteristics of some of the more numerous groups of bacteria in the bovine rumen. *Journal of Dairy Science*, **36**, 205–217.

Buisson, J. (1923) Sur quelques infusoires nouveaux ou peu connus parasites des mammifères. *Annales de Parasitologie Humaine et Comparée*, **1**, 209–246.

Clarke, R.T.J. (1964) Ciliates of the rumen of domestic cattle (*Bos taurus* L.). *New Zealand Journal of Agriculture Research*, **7**, 248–257.

Dehority, B.A. (1986) Protozoa of the digestive tract of herbivorous mammals. *Insect Science Application*, **7**, 279–296.

Dogiel, V.A. (1926) Une nouvelle espèce du genre *Blepharocorys*. *B. bovis* n. sp. habitant l'estomac du boeuf. *Annales de Parasitologie Humaine et Comparée*, **4**, 61–64.

Hoare, C.A. (1937) A new cycloposthiid ciliate (*Triplumaria hamertoni* gen.n., sp.n.) parasitic in the Indian rhinoceros. *Parasitology*, **29**, 559–569.

Hsiung, T.S. (1930) A monograph on the protozoan fauna of the large intestine of the horse. *Iowa State College Journal of Science*, **4**, 359–405.

Jameson, A.P. (1925) A new ciliate, *Charon ventriculi* n.g., n.sp., from the stomach of ruminants. *Parasitology*, **17**, 403–405.

Lubinsky, G. (1957) Studies on the evolution of the Ophryoscolecidae (Ciliata: Oligotricha). II. On the origin of the higher Ophryoscolecidae. *Canadian Journal of Zoology*, **35**, 135–140.

Lubinsky, G. (1958) Ophryoscolecidae (Ciliata: Entodiniomorphida) of reindeer (*Rangifer tarandus* L.) from the Canadian Arctic. I. Entodiniinae. *Canadian Journal of Zoology*, **36**, 819–835.

Strand, E. (1928) Miscellanea nomenclatorica zoologica et paleanontologica. *Charonina*. I–II. *Archiv für Naturgeschichte*, **92**(A8)(1926), 30–75.

Strelkow, A. (1939) Parasitic infusoria from the intestine of Ungulata belonging to the family Equidae. *Uchenye Zapiski Leningradskii Gosudarstvennyi Pedagogicheskii Institut Gercena* **17**, 1–262.

Teunissen, M.T., Op-den-Camp, H.J.M., Orpin, C.G., Huis-in-t'Veld, J.H.J. & Vogels, G.D. (1991) Comparison of growth characteristics of anaerobic fungi isolated from ruminant and non-ruminant herbivores during cultivation in a defined medium. *Journal of General Microbiology*, **137**, 1401–1408.

Thurston, J.P. & Grain, J. (1971) Holotrich ciliates from the stomach of *Hippopotamus amphibius* with description of two new genera and four new species. *Journal of Protozoology*, **8**, 133–141.

Van Hoven, W. (1983) Rumen ciliates with description of two new species from three African reedbuck species. *Journal of Protozoology*, **30**, 688–691.

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). *Journal of Protozoology*, **34**, 338–342.

Van Hoven, W., Gilchrist, F.M.C. & Hamilton-Atwell, V.L. (1988) A new family, genus and seven new species of Entodi-

Figs 6–18. Light micrographs (differential interference contrast). 6. *Charonina dicerotis* n. sp., upper view, arrows A on cilia borne on left wall of oral opening and cytopharyngeal canal, B on central granular endoplasmic column, C&D on clear ectoplasmic border. 7. *C. dicerotis* n. sp., dividing cell, arrow on line of division. 8. *C. tortuosa* n. sp., upper view. 9. *C. tortuosa* n. sp., anterior view, arrows on central ridge in oral-opening. 10. *C. tortuosa* n. sp., anterior half of body, arrows A on bend in cytopharyngeal canal, B on short stout cilia in canal, C on long thin pliable cilia in oral-opening. 11. *C. tortuosa* n. sp., posterior view showing two ciliary tufts. 12. *C. odontophora* n. sp., upper view arrows A on prong-like structure, B on short stout cilia in cytopharyngeal canal, C on long thin pliable cilia borne on right wall of oral opening, D on ectoplasmic membrane. 13. *C. tenuis* n. sp. upper view. 14. *C. tenuis* n. sp., longitudinal surface striations. 15. *C. tetragona* n. sp., upper view, arrows A on frontal lobe, B&C on ectoplasmic lips, D on two anal ciliary tufts. 16. *C. tetragona* n. sp., anterior view, elongate cytopharyngeal canal. 17. *C. tetragona* n. sp., anterior view, arrows A on frontal lobe, B&C on ectoplasmic lips. 18. *C. tetragona* n. sp., posterior view, arrows A&B on two anal ciliary tufts, C on caudal flaps.

niomorphida (protozoa) from the gut of African Rhinoceros. *Journal of Protozoology*, **35**, 92–97.

Wolska, M. (1967) Study on the family Blepharocorythidae Hsiung. II. *Charonina ventriculi* (Jameson). *Acta Protozoologica*, **4**, 279–283.

Wolska, M. (1971) Studies on the family Blepharocorythidae Hsiung, 1929. VI. Phylogenesis of the family, and the description of the new genus *Circodinium* gen. n. with the species *C. minimum* (Grassovsky 1918). *Acta Protozoologica*, **9**, 171–194.