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Skeleton Anatomy of Five Species of Genus *Urotrygon* (Chondrichthyes: Urotrygonidae)

Anatomía del Esqueleto de Cinco Especies del Género *Urotrygon* (Chondrichthyes: Urotrygonidae)

Héctor M. Montes Domínguez & Mónica González Isáis

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SUMMARY: Skeleton of batoids has been important to outline kinship relations in this group. Therefore, the objective of this work is describing the anatomy of five species of genus *Urotrygon*. Skeleton of Urotrygonids displayed a common morphological pattern, with the following differences: 1) preorbital processes are reduced in *Urotrygon nana* and *Urotrygon munda,* and developed on all other species; 2) the first postorbital process is reduced in *U. nana* and *U. munda*; 3) the first hypobranchial cartilage is fragmented only in *Urotrygon rogersi*; 4) only *Urotrygon aspidura* had a bridge in the basibranchial cartilage; lateral processes of the synarcuale in *U. aspidura* are long and thin, while short and wide in *U. nana* and *U. rogersi*; 6) *U. nana* has only one single fenestra in its pectoral girdle, while other species have two; 7) In *U. nana* and *U. munda* the mesopterygium is rounded, but in all other species it is elongated in its anterior part; 8) *U. nana* y *U. munda* have a more arched pelvic girdle. Species with more plesiomorphic characters are *U. nana* and *U. munda*.

KEY WORDS: Batoids; Urotrygonidae; *Urotrygon*; Neurocranium; Skeleton.

INTRODUCTION

Suborder Myliobatoidei contains about 218 species distributed all over the world, and includes family *Urotrygonidae* with 17 species and two genus, *Urobatis* and *Urotrygon* (Nelson *et al*., 2016), which were formerly placed in the Urolophidae family (Nelson, 2006). Species of this group range from tropical to temperate waters in continental platforms of the Western Atlantic and Eastern Pacific. They characterize because their disc is not more than 1.3 times wider than longer; their tail is narrow and as long as the disc length, have no dorsal fin but have one spine, as a minimum and caudal fin (Nelson *et al*.).

Works conducted on *Urotrygon* species are mainly taxonomic based on external morphology (Gill, 1863; Jordan & Gilbert, 1882; Jordan & Everman, 1896; Beebe & Tee-Van, 1941; Bigelow & Schroeder, 1953; Miyake & McEachran, 1988; Miyake, 1988). Despite the skeleton of myliobatoids has been studied, there are only a few works focused on the anatomy of less specialized groups. Miyake & McEachran (1991) worked with the branchial arches skeleton of batoids, including some Urotrygonids species. Nishida conducted a study on myliobatoids phylogeny including diagrams of some skeletal structures of *Urolophus aurantiacus* and *Urotrygon microphthalmum*. Therefore, this work aims to expand our current knowledge on the skeleton anatomy of five species of genus *Urotrygon*.

MATERIAL AND METHOD

This study considered five species from family *Urotrygonidae*: *Urotrygon aspidura*, *Urotrygon chilensis*, *Urotrygon munda*, *Urotrygon nana* and *Urotrygon rogersi*. Organisms were collected as accompanying fauna in the Pacific Ocean coasts, using dragnets in shrimp boats. The specimens were fixed in formaldehyde 10 %, to be later transported to the laboratory. Dissections were conducted with conventional techniques. Then skeletons of each species were prepared with the modified Dingerkus & Uhler (1977) differential staining methodology. The cranium, synarcual, scapulacoracoid, and pelvic girdle structures were described based on their form, location, and dimensions, using terminology used by Nishida (1985, 1990) & Miyake.

UNAM FES Iztacala, Laboratorio de Anatomía Animal Comparada, Los Reyes Iztacala, Tlalnepantla, Estado de México, C.P. 54090, México.

RESULTS

Skeletal anatomy of *Urotrygon* species showed little variability. However, some characters were recognized. Therefore, their anatomy is described, and differences are later discussed.

Neurocranium. In dorsal view a rostral appendix separated from the neurocranium can be observed, anterior to the nasal capsules where pectoral fins meet. Nasal capsules expand ventro-laterally (Figs. 1 & 2); the anterorbitary condyles are posterolateral; in the anterior margin of the nasal capsules an outline of the rostral cartilage occurs; the anterior foramina of the preorbital chanel are in the posteromedial region of

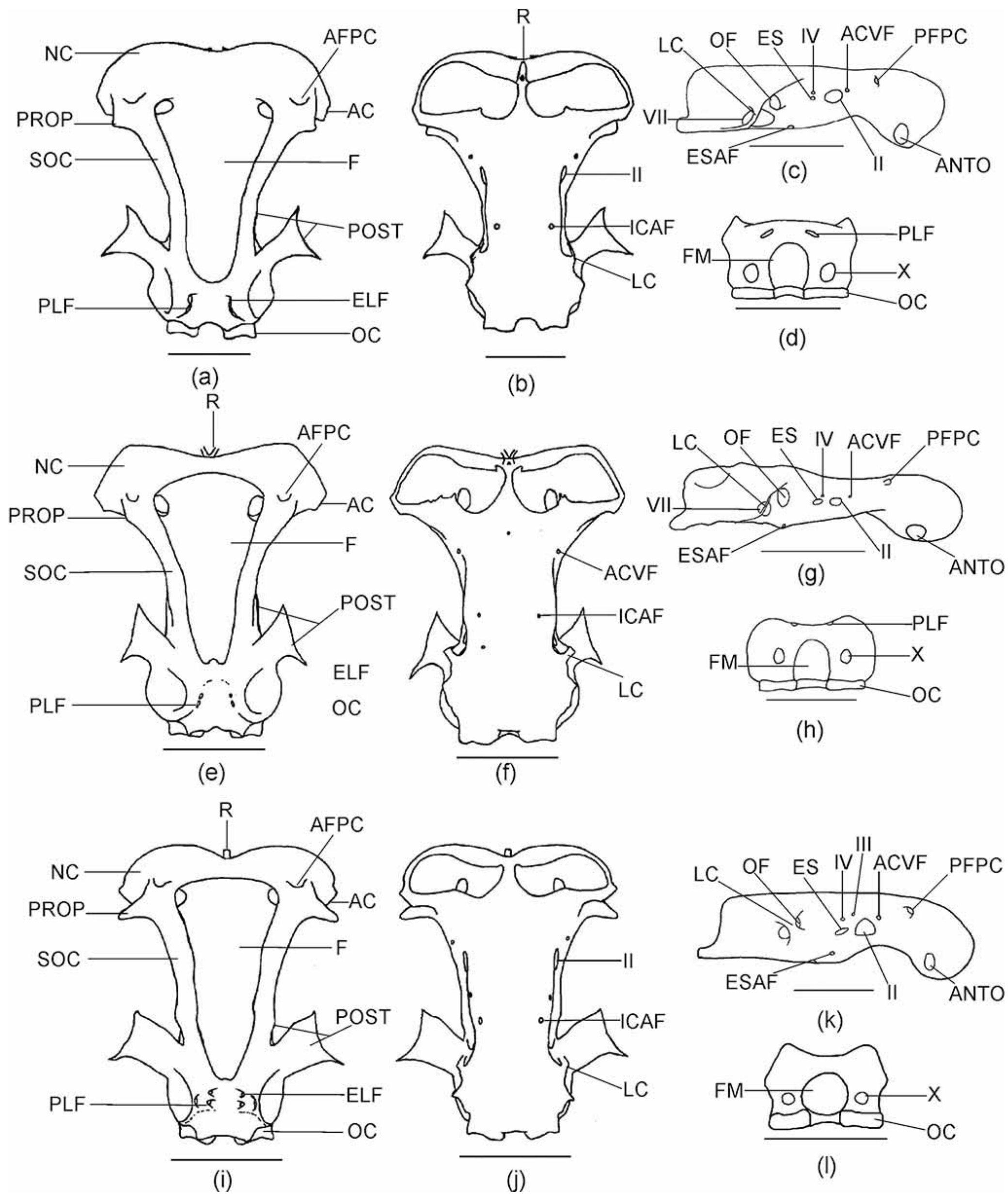

Fig. 1. Neurocranium. *Urotrygon munda*: a) dorsal view, b) ventral view, c) lateral view, d) occipital view. *Urotrygon nana*: e) dorsal view, f) ventral view, g) lateral view, h) occipital view. *Urotrygon chilensis*: i) dorsal view, j) ventral view, k) lateral view, i) occipital view. ACVF, anterior cerebral vein foramen; AFPC, anterior foramen for preorbital canal; ANTO, antorbital condyle; ELF, endolymphatic foramen; ES, eye stalk; ESAF, efferent spiracular artery foramen; F, fontanelle; FM, foramen magnum; ICAF, internal carotid artery; LC, lateral commissure; NC, nasal capsule; OC, occipital condyle; OF, orbital fissure; PFPC, posterior foramen for preorbital canal; PLF, perilymphatic foramen; PROP, preorbital process; POST, postorbital process; R, rostrum; SOC, supraorbital crest; II, optic nerve foramen; IV, trochlear nerve foramen; VII, hyomandibular branch of facial nerve foramen; X, vagus nerve foramen. Scale indicates 10 mm.

the nasal capsules, between the anterior region of the preorbital process and the fontanelle; preorbital processes are triangle-shaped, and located on the posterior part of nasal capsules. Anterior preorbital processes appear as small projections of the supraorbital crest, while the postorbital processes are more developed, with a rectangular plate shape, which in the anterolateral region are at the same level as the preorbital process. In the middle part of the otic region, two pairs of foramina are almost fused. The anterior pair is the endolymphatic foramina, and the second is the perilymphatic. A pair of occipital condyles can be observed in the posterior part of the neurocranium.

In anterior ventral view (Figs. 1 & 2), a remnant of the rostral cartilage can be observed between the nasal capsules. The anterior part of the rostral cartilage is rounded, not protruding over the neurocranium. In the lateral part in the neurocranium, of the orbital region two pairs of foramina occur. The most anterior one is the foramen of the anterior brain vein, while the posterior is the optic nerve foramen. In the medial part of the basal plate is the foramen of the internal carotid artery. The foramen of the facial nerve of the mandibular branch is located right where the otic region starts, ahead of the lateral commissure.

On the lateral view (Figs. 1 & 2), it can be observed that nasal capsules have moved to the region. The foramen of the preorbital channel is behind this structure. The orbital region has seven pairs of foramina, two on dorsal position: one for the trochlear nerve and another for the oculomotor nerve; two on median position: one for the orbitonasal channel and another for the optic nerve; and two in ventral position: one for the interorbital vein and another for the efferent artery. The orbital fissure can be observed ahead of the otic capsules, in dorsal position, and the hyomandibular branch of the facial nerve in ventral position. Finally, the glossofaringeal nerve foramen (IX) is in the otic region.

In occipital view (Figs. 1 & 2), the foramen magnum can be observed, and the vagus nerve (X) is on each side.

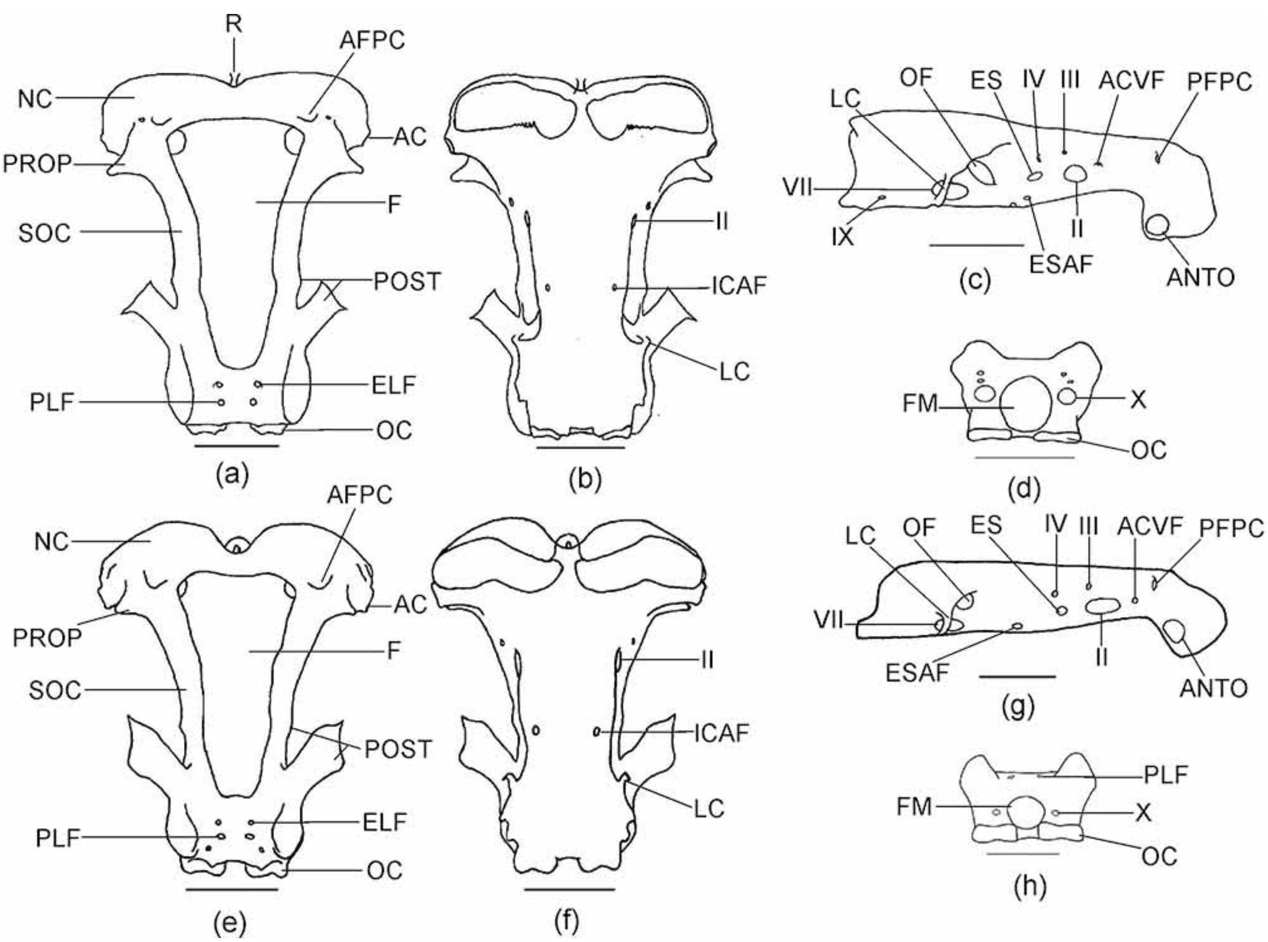

Fig. 2. Neurocranium. *Urotrygon rogersi*: a) dorsal view, b) ventral view, c) lateral view, d) occipital view. *Urotrygon aspidura*: e) dorsal view, f) ventral view, g) lateral view, h) occipital view. For abbreviations see Figure 1. Scale indicates 10 mm.

Hyobranchial Skeleton. The hyobranchial skeleton (Fig. 3) is formed by eight arch's. The first one is the mandibular arch, including the palatoquadrate (upper mandible) and Meckel's cartilage (lower mandible). The second is the hyoid arch which, in these organisms, consists only of the hyomandibular cartilage, articulated to the neurocranium and the mandible. Ceratohyal and basihyal cartilages of the second arch are absent. The third arch is formed by pseudohyal cartilage (dorsal and ventral). Proximally, this cartilage is fused with the first ceratobranchial cartilage and articulated with the distal margin of the first hypobranchial cartilage. Then, five branchial cartilages can be found, formed by the faringobranchial, epibanchial, ceratobranchial, hypobranchial and basibranchial cartilages. The first ceratobranchial cartilages in ventral position, together with faringobanchial and epibranchial cartilages in dorsal position, support the gill rays, together with the pseudohyal. Five ceratobranchial cartilages are in the ventral region which, with the exception of the fifth one are horizontally oriented and articulated proximally. The fifth ceratobranchial articulates the hypobranchial skeleton with the anterior face of the scapulocoracoid cartilage, which is not supporting the gill rays. The first hypobranchial is a non-fragmented cartilage. The basibranchial cartilage forms a continuous plate with a posterior part terminating in a sharp process.

Synarcual. The synarcual (Fig. 4) is a long tube-shaped cartilage, in lateral view it has a numerous foramina through which the nerves pass, located along the spinal nerve channel. There is a lateral process, relatively thick, dorsally projected from the ventrolateral part of the synarcual. The articular surface – relatively small – is on the posterior region, where the scapular process of the scapulacoracoid cartilage is articulated, with one or two articulation points.

In dorsal view, a crest in medial position is observed, caudally projected, where the scapulcoracoid cartilage is fused, which is horizontally oriented.

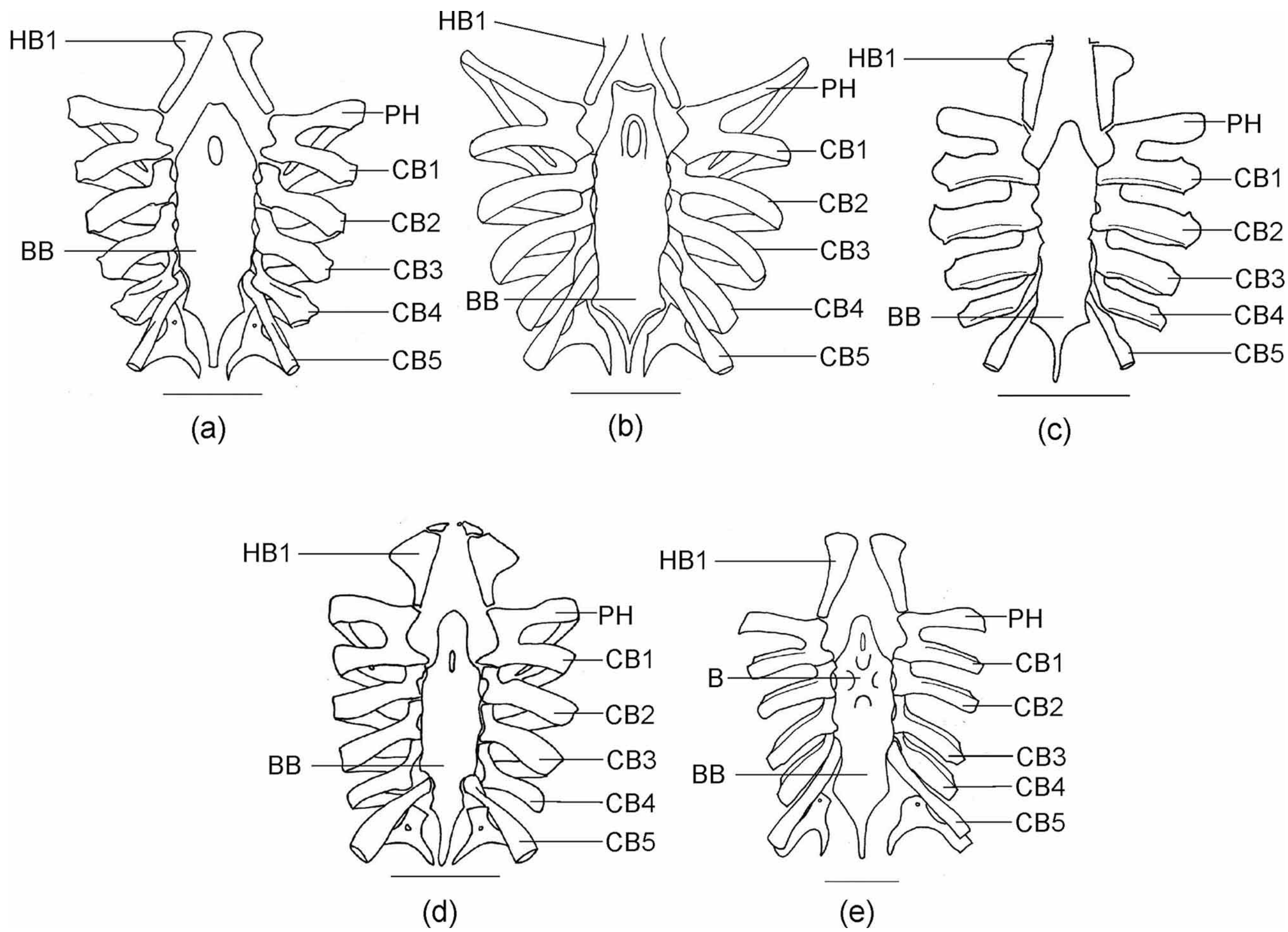

Fig. 3. Ventral view of the hyoid and branchial arches. a) *Urotrygon munda*, b) *Urotrygon nana,* c) *Urotrygon chilensis*, d) *Urotrygon rogersi*, e) *Urotrygon aspidura*. B, bridge; BB, basibranchial; CB1-CB5, ceratobranchial cartilages 1-5; HB1, hypobranchial 1; PH, pseudohyal. Scale indicates 10 mm.

Scapular Girdle. The scapular girdle is formed by the scapulcoracoid cartilage (Fig. 5), which include the coracoids cartilage and the scapular and suprascapular processes. It is dorsoventrally compressed. It is located under the synarcual, and articulates with it at the articular surface of the dorsally elevated scapular process. The procondyle articulates with the propterygium; the mesocondyle with the mesopterygium, and the metacondyle with the metapterygium, which are located along the horizontal axis of the scapulacoracoid.

The scapulacoracoid has four fenestrae: two dorsal (anterodorsal and posterodorsal), and two ventral (anteroventral and posteroventral). The posteroventral fenestra is smaller. The scapulacoracoid is narrow and elongated in its dorsal aspect. In dorsal view, three other elements of the pectoral girdle can be observed: propterygium, mesopterygium and metapterygium. The propterygium is anteriorly articulated with anterorbital cartilages. The mesopterygium is a structure articulating a part of the pectoral fins radials; and the metapterygium articulates with the pelvic girdle. The distal part of these cartilages articulate with the pectoral fin radials, and the proximal part articulate with the synarcual (fusion of the first vertebrae).

Pelvic Girdle. The puboischiadic bar of the pelvic girdle is significantly arched. With an evident depression on the puboischiadic bar in the anterior region, prepelvic lateral processes are well developed, and anterolaterally oriented. Obturador foramina are located on the puboischiadic bar, at level of the iliac region. Iliac processes are oriented towards the posterior part of the pelvic girdle (Fig. 6).

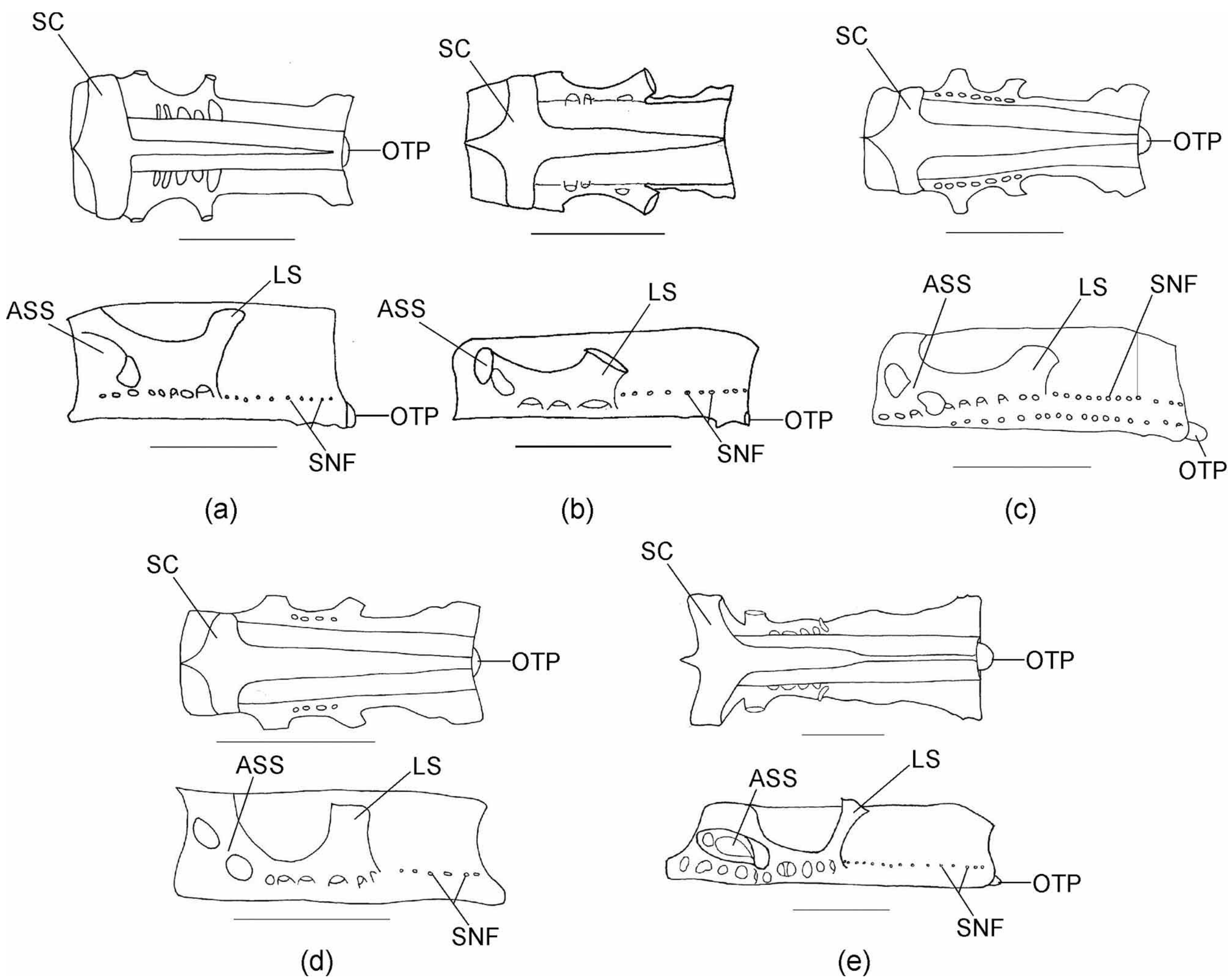

Fig. 4. Dorsal (upper) and lateral (lower) views of synarcual. a) *Urotrygon munda,* b) *Urotrygon nana,* c) *Urotrygon chilensis,* d) *Urotrygon rogersi,* e) *Urotrygon aspidura*. ASS, articular surface for scapular process; LS, lateral stay; OTP, odontoid process; SC, suprasynarcual cartilage; SNF, spinal nerve foramen. Scale indicates 10 mm.

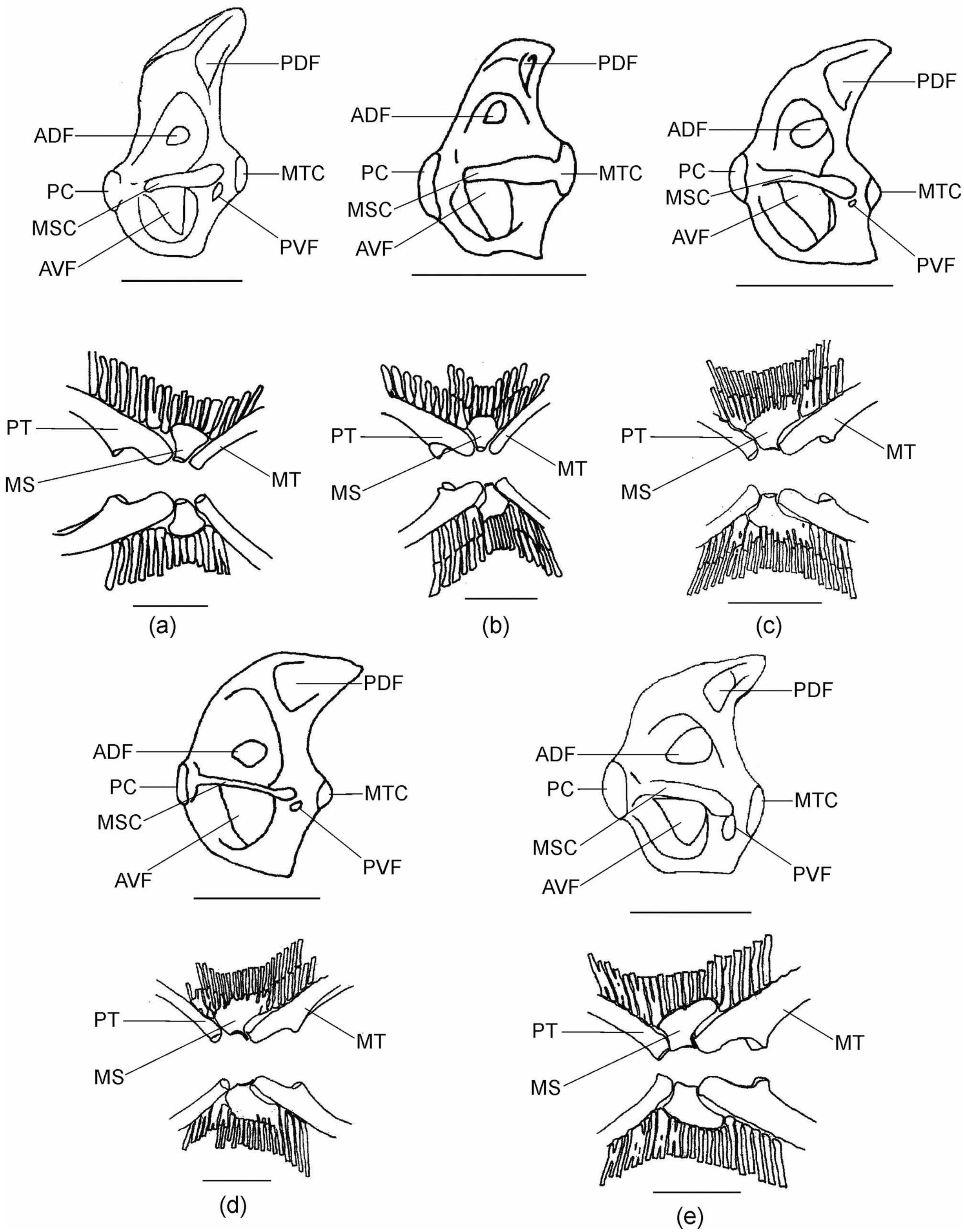

Fig. 5. Lateral (upper) and dorsal (lower) views of the scapulacoracoid. a) *Urotrygon munda*, b) *Urotrygon* nana, c) *Urotrygon chilensis*, d) *Urotrygon rogersi*, e) *Urotrygon aspidura*. ADF, anterodorsal fenestra; AVF, anteroventral fenestra; MS, mesopterygium; MSC, mesocondyle; MT, metapterygium; MTC, metacondyle; PC, procondyle; PDF, postdorsal fenestra; PT, propterygium; PVF, postventral fenestra. Scale indicates 10 mm.

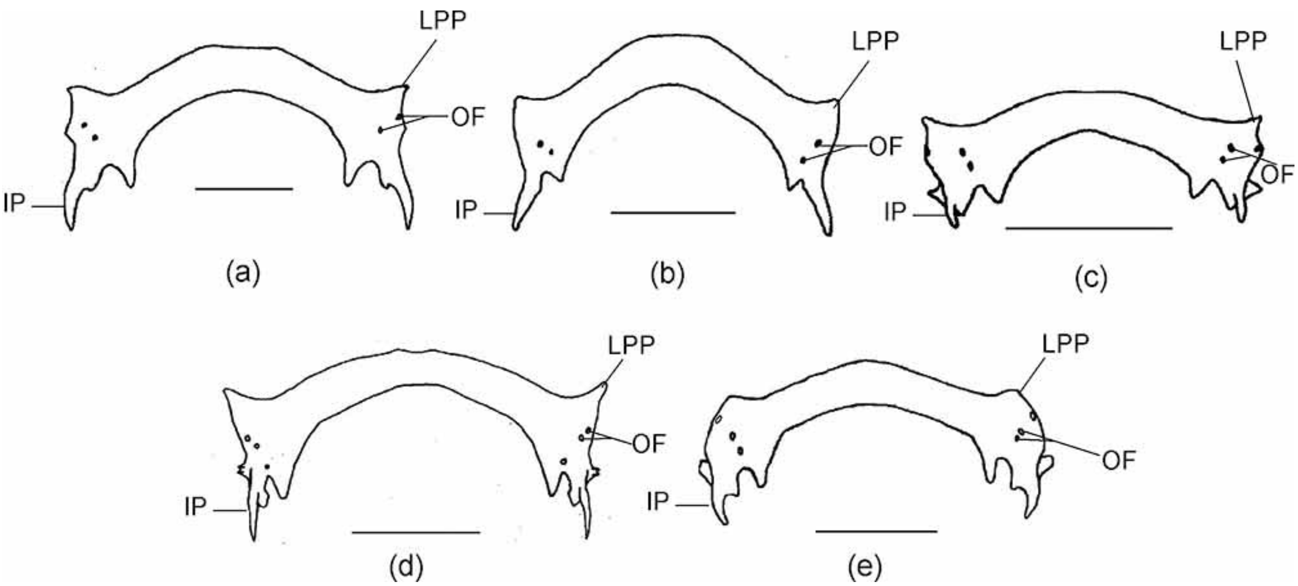

Fig. 6. Dorsal view of the pelvic girdle. a) *Urotrygon munda*, b) *Urotrygon nana*, c) *Urotrygon chilensis*, d) *Urotrygon rogersi*, e) *Urotrygon aspidura*. IP, iliac process; LPP, lateral prepelvic process; OF, obturador foramina. Scale indicates 10 mm.

DISCUSSION

Based on characteristics observed in the skeleton, the little variation of species in the *Urotrygon* genus was proven. A common morphologic pattern, similar to that reported by Miyake and Nishida (1990), for other species in this genus (*Urotrygon simulatryx, U. reticulata, U. venezuelae*, and *U. microphthalmun*), was also found.

Some variable characters can be analyzed among different species. In the neurocranium, nasal capsules expand ventrolaterally; in *Urotrygon nana* and *Urotrygon munda* the capsules migration towards the ventral region is barely evident (Fig. 1), but such migration is clearer in *Urotrygon aspidura* and *Urotrygon rogersi* (Fig. 2). In groups of more specialized myliobatods, such capsules are fully projected towards the ventral region (González-Isáis & Montes, 2004). The preorbital processes were found in the anterior region of this structure. Such processes are reduced in *U. nana*, and slightly more developed in *U. munda* (Fig. 1). In *Urotrygon* remaining species, these structures are more developed (Figs. 1f, 2), matching reports of Miyake and Nishida (1990), for species of genus Urolophus, Dasyatis, Taeniura and Potamotrygon. In *Plesiobatis daviesi* (Miyake; Nishida, 1990) they are well developed.

Postorbital processes are found in the posterior part of the optic region. The first process is reduced in *Urotrygon* species, more evidently in *U. nana* and *U. munda* (Fig 1). In ventral view, it can be observed that internasal space is relatively reduced in *Urotrygon* species.

As related to the hyobranchial skeleton, the the basihyal cartilage was not found in any *Urotrygon* species, which is considered as a synapomorphy. The first hypobranchial cartilage is found in all organisms – fragmented in *U. rogersi* (Fig. 3d)– which has also been reported for *U. venezuelae* and *U. reticulata*, and as a single unit in all other species. The pseudohyal cartilage is proximally fused to the first ceratobranchial, while ceratobranchial cartilages remaining articulate in their proximal region as reported by Nishida (1990), Miyake & McEachran (1991), and González-Isáis & Montes for Miliobatoids remaining. Miyake & McEachran (1991) have considered that the pseudohyal cartilage originally appeared to function as the ceratohyal cartilage in sharks (Compagno, 1977), which is reduced in torpedinoids (Fechhelm & McEachran, 1984). In rays, the ceratohyal cartilage is articulated in rhinobatoids and rajoids (Compagno, 1973, 1977). In all myliobatoids it is fused to the first ceratobranchial cartilage (Nishida, 1990; González-Isáis & Montes), and supports the first gill.

In *Urotrygon aspidura*, the bridge is observed in the anterior part of the cartilage basibranchial (Fig. 3e), which has only been reported for *Gymnura* (Miyake & McEachran, 1991; González-Isáis & Montes). In all species, excepting *Urotrygon rogersi* an orifice was observed in the anterior part of cartilage the cartilage basibranchial.

In the synarcual, the character with the widest variation was the lateral process, which is long and narrow in *Urotrygon aspidura* (Fig. 4e). A similar situation was observed in the synarcual of *U. munda*, but the process is not that long. In *U. nana* and *U. rogersi* this structure is width and short.

The pectoral girdle is similar in all *Urotrygon* species. In the ventral part, all organisms had an anteroventral fenestra, while the posteroventral fenestra had different development degrees: well developed in *U. aspidura* and *U. munda*; little developed in *U. chilensis* and *U. rogersi* (Fig. 5). The only exception was *U. nana* with a single ventral fenestra (Fig. 5b).

In dorsal view, the pectoral girdle has three more elements: the propterygium, mesopterygium and metapterygium, the more variable of which is the mesopterygium articulating the other two. In *U. munda* and *U. nana*, it is a relatively rounded structure (Fig. 5a, b); in *U. munda* it articulates some pectoral fins radials; in *U. nana* some radials fuse and other articulate. In all other species, the mesopterygium is elongated in its anterior part. In U. aspidura, some pectoral fins radials are articulated (Fig. 5e); and in *U. chilensis* and *U. rogersi* some are fused and other, articulated (Fig. 5c, d).

Little variations were observed in the pelvis girdle (Fig. 6). The iliac processes are relatively large in all species, excepting *Urotrygon rogersi*, which are more reduced. The lateral prepelvic processes are developed in all species. The pelvic girdle is more arched in *U. munda* and *U. nana* than in other species. The prepelvic process was absent in *Urotrygon* species, as it is in species of genus *Urolophus*.

It has to be noted that, despite *U. rogersi* and *U. simulatrix* have large similarities in their external morphology, their neurocraniums are very different. *U. simulatrix* cranium is more similar to that of *U. nana*, *U. mundus* and *U. microphthalmum*. It was also observed that cranium of *Plesiobatis daviesi* is very different to species of *Urotrygon*, mainly because it has well developed and fused postorbital processes – condition only reported for the most specialized myliobatoids (Nihida, 1990; González-Isáis & Montes).

Based on anatomical characters described, species studied can be split in two groups. The first one would include *Urotrygon* nana and *Urotrygon* munda, as their cranium shows reduced preorbital processes and nasal capsules slightly projected towards their ventral region, and the mesopterygium in the pectoral girdle is rounded. The second group would be integrated by *Urotrygon chilensis, Urotrygon rogersi* and *Urotrygon munda*. In their cranium, preorbital processes are more developed, and migration of nasal capsules to the ventral region is more evident. Mesopterygium in the pectoral girdle is elongated. Based on phylogeny proposed by Nishida (1990), it can be stated that *Urotrygon* nana and *Urotrygon* munda have the most plesiomorphic characters.

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RESUMEN: El esqueleto de los batoideos ha sido importante para establecer las relaciones de parentesco de este grupo. Es por ello que el objetivo del presente trabajo fue describir la anatomía de cinco especies del género *Urotrygon*. El esqueleto de las especies de urotrigonidos mostró un patrón morfológico común; sin embargo, se observaron las siguientes diferencias: 1) los procesos preorbitales están reducidos en *Urotrygon nana* y *Urotrygon munda,* en el resto de las especies están más desarrollados. 2) El primer proceso postorbital está reducido en *U. nana* y *U. munda*. 3) El primer cartílago hipobranquial se fragmenta únicamente en *Urotrygon rogersi*. 4) Solo en *Urotrygon aspidura* el cartílago basibranquial presentó un puente. 5) Los procesos laterales de la sinarcualia en *U. aspidura* son largos y delgados, mientras que en *U. nana* y *U. rogersi* son anchos y cortos. 6) En la cintura pectoral *U. nana* presenta una sola fenestra, en el resto de las especies hay dos. 7) En *U. nana* y *U. munda* el mesopterigio es redondeado, en el resto de las especies está alargado en su parte anterior. 8) La cintura pélvica está más arqueada en *U. nana* y *U. munda*. Las especies que presentaron los caracteres más plesiomórficos fueron *U. nana* y *U. munda*.

PALABRAS CLAVE: Batoideos; Urotrygonidae; *Urotrygon*; Neurocráneo; Esqueleto.

REFERENCES

Beebe, W. & Tee-Van, J. Fishes from the Tropical Eastern Pacific (from Cedros Island, Baja California, south to the Galapagos Island and northern Peru). Part 3. Rays, mantas and chimaeras. *Zoologica, 26(3)*:245-80, 1941.

Bigelow, H. B. & Shroeder H. B. *Fishes of Western North Atlantic*. Part 2. Sawfishes, guitarfishes, skates, rays, chimaeroids. New Haven, Sears Foundation for Marine Research, 1953.

Compagno, L. J. V. *Interrelationships of living elasmobranchs*. In: Greenwood, P. H.; Miles, R. S. & Patterson, C. (Eds.). Interrelationships of Fishes. London, Academic Press, 1973. pp.15-61.

Compagno, L. J. V. Phyletic relationships of living sharks and rays. *Amer. Zool., 17(2)*:303-22, 1977.

Dingerkus, G. & Uhler, L. D. Enzyme clearing of alcian blue stained whole small vertebrates for demonstration of cartilage. *Stain Technol., 52(4)*:229-32, 1977.

Fechhelm, J. D. & McEachran, J. D. A revision of the electric ray genus Diplobatis with notes on the interrelationships of Narcinidae (Chondrichthyes, Torpediniformes). *Bull. Fla. State Mus. Biol. Sci., 29(5)*:171-209, 1984.

Gill, T. Descriptive Enumeration of a Collection of Fishes from the Western Coast of Central America, Presented to the Smithsonian Institution, by Capt. John M. Dow. *Proc. Acad. Nat. Sci. Phila., 15*:162-74, 1863.

González-Isáis, M. & Montes, H. M. Comparative anatomy of the superfamily Myliobatoidea (Chondrichthyes) with some comments on phylogeny. *J. Morphol., 262(1)*:517-35, 2004.

Jordan, D. S. & Everman, B. W. *The Fishes*. Part 1. Washington, Smithsonian Institution, 1896.

Jordan, D. S. & Gilbert, C. H. Descriptions of nineteen new species of fishes from the Bay of Panama. *Bull. U. S. Fish. Comm., 1*:306-35, 1882.

Miyake, T. & McEachran, J. D. The morphology and evolution of the ventral gill arch skeleton in batoid fishes (Chondirchthyes: Batoidea). *Zool. J. Linn. Soc., 102(1)*:75-100, 1991.

Miyake, T. & McEachran, J. D. Three new species of the stingray genus *Urotrygon* (Myliobatiformes: Urolophidae) from the Eastern Pacific. *Bull. Mar. Sci., 42(3)*:366-75, 1988.

Miyake, T. *The systematics of the stingray genus Urotrygon with comments on the interrelationships within Urolophidae (Chondirchthyes, Myliobatiformes)*. PhD Dissertation. College Station, Texas A&M University, 1988.

Nelson, J. S. *Fishes of the World*. 4th ed. New York, John Wiley & Sons, 2006.

Nelson, J. S.; Grande, T. C. & Wilson, M. V. H. *Fishes of the World*. 5th ed. New Jersey, John Wiley & Sons, 2016.

Nishida, K. Comparative skeletal of six myliobatoid fishes from Japan. *Rep. Jpn. Soc. Elasmobranch Stud., 19*:21-43, 1985.

Nishida, K. Phylogeny of the suborder Myliobatoidei. *Mem. Fac. Fish. Hokkaido Univ., 37(1-2)*:1-108, 1990.

Corresponding author:
Dra. Mónica González Isáis
Laboratorio de Anatomía Animal Comparada
UNAM FES Iztacala
Los Reyes Iztacala
Tlalnepantla
MÉXICO

E-mail: monigi@unam.mx

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