

## THREE NEW SPECIES OF THE GENUS *OSWALDOCRUZIA* TRAVASSOS, 1917 (NEMATODA, TRICHOSTRONGYLINA, MOLINEOIDEA) PARASITES OF *ENYALIUS* SPP. (IGUANIDAE) FROM BRAZIL

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### Summary:

Three new species of the genus *Oswaldocruzia* Travassos, 1917 belonging to the sub-family Molineinae are described from the stomach and/or the small intestine of *Enyalius* spp. from Brazil. They belong to group 6 of Ben Slimane, Chabaud & Durette-Desset (1996). In this group they share along with *O. peruvensis* Ben Slimane, Verhaag & Durette-Desset, 1995, a parasite of Iguanidae from Peru the followings linked characters: (i) a caudal bursa of type II; (ii) cervical alae present; (iii) undulated cuticular ridges. The Peruvian species differs from the Brazilian species by the absence of a strut in the cervical alae, by a small number of cuticular ridges at mid-body and by a spicular fork with a ramified inner twig. *Oswaldocruzia fredii* n. sp., a parasite of the stomach and the small intestine of *Enyalius iheringii*, mainly differs from the two other species by the absence of the oesophageal ventral cuticular ridges. *Oswaldocruzia benslimanei* n. sp., a parasite of the small intestine of *Enyalius bilineatus*, differs from *Oswaldocruzia burseyi* n. sp., a parasite of the stomach of *Enyalius perditus*, by the division of the fork at 23.4 % of spicule length (versus 32 %), and the length of the blade longer than the fork. *Oswaldocruzia subauricularis sensu* Freitas, 1955 nec Rudolphi, 1819 and *O. mazzai sensu* Vicente, 1981 nec Travassos, 1935 should be considered as *species inquirendae*.

**KEY WORDS :** Nematoda, Trichostrongylina, *Oswaldocruzia burseyi* n. sp., *Oswaldocruzia benslimanei* n. sp., *Oswaldocruzia fredii* n. sp., Molineoidea, Molineidae, Iguanidae, Brazil, systematics.

**Résumé :** TROIS NOUVELLES ESPÈCES DU GENRE *OSWALDOCRUZIA* (NEMATODA, TRICHOSTRONGYLINA, MOLINEOIDEA) PARASITES D'*ENYALIUS* SPP. (IGUANIDAE) AU BRÉSIL

Trois nouvelles espèces du genre *Oswaldocruzia* Travassos, 1917 appartenant à la sous-famille des Molineinae sont décrites de l'estomac et/ou de l'intestin grêle d'*Enyalius* spp. au Brésil. Elles font partie du groupe 6 de Ben Slimane, Durette-Desset et Chabaud (1996). Dans ce groupe, elles présentent comme *O. peruvensis* Ben Slimane, Verhaag et Durette-Desset, 1995, un parasite d'Iguanidae du Pérou, les caractères liés suivants : i) une bourse caudale de type II; ii) des ailes cervicales présentes; iii) des crêtes cuticulaires ondulées. L'espèce péruvienne diffère des espèces brésiliennes par l'absence de soutien chitinoïde dans les ailes cervicales, par un petit nombre de crêtes cuticulaires au milieu du corps et par la ramification de la branche interne de la fourche spiculaire. *Oswaldocruzia fredii* n. sp., parasite de l'estomac et de l'intestin grêle d'*Enyalius iheringii*, se différencie des deux autres espèces principalement par l'absence de crêtes cuticulaires ventrales dans la région oesophagienne. *Oswaldocruzia benslimanei* n. sp., parasite de l'intestin grêle d'*Enyalius bilineatus*, se différencie d'*O. burseyi* n. sp., parasite de l'estomac d'*Enyalius perditus*, par la division de la fourche à 23,4 % de la longueur du spicule (contre 32 %) et par la longueur de la lame plus longue que la fourche. *Oswaldocruzia subauricularis sensu* Freitas, 1955 nec Rudolphi, 1819 et *O. mazzai sensu* Vicente, 1981 nec Travassos, 1935 sont considérées comme espèces *inquirendae*.

**MOTS CLÉS :** Nematoda, Trichostrongylina, *Oswaldocruzia burseyi* n. sp., *Oswaldocruzia benslimanei* n. sp., *Oswaldocruzia fredii* n. p. Molineoidea, Molineidae, Iguanidae, Brésil, systématique.

## INTRODUCTION

The Trichostrongylina (Nematoda) parasites of amphibians and reptiles are a diverse group whose species and genera are considered as being difficult to determine, mainly due to their general morphological uniformity and usually poor host-specificity (Ben Slimane *et al.*, 1996a). The great majority

of species in this group belongs to the cosmopolitan genus *Oswaldocruzia* Travassos, 1917 which parasitizes mainly amphibians and, less frequently, reptiles. This genus was reviewed by Ben Slimane *et al.* (1996a), who divided it into five groups (*i.e.* groups 3 to 7), each being characterised by the morphology of the spicules and corresponding to a biogeographical region. One of these, termed group 6 (or Continental Neotropical group), comprised 21 species distributed throughout the South American continent. Since then, two new species belonging to this group (*pers. obs.*) have been described by Bursey & Goldberg (2004, 2005). One of them, *O. costaricensis* Bursey & Goldberg, 2004, a parasite of Ranidae frogs from Costa Rica, extended the group's geographic distribution to Central America. Of the 23 currently recognized species in group 6, only

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four are parasites of reptiles: *O. brasiliensis* Lent & Freitas, 1935, (parasite of Colubrid snakes and Gekkonid lizards from Brazil), *O. peruensis* Ben Slimane, Verhaag & Durette-Desset, 1995 (parasite of Iguanid lizards from Peru), *O. bainaie* Ben Slimane & Durette-Desset, 1996a (parasite of Iguanid lizards from Ecuador), and *O. vittii* Bursey & Goldberg, 2004 (parasite of Gymnophthalmid lizards from Brazil and Ecuador). In the present paper we describe three new South American species of *Oswaldocruzia*, each parasitizing a different species of *Enyalius* (Lacertilia, Iguanidae) from Brazil. We also discuss previous references of *Oswaldocruzia subauricularis* (Rudolphi, 1819) and of *Oswaldocruzia mazzai* Travassos, 1935 in Iguanidae both from Brazil.

## MATERIAL AND METHODS

14 specimens of *Enyalius perditus* Jackson, 1978 and six specimens of *Enyalius iberingii* Boulenger, 1885 were collected manually by the second author and colleagues between July 1997 and January 1998 at Island of São Sebastião (23° 45' to 23° 55' S; 45° 17' to 45° 24' W), municipality of Ilhabela, state of São Paulo. 27 specimens of *Enyalius bilineatus* Duméril & Bibron, 1837 were donated to the third author by Rogério L. Teixeira. They had been collected by the late Cláudio Zamprogno between February 1995 and March 1996 in the municipality of Marechal Floriano (20° 24' S, 40° 49' W), state of Espírito Santo. Both localities are in southeastern Brazil, and are located within the Atlantic Rainforest biome. The lizards were opened and their digestive tracts (stomachs and intestines) were examined. Six (43 %) of the *E. perditus*, two (33 %) of the *E. iberingii* and two (7 %) of the *E. bilineatus* were found to harbor, respectively, a total of 17, 10, and three nematodes of the genus *Oswaldocruzia*, which are described herein as three new species.

The nomenclature used above for the family group is that of Durette-Desset & Chabaud (1993). The nomenclature used for the study of the caudal bursa is that of Durette-Desset & Chabaud (1981). The nomenclature concerning the disposition of rays 8 in relation to rays 6 is that of Durette-Desset *et al.* (1992). The synopse and the spicules are described according to Ben Slimane *et al.* (1993) and Ben Slimane *et al.* (1996a). In the calculations of the uterus length/body length ratio, the measurement of the uterus includes the two uterine branches. Measurements are in micrometers except where otherwise stated. The nomenclature of the hosts follows Jackson (1978). The references of *Enyalius* genus to the family Iguanidae follows Schülte *et al.* (2003).

## RESULTS

Common characters of the three species: the species are closely related to each other. Some characters do not provide interspecific differences and can be defined similarly for the three species:

Body: relatively long for a Trichostrongylina (more than 10 mm long in females), curved along ventral side.

Head: cephalic vesicle present with anterior swelling generally absent or reduced. Triangular oral opening surrounded by two amphids, four externo-lateral papillae and four submedian cephalic papillae (Figs 10, 36). Oesophageal dorsal tooth not observed but oesophageal gland visible (Figs 11, 18, 33).

Anterior extremity: triangular-shaped deirids, situated near excretory pore and generally posterior to it (Figs 11, 18, 33, 34). Well-developed excretory glands (Figs 1, 21, 29).

Synopse: in both sexes, presence of longitudinal ridges most uninterrupted. Some ridges irregularly interrupted and replaced by beginning of new ridge. Ridges present all along body except in female at level of vulvar opening where medio-ventral, then latero-ventral ridges disappear (Fig. 7). Ventral ridges reappear posterior to vulvar level (Figs 12, 26, 38), then progressively disappear up to tail. Presence of cervical alae orientated towards ventral side, arising posterior to cephalic vesicle but evident only 50 to 80 µm posterior to it. (Figs 14, 35). Each ala is composed of one crest held up by chitinous support (strut) (Figs 1, 19, 28). Other cuticular ridges undulated in section, orientated perpendicularly to body and more or less regularly spaced. At mid-body, similar number of dorsal and ventral ridges.

Male: sub-symmetrical caudal bursa, with pattern of type 2-3 with tendency 2-1-2. Rays 8 arising on dorsal ray and overlapped by rays 6 in median part (type II). "Idiomorphic" spicules. Fork divided within distal third of spicule. Gubernaculum absent. Genital cone bearing a large papilla zero on ventral lip and two minute papillae 7 on dorsal lip (Figs 23, 40).

Female: didelphic. Vulvar opening situated within third quarter of body. Ovejector with very short infundibula (Figs 13, 27, 39). Caudal extremity with spine. (Figs 15, 26, 37).

### *OSWALDOCRUZIA BURSEYI* N. SP. (Figs 1-17)

Studied material

A - Type material: holotype male, allotype female, MNHN 341 MQa, one male, three female paratypes MNHN 341 MQb.

Type host: *Enyalius perditus* Jackson, 1978 (Iguanidae).

Site: stomach.

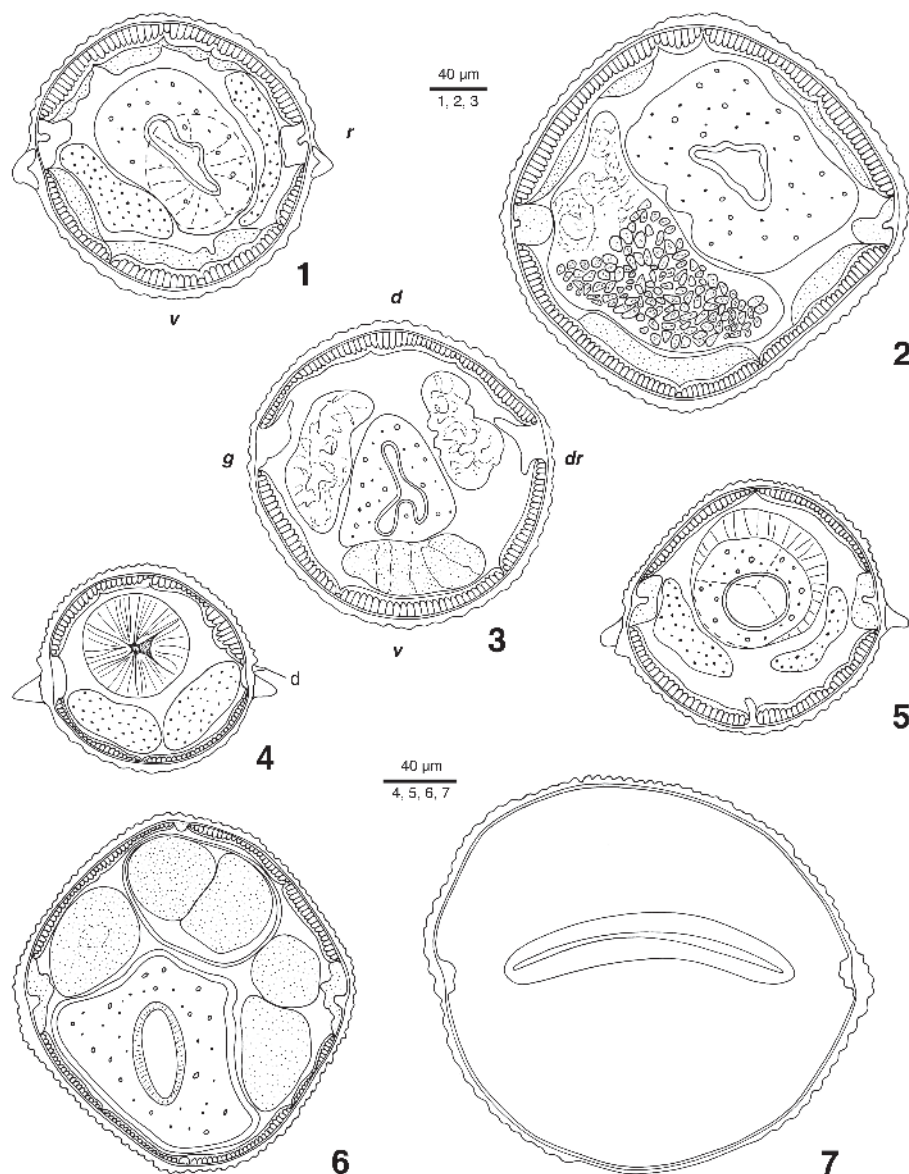
Geographic origin: Island of São Sebastião (23° 47' S, 45° 24' W), São Paulo State, Brazil.

B - Voucher material: from stomach, four females (one being a posterior part), MNHN 337 MQ; from small intestine, one female, MNHN 353 MQ; three females (two being posterior parts) MNHN 354 MQ; one female MNHN 355 MQ, from same host and same locality.

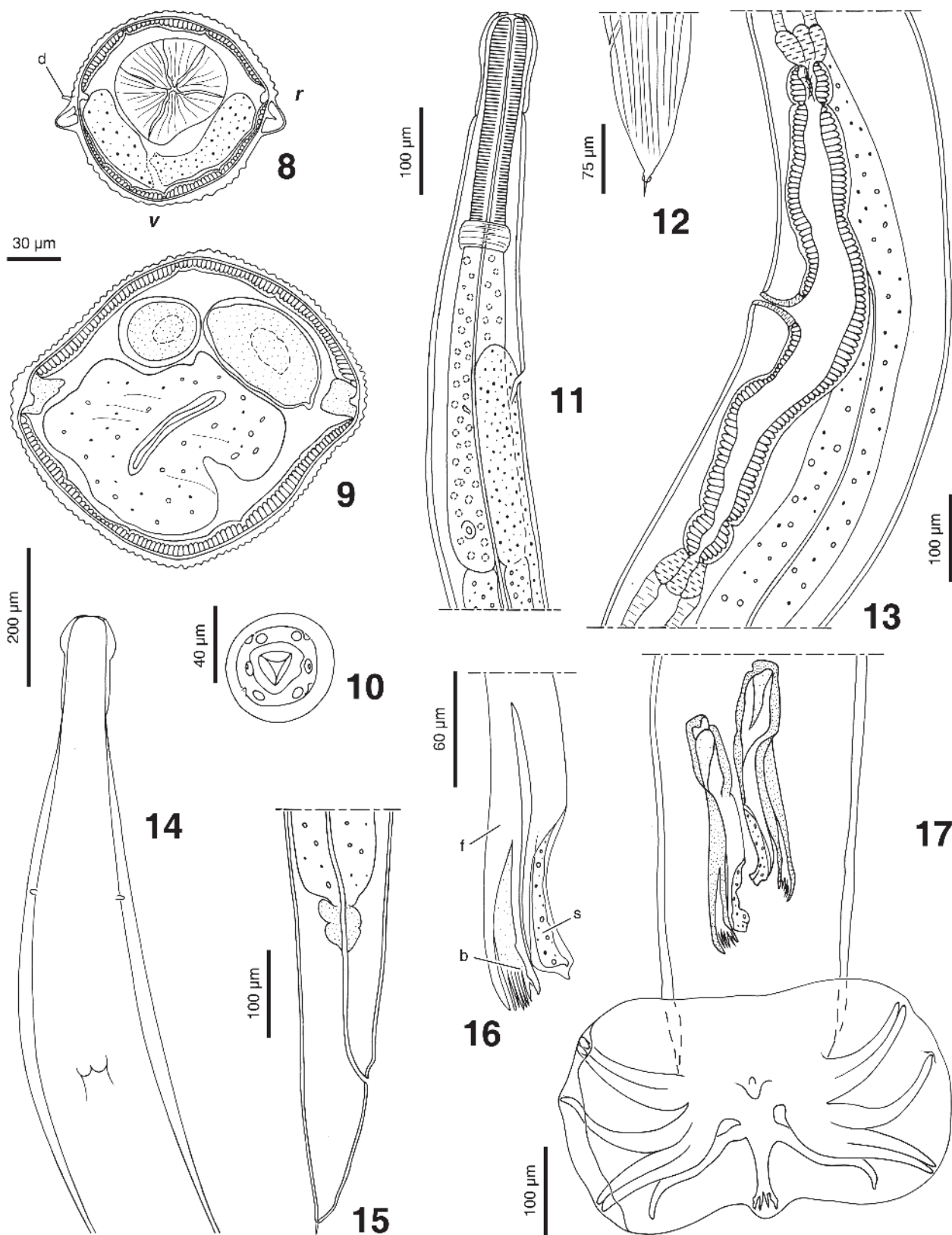
Synlophe (studied in transverse sections in one paratype male and two females from voucher material 337 MQ, 353 MQ). In male, 51 % of ridges appear in oesophageal region made up of 64 % of dorsal ridges and 35 % of ventral ridges. In female, 42, 59 % of ridges appear in oesophageal region made up of 50, 72 % of dorsal ridges and 33, 45 % of ventral ridges. Cervical alae, 670 long in male, 650, 820 long in female and 20 wide at maximum in both sexes (Fig. 14). In section,

each ala composed of crest forming triangle with base 20 wide at maximum and sharp tip (Figs 1, 4, 5, 8). Number of ridges: in male, 45 (alae, 28 dorsal, 15 ventral) at level of oesophago-intestinal junction (Fig. 1), 88 (44 dorsal, 44 ventral) at mid-body (Fig. 2), 61 (29 dorsal, 32 ventral) at 350 anterior to caudal bursa (Fig. 3). In females, 50 (alae, 31 dorsal, 17 ventral) 49 (alae, 35 dorsal, 12 ventral) at level of deirids (Figs 4, 8), 52 (alae, 31 dorsal, 19 ventral), 65 (alae, 39 dorsal, 24 ventral) at level of oesophago-intestinal junction (Fig. 5), 120 (62 dorsal, 58 ventral), 107 (54 dorsal, 53 ventral) at mid-body (Figs 6, 9). 31, 29 median ventral ridges disappear anteriorly to vulva level, then 24 latero-ventral. (Fig. 7).

Holotype male and the paratype (in brackets): 9.7 (9.0 mm) long and 250 (250) wide at mid-body. Cephalic vesicle 120 (90) long and 60 (55) wide. Nerve ring,



Figs 1-7. - *Oswaldocruzia burseyi* n. sp. 1-7. Transverse sections of body. 1-3. Paratype male, 9 mm long. 1 - at level of oesophago-intestinal junction. 2 - at mid-body (4.7 mm from apex). 3 - at 450  $\mu$ m anterior to caudal bursa. 4-8. Female from voucher material (353 MQ), 12.3 mm long. 4 - at level of right deirid. 5 - at level of oesophago-intestinal junction. 6 - at mid-body (6 mm from apex). 7 - just anterior to vulvar level. Abbreviations: v, ventral side; r, right side; d, deirid. Sections are orientated as 1.



Figs 8-17. – *Oswaldocruzia burseyi* n. sp. 8, 9. Transverse sections of body, female paratype, 9.4 mm long. 8 - at level of left deirid. 9 - at mid-body (5 mm from apex). 10-15. Female. 10 - head, apical view. 11 - anterior extremity, right lateral view. 12 - tail, with disappearance of cuticular ridges, left lateral view. 13 - ovejector, left lateral view. 14 - silhouette with cervical alae, dorsal view. 15 - posterior extremity, right lateral view. 16, 17. Male. 16 - lamina of dissected right spicule, ventral view. 17 - caudal bursa, ventral view. Abbreviations: v, ventral side; r, right side; d, deirid; f, fork; s, shoe; b, blade. Sections are orientated as 8.



excretory pore and deirids situated at 230 (225), 370 (340), and 380 (360) from apex, respectively. Oesophagus 610 (620) long.

Dorsal ray divided at distal extremity into two branches, each branch divided into two twigs, rays 9 (external branches) slightly longer and thicker than rays 10 (internal branches). Alate spicules 250 (280) long, blade divided at its distal part into six processes, fork distally divided at 32 % of whole length of spicule (Fig. 16). Genital cone 20 long and 50 wide at base. Papilla zero relatively small, papillae 7 not observed. (Fig. 17).

Allotype female and the three paratypes (average and range in brackets): 14.5 [13.5 (11.5-15.0)] mm long and 300 [280 (260-300)] wide at mid-body. Cephalic vesicle 100 [107 (100-115)] long and 60 [60 (55-65)] wide. Nerve ring, excretory pore and deirids situated at 210 [223 (200-250)], 380 [373 (320-400)] and 400 [367 (330-390)] from apex, respectively. Oesophagus 650 [630 (600-680)] long (Fig. 11). Vulva situated at 5.3 [5.3 (4.5-5.8)] mm from caudal extremity *i.e.* 37 [39 (37-41)] % of body length. *Vagina vera*, 50 [47(45-50)] long, dividing vestibule 550 [482 (425-550)] long into two parts of equivalent size in one paratype or with anterior part longer. Anterior sphincter and infundibulum 50 [52 (50-55)], 40 [38 (35-40)] long, respectively. Posterior sphincter and infundibulum, 50 [55 (50-60)], 35 [32 (30-35)] (Fig. 13). Anterior uterine branch 2.0 [2.1 (1.9-2.2)] mm with 65 [84 (64-115)] eggs; posterior uterine branch 2.3 [2.5 (2.3-3.0)] mm with 72 [78 (76-82)] eggs. Eggs at morula stage, 75 long and 45 wide on average. Ratio uterus length/body length 34 [34 (30-39)]%. Tail 215 [220 (170-250)] long including caudal spine 10 [10 (10, 10)] long and 115 [92 (90- 95)] wide at level of anus (Fig. 15).

Measurements (average and range) of four females from voucher material (one female by host): 12.8 (12.3-13.3) long and 197 (190-200) wide at mid-body. Cephalic vesicle, 108 (90-120) and 55 (50-60) wide. Nerve ring, excretory pore and deirids situated at 223 (210-250), 395 (380-430), 424 (400-465) from apex, respectively. Oesophagus 595 (540-650) long. Vulva situated at 4.7 (4.4-5.3) mm from apex. Vestibule 460 (430-510) long, anterior sphincter and infundibulum 47,5 (45-50) and 41,5 (40-45), respectively, posterior sphincter and infundibulum 45 (40-50) and 45 (40-50), respectively, anterior uterine branch 1.8 (1.1-3.1) mm with 58 (15-120) eggs, posterior uterine branch 1.5 (1.2-2.1) mm with 42 (19-80) eggs. Ratio uterus length/body length 25.9 (18.4-42) %. Tail 170 (150-180) long including caudal spine 10 (10-10) long and 80 (70-100) wide at level of anus (Fig. 15).

Diagnosis: for the reasons explained below (see comments on *Oswaldocruzia fredii* n. sp.), we consider these specimens as belonging to a new species we have named *Oswaldocruzia burseyi* n. sp. in honour

of Dr Charles R. Bursey for his contribution to the study of reptile and amphibian helminths.

*OSWALDOCRUZIA BENSLIMANEI* N. SP.

(Figs. 18-27)

Studied material

A - Type material: holotype male, allotype female, MNHN 339 MQ.

Type host: *Enyalius bilineatus* (Duméril & Bibron, 1837) (Iguanidae).

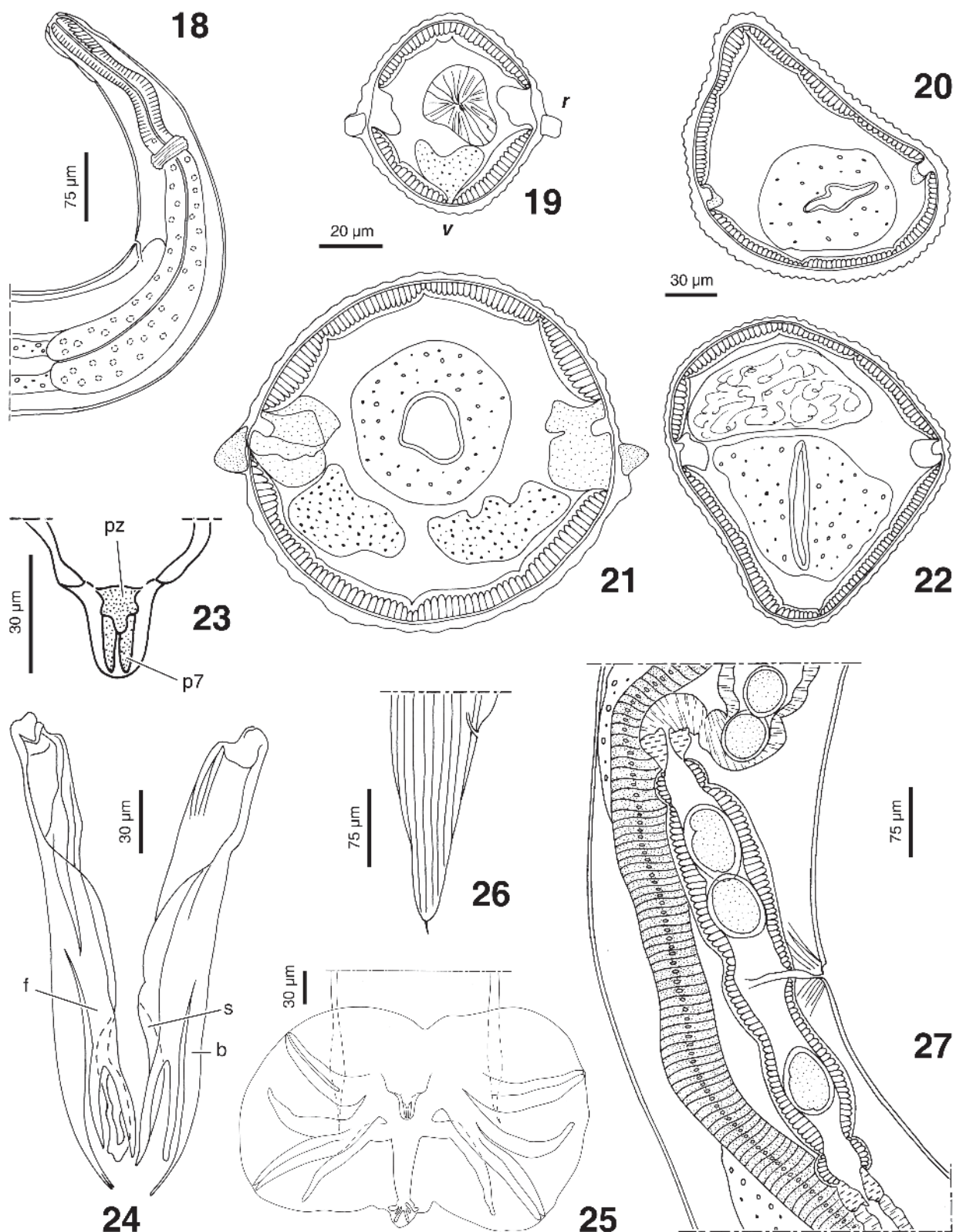
Site: small intestine.

Geographic origin: Marechal Floriano (20° 24' S, 40° 49' W), Espírito Santo State, Brazil.

B - Voucher material: one female (anterior part), MNHN 338 MQ from same host (duodenum) and same locality.

Synopse (studied in transverse sections in the holotype male and the female from voucher material). In male, 58 % of ridges appear in oesophageal region made up of 68 % of dorsal ridges and 47 % of ventral ridges. In female, 48 % of ridges appear in oesophageal region made up of 50 % of dorsal ridges and 46 % of ventral ridges. Cervical alae, 530 long in male, 550 long in female and 10 wide at maximum in male, 7 in female. Each ala is composed of one crest forming in male an isocetes triangle 12 wide at base with rounded tip (Fig. 21) and in female a rectangle 6 wide at base (Fig. 19). Number of ridges: in male, 44 (alae, 25 dorsal, 17 ventral) at level of oesophago-intestinal junction (Fig. 21), 73 (37 dorsal, 36 ventral) at mid-body (Fig. 22). In female, 40 (alae, 20 dorsal, 18 ventral) at level of nerve ring (Fig. 19), 79 (40 dorsal, 39 ventral) at the end of the piece, *i.e.* at about third of body in comparison with the length of the paratype female (Fig. 20). Holotype male: 7.9 mm long and 210 wide at mid-body. Cephalic vesicle 80 long and 50 wide. Nerve ring and deirids not observed, excretory pore situated at 310 from apex. Oesophagus 490 long. Rays 8 thick at base. Dorsal ray thick at base, divided at distal extremity into three branches, curved rays 9 (external branches) as long as straight rays 10 (internal branches) and phasmids smaller than rays 9 and 10 but well developed. Rays 9 arising on dorsal ray anterior to its division (Fig. 25). Spicules 235 long, number of processes of blade not observed, fork distally divided at 23.4 % of whole length of spicule (Fig. 24). Genital cone 45 long and 45 wide at base. Papilla zero 7 long, papillae 7 with a long peduncle (Fig. 23).

Allotype female: 13.7 mm long and 250 wide at mid-body. Cephalic vesicle 82 long and 45 wide. Nerve ring, excretory pore and deirids situated at 150, 325 and 330 from apex, respectively. Oesophagus 510 long (Fig. 18). Vulva situated at 4.9 mm from caudal extremity *i.e.* 35.8 % of body length. *Vagina vera*: 60 long dividing vestibule 400 long into two parts with poste-



Figs 18-27. – *Oswaldocruzia benslimanei* n. sp. 18. Female, anterior extremity, left lateral view. 19-22. Transverse sections of body. 19, 20. Anterior piece of a female from voucher material (338 MQ). 19 - at 225  $\mu$ m from apex, anterior to level of excretory pore. 20 - at 4.3 mm from apex. 21, 22. Male holotype, 7.9 mm long. 21 - at 60  $\mu$ m posterior to level of oesophago-intestinal junction. 22 - at mid-body (4 mm from apex). 23-25. Male. 23 - genital cone, ventral view. 24 - spicules *in situ*, ventral view. 25 - caudal bursa, ventral view. 26, 27. Female. 26 - tail with disappearance of cuticular ridges, right lateral view. 27 - ovejector, right lateral view. Abbreviations: v, ventral side; r, right side; f, fork; s, shoe; b, blade; pz, papilla zero; p7, papilla 7. Sections are orientated as 19.

rior part longer. Anterior part of ovejector, 210 long, posterior part 190 long. Anterior sphincter and infundibulum 45 and 40 long, respectively. Posterior sphincter and infundibulum 40 and 40 long, respectively (Fig. 27). Anterior uterine branch 2.1 mm long with 57 eggs at morula stage; posterior uterine branch 2.2 mm with 60 eggs at morula stage. Eggs 80 long and 47 wide on average. Ratio uterus length/body length: 32 %. Tail 210 long including caudal spine 10 long (Fig. 26) and 80 wide at level of anus.

Diagnosis: for the reasons explained below (see comments on *Oswaldocruzia fredii* n. sp.) we consider these specimens as belonging to a new species we have named *Oswaldocruzia benslimanei* n. sp. in honour of Dr Baddredine Ben Slimane for his contribution to the study of the Trichostrongyline parasites of amphibians and reptiles.

*OSWALDOCRUZIA FREDII* N. SP.  
(Figs 28-42)

Studied material

A - Type material: holotype male, allotype female, MNHN 335 MQa, one male (posterior part), three female paratypes (two posterior parts) MNHN 335 MQb.

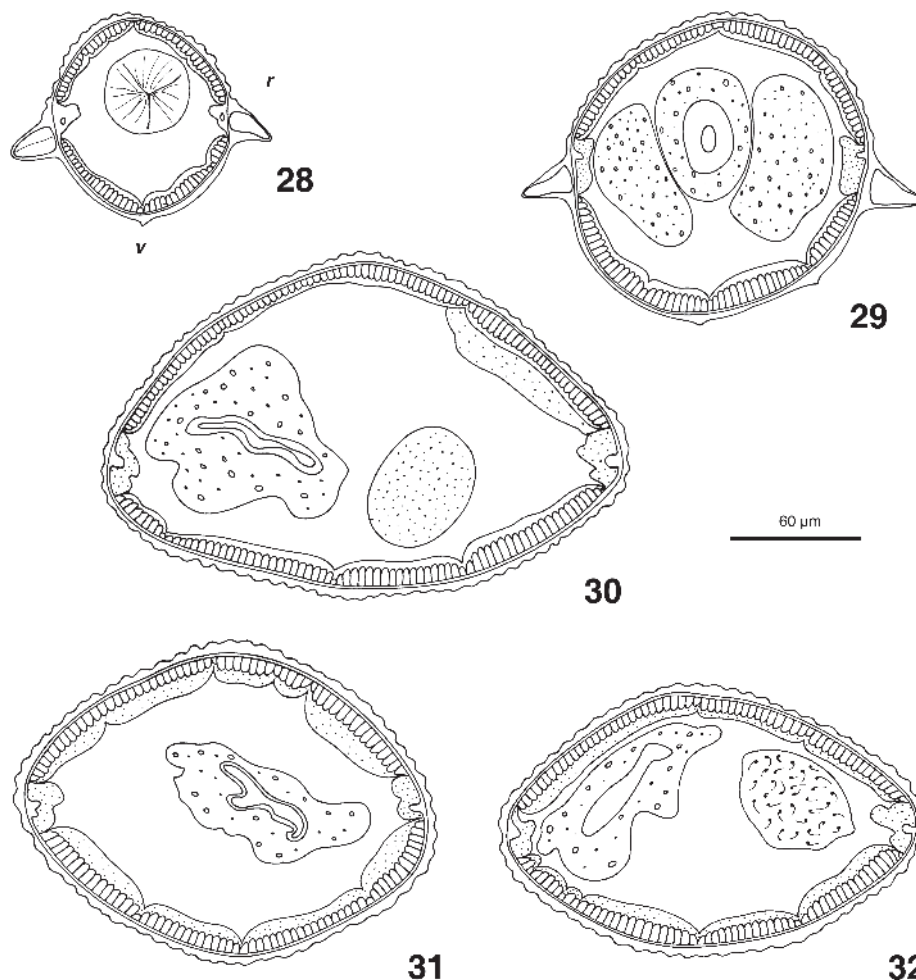
Type host: *Enyalius iberingii* Boulenger, 1885 (Iguanidae).

Site: stomach.

Geographic origin: Island of São Sebastião (23° 47' S, 45° 24' W), São Paulo State, Brazil.

B - Voucher material: one female, MNHN 340 MQ, from the same host (small intestine) and the same locality.

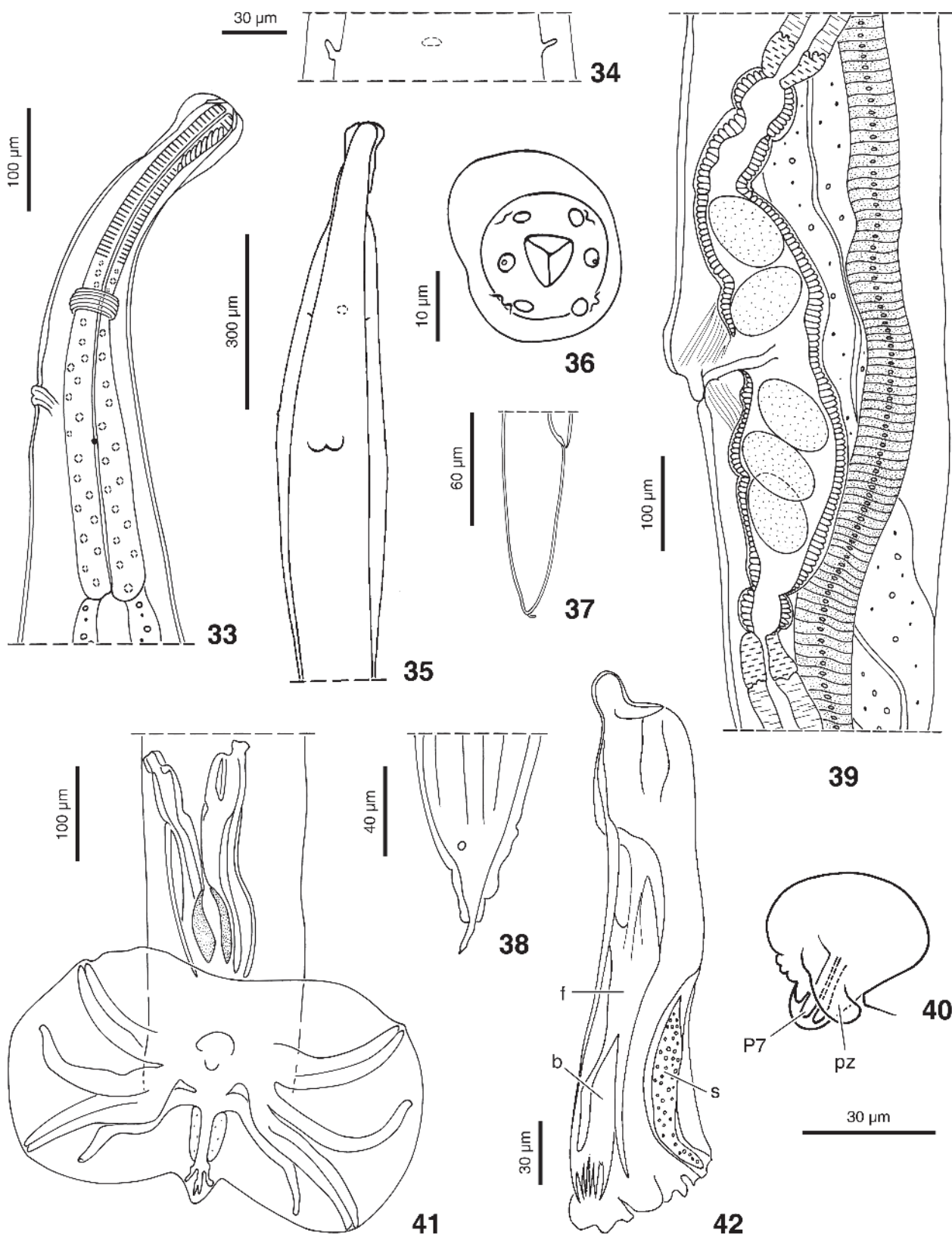
Synopse (studied in transverse sections in one posterior part of a male paratype and one female paratype). In female, 69 % of dorsal ridges appear in oesophageal region, ventral ridges appear posterior to oesophago-intestinal junction. Cervical alae 860 long in male, (Fig. 35), 880 long in female and 30 at maximum width in male, 25 in female. In female, each ala composed in section, by a triangular crest forming an isosceles triangle, 25 high and 20 wide at base with rounded tip (Figs 28, 29). Number of ridges: in male 62 (32 dorsal, 30 ventral) at 4.6 mm from caudal bursa (Fig. 31) (*i.e.* at about mid-body in comparison to holotype length), 59 (30 dorsal, 29 ventral) at 500 anterior to caudal bursa (Fig. 32). In female, 18 (alae, 16 dorsal) at level of nerve ring (Fig. 28), 22 (alae, 19 dorsal, one ventral) at level of excretory pore, 29 (alae, 25 dorsal,



Figs 28-32. - *Oswaldocruzia fredii* n. sp. Transverse sections of body. 28-30. Female paratype 12.4 mm long. 28 - at 300 µm from apex. 29 - at level of oesophago-intestinal junction. 30 - at mid-body (6.8 mm from apex). 31, 32. Posterior piece of a paratype male. 31 - at 4.6 mm anterior to caudal bursa. 32 - at 500 µm anterior to caudal bursa.

Abbreviations: v, ventral side; r, right side. Sections orientated as 28.





Figs 33-42. – *Oswaldocruzia fredii* n. sp. 33-35. Holotype male. 33 - anterior extremity, left lateral view. 34 - detail of excretory pore and deirids, dorsal view. 35 - silhouette with cervical alae, dorsal view. 36-39. Female. 36 - head, apical view. 37 - tail, right lateral view. 38 - posterior extremity, disappearance of cuticular ridges, right lateral view. 39 - ovejector, left lateral view. 40-42. Male. 40 - genital cone, ventral view. 41 - caudal bursa, ventral view. 42 - right spicule, interno-ventral view. Abbreviations: f, fork; s, shoe; b, blade; pz, papilla zero; p7, papilla 7.



two ventral) at level of oesophago-intestinal junction (Fig. 29), 79 (42 dorsal, 37 ventral) at mid-body (Fig. 30). Holotype male: 7.3 mm long and 150 wide at mid-body. Cephalic vesicle 100 long and 55 wide. Nerve ring, excretory pore and deirids situated at 212, 340 and 360 from apex, respectively. Oesophagus 540 long (Fig. 33). Rays 9 (external branches) arising asymmetrically on dorsal ray, first left ray, more distally right ray 9. Rays 9 arising anterior to division of dorsal ray. Dorsal ray divided at extremity into two small branches, right and left rays 10 (Fig. 41). Spicules 240 long, blade divided at its distal part into six processes, fork distally divided at 33.3 % of whole length of spicule (Fig. 42). Genital cone 30 long and 40 wide at base bearing long papilla zero 20 long on dorsal lip and thin papillae 7 on ventral lip (Fig. 40).

Allotype female and three paratype females (in brackets): 12.4 (12.3) mm long and 250 (250) wide at mid-body. Cephalic vesicle 100 (100) long and 52 (60) wide. Nerve ring, excretory pore and deirids situated at 240 (200), 360 (400) and 415 (450) from apex, respectively. Oesophagus 600 (640) long. Vulva situated at 4.8 [4.4 (3.5-5.3)] mm from caudal extremity *i.e.* 31.6 (30) % of body length. *Vagina vera*: 90 [80 (70-90)] long dividing vestibule 520 [458 (425-480)] long into two parts of equivalent size or with anterior part longer. Anterior part of ovejector 260 [240 (210-260)] long, posterior part 260 [218 (215-220)] long. Anterior sphincter and infundibulum 60 [54 (50-60)] and 50 [38 (35-40)] long, respectively. Posterior sphincter and infundibulum 55 [60 (50-70)] and 50 [45 (40-50)] long, respectively (Fig. 39). Anterior uterine branch 1.75 [1.9 (1.6-2.1)] mm long with 6 [4 (2-6)] eggs at morula stage; posterior uterine branch 2.1 [1.5 (1.3-1.6)] mm long with 7 [5 (4-6)] eggs at morula stage. Eggs 85 long and 45 wide on average. Tail 90 [96 (95-100)] long including caudal spine 15 [11 (10-12)] long and 35 [36 (32-40)] wide at level of anus (Fig. 37).

Measurements of the female from voucher material: 14.3 long and 290 wide at mid-body. Cephalic vesicle 100 long and 60 wide. Nerve ring, excretory pore and deirids situated at 230, 380 and 420 from apex, respectively. Oesophagus 630 long. Vulva situated at 5.5 mm from caudal extremity, *i.e.* 38 % of body length. Vestibule 430 long, anterior sphincter and infundibulum 60 and 45 long, respectively, posterior sphincter and infundibulum 60 and 40 long, respectively. Anterior uterine branch 1.15 mm long with 32 eggs at morula stage. Posterior uterine branch, 1.6 mm long with 20 eggs. Eggs 95 long and 50 wide on average. Ratio uterus length/body length, 21.6 %. Tail 95 long including caudal spine 10 long and 40 wide at level of anus.

For the reasons explained hereafter, we consider these specimens as belonging to a new species we have named *Oswaldocruzia fredii* n. sp. in honour of Dr Carlos Frederico D. Rocha (alias "Fred"), for his contribution

to the knowledge of Brazilian reptile and amphibian ecology.

#### DIAGNOSIS

The three species described above possess "idiomorphic" spicules and a spicular fork divided within the distal third of the spicule. These characteristics and the geographic origin of these species allow us to include them in group 6 of Ben Slimane *et al.* (1996a). The new species all have a caudal bursa of type II and cervical alae, with each ala being made up of a sole ridge, and the cuticular ridges are undulated. Within the species of group 6, only *O. peruensis* Ben Slimane, Verhaag & Durette-Desset, 1995, presents these linked characters, but it is differentiated from the three new species by the absence of struts in the cervical alae, a small number of cuticular ridges at mid-body (37 in males, 43 in females versus 62-88 in males, 79-120 in females) and a spicular fork with ramified inner twig. The three new species are closely related to each other and are differentiated by characters usually considered of minor specific value in the Trichostrongylinea. *O. fredii* n. sp. is differentiated from the other two species by the absence of the oesophageal ventral cuticular ridges, by longer wider cervical alae; in males, by arising of rays 9 on the dorsal ray anterior to the division of the latter and rays 10 smaller than rays 9. In *O. fredii* n. sp., the fork is distally divided at 33 % of whole spicule length as in *O. burseyi* n. sp. (32 %), but it is smaller than blade as in *O. benslimanei* n. sp. *O. benslimanei* is differentiated from *O. burseyi* by fork divided at 23.4 % (versus 32 %) of spicule length and by blade longer than fork (equivalent length in *O. burseyi*). In addition, in males of *O. benslimanei*, the phasmids are well developed and papillae 7 are pedunculated. The three new species described above raise to 12 the number of species in group 6 with a caudal bursa of type II. Although Bursey & Goldberg (2005) mentioned the recently described *O. costaricensis* as possessing a caudal bursa of type II, their figure 7 indicate that the caudal bursa is actually of type I.

#### DISCUSSION

To date, nine species of *Oswaldocruzia* are known to be parasites of Iguanidae. Five species belong to group 6 of Ben Slimane *et al.* (1996a) and originate from Peru (*O. peruensis* Ben Slimane *et al.* 1995a), Ecuador (*O. binae* Ben Slimane & Durette-Desset, 1996a) and Brazil (*O. burseyi* n. sp., *O. benslimanei* n. sp. and *O. fredii* n. sp.). Four species belong to group 7 and originate from Cuba (*O. anolisi* Barus & Coy Otero, 1968) and Guadeloupe (*O. marechali* Ben Slimane & Durette-Desset, 1995, *O. mauleoni* Ben Slimane, Durette-

Desset & Chabaud, 1995 and *O. jeanbarti* Ben Slimane, Durette-Desset & Chabaud, 1995, which is a parasite both of Iguanidae and of Leptodactylidae frogs).

Freitas (1955) reported the presence of *Oswaldocruzia subauricularis* (Rudolphi, 1819) in *Enyalius catenatus* from Rio de Janeiro, Brazil [the populations of *E. catenatus* originating from Rio de Janeiro and São Paulo states would later be described as a new species, *E. perditus*, by Jackson (1978)]. *O. subauricularis* is a common parasite of amphibians from Brazil. After the description of its synopse provided by Ben Slimane & Durette-Desset, (1995) on specimens which are parasites of Bufonidae from Brazil and Ecuador, the cervical alae are absent. This differentiates this species from the other species parasites of *Enyalius* spp. The species reported by Freitas (1955) as *O. subauricularis* included some features (*i.e.* caudal bursa of type II, idiomorphic spicules with blade divided at its extremity into several processes) that relate it to the three new species described here and more particularly to *O. benslimanei*, by the characters of the dorsal ray (presence of phasmids) and the relative lengths of the spicular branches (blade longer than fork, and fork as long as shoe). However, as the synopse of the material studied by Freitas (1955) has not been studied, particularly in the oesophageal region, it is not possible to identify *O. benslimanei* to this species. We think that the species reported as *O. subauricularis sensu* Freitas, 1955 *nec* Rudolphi, 1819 should presently be considered as a *species inquirenda*.

Vicente (1981) reported the presence of *Oswaldocruzia mazzai* Travassos, 1935 in *Tropidurus torquatus* (Iguanidae) from Brazil. The type host of *O. mazzai* is *Bufo marinus* from Argentina (Travassos, 1935). Vicente (1981) provided only a drawing of the caudal bursa in lateral view, which is insufficient to identify this species to *O. mazzai*. We think that *O. mazzai sensu* Vicente (1981) *nec* Travassos (1935) should also be considered as *species inquirenda*.

Numerous new species of *Oswaldocruzia* have recently been described from South American reptiles and amphibians (Ben Slimane & Durette-Desset, 1993; 1995; 1996a,b; Ben Slimane, *et al.*, 1995a,b; Ben Slimane, Guerrero & Durette-Desset, 1996; Bursey & Goldberg, 2004; 2005, this study) and several other species yet undescribed until now are likely awaiting discovery (Ben Slimane *et al.*, 1996a). The description of the three new species in the present study raises to 26 the number of taxa in the so-called Continental Neotropical radiation of the genus *Oswaldocruzia* (*i.e.* group 6), making it the most speciose of the five groups proposed by Ben Slimane *et al.* (1996a) for the genus. This indicates that the genus *Oswaldocruzia* has undergone considerable diversification in the South American continent, perhaps paralleling the great diversification of their amphibian and reptilian hosts in that region.

Ben Slimane *et al.* (1996a) proposed that the diversification of their Continental Neotropical group (or group 6) has occurred during the Pliocene period, and that the morphologically derived Caribbean Neotropical group (or group 7) originated within the previous group, following an invasion of the Caribbean region. Thus, it is likely that the much lower species richness of group 7 compared to group 6 may be due to the former's relatively recent origin. However, it is also probable that further surveys of helminths from the rich Caribbean fauna of reptiles and amphibians may uncover more hitherto undescribed species, thereby increasing the species richness in group 7.

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