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A NEW SPECIES OF NEOTROPICAL FRESHWATER STINGRAY OF THE GENUS *POTAMOTRYGON* GARMAN, 1877 FROM THE RÍO MADRE DE DÍOS, PERU (CHONDRICHTHYES: POTAMOTRYGONIDAE)

JOÃO PAULO C.B. DA SILVA^{1,2}
MARCELO R. DE CARVALHO^{1,3}

ABSTRACT

Potamotrygon tatiana sp. nov., is described from Río Madre de Díos, Peru, upper Rio Madeira basin. The new species is distinguished from all congeners by a unique combination of characters, including its dorsal color pattern formed by a relatively slender, highly convoluted, beige to dark brown vermicular pattern, a single row of dorsal tail spines, and a relatively longer tail posterior to caudal stings. *Potamotrygon tatiana* sp. nov., occurs sympatrically with other species of *Potamotrygon* (*P. falkneri*, *P. orbignyi* and *P. motoro*). From the similar species *P. falkneri*, *P. tatiana* sp. nov., is further distinguished by the absence of circular, reniform, and oval spots, by its proportionally much longer tail, by having dorsal tail spines in one irregular row, and by features of the ventral lateral-line canal, dermal denticles and neurocranium. From *P. orbignyi*, the new species is distinct by lacking a reticulate pattern on dorsal disc and by the presence of two angular cartilages. From *P. motoro*, *P. tatiana* sp. nov., is further separated by the lack of ocelli formed by strong black concentric rings, by the more flattened aspect of its head and disc, and by having smaller and more numerous teeth. The discovery of a new species that so closely resembles a congeneric form in color pattern, a feature highly variable within the latter, highlights the importance of examining large series of individuals and of detailed morphological analyses in revealing the potentially highly cryptic nature of the diversity within the family.

KEY-WORDS: *Potamotrygon tatiana* sp. nov.; *Potamotrygon falkneri*; Taxonomy; Morphology; Cryptic species; Río Madeira; South America.

INTRODUCTION

Species of *Potamotrygonidae* Garman, 1913 are well known members of the Neotropical fish fauna,

but perhaps more notoriously from the injuries they may accidentally cause than from their unique biological properties or intriguing evolutionary history. Unlike any other living family of rays, *potamotrygonids*

1. Departamento de Zoologia, Instituto de Biociências, Universidade de São Paulo. Rua do Matão, Travessa 14, nº 101, CEP 05508-900, São Paulo, SP, Brasil.

2. E-mail: jpcbs@ib.usp.br

3. E-mail: mrcarvalho@ib.usp.br

diversified in the (South American) freshwater environment (Thorson *et al.*, 1983; Lovejoy, 1996; Lovejoy *et al.*, 1998; Carvalho *et al.*, 2003, 2004). Four potamotrygonid genera are currently recognized: *Paratrygon* Duméril, 1865, *Potamotrygon* Garman, 1877, *Plesiotrygon* Rosa, Castello & Thorson, 1987 (Rosa *et al.*, 1987; Carvalho *et al.*, 2003) and the recently described *Heliotrygon* (Carvalho & Lovejoy, 2011). *Potamotrygon* is the most diverse genus with approximately 20 valid species (Carvalho *et al.*, 2003; Rosa *et al.*, 2008).

The present paper describes and compares with congeners a new species of *Potamotrygon* from Río Madre de Dios, Peru. This species was discovered during the preparation of a taxonomic revision of *Potamotrygon falkneri* Castex & Maciel, 1963, in which it was presented as *Potamotrygon* sp. (Silva & Carvalho, 2011). However, after a thorough morphological analysis of this form (more in-depth than in Silva & Carvalho, 2011), and a re-examination of material of *Potamotrygon falkneri*, it became evident that *Potamotrygon* sp. represents a new species, described here as *Potamotrygon tatianae* sp. nov. Although this new species has a color pattern that resembles *P. falkneri*, and overlaps in many morphological characters, it represents the only group of specimens that could not be placed among the limits of variation found within *P. falkneri*. Characters that separate the new species from *P. falkneri* were found in its distinct dermal denticles, ventral lateral-line canal system, neurocranial morphology, proportions of its tail, and conspicuous color pattern. The discovery of this new species demonstrates that much of the diversity within the family may be highly cryptic, requiring the examination of large series of specimens.

MATERIAL AND METHODS

Measurements of specimens were modified from Bigelow & Schroeder (1953) and Rosa (1985), and are listed and further described in Carvalho & Lovejoy (2011) and Silva & Carvalho (2011). Measurements were transformed into percentages of disc width (% DW) to allow direct comparisons.

Counts are according to Compagno & Roberts (1982) and Rosa (1985), excluding lower median teeth, mid-dorsal spines, and caudal vertebrae to base of sting, which were not recorded. Skeletal structures were studied from dissected and radiographed specimens; anatomical structures were subsequently preserved in ethanol (70%). Photographs were taken with a high-resolution digital camera, and illustrations were done employing a stereomicroscope

equipped with a camera lucida attachment. X-ray radiographs were taken on Kodak mammography film (Min-R2000). Terminology for skeletal structures follows Nishida (1990) and Carvalho *et al.* (2004), for dermal denticles Deynat & Séret (1996), for internal and external clasper components Taniuchi & Ishihara (1990), for dentition Compagno (1973), and for lateral-line canals Garman (1888), Ewart & Mitchell (1892), and Chu & Wen (1979).

Material examined is from Academy of Natural Sciences of Philadelphia, Philadelphia (ANSP), Field Museum of Natural History, Chicago (FMNH); Natural History Museum of Los Angeles County, Los Angeles (LACM); Museu de Zoologia da Universidade de São Paulo, São Paulo (MZUSP); and Museum of Zoology, University of Michigan, Ann Arbor (UMMZ). Abbreviations used throughout the text include DL for disc length, DW for disc width and TL for total length.

RESULTS

Family Potamotrygonidae Garman, 1913

Genus *Potamotrygon* Garman, 1877

Potamotrygon tatianae, sp. nov.

(Figures 1-12, Tables 1-2)

Potamotrygon sp: Silva & Carvalho, 2011: 209, 212, 223, 224, 227, 228, figs. 12-13 (redescription of *Potamotrygon falkneri*).

Holotype

MZUSP 107673 (adult male, 348 mm DW), Río Madre de Dios, municipal district of Boca Manu, upper Amazon basin, state of Madre de Dios, Peru, 12°40'S, 71°04'06"W, May 2001, coll. F.B. Reyda (Figure 1).

Paratypes

MZUSP 107667 (adult male, 362 mm DW), Río Madre de Dios, municipal district of Boca Manu, upper Amazon basin, state of Madre de Dios, Peru, 12°40'S, 71°04'06"W, May 2001, coll. F.B. Reyda (Figure 2); MZUSP 107668 (PREADULT ?female, 265 mm DW), same data as MZUSP 107667 (Figure 3).

Non type material

MZUSP 107669 (adult male, 293 mm DW), Río Madre de Dios, municipal district of Boca Manu,

upper Amazon basin, state of Madre de D os, Peru, 12 40'S, 71 04'06"W, May 2001, coll. F.B. Reyda; MZUSP 107670 (adult male, 300 mm DW), same data as MZUSP 107669; MZUSP 107671 (adult male, 351 mm DW), same data as MZUSP 107669; MZUSP 107672 (preadult? male, 291 mm DW), same data as MZUSP 107669.

Diagnosis

A species of *Potamotrygon* distinguished from congeners by the following unique combination of characters: dorsal disc with dark background, with a beige or light brown, closely packed and highly convoluted vermicular pattern; a single row of irregular

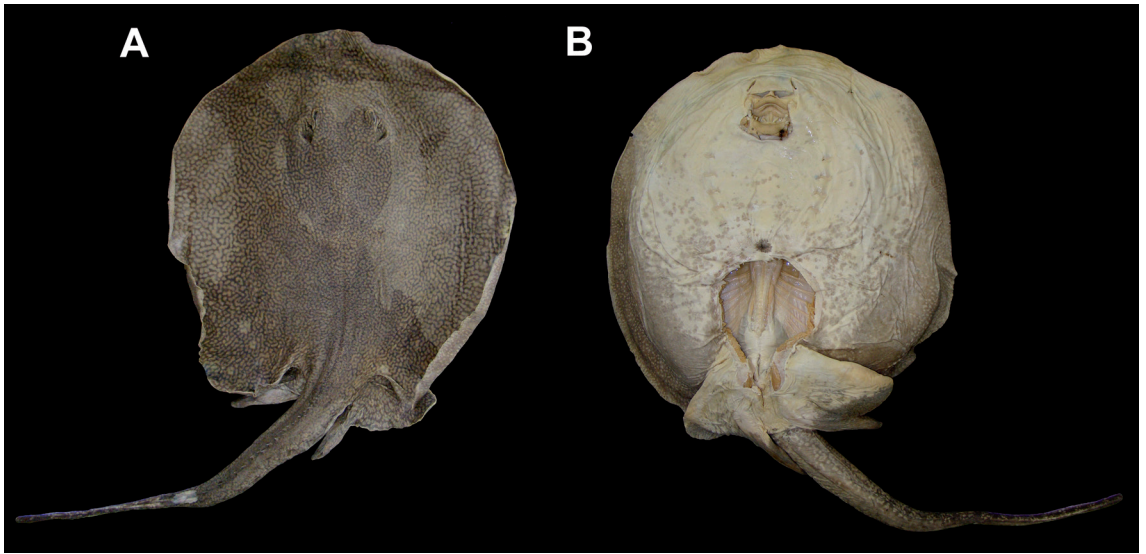


FIGURE 1: Holotype of *Potamotrygon tatianae* sp. nov. (MZUSP 107673, male, 348 mm DW) in dorsal (A) and ventral (B) views (R o Madre de D os, Peru).

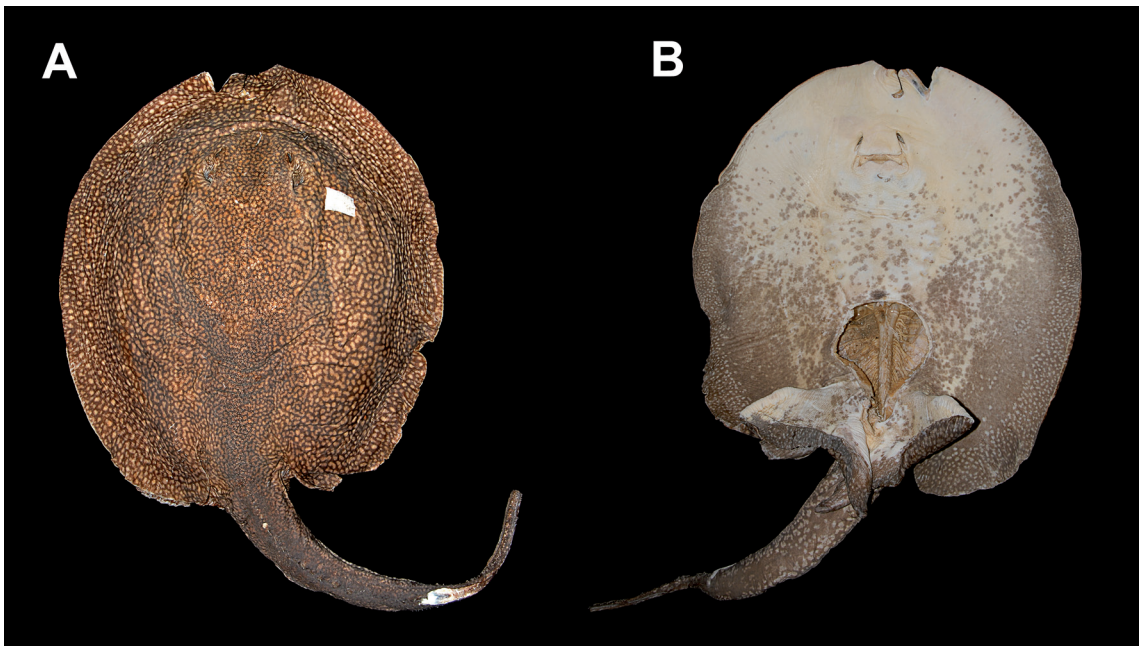


FIGURE 2: Paratype of *Potamotrygon tatianae* sp. nov. (MZUSP 107667, male, 362 mm DW) in dorsal (A) and ventral (B) views (R o Madre de D os, Peru).

spines on dorsal tail midline; and presence of star-shaped, asymmetrical and minute dermal denticles, rarely with crown dichotomies, and concentrated over central region of disc. In relation to species of *Potamotrygon* in the upper Río Madeira basin, *P. tatianae* sp. nov., is further distinguished from *P. motoro* (Müller & Henle, 1841) by lacking on disc ocelli formed by strong black concentric rings, by the more flattened aspect of its disc, by presenting much smaller dermal denticles, and considerably smaller eyes. From *P. orbignyi* (Castelnau, 1855), *P. tatianae* sp. nov., is further distinguished by lacking a dorsal reticulate pattern, presence of two angular cartilages, and lower number of total pectoral radials (modal values 97 *vs.* 90, respectively). *Potamotrygon tatianae* sp. nov., is distinguished from *P. falkneri* by having tail spines in one irregular row (instead of in one to three irregular rows), lower total pectoral radial count (90-93 *vs.* 94-100, respectively), by presenting a proportionally much longer tail (mean values 109% *vs.* 93.5% of DW, respectively), by presenting teeth with no prominent cusps in adult males (males usually with

prominent cusps in *P. falkneri*), and by presenting spots on dorsal disc that are exclusively vermicular, not occurring as independent spots (many specimens with individual spots on background, these mostly circular, reniform, or oval, with diameter equal to or smaller than eye in *P. falkneri*).

Description

Morphometric and meristic data are presented in Tables 1 and 2.

External morphology: Disc oval, longer than wide (DL varying from 102.6 to 131.2% of DW) (Figures 1-5). Anterior margin of disc convex, with a small fleshy protuberance on snout. Posterior margins of disc also convex. Disc dorsoventrally compressed. Anterior portion of disc with small, prominent, and oval shaped eyes (Figure 6). Spiracles oval and small (two to three times eye diameter) situated posterior to orbits and projecting obliquely from midline. Interspiracular distance approximately 1.6 times greater

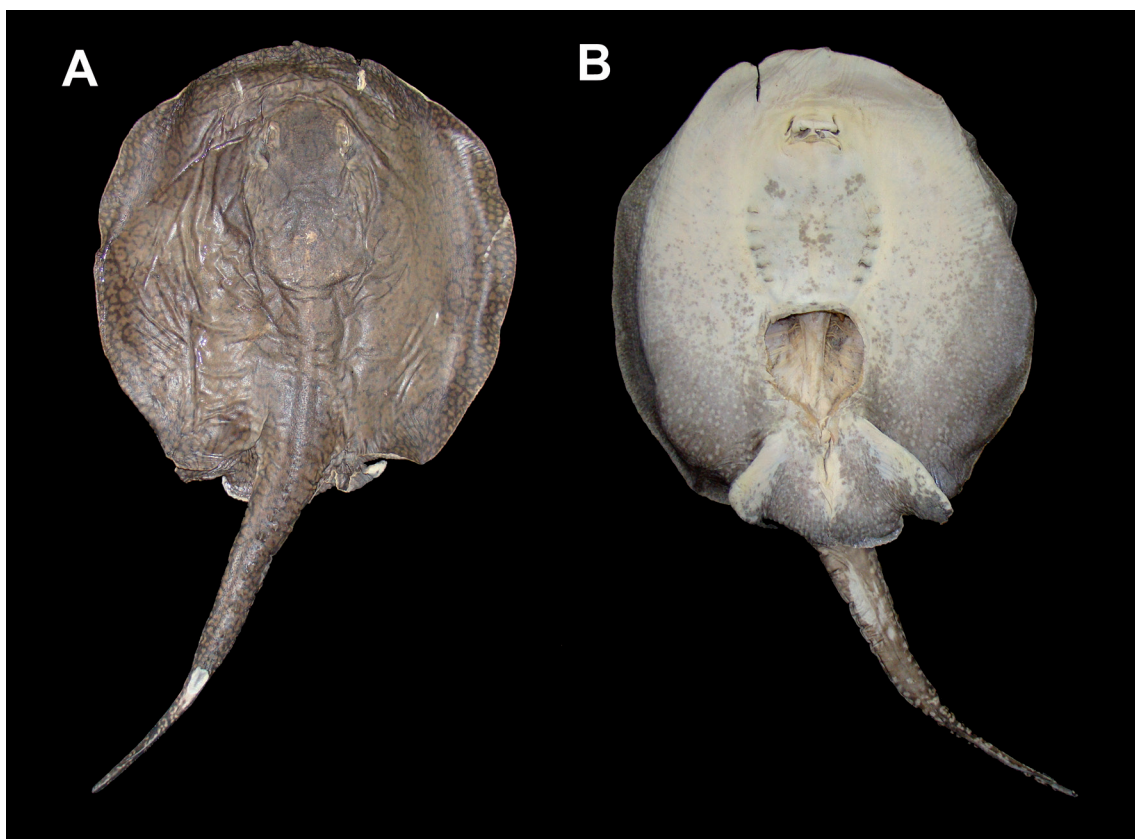


FIGURE 3: Paratype of *Potamotrygon tatianae* sp. nov. (MZUSP 107668, female, 265 mm DW) in dorsal (A) and ventral (B) views (Río Madre de Dios, Peru).

than interorbital distance. Nasal curtain partially covering mouth and presenting small, fringed posterior margin (Figure 6). Mouth small (mouth width ranging from 7.8 to 11% DW); mouth opening relatively

straight across, and with five buccal papillae, two lateral and three central. One of three central papillae closer to lower jaw tooth plate. Mouth width and internarial space about equal. Labial ridges present.

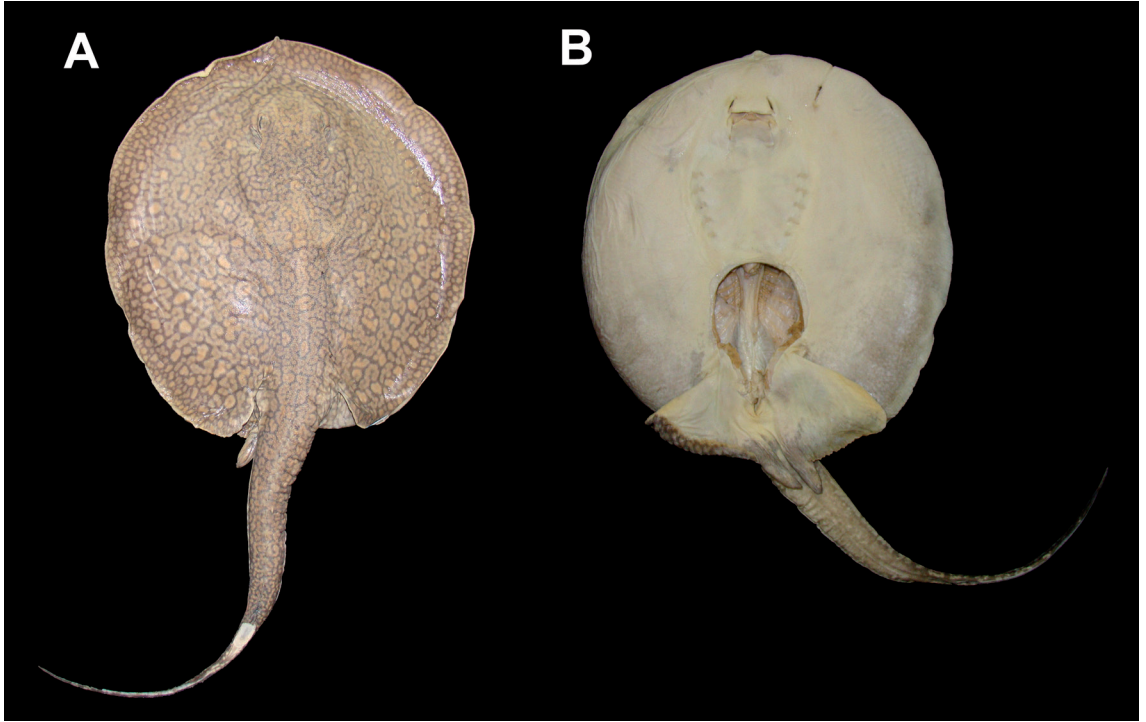


FIGURE 4: Specimen of *Potamotrygon tatianae* sp. nov. (MZUSP 107672, male, 291 mm DW) in dorsal (A) and ventral (B) views (Río Madre de Dios, Peru).

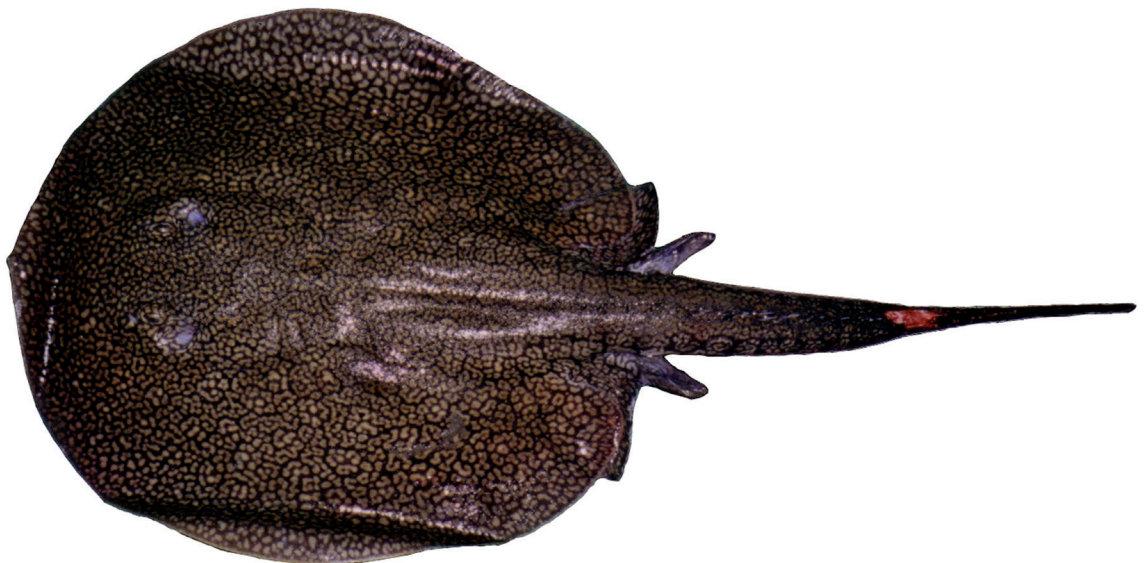


FIGURE 5: Specimen of *Potamotrygon tatianae* sp. nov. (MZUSP 107671, male, 351 mm DW) photographed upon capture in the field (Río Madre de Dios, Peru). Courtesy of F. Reyda.

TABLE 1: Morphometric data for *Potamotrygon tatiannae* sp. nov. (Río Madre de Dios, Peru). Data are expressed in millimeters and percentages of disc width (% DW). SD: standard deviation.

MEASUREMENTS	N	Range		Mean % DW	SD % DW
		mm	% DW		
Total length	7	480-755	160-214.8	195.2	18.2
Disc length	7	283-475	102.6-131.2	110.3	9.5
Disc width	7	265-362	—	—	—
Interorbital space	7	32-51	10.5-14.1	11.8	1.1
Interspiracular space	7	51-75	17.9-20.7	19	0.9
Eye length	7	9-11	2.8-3.8	3.2	0.4
Spiracle length	7	19-30	7-8.3	7.4	0.6
Sting length	7	—	—	—	—
Sting width	7	—	—	—	—
Preorbital length	7	66-107	23.9-29.6	25.1	2.2
Prenasal length	7	41-74	15.4-21.1	18.1	2.5
Preoral length	7	54-95	20.4-27.1	23.3	2.9
Internarial space	7	23-32	8.2-9.3	9	0.5
Mouth width	7	23-40	7.8-11	9.5	0.9
Space between 1st branchial slits	7	61-102	22.7-28.2	24.9	2.1
Space between 5th branchial slits	7	44-71	16.2-19.6	17.8	1.4
Branchial basket length	7	44-66	15.8-19	17.1	1.2
Pelvic fin length	7	60-103	20.2-28.5	24	3.5
Pelvic fin width	6	144-235	54.3-67	62.2	4.2
Clasper external edge	6	32-50	10.9-13.8	12.3	1.1
Clasper internal edge	7	65-95	22.3-27.3	24.9	1.8
Cloaca to tail tip	7	252-400	95-123.7	109	10.8
Tail width	7	42-57	14-16.2	15.5	0.7
Snout to cloaca	7	237-369	84.3-106	92.4	9.2
Pectoral axil to posterior edge of pelvic fin	7	35-66	11.9-18.2	13.5	2
Cloaca to sting	7	145-217	53.3-62.4	57.8	3.3

Teeth set in quincunx, with narrow and arched upper tooth plate, and wide and trapezoidal lower tooth plate. Tooth rows varying from 36-46 on upper jaw and 33-45 on lower jaw. Teeth relatively small, wider than long, and with flattened, elliptical, or lozenge-shaped crowns. Cusps rounded in males, or absent. Tooth plates presenting dignathic heterodonty. Teeth in lateral rows with elliptical crowns and generally lacking cusps. Teeth in central rows more robust, with lozenge-shaped crowns and rounded cusps; sexual dimorphism not present. Roots bilobed (holaulacorhize), with lobes separated by a shallow basal median groove.

Branchial basket relatively narrow and short, with space between first branchial slits from 22.7 to 28.2% of DW, and distance between first and last branchial slits from 15.8 to 19% of DW. Pelvic fins wider than long, partially covered by disc, and with posterior margins exposed posterior to disc margins. Clasper dorsoventrally depressed (Figure 7A), wider at bases and narrowing toward tips. Clasper groove beginning proximally at level of posterior margin

of pelvics. Anterior half of clasper groove running obliquely from inner margin to outer margin of clasper. Posterior half of clasper groove curving inward at level of dorsal pseudosiphon, reaching midline and extending to clasper tip. Dorsal pseudosiphon well developed near inner edge, elliptical, and obliquely oriented in relation to midline. Ventral pseudosiphon also well developed, located at lateral distal edge of clasper.

Tail elongated (mean tail length 109% of DW) and wide (mean width 15.5% of DW), with proximal portion slightly depressed dorsoventrally, and tapering from base to just posterior to caudal sting insertion. Distal portion of tail, posterior to sting base, laterally compressed and presenting membranous dorsal and ventral caudal folds (these about 3 mm in height). Dorsal caudal fold originating underneath sting tip and extending to tail extremity. Ventral caudal fold originating at level ventral to sting base, extending to tail extremity. One irregular row of spines on mid-dorsal tail extending from base of tail to level of sting origin. Enlarged spines on tail with rounded bases.

Dermal denticles: Disc with scattered dermal denticles mainly on midregion, from interorbital area to tail base (Figure 8). Denticles on middisc with predominantly four crown ridges. Crown ridges rarely showing crown dichotomies. In dorsal view, denticles asymmetrical and star-shaped due to different lengths of crown ridges. Denticles in central region with wide and flattened crown plates, bearing pointed projections. Anterior crown ridges or closer to crown plate projection shorter than posterior ones. Minute dermal denticles interspersed with larger denticles, exhibiting two crown ridges. Denticles become dispersed and smaller farther away from central disc region, with crown ridges becoming less evident. Denticles on disc margins practically absent. Dermal denticles also occur around and on margins of spiracle openings, as well as on orbits. Denticles devoid of crown ridges, but with pointed crowns, occur exclusively on spiracle superior margins, whereas denticles with two crown ridges occur on remaining regions. Pelvic fins and claspers devoid of dermal denticles. Denticles on dorsal tail small, devoid of crown ridges and with crowns sharply pointed. Dorsal caudal fold presenting numerous very small dermal denticles; ventral caudal fold devoid of dermal denticles. Dermal denticles also occur on lateral tail region, from slightly anterior to sting base to distal tail extremity. Denticles more developed near base of caudal stings.

Coloration: Disc background color generally blackish-brown. Spots on background close together, narrow, with variable extensions and presenting

exclusively vermicular shapes (Figures 1-5). Spots beige, light beige or dark brown. Some specimens presenting irregular vermicular spots forming strong vermicular patterns (Figure 4). Spots on central region narrower than the ones positioned marginally. In addition, small circular spots on disc edges present in most specimens. Pelvic fins dorsally similar to disc. Dorsal tail also with same basic color pattern. Ventral medial region of disc white in majority of specimens. In some cases, within white background, small, rounded grey spots occur laterally and posterolaterally to gill slits. These spots scattered anteriorly, and coalesce posteriorly. In some specimens, rounded and scattered grey spots also occur within the space between branchial slits. Border of disc margins gray, from level of nasal slits to posterior region of disc. Some specimens predominantly gray ventrally, with white embracing only a small portion of anterior region. In these specimens, branchial slits surrounded by gray coloration. Light gray and white circular spots may occur over gray background. Closely packed spots form continuous stripes on lateral borders of disc. In region posterior to branchial slits, a black oval spot of varying shape and intensity occurs. Pelvic fins with predominantly white ventral coloration. Dark gray coloration restricted to fine bands on posterior region of fins, presenting small circular light gray spots. Ventral tail region with white circular and sometimes vermicular spots restricted to tail borders, over a light gray background. At ventral midtail, gray background coloration homogeneous and without spots.

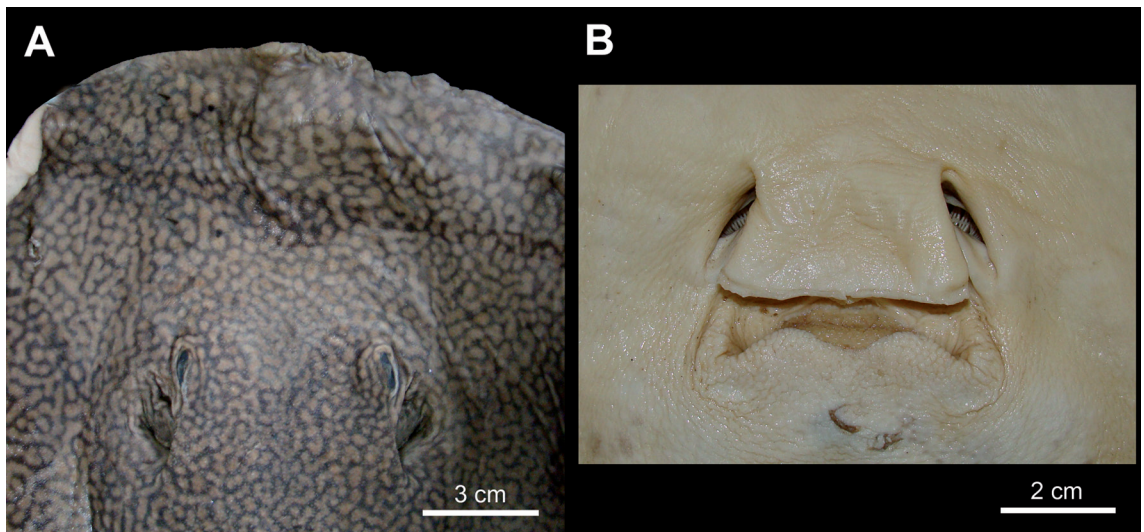


FIGURE 6: Morphological details of *Potamotrygon tatianae* sp. nov. **A)** Eyes and spiracles of holotype (MZUSP 107673, male, 348 mm DW). **B)** Nasoral region of paratype (MZUSP 107667, male, 362 mm DW).

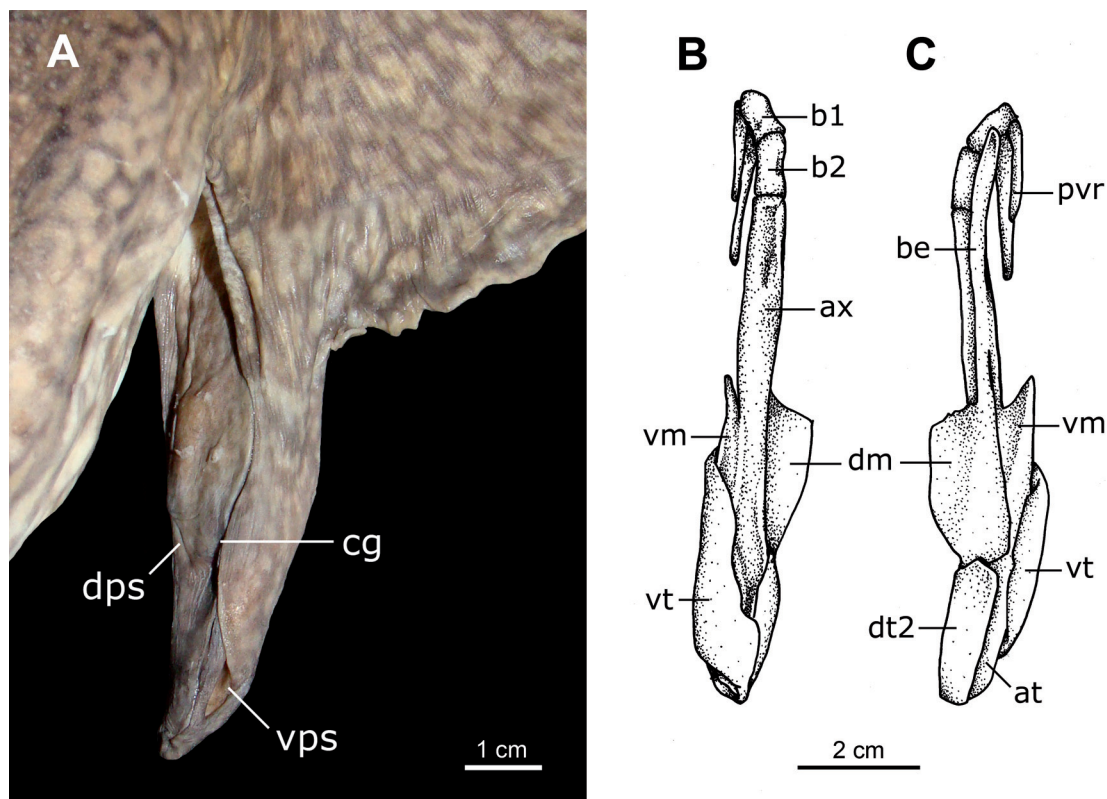


FIGURE 7: Clasper morphology of *Potamotrygon tatianae* sp. nov. (MZUSP 107671, male, 351 mm DW). **A)** External morphology. **B)** Clasper skeleton in dorsal view. **C)** Clasper skeleton in ventral view. Abbreviations: **at**, accessory terminal; **ax**, axial cartilage; **b1**, first basal segment; **b2**, second basal segment; **be**, beta cartilage; **dm**, dorsal marginal; **dt2**, dorsal terminal 2; **pvr**, pelvic fin radial; **vm**, ventral marginal; **vt**, ventral terminal.

Sensory canal system: Characteristics of ventral lateral-line canals in *Potamotrygon tatianae* consist of: suborbital loop originated from the infraorbital canal, close to hyomandibular canal anteriorly, and with prominent extension projecting towards middle portion of disc; numerous anterior subpleural tubules projecting from hyomandibular canal on anterior-most part of the disc; hyomandibular canal presenting a distinct undulation towards disc margin after anterior subpleural tubules; hyomandibular jugular component notoriously undulated at level of first three branchial slits; jugular canal presents a marked undulation adjacent to branchial slits; hyomandibular subpleural component presents a marked and wide undulation at level of branchial slits; mandibular canal short, obliquely oriented and with two marked undulations on its proximal portion; infraorbital loop with weak undulations at its internal corners; orbitonasal component of supraorbital canal highly undulated; final ascendant part of suborbital component highly undulated; prenasal loop short and straight; posterior subpleural tubule usually single and projecting obliquely

from subpleural loop to posterolateral margin of disc. Subpleural loop also more extended posteriorly (after anterior margins of pelvic fins) (Figure 9).

Neurocranium: Neurocranium longer than wide, with elliptic and ventrolaterally expanded nasal capsules (Figure 10). Preorbital processes short and curved backwards. Postorbital processes wide, shelf-like and anterolaterally expanded. Triangular supraorbital processes slightly anterior to postorbital processes. Supraorbital crests extending from region posterior to preorbital processes to postorbital processes. Condyles of antorbital cartilages on posterolateral extremities of nasal capsules. Precerebral fontanelle and frontoparietal fontanelle partially separated by a well developed epiphysial bar. Hyomandibular facet located on ventrolateral corner of otic region. Dorsally, presence of anterior foramen for preorbital canal, and several foramina for the superficial ophthalmic nerve, piercing supraorbital crest. Paired internal carotid artery foramina near ventrolateral edges of neurocranium. Laterally, neurocranium

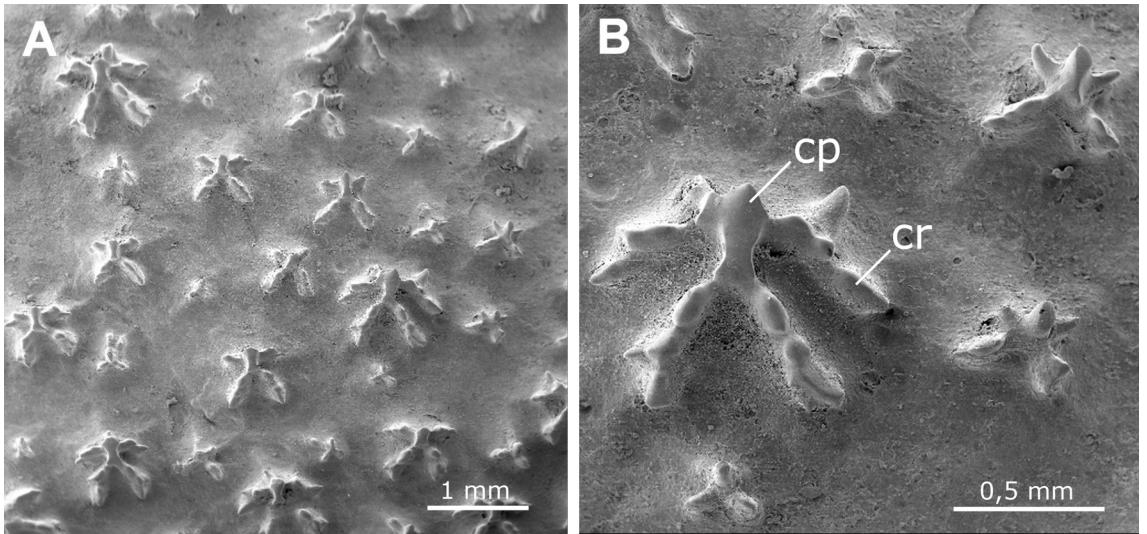


FIGURE 8: Dermal denticles of *Potamotrygon tatianae* sp. nov., in dorsal view, from mid region of back. **A)** Denticle arrangement. **B)** Individual dermal denticle amplified. Abbreviations: **cd**, crown dichotomy; **cp**, crown plate; **cr**, crown ridge.

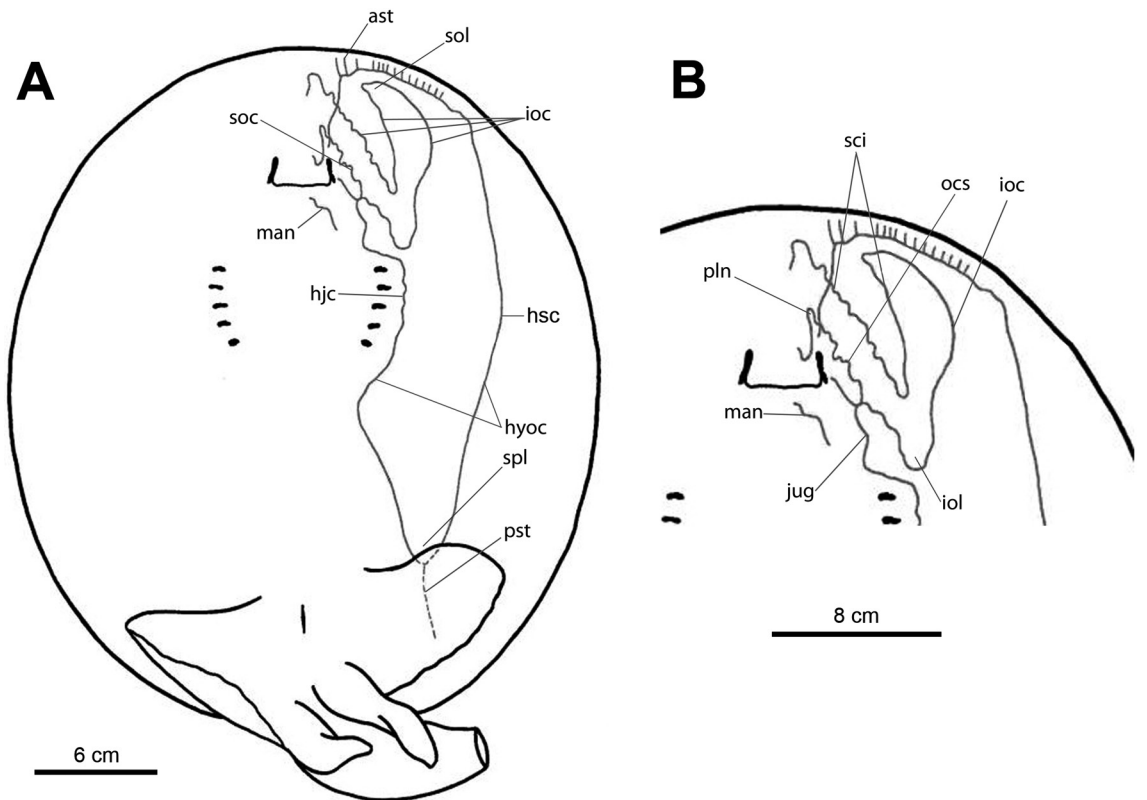


FIGURE 9: Ventral lateral line canal system of *Potamotrygon tatianae* sp. nov. (MZUSP 107669, male, 293 mm DW). Prenasal canal is not depicted in figure. **A)** Overall canal arrangement. **B)** Anterior disc region amplified highlighting separate components of canals. Abbreviations: **ast**, anterior subpleural tubules; **hjc**, hyomandibular jugular component; **hsc**, hyomandibular subpleural component; **hyoc**, hyomandibular canal; **ioc**, infraorbital canal; **iol**, infraorbital loop; **jug**, jugular canal; **man**, mandibular canal; **nas**, nasal canal; **ocs**, orbitonasal component of supraorbital canal; **pln**, prenasal loop; **pst**, posterior subpleural tubule; **sci**, suborbital component of infraorbital canal; **soc**, supraorbital canal; **sol**, suborbital loop; **spl**, subpleural loop.

with oval eye-stalk just posterior to wide and oval optic nerve foramen. Oculomotor nerve foramen dorsal to eye-stalk. A bridge-like lateral commissure present external to hyomandibular branch of facial nerve foramen. Posterior foramen for preorbital canal located dorsally, at junction of nasal capsule and orbit. Anterior cerebral vein foramen anterior located to optic nerve foramen. Efferent spiracular artery foramen posteroventral to eye-stalk. Orbital fissure located above and slightly anterior to hyomandibular branch of facial nerve foramen. Foramen magnum circular. Articular surface and occipital condyles ventral to foramen magnum. Vagus nerve foramen

positioned laterally to foramen magnum; glossopharyngeal nerve foramen located dorsolaterally to occipital condyles. Anterior endolymphatic foramen and posterior perilymphatic foramen in parietal fossa dorsally in otic region.

Hyomandibular arch: Hyomandibular cartilages elongate, wide and laterally compressed (Figure 11). Hyomandibula articulates with Meckel's cartilage by means of robust hyomandibular-Meckelian ligament in which anterior and posterior angular cartilages are embedded; anterior angular more robust than posterior. Meckel's cartilage and palatoquadrate flattened;

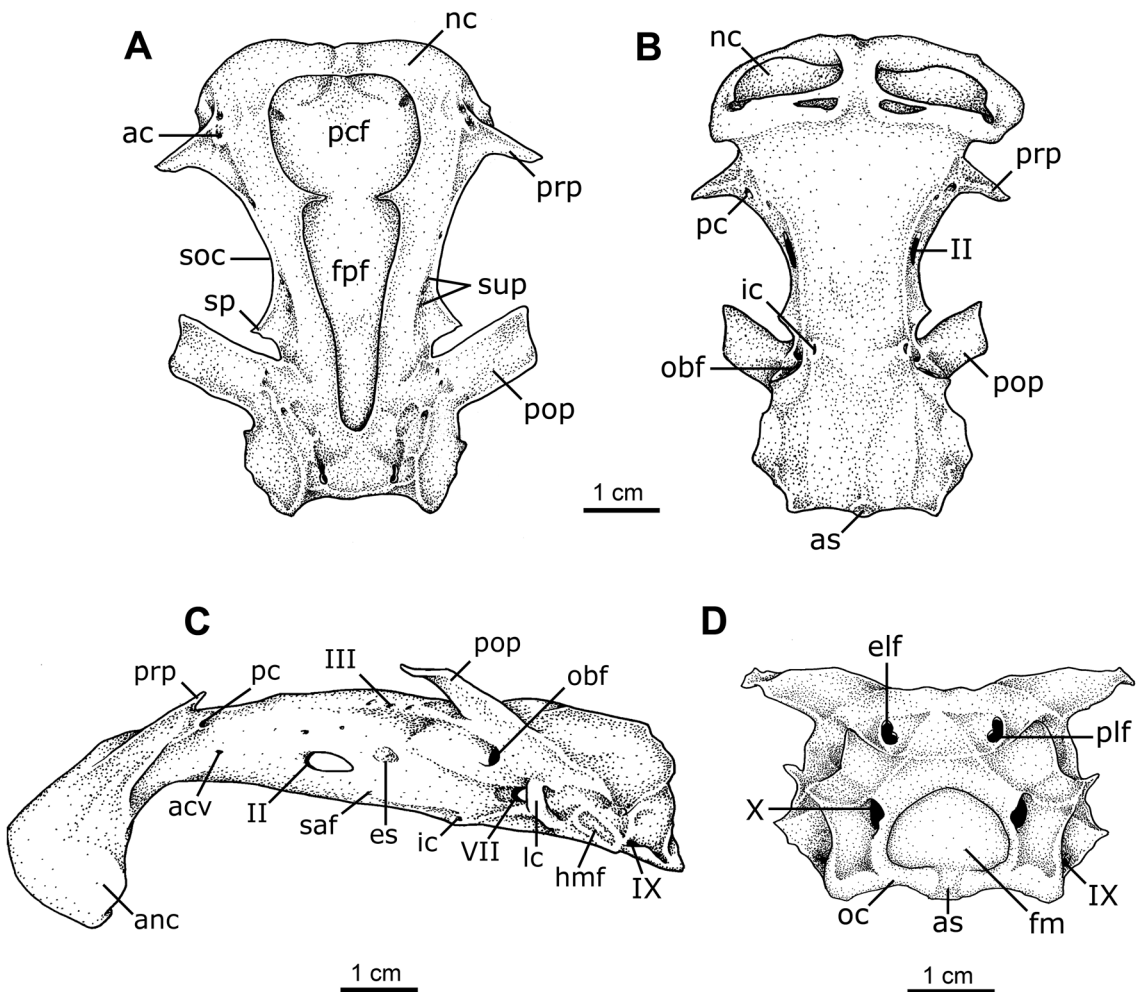


FIGURE 10: Dorsal (A), ventral (B), lateral (C) and posterior (D) views of neurocranium of *Potamotrygon tatiاناe* sp. nov. (MZUSP 107671, male, 351 mm DW). Abbreviations: **acv**, anterior cerebral vein foramen; **ac**, anterior foramen for preorbital canal; **anc**, anterior orbital cartilage condyle; **as**, articular surface; **elf**, endolymphatic foramen; **es**, eye-stalk; **saf**, efferent spiracular artery foramen; **fpf**, frontoparietal fontanelle; **fm**, foramen magnum; **hmf**, hyomandibular facet; **ic**, internal carotid artery foramen; **lc**, lateral commissure; **nc**, nasal capsule; **obf**, orbital fissure; **oc**, occipital condyle; **pcf**, precerebral fontanelle; **pc**, posterior foramen for preorbital canal; **plf**, perilymphatic foramen; **pop**, postorbital process; **pq**, palatoquadrate; **prp**, preorbital process; **soc**, supraorbital crest; **sp**, supraorbital process; **sup**, superficial ophthalmic nerve foramina; **II**, optic nerve foramen; **III**, oculomotor nerve foramen; **VII**, hyomandibular branch of facial nerve foramen; **IX**, glossopharyngeal nerve foramen; **X**, vagus nerve foramen.

antimeres of both arches not fused symphysially. Palatoquadrate slightly arched, straight at dorsal border and with pronounced curvature on proximal region of ventral margin. Robust posterior triangular projections present close to lateral edges of palatoquadrates. Meckel's cartilages more arched than palatoquadrates, with striking curvature on dorsal margins and with a pronounced concavity on inner corners that articulate with palatoquadrates. A marked curvature present on external aspect of Meckel's cartilage for attachment of hyomandibular-Meckelian ligament. Ventrolateral processes projecting from both extremities of Meckel's cartilages.

Claspers: Dorsal terminal 2 long, narrow and oval-shaped with a marked groove present along its proximal portion (Figures 7B-C). Dorsal marginal trapezoidal and with a notorious groove along its axis. Accessory terminal elongated and fusiform, underlying dorsal terminal 2. Ventral terminal broad, long and oval. Ventral marginal long and narrow, with pointed anterior tip. Axial cartilage) straight, depressed anteriorly and distally cylindrical, tapering

toward extremity. First basal segment connecting to basipterygium and second basal segment linked to proximal part of axial cartilage. Beta cartilage originating at first basal segment and distally articulated with dorsal marginal.

Geographical distribution

Potamotrygon tatianae is known only from Río Madre de Dios, upper Río Madeira basin, Peru (Figure 12).

Etymology

This new species honors Tatiana Raso de Moraes Possato, a late student of biology that was an enthusiastic researcher of chondrichthyans, in particular potamotrygonids.

Remarks

All specimens of *P. tatianae* including the type specimens, had their stings removed upon capture;

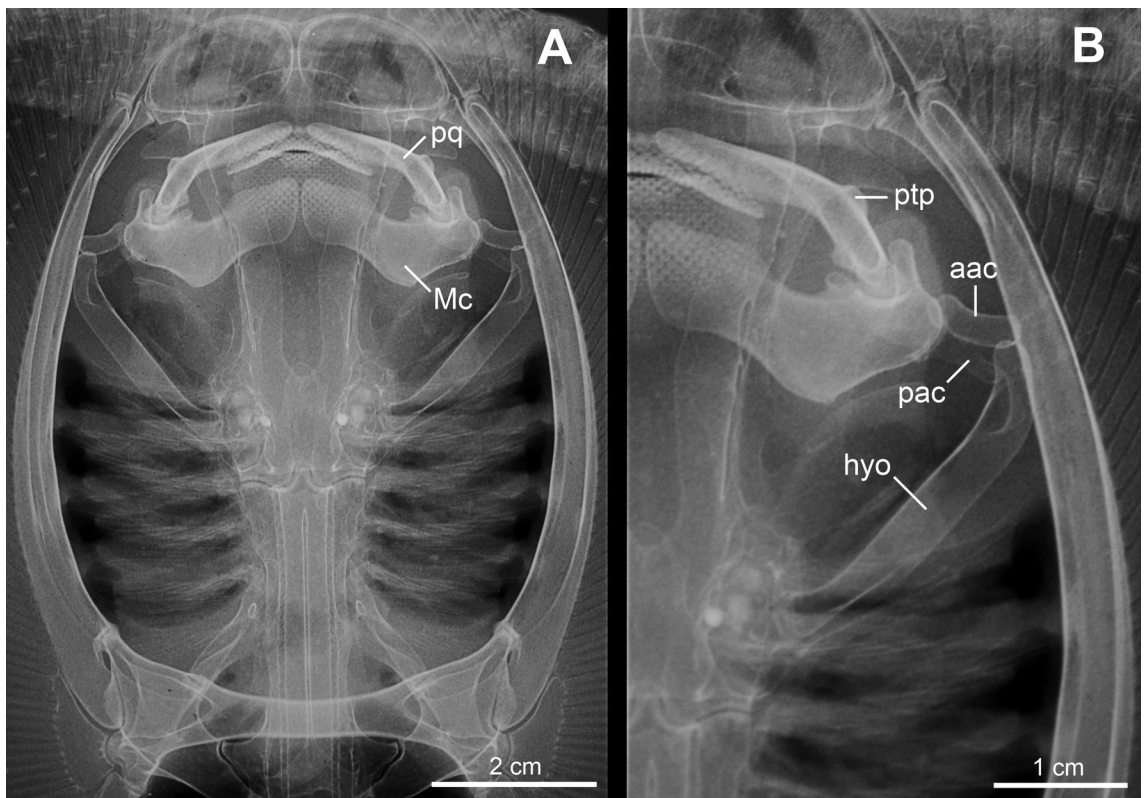


FIGURE 11: Morphological details of hyomandibular arch of *Potamotrygon tatianae* sp. nov. (based on MZUSP 107670, male, 300 mm DW). Abbreviations: **aac**, anterior angular cartilage; **hyo**, hyomandibula; **Mc**, Meckel's cartilage; **pac**, posterior angular cartilage; **pq**, palatoquadrate; **ptp**, posterior triangular projection.

TABLE 2: Meristic data for specimens of *Potamotrygon tatianae* sp. nov. All specimens from Río Madre de Dios, Peru. **A:** MZUSP 107673 (holotype), adult male. **B:** MZUSP 107669, adult male. **C:** MZUSP 107670, adult male. **D:** MZUSP 107671, adult male **E:** MZUSP 107672, juvenile male.

PARAMETER	A	B	C	D	E	Range	Mean	Mode	SD
Precaudal vertebrae	32	29	30	27	29	27-32	29.4	29	1.8
Caudal vertebrae	100	96	92	100	103	92-103	98.2	100	4.3
Total vertebrae	132	125	122	127	132	122-132	127,6	132	4,4
Diplospondylous vertebrae	—	94	92	98	100	92-100	96.0	—	3.7
Upper tooth rows	44	39	36	—	39	36-44	39,5	39	3,3
Lower tooth rows	45	33	35	—	37	33-45	37,5	—	5,3
Propterygial radials	42	42	44	42	42	42-45	42.4	42	0.9
Mesopterygial radials	14	14	14	13	14	13-14	13.8	14	0.4
Metapterygial radials	35	34	34	35	37	34-37	35.0	35	1.2
Total pectoral radials	91	90	92	90	93	90-93	91.2	90	1.3
Pelvic radials	21	21	21	21	22	21-22	21.2	21	0.4

consequently, morphometric data from this structure could not be analyzed. *Potamotrygon tatianae* has been erroneously identified as *Potamotrygon castexi* in systematic collections. This mistaken identification was due to similarities in dorsal disc color (vermiculate pattern), which figured as an important character in the original description of *P. castexi* by Castello & Yagolkowski (1969). However, a recent systematic revision of *P. falkneri*, based on large series of specimens

including material similar to the holotype of *P. castexi* and from close to its type-locality, confirmed that this species is a junior synonym of *P. falkneri*, which is highly variable in coloration (Silva & Carvalho, 2011). *Potamotrygon tatianae* was previously presented, and provisionally separated, from *P. falkneri* in that same taxonomic work (as *Potamotrygon* sp.). This species is described here after a more in-depth study of its morphology.



FIGURE 12: Map showing geographic distribution of *Potamotrygon tatianae* sp. nov. Star indicates collection locality of specimens and all of type-species.

Comparative material

Potamotrygon falkneri: ANSP 142482 (adult male, 429 mm DW), Río Manu below Boca Pinquen, Gomero, Peru, 12°11'S, 70°58'W, 10 Aug 1977; ANSP 142483 (adult male, 265 mm DW), same data as ANSP 142482; FMNH 84091 (male, 354 mm DW), Río San Alejandro, near Puerto Nuevo, Río Pachitea drainage, Peru; LACM 39934-1 (female, 286 mm DW), Río Yutupis, Shiringa, Amazonas, Peru; LACM 39942-1 (male, 432 mm DW), same data as LACM 39934-1; LACM 41772-2 (male, 225 mm DW), Río Santiago, small "quebrada" across from La Poza, Amazonas, Peru; UMMZ 204551 (female, 366 mm DW), Río Itenez, 9 km southwest of Costa Marques, state of Rondônia, Brazil, 12°32.4'S, 64°16.6'W, 18 Sep 1964.

Potamotrygon orbignyi: MZUSP 14775 (male, 302 mm DW), rio Tocantins, lagoa em frente à Jabotal, municipal district of Jabotal, Amazon basin, Pará, Brazil; MZUSP 14791 (male, 167 mm DW), lagoa marginal do rio Tocantins, municipal district of Baião, Amazon basin, Pará, Brazil, 02°50'S, 49°40'W.

Potamotrygon motoro: MZUSP (uncat.) PU-24 (male, 306 mm DW), Río Madre de Díos, municipal district of Boca Manu, upper Amazon basin, state of Madre de Dios, Peru, 12°40'36"S, 71°13'58"W, 2002.

DISCUSSION

Potamotrygon tatiánae was briefly, but only tentatively presented as distinct in a recent taxonomic revision of *P. falkneri* (Silva & Carvalho, 2011), but the acquisition of new morphological data, concerning dermal denticle morphology, ventral lateral-line system, and skeletal anatomy, further corroborated that it represents a separate species. Although occurring sympatrically with *P. falkneri* in Río Madre de Díos, and *P. falkneri* is a species with a demonstrably high intraspecific variation in color pattern, we were able to conclude that *P. tatiánae* does not represent an example of this variation because it can be distinguished by other internal and external morphological features. *Potamotrygon tatiánae* was compared to all valid species of *Potamotrygon*, including species presently being described. Our comparisons, however, are restricted

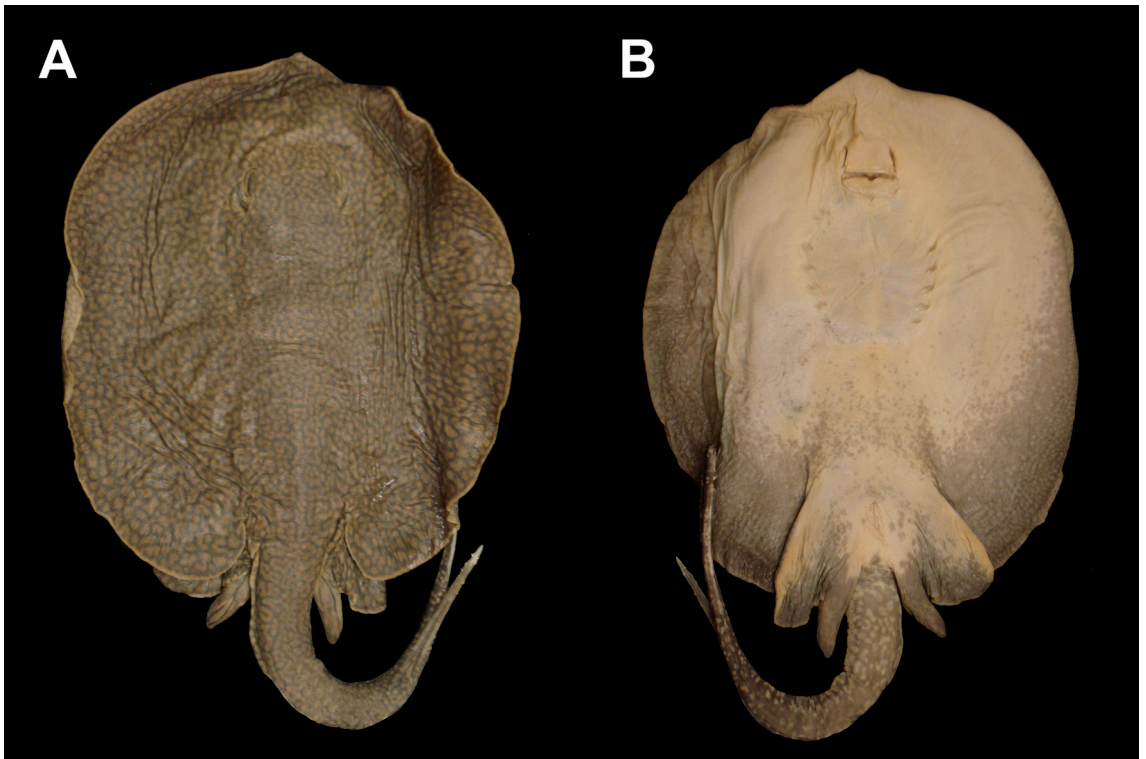


FIGURE 13: Specimen of *Potamotrygon falkneri* (ANSP 142483, male, 265 mm DW) in dorsal (A) and ventral (B) views (Río Manu below Boca Pinquén, Río Madre de Díos, Río Madeira basin, Peru).

here to sympatric species, with special attention given to *P. falkneri*.

Silva & Carvalho (2011) presented a series of external morphological characters, in addition to morphometric and meristic data, which separated *P. tatiana* from *P. falkneri*. These characters are expanded here, with the inclusion of further features from internal anatomy. *Potamotrygon tatiana* can be distinguished from *P. falkneri* by the following external characters: presence of a single row of spines over dorsal tail, not nearly as irregularly arranged (*vs.* one to three highly irregular rows in *P. falkneri*); dermal denticles rarely presenting crown dichotomies and with flattened, wide and pointed, highly protruded crown plates (*vs.* high number crown dichotomies and rounded, small-sized crown plates in *P. falkneri*); teeth with rounded cusps in males, with males and females presenting equal-sized, morphologically similar teeth (*vs.* some males bearing triangular prominent cusps in *P. falkneri*); tail homogeneously gray on its central, ventral portion, with irregular white spots scattered laterally (*vs.* disorganized reticulated pattern on tail, formed by irregular vermicular white spots in *P. falkneri*); coloration on dorsal disc exclusively composed of slender, closely packed vermiculations (*vs.* reniform, and oval spots on background with diameter equal to or smaller than eye diameter in *P. falkneri*) (Figure 13). A meristic feature that also supports *P. tatiana* as a distinct species is the slightly lower number of total pectoral radials (modal values 90 *vs.* 97, respectively). *Potamotrygon tatiana* has a considerably longer tail region posterior to sting insertion (mean 109% of DW, $n = 7$), compared to *P. falkneri* from Paraná-Paraguay and upper Amazon basins (mean 87.9% DW, $n = 65$ and mean 93.5% DW, $n = 10$, respectively). This greater tail extension is not related to the number of total vertebrae, but is associated to the presence of a longer cartilaginous rod which supports the distal part of tail posterior to last vertebral centrum (individual centra do not occur posterior to caudal stings). For some measurements, *P. tatiana* has higher proportional values compared with *P. falkneri* from upper Amazon and Paraná-Paraguay basins: snout to cloaca (mean 92.4% DW, $n = 7$ *vs.* mean 89.2% DW, $n = 10$ and mean 87.3% DW, $n = 65$, respectively), pelvic fin width (mean 62.2% DW, $n = 7$ *vs.* mean 58.1% DW, $n = 10$ and mean 57% DW, $n = 65$, respectively), and branchial basket length (mean 17.1% DW, $n = 7$ *vs.* mean 15.1% DW, $n = 10$ and mean 15.7% DW, $n = 65$, respectively).

The ventral lateral-line canal system (Figure 9) differs between *P. tatiana* and *P. falkneri* in the following characters: the hyomandibular canal presents

in *P. tatiana* a distinctive undulation towards outer disc margin just before the beginning of anterior subpleural tubules (absent in *P. falkneri*); hyomandibular subpleural component with a marked and wide undulation in *P. tatiana* at level of branchial slits (devoid of any evident undulation in *P. falkneri*); orbitonasal component of supraorbital canal highly undulated in *P. tatiana* (rather homogeneous in *P. falkneri*); and subpleural loop also more extended posteriorly, surpassing the limits of anterior margins of pelvic fins in *P. tatiana* (not extended posteriorly in *P. falkneri*).

In relation to the neurocranium (Figure 10), *P. tatiana* has the anterior cerebral vein foramen farther from the optic nerve foramen and closer to posterior foramen for preorbital canal when compared with *P. falkneri* (three specimens of *P. falkneri* examined, one of *P. tatiana*). Additionally, in *P. tatiana*, the efferent spiracular artery foramen is not closely positioned to the optic nerve foramen and eye stalk as it is in *P. falkneri*, but is more ventrally situated, closer to neurocranial shelf.

Potamotrygon tatiana is further distinguished from *P. orbignyi* (more information on this species is provided in Silva, 2010) by the absence of a strong reticulate dorsal pattern that forms hexagonal figures (that are sometimes interrupted) on dorsal disc, presence of two angular cartilages (a single, long anterior angular cartilage in *P. orbignyi*), teeth with rounded cusps (teeth with three pointed cusps in *P. orbignyi*), slight higher number of total pectoral radials (modal 90 *vs.* 97 in *P. orbignyi*), suborbital loop close to the hyomandibular canal anteriorly (suborbital loop far from hyomandibular canal anteriorly in *P. orbignyi*), neurocranium highly calcified and with preorbital process not much developed (neurocranium less calcified and with well developed, lateroposteriorly extended preorbital process in *P. orbignyi*), and considerably wider (mean 15.5% DW *vs.* 11.7% DW in *P. orbignyi*) and longer (mean 109.0% DW *vs.* 92.0% DW in *P. orbignyi*) tail region.

Potamotrygon tatiana is differentiated from *P. motoro* (Rosa, 1985) by the lack of ocelli on dorsal disc, smaller lozenge-shaped teeth on both jaws (large placoid-like teeth on both jaws in *P. motoro*), a greater number of tooth rows in both jaws (36-44/33-45 *vs.* 18-39/20-39 in *P. motoro*), smaller dermal denticles with a lower number of crown ridges (greater denticles with an elevated number of crown ridges in *P. motoro*), eyes proportionally smaller (mean 3.2% DW *vs.* 4.2% DW in *P. motoro*), disc length noticeably longer (102.6-131.2% DW *vs.* 95-119% DW in *P. motoro*), and number of total vertebrae slightly greater (123-132 *vs.* 112-128 in *P. motoro*).

The discovery of a new species so similar to a pre-existing, valid species that is widely distributed (*P. falkneri*), and which is demonstrably highly variable in color pattern (and in a few other characters as well, such as in number of dorsal tail spine rows), highlights that much cryptic diversity may exist in the family. Such cryptic diversity can only be brought to light through the examination of large, well represented series of specimens. This discovery also highlights the continual importance of morphology in uncovering such cryptic diversity, as dissections and close inspection of the ventral lateral-line canals, dermal denticles and neurocrania were of paramount importance in separating *P. tatianae* from *P. falkneri*.

RESUMO

Potamotrygon tatianae sp. nov., é descrita do Rio Madre de Díos, Peru, alto da bacia do Rio Madeira. Essa nova espécie é distinta de todas as espécies congênericas por uma combinação única de caracteres, incluindo sua coloração dorsal formada por um padrão vermicular de cor bege a marrom escuro, relativamente delgado e altamente convoluto, uma única fileira mediana dorsal de espinhos sobre a cauda e uma cauda relativamente longa posteriormente aos ferrões caudais. *Potamotrygon tatianae* sp. nov., ocorre em sympatria com outras espécies de *Potamotrygon* (*P. falkneri*, *P. orbignyi* and *P. motoro*). Da espécie similar *P. falkneri*, *P. tatianae* sp. nov., é também distinguida pela ausência de manchas circulares, reniformes e ovais, por sua cauda proporcionalmente mais longa, por apresentar espinhos caudais em uma única fileira irregular e por caracteres dos canais ventrais da linha lateral, denticulos dérmicos e neurocrânio. De *P. orbignyi*, a nova espécie é distinguida pela ausência de um padrão reticulado no dorso do disco e pela presença de duas cartilagens angulares. De *P. motoro*, *P. tatianae* sp. nov., é separada pela ausência de ocelos formados por anéis negros concêntricos intensos, pelo aspecto mais achatado da cabeça e disco e pela presença de dentes menores e mais numerosos. A descoberta de uma espécie nova que é semelhante a uma outra espécie congênerica que possui um padrão de colorido dorsal semelhante, um caráter muito variável nesta espécie, ressalta a importância de examinar séries grandes de indivíduos e de análises morfológicas detalhadas para revelar a natureza potencialmente críptica da diversidade dentro da família.

PALAVRAS-CHAVE: *Potamotrygon tatianae* sp. nov.; *Potamotrygon falkneri*; Taxonomia; Morfologia; Espécies crípticas; Rio Madeira; América do Sul.

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