

# A new species of *Procyrnea* (Nematoda: Habronematidae) parasitic in *Rhea pennata* (Aves: Rheidae) from Patagonia, Argentina, with a key to species of the genus

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## Abstract

*Procyrnea choique* n. sp. is described from the lesser rhea, *Rhea pennata* d'Orbigny (Aves: Rheidae), from the Protected Natural Area Península Valdés, Chubut province, Argentina. The new species resembles *P. fischeuri*, *P. murrayi*, *P. excisiformis*, *P. dollfusi*, *P. haliasturi*, *P. anterovulvata*, *P. graculae*, *P. brevicaudata*, *P. uncinipenis*, *P. javaensis*, *P. ameerae*, *P. ornata*, *P. aegothales*, *P. spiralis*, *P. ruschii* and *P. aptera*, mainly in the absence of lateral alae; but differs from its congeners by having a left spicule without barbs, the position of the vulva which is post-equatorial, the absence of lateral ridges, absent median precloacal papilla, asymmetrical caudal alae, males more than 6 mm long, left spicule 1 mm long and spicule ratio 1:3. Our results extend the taxonomy of *Procyrnea* Chabaud, 1958 and comprise the first report of a habronematid from *R. pennata*. A key to species of *Procyrnea* is presented.

## Introduction

*Rhea pennata* d'Orbigny (Aves: Rheidae), the lesser rhea (known locally as 'choique') is a large, flightless and endemic species which inhabits steppes and semi-deserts of Argentine Patagonia and southern Chile (Sales, 2006; Barri *et al.*, 2009). The lesser rhea is probably the dominant herbivore-omnivore component of the fauna of this region (Novaro *et al.*, 2000). The control of parasitic diseases is one of the main concerns in captive breeding of this

bird, as they can be responsible for losses in productivity (Chang Reissig & Robles, 2001).

The identification and characterization of the nematode species affecting rheas is only possible by the examination of adult worms (Ederli & Oliveira, 2014). Most of the studies regarding the parasitic fauna of *R. pennata* are from specimens farmed in captivity (Chang Reissig *et al.*, 2001); the information on wild populations is still scarce. To date, most of the nematodes reported in this bird species were identified from eggs in faeces: *Deletocephalus dimidiatus* Diesing, 1851 (Deletocephalidae), *Trichostrongylus* sp. (Trichostrongylidae), *Heterakis*-like (Heterakidae), Capillariinae gen. et sp., Strongylidae gen. et sp. and Spirurida fam. gen. et sp. (Chang Reissig

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*et al.*, 2001; Martínez-Díaz *et al.*, 2013; Frixione *et al.*, 2014). The exception is the work of Ewing *et al.* (1995), who found *D. dimidiatus* after dissection of a bird.

In this study we describe a new species of *Procyrnea* from the proventriculus of *R. pennata* using light and scanning electron microscopy, and present a key for identification of the species of the genus.

## Materials and methods

Three specimens of lesser rhea were found dead and were collected, dissected and examined for helminths: two chicks, one about 3 months old from Estancia San Pablo, Península Valdés (42°42'52.08"S, 64°12'0.48"W) on February 2014 and another about 5 months old from the intersection of roads 2 and 42 (42°32'26.75"S; 64°47'24.34"W) from the Protected Natural Area Península Valdés on March 2014; and one adult male from Dique Ameghino (43°40'25.94"S; 66°29'24.24"W); all from Chubut province, Argentina.

Nematodes collected from the proventriculus were fixed in 10% formalin and preserved and stored in 70% ethanol. They were later cleared in lactoglycerol for examination under a light microscope (Leica DM2500; Leica, Wetzlar, Germany); drawings were made with the aid of a drawing tube. Measurements (range, followed by mean in parentheses) are given in micrometres (µm), unless otherwise stated (SpL/TBL = left spicule length (SpL) as a proportion of total body length (TBL) in percentage). Photographs of mounted specimens were taken with a Leica DFC280 camera with the software connected to the microscope. Specimens intended for study by scanning electron microscopy (SEM) were dehydrated in ethanol, dried by the critical point technique, coated with gold and examined in a Jeol 6360 LV microscope (Jeol, Tokyo, Japan). The specimens were deposited in the Parasitological Collection (CNP-Par) of the Instituto de Biología de Organismos Marinos (CCT CONICET-CENPAT), Puerto Madryn, Chubut, Argentina and the Helminthological Collection of the Museo de La Plata (MLP-He), La Plata, Buenos Aires province, Argentina.

The key to species was made by collecting all the original descriptions of the species of the genus *Procyrnea* and evaluating which ones are valid at present. We considered 60 valid species (including this new species). Only *P. cameroni* (Gupta & Kazim, 1978) was not included in the key because the original description could not be obtained.

## Results

### *Procyrnea choique* n. sp.

#### Description

The appearance under light microscopy and SEM is shown in *figs 1* and *2*, respectively. Body small with distinct transverse striations (*fig. 2e*). Lip region continuous with body contour, lacking constriction. Lateral alae absent. Labial region consisting of two lateral pseudolabia, and dorsal and ventral labia (*figs 1d* and *2a, e*). Pseudolabia wider distally than at base, narrower in the mid-region; amphids located near base of pseudolabia

(*figs 1d* and *2c*). Lining of the internal border of the pseudolabia thickened on the extremities, forming curved points. Internal middle part of each pseudolabium with a tongue-shaped projection, inserted more posteriorly, bearing three small teeth on its free margin (*figs 1d* and *2b*). Dorsal and ventral labia consisting each of two submedian, rounded lobes and a less salient median process, keel-like, flanked by two small, slit-like depressions. Each labium bearing two double cephalic papillae, submedian, plus a pair of small pores on its anterior border (*figs 1d* and *2b, c*). Buccal capsule slightly compressed laterally on the top. Oesophagus divided into short anterior muscular part and long posterior glandular part. Muscular oesophagus 2.4–3.0% (2.7%) of TBL in male and 2.2–2.6% (2.4%) of TBL in female; glandular oesophagus 32–36% (34%) of TBL in male and 11.4–39.6% (24.3%) of TBL in female. Nerve ring located between deirids and excretory pore. Deirids approximately bifid (*fig. 2d*).

*Male* ( $n=2$ ). Body length 8.25–9.85 mm. Maximum width 350–400. Buccal capsule 30–40 long and 25–30 wide. Muscular oesophagus 200–300 long and 40 wide; glandular oesophagus 2.64–3.56 mm long and 80–120 wide. Nerve ring, excretory pore and deirids 180–200, 250–290 and 140–180, respectively, from anterior end. Posterior end of body ventrally curved. Caudal alae well developed and asymmetrical, left ala 1150–1270 long, right ala 1090–1210 long (*figs 1f, g* and *2f*). Caudal alae with longitudinal striations on ventral surface and transverse striations on dorsal surface. Tail with rounded tip, 260–320 long. Six pairs of symmetrically arranged pedunculate papillae: four pairs preanal and two pairs postanal (*figs 1f, g* and *2f*). Median preloacal papilla not observed. Nine sessile papillae and phasmids located near tail tip, i. e. eight papillae arranged in pairs, of which the second and third pair contacting each other, one single papilla and pair of phasmids (*fig. 1e*). Spicules unequal and dissimilar. Left spicule 0.97–1.05 mm long, with pointed distal end (*figs 1i* and *2f*). Right spicule 300–360 long, with curved and rounded tip, ending in a slight knob-like process (*figs 1h* and *2f*). Ratio of right spicule–left spicule, 1:2.7–3.5. SpL/TBL 9.85–12.73%. Gubernaculum gutter-shaped, ends rounded, with proximal end wider than distal one (*fig. 1h*), 60–80 long and 25–30 wide.

*Female* ( $n=3$ ). Body length 13.4–17.8 mm (15.87 mm). Maximum width 400–600 (500). Buccal capsule 45–50 (47) long and 30–40 (37) wide. Muscular oesophagus 340–460 (387) long and 40–55 (47) wide; glandular oesophagus 1.87–5.30 mm (3.70 mm) long and 70–80 (75) wide. Nerve ring, excretory pore and deirids 250–330 (282), 350–550 (443) and 170–230 (195), respectively, from anterior end (*fig. 1a*). Didelphic. Vulva opening ventrally (*fig. 1b*), post-equatorial, 6.2–7.1 mm (6.70 mm) or 38.0–46.0% (42.3%) of TBL, from posterior end. Tail short and rounded, 80–100 (88) long (*fig. 1c*). Eggs ellipsoidal, thick shelled, embryonated (*fig. 1b*), 50.0–55.0 (51.7) long, 30.0–35.0 (31.7) wide.

#### Taxonomic summary

*Type host.* *Rhea pennata* d'Orbigny, 1834 (Aves: Rheiformes: Rheidae).

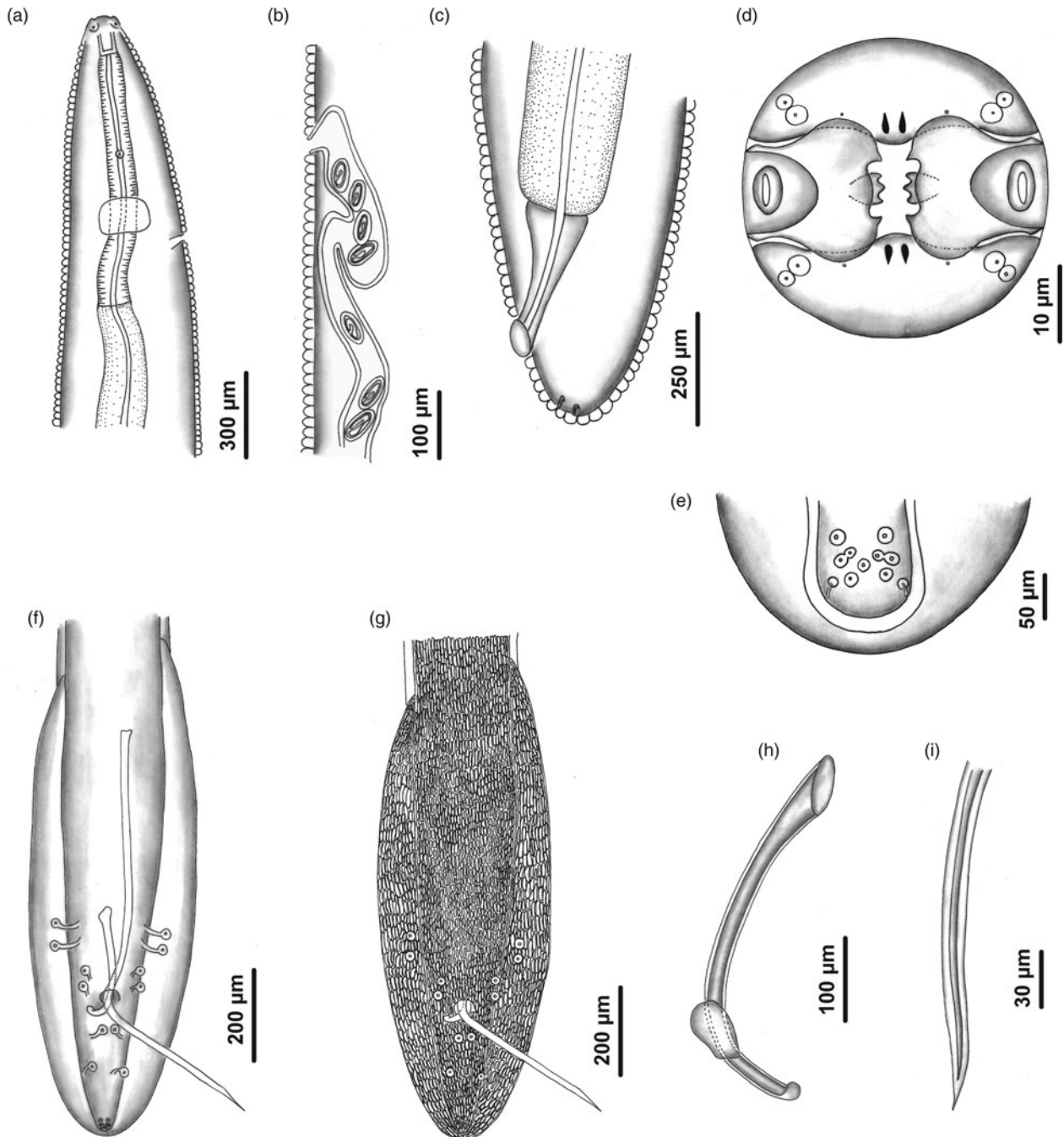


Fig. 1. Drawings of *Procyrnea choique* n. sp. (Nematoda: Habronematidae) in a lesser rhea from the Protected Natural Area Península Valdés, Argentina. Scale values are given beside each bar. (a) Anterior end of female, lateral view; (b) vulvar region of female, lateral view; (c) posterior end of female, details of anus and phasmids, lateral view; (d) anterior end of female, apical view; (e) posterior end of male, details of caudal sessile papillae and phasmids; (f) posterior end of male, details of caudal alae, internal and ventral view; (g) posterior end of male, details of caudal alae, ornamented cuticle, superficial and ventral view; (h) right spicule and gubernaculum, lateral view; (i) distal end of left spicule.

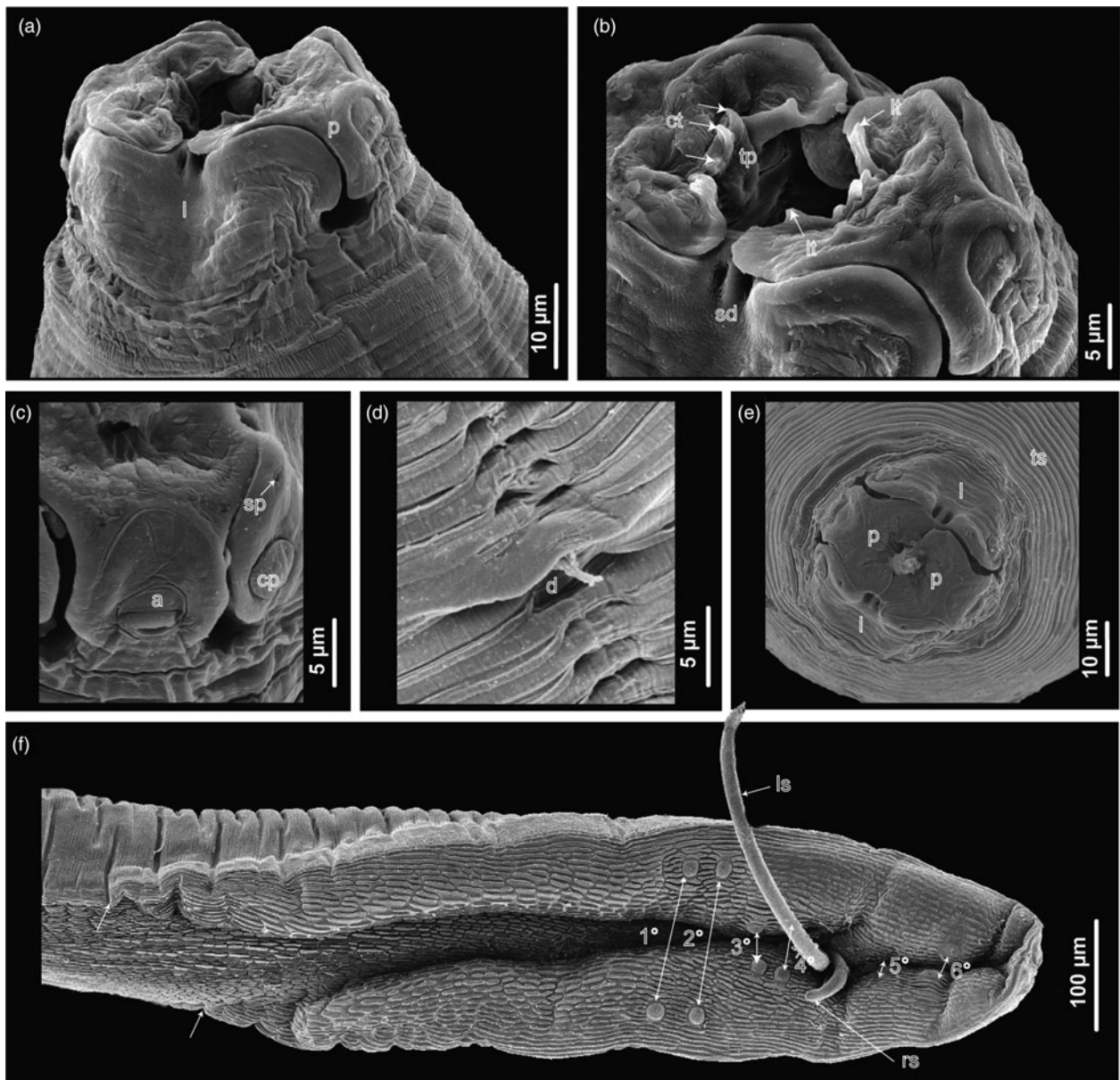


Fig. 2. Scanning electron micrographs of *Procyrnea choique* n. sp. (Nematoda: Habronematidae) in a lesser rhea from the Protected Natural Area Península Valdés, Argentina. Scale values are given beside each bar. (a) Cephalic end of female, view of a labium and a pseudolabium, subapical view; (b) cephalic end of female, details of internal tongue-shaped projection with three sharp teeth (central teeth of pseudolabia) and two lateral teeth, subapical view; (c) detail of amphid in pseudolabium, lateral view; (d) detail of deirid, approximately bifid, median-lateral view; (e) cephalic end of male and transverse striations of cuticle, apical view; (f) posterior end of male, details of asymmetrical caudal alae (arrows), prelocaal and postlocaal papillae and spicules, latero-ventral view. Abbreviations: a, amphid; cp, cephalic papilla; ct, central teeth; d, deirid; l, labium; ls, left spicule; lt, lateral teeth; p, pseudolabium; rs, right spicule; sd, slit-like depressions; sp, small pore; tp, tongue-shaped projection; ts, transverse striations. The numeration (e.g. 1°) indicates the pairs of papillae of the male (double arrows).

*Type locality.* Protected Natural Area Península Valdés (42°32'26.75"S; 64°47'24.34"W), Chubut province, Argentina.

*Site of infection.* Proventriculus.

*Prevalence and intensity of infection.* One out of three birds infected with two males and three females.

*Type specimens.* Holotype male, CNP-Par 144/1; allotype female, CNP-Par 144/2; paratype female, CNP-Par 144/3; paratype male and paratype female, MLP-He 7363 (mounted for SEM).

*Etymology.* The specific epithet refers to the host common name, 'choique'; the aboriginal name in the Araucanian language.

### Remarks

The genus *Procyrnea* was proposed by Chabaud (1958) initially as a subgenus of *Cyrnea* and later raised to the generic rank by Chabaud (1975). Chabaud (1958) proposed the name *Procyrnea* for those species having the lateral teeth inserted near the anterior border of the pseudolabia and the deirids located anteriorly to the nerve ring. Also, the specimens belonging to *Procyrnea* have cloacal papillae with the usual disposition of spirurid species, with four pairs of pedunculate preanal papillae, a single preanal papilla, two pairs of pedunculate postanal papillae and a terminal group composed of four pairs of sessile papillae and a pair of phasmids (Chabaud, 1958). At present, 59 nominal species of *Procyrnea* have been described, all from avian hosts, most in Falconiformes and Strigiformes, and, to a much lesser degree, parasitizing Piciformes, Passeriformes, Tinamiformes and Rheiformes (e.g. Walton, 1927; Maplestone, 1932; Freitas & Lent, 1947; Ali, 1961; Mawson, 1968; Gupta & Kumar, 1980; Zhang, 1991; Pinto *et al.*, 1996; Cheng & Ye, 2000; Zhang *et al.*, 2004, 2009, 2011; Eduardo & Villa, 2011).

*Procyrnea choique* n. sp. shares the lack of lateral alae with *P. fischeuri* (Seurat, 1916), *P. murrayi* (Ortlepp, 1934), *P. excisiformis* (Yamaguti, 1935), *P. ameerae* (Ali, 1961), *P. ruschii* (Freitas, 1967), *P. dollfusi* Mawson, 1968, *P. aptera* (Wang, 1976), *P. haliasturi* (Gupta & Kumar, 1980), *P. ornata* Cheng & Ye, 2000, *P. brevicaudata* Zhang, Brooks & Causey, 2004 and *P. javaensis* Zhang, Dewi & Purwaningsih, 2009. However, it differs from *P. fischeuri*, *P. murrayi*, *P. excisiformis* and *P. dollfusi* by having the left spicule with a pointed tip, instead of a barbed tip (single-barbed in *P. murrayi* and *P. dollfusi*, double-barbed in *P. fischeuri* and *P. excisiformis*), and by lacking the single preanal papilla. It differs from *P. brevicaudata* by the absence of lateral ridges on the left side of the body, from *P. ameerae* and *P. ornata* by having asymmetrical, instead of symmetrical, caudal alae and from *P. haliasturi* by having a postequatorial vulva. It also differs from *P. aptera*, *P. ruschii* and *P. javaensis* by having a shorter left spicule ( $\approx 1$  mm vs.  $\geq 1.2$  mm) and a SpL/TBL of about 9–12% vs. 15–18%.

Other species of *Procyrnea* whose original descriptions are not clear with respect to the presence of lateral alae are *P. aegotheles* Johnston & Mawson, 1941, *P. spiralis* Mawson, 1968, *P. anteroovulvata* Pinto, Vicente & Noronha, 1996, *P. graculae* Eduardo & Villa, 2011, *P. uncinipenis* (Molin, 1860) and *P. waltoni* (Freitas & Lent, 1947). In any case, these species can be differentiated from *P. choique* n. sp. *Procyrnea aegotheles* is characterized by having ten precloacal papillae (six on the left, four on the right) and a SpL/TBL ratio of 28%, whereas *P. graculae* is characterized by having pre- and post-cloacal papillae strongly unpaired, the lack of a gubernaculum, and a female with a markedly pre-equatorial vulva. This latter character is shared with *P. anteroovulvata*. *Procyrnea spiralis* has much shorter spicules (left spicule 215–290  $\mu$ m, right spicule 70–75  $\mu$ m) and a SpL/TBL ratio of 4.5–5.3% versus 9.8–12.7% in *P. choique* n. sp. *Procyrnea uncinipenis* and *P. waltoni* have both been described from the greater rhea, *Rhea americana*, and have been confused with each other several times (Freitas & Lent, 1947; Chabaud, 1958). Both species were described as having denticulated pseudolabia. Paired lateral alae are apparently absent in *P. uncinipenis*, although specimens assigned to *P. waltoni*

were referred to as having a single, short cervical ala on the left side (Walton, 1927; Freitas & Lent, 1947). Another remarkable difference between *P. waltoni* and the new species is the spicule ratio, which in *P. waltoni* is about 1:8. Other differences between *P. uncinipenis* and the new species, besides the denticulation on the pseudolabia, lie in the body size (male size is 8.25–9.85 mm in *P. choique* n. sp. vs. 17.75–21.77 mm in *P. uncinipenis*), spicule size (SpL = 0.97–1.05 mm in *P. choique* n. sp. vs. 3–3.7 mm in *P. uncinipenis*), spicular ratio (1:3–4 in *P. choique* n. sp. vs. 1:5 in *P. uncinipenis*) and in the presence of the single preanal papilla (absent in *P. choique* n. sp. vs. present in *P. uncinipenis*) (Freitas & Lent, 1947).

### Discussion

Our results extend the taxonomy of *Procyrnea* Chabaud, 1958 and comprise the first report of a habronematid nematode from *R. pennata*. Frixione *et al.* (2014) did not find eggs of this nematode in the faeces of adults/sub-adults and chicks from the same study area. This is possibly due to the fact that eggs of *Procyrnea* and related genera are hard to find by standard techniques of faecal examination. Besides, ratites are relatively disease-resistant birds after the third month of age (Ederli & Oliveira, 2014). Habronematids are quite pathogenic in birds; being a possible cause of mortality in chicks. Despite parasitism being the major cause of the limited success in captive breeding of these birds, there are few studies concerning the parasites of rheas (Ederli & Oliveira, 2014).

The key presented below includes 60 species of *Procyrnea* Chabaud, 1958. The previous key of this genus was published in the 1960s by Ali (1961); therefore, the contribution of this key, which includes all the information collected from papers from 1819 to the present time, will be useful for future research, helping with the taxonomic identification of species of *Procyrnea*.

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Key to species of *Procyrnea* Chabaud, 1958

- 1 Body without lateral alae ..... 2
- 1' Body with one or two lateral alae ..... 18
- 2 Left spicule with barbed tip ..... 3
- 2' Left spicules with pointed tip, without barbs ..... 6
- 3 Left spicule with double barbed tip ..... 4
- 3' Left spicule with single barbed tip ..... 5
- 4 Male 8.4 mm., left spicule 1.27 mm, right spicule 350  $\mu\text{m}$ . Parasites of Ardeidae from Asia, Europe and Africa ..... *Procyrnea fischeuri* (Seurat, 1916)
- 4' Male 7.4–9.3 mm, left spicule 1–1.2 mm, right spicule 333–408  $\mu\text{m}$ . Parasites of Strigidae from China and Japan ..... *Procyrnea excisiformis* (Yamaguti, 1935)
- 5 Cuticle with coarse annulations giving a serrated appearance to the body margins, preloacal papillae 4 pairs or more, left spicule 0.88–0.90 mm. Parasites of *Tyto alba* (Scopoli, 1769) (Tytonidae) from Africa ..... *Procyrnea murrayi* (Ortlepp, 1934)
- 5' Cuticle with fine annulations, preloacal papillae 4 pairs, left spicule 1.35 mm. Parasites of Strigidae from Australia ..... *Procyrnea dollfusi* (Mawson, 1968)
- 6 Females with vulva pre-equatorial ..... 7
- 6' Females with vulva postequatorial ..... 9
- 7 Vulva slightly pre-equatorial (c. 45% of TBL). Spicule ratio 1:3. Parasites of Accipitridae from India ..... *Procyrnea haliasturi* (Gupta & Kumar, 1980)
- 7' Vulva strongly pre-equatorial (c. 14–16% of TBL) ..... 8
- 8 Spicule ratio 1:6.5. Parasites of Bucconidae from Brazil ..... *Procyrnea anterovulvata* Pinto, Vicente & Noronha, 1996
- 8' Spicule ratio 1:3–4. Parasites of Sturnidae from Philippines ..... *Procyrnea graculae* Eduardo & Villa, 2011
- 9 Presence of two ridges longitudinal striated on the left side of the body, extending from level of deirid to posterior end of body. Parasites of Tinamidae from Costa Rica ..... *Procyrnea brevicaudata* Zhang, Brooks & Causey, 2004
- 9' Striated lateral ridges absent ..... 10
- 10 Median preloacal papilla present ..... 11
- 10' Median preloacal papilla absent ..... 12
- 11 Pseudolabia bearing small denticles. Male 17.75–21.77 mm long, left spicule 3–3.7 mm, spicule ratio 1:5. Parasites of Rheiidae from Brazil ..... *Procyrnea uncinipenis* (Molin, 1860)
- 11' Pseudolabia lacking small denticles. Male 7.44–8.1 mm long, left spicule 1.35–1.63 mm, spicule ratio 1:4. Parasites of Strigidae from Indonesia ..... *Procyrnea javaensis* Zhang, Dewi & Purwaningsih, 2009
- 12 Caudal alae symmetrical ..... 13
- 12' Caudal alae asymmetrical ..... 14
- 13 Male 4.5–5.3 mm long, left spicule 0.78–0.89 mm, SpL/TBL = 17%. Parasites of Falconidae from India ..... *Procyrnea amerae* (Ali, 1961)
- 13' Male 8.61–8.84 mm long, left spicule 0.77–0.78 mm, SpL/TBL = 8.9%. Parasites of Leiothrichidae from China ..... *Procyrnea ornata* (Cheng & Ye, 2000)
- 14 Males less than 6.0 mm long ..... 15
- 14' Males more than 6.0 mm long ..... 16
- 15 Male 2.5 mm, left spicule 0.7 mm, SpL/TBL = 28%, spicule ratio 1:4. Parasites of *Aegotheles cristatus* (Shaw, 1790) (Aegothelidae) from Australia ..... *Procyrnea aegotheles* (Johnston & Mawson, 1941)
- 15' Male 4.7–5.4 mm., left spicule 0.22–0.29 mm, SpL/TBL = 4.68%. Parasites of Meliphagidae, Oriolidae and Campephagidae from Australia ..... *Procyrnea spiralis* (Mawson, 1968)
- 16 Left spicule 1 mm long. Spicule ratio 1:3. Parasites of *Rhea pennata* d'Orbigny from Argentina ..... *Procyrnea choique* n. sp.
- 16' Left spicule >1 mm long ..... 17
- 17 Left spicule 1.20 mm, spicule ratio 1:2.42. Parasites of Strigidae from China ..... *Procyrnea aptera* (Wang, 1976)

17'	Left spicule 1.47–1.60 mm, spicule ratio 1:3.1–3.6. Parasites of Apodiformes (Trochilidae) from Brazil <i>Procyrnea ruschii</i> (Freitas, 1967)	
18	Body with one lateral ala .....	19
18'	Body with two lateral alae .....	38
19	Left spicule with barbed tip .....	20
19'	Left spicules with pointed tip, without barbs .....	23
20	Left spicule with single barbed tip .....	21
20'	Left spicule with double barbed tip .....	22
21	Cuticle with coarse annulations giving a imbricated appearance to the body margins, preanal papillae 4 pairs or more, median precloacal papilla present, left spicule 1.86–1.90 mm. Parasites of Accipitridae and Falconidae from Africa and Asia .....	<i>Procyrnea monoptera</i> (Gendre, 1922)
21'	Cuticle with fine annulations, preanal papillae 4 pairs, median postcloacal papilla absent, left spicule 1.1 mm. Parasites of Strigidae from China .....	<i>Procyrnea sinica</i> Zhang, Song & Zhang, 2011
22	Male 5.47–6.86 mm, left spicule 1.22–1.37 mm, right spicule 340–410 $\mu$ m. Parasites of Accipitridae and Falconidae from Asia, Europe and South America (Chile) .....	<i>Procyrnea spinosa</i> (Gendre, 1923)
22'	Male 7.2–11.1 mm, left spicule 1.4–2.5 mm, right spicule 400–430 $\mu$ m. Parasites of Falconidae from Australia .....	<i>Procyrnea falco</i> (Mawson, 1968)
23	Pseudolabia with small denticles. Male 20 mm long, left spicule 2.4–2.65 mm, spicule ratio 1:8. Parasites of <i>Rhea americana</i> (Linnaeus, 1758) (Rheidae) from Brazil .....	<i>Procyrnea waltoni</i> (Freitas & Lent, 1947)
23'	Pseudolabia lacking small denticles .....	24
24	Male <10 mm .....	25
24'	Male $\geq$ 10 mm .....	31
25	Caudal alae symmetrical .....	26
25'	Caudal alae asymmetrical .....	29
26	Pseudolabia with teeth, median precloacal papilla absent, male 8.3 mm long. Parasites of Strigidae from India and China .....	<i>Procyrnea imbricata</i> (Maplestone, 1930)
26'	Pseudolabia lacking teeth .....	27
27	Females with vulva pre-equatorial or slightly equatorial, male 6.6 mm long, spicule ratio 1:8. Parasites of Falconidae from Democratic Republic of Congo .....	<i>Procyrnea skrjabini</i> (Vuylsteke, 1953)
27'	Females with vulva postequatorial .....	28
28	Lateral ala moderately wide, male 7–9 mm long. Parasites <i>Ramphastos vitellinus</i> Lichtenstein, 1823 (Rhamphastidae) from Brazil .....	<i>Procyrnea unilateralis</i> (Molin, 1860)
28'	Lateral ala narrow, on the anterior fourth of the body, male 7.5–8.2 mm long. Parasites of Picidae and Rhamphastidae from United States and Brazil .....	<i>Procyrnea pileata</i> (Walton, 1927)
29	Left spicule $\leq$ 0.65 mm, SpL/TBL = 8.67%, asymmetrical and double papillae of caudal end of male. Parasites of <i>Circus macrourus</i> Gmelin, 1770 (Accipitridae) from India .....	<i>Procyrnea asymmetrica</i> (Maplestone, 1932)
29'	Left spicule >0.65 mm .....	30
30	Pseudolabia with teeth, male 8–8.9 mm long, left spicule 0.99–1.21 mm, SpL/TBL = 12.38%. Parasites of Columbidae from India .....	<i>Procyrnea daleri</i> (Ali, 1961)
30'	Pseudolabia lacking teeth, male 9 mm long, left spicule 1.78 mm, SpL/TBL = 19.56%. Parasites of Accipitridae from India .....	<i>Procyrnea magnilabiata</i> (Maplestone, 1932)
31	Left spicule $\leq$ 1.5 mm long .....	32
31'	Left spicule >1.5 mm long .....	35
32	Four median precloacal papillae, SpL/TBL = 7.59%. Parasites of <i>Centrocercus urophasianus</i> (Bonaparte, 1827) (Phasianidae) from United States .....	<i>Procyrnea urophasiana</i> (Wher, 1931)
32'	Fewer than 4 median precloacal papillae or absent .....	33
33	One median precloacal papilla, male 10.2–12.9 mm long. Parasites of Accipitridae from India .....	<i>Procyrnea singhi</i> (Ali, 1961)
33'	Two median precloacal papillae .....	34

- 34 Caudal alae symmetrical, 6 caudal sessile papillae. Parasites of Falconidae from India ..... *Procyrnea suraiyae* (Ali, 1961)
- 34' Caudal alae asymmetrical, 8 caudal sessile papillae. Parasites of Strigidae from India ..... *Procyrnea vinodi* (Gupta & Kumar, 1980)
- 35 Caudal alae symmetrical ..... 36
- 35' Caudal alae asymmetrical ..... 37
- 36 Six sessile caudal papillae. Parasites of Accipitridae of genus *Neophron* from Asia and Africa ..... *Procyrnea tulostoma* (Hemprich & Ehrenberg, 1866)
- 36' Eight sessile caudal papillae. Parasites of Falconidae from India ..... *Procyrnea chabaudi* (Ali, 1961)
- 37 Male 13.65 mm long, left spicule 1.81 mm long, spicule ratio 1:5. Parasites of Strigidae from India ... *Procyrnea fotedari* (Gupta & Kumar, 1980)
- 37' Male 14.4–17.4 mm long, left spicule 1.81–2.15 mm long, spicule ratio 1:3. Parasites of Strigidae from India ..... *Procyrnea rauschi* (Gupta & Kumar, 1980)
- 38 Lateral alae symmetrical ..... 39
- 38' Lateral alae asymmetrical ..... 52
- 39 Left spicule with barbed tip ..... 40
- 39' Left spicules with pointed tip, without barbs ..... 44
- 40 Left spicule with single barbed tip ..... 41
- 40' Left spicule with double barbed tip ..... 42
- 41 Left spicule 2.1 mm, right spicule 0.45 mm, spicule ratio 1:5. Parasites of Falconidae of genus *Falco* from Asia (Siberia) and Africa ..... *Procyrnea seurati* (Skrjabini, 1917)
- 41' Left spicule 3.24 mm, right spicule 1.08 mm, spicule ratio 1:3. Parasites of *Strix nebulosa* Forster, 1772 (Strigidae) from United States ..... *Procyrnea longispiculata* (Walton, 1927)
- 42 Pseudolabia with  $\leq 3$  teeth ..... 43
- 42' Pseudolabia with 3 teeth, male 10.24–12.42 mm long. Parasites of Trochilidae from Costa Rica ..... *Procyrnea mcLennanae* Zhang, Brooks & Causey, 2004
- 43 Caudal alae symmetrical, male 8.18–10.59 mm long. Parasites of Nestoridae from New Zealand ..... *Procyrnea kea* Clark, 1978
- 43' Caudal alae asymmetrical, male 7.21–10.69 mm long. Parasites of Accipitridae from Costa Rica ..... *Procyrnea mawsonae* Zhang, Brooks & Causey, 2004
- 44 Median preloacal papillae absent, male 7.1 mm long; SpL/TBL 9%; spicule ratio 1:3. Parasites of families Accipitridae, Falconidae, Icteridae, Phasianidae, Tytonidae and Strigidae from Europe, Asia, Africa and South America (Brazil, Chile) ..... *Procyrnea leptoptera* (Rudolphi, 1819)
- 44' Median preloacal papillae present ..... 45
- 45 One median preloacal papillae ..... 46
- 45' Two median preloacal papillae ..... 49
- 46 Caudal alae symmetrical ..... 47
- 46' Caudal alae asymmetrical ..... 48
- 47 Female with vulva pre-equatorial, 11 sessile caudal papillae, male 17.4–19.1 mm, spicule ratio 1:4. Parasites of Strigidae from Asia (Turkmenistán) ..... *Procyrnea zorillae* (Seurat, 1919)
- 47' Female with vulva postequatorial, 6 sessile caudal papillae, male <10 mm, spicule ratio 1:3. Parasites of Falconidae from Australia ..... *Procyrnea paraleptoptera* (Johnston & Mawson, 1941)
- 48 Ten caudal sessile papillae, male 10–15 mm long, spicule ratio 1:5. Parasites of Picidae from United States and Brazil ..... *Procyrnea colaptes* (Walton, 1927)
- 48' Eight caudal sessile papillae, male 6.72–8.64 mm long, spicule ratio 1:3. Parasites of Accipitridae from China ..... *Procyrnea striolata* (Zhang, 1991)
- 49 Pseudolabia with 3 teeth ..... 50
- 49' Pseudolabia without teeth, male 8.8 mm long, left spicule 1.7 mm, SpL/TBL 19.32%. Parasites of *Acryllium vulturinum* Hardwicke, 1834 (Numididae) from India ..... *Procyrnea diesingi* (Maplestone, 1932)
- 50 Six caudal sessile papillae, male 6–9 mm long, 2 median preloacal papillae. Parasites of Picidae of genera *Celeus* and *Colaptes* from South America (Brazil) ..... *Procyrnea longistriata* (Molin, 1859)



- 50' Eight caudal sessile papillae ..... 51
- 51 Left spicule 1.2–1.6 mm long, spicule ratio 1:4. Parasites of Sturnidae from India .....  
..... *Procyrnea hyderabadensis* (Ali, 1961)
- 51' Left spicule 1.43–1.82 mm long, spicule ratio 1:3. Parasites of Accipitridae from India .....  
..... *Procyrnea hrishii* (Agrawal, 1965)
- 52 Median precloacal papillae present ..... 53
- 52' Median precloacal papillae absent ..... 57
- 53 Pseudolabia with 3 teeth ..... 54
- 53' Pseudolabia with 4 teeth, male 5.5–10.1 mm, left spicule 0.55–0.63 mm, right spicule 200–210  $\mu$ m.  
Parasites of Falconidae, Accipitridae and Picidae from Asia, Australia, Europe and Brazil .....  
..... *Procyrnea mansioni* (Seurat, 1914)
- 54 Male  $\leq$ 12 mm long ..... 55
- 54' Male >12 mm long, left spicule 6.3 mm, right spicule 600  $\mu$ m. Parasites of Accipitridae from Africa...  
..... *Procyrnea dolichocolpos* (Chabaud & Brygoo, 1958)
- 55 Caudal alae symmetrical, male 8.1–11.8. Parasites of Accipitridae from China .....  
..... *Procyrnea beveridgei* Zhang, Song & Zhang, 2011
- 55' Caudal alae asymmetrical ..... 56
- 56 Female with vulva pre-equatorial (33%), male 8–12 mm long. Parasites of Psittaculidae, Ardeidae and  
Odontophoridae from United States ..... *Procyrnea incerta* (Smith, 1908)
- 56' Female with vulva slightly pre-equatorial (49%), male 7.9–8 mm long. Parasites of *Eupodotis afroides*  
(Smith, 1831) (Otididae) from Africa ..... *Procyrnea buckleyi* (Bisseru, 1955)
- 57 Two pedunculate postcloacal papillae, left spicule 0.725–0.750 mm, right spicule 225–250  $\mu$ m. Parasites  
of *Buteo platypterus* (Vieillot, 1823) (Accipitridae) from United States .....  
..... *Procyrnea americana* (Chandler, 1941)
- 57' Four pedunculate postcloacal papillae ..... 58
- 58 Twelve caudal sessile papillae, male 10.2–12.2 mm long. Parasites of Accipitridae from India .....  
..... *Procyrnea magnipapillata* (Ali, 1961)
- 58' Eight caudal sessile papillae ..... 59
- 59 Caudal alae symmetrical, male 9.1–9.9 mm long, left spicule 0.91–0.98 mm, right spicule 320–360  $\mu$ m.  
Parasites of Accipitridae from India ..... *Procyrnea waheedae* (Ali, 1961)
- 59' Caudal alae asymmetrical, male 5.8–7.8 mm long, left spicule 0.87–1.00 mm, right spicule 320–370  $\mu$ m.  
Parasites of Zosteropidae and Fringillidae from Hawaii .....  
..... *Procyrnea longialatus* Cid del Prado, Maggenti & van Riper, 1985

### Conflict of interest

None.

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