

Myological Peculiarities in *Rhinoderma darwinii* (Anura: Rhinodermatidae)

ADRIANA S. MANZANO AND E.O. LAVILLA

*Instituto de Herpetología Fundación Miguel Lillo, 4000 Tucumán,
Argentina*

ABSTRACT The myology of *Rhinoderma darwinii* is re-analyzed. Fourteen muscles (m. deltoideus scapularis, m. coracoradialis, m. coracobrachialis brevis, m. omohyoideus, m. cucularis, m. interhyoideus, m. levator mandibular posterior externus, m. levator mandibular posterior articularis, m. levator posterior longus, m. geniohyoideus lateralis, m. geniohyoideus medialis, m. intermaxillaris, m. iliofibularis and m. iliofemoralis) are unique with respect to either structure or points of origin and/or insertion. An apical supplementary element of the m. intermandibularis is reported for the first time in the species, and another muscle, associated with the skin of the thigh, is described for the first time among anurans. Myological characters may be useful characters for future systematic and phylogenetic analysis of the Rhinodermatidae, one of the less diversified and enigmatic groups of neotropical frogs. © 1995 Wiley-Liss, Inc.

Myological information for the anuran *Rhinoderma darwinii* is limited to Beddard's ('08) general description and Andersen's ('78) work on the carpus and tarsus. Re-examination of the musculature of *Rhinoderma darwinii* revealed the presence of muscles that are unique in structure and/or position, and the occurrence of one muscle previously undescribed in the species, and another undescribed among anurans.

Myological characters may be useful for future assessment of the systematic relationships of the peculiar anuran family Rhinodermatidae, which comprises one genus and two species that are restricted to the austral forest of Argentina and Chile. Although several taxa have been proposed as sister groups of the Rhinodermatidae based on different kinds of evidence (e.g., Ardila-Robayo, '79; Barrio and Rinaldi de Chieri, '71; Griffiths, '59; Laurent, '42; Noble, '31), the phylogenetic relationships of this family remain unresolved (Duellman and Trueb, '86; Ford and Cannatella, '93).

Herein, we describe characteristics of 16 muscles of *Rhinoderma darwinii* that differ significantly from available descriptions of the same muscles in other anurans.

MATERIALS AND METHODS

The following descriptions are based on two male and two female *Rhinoderma darwinii* Duméril and Bibron, 1841, from Estero

de Cabrerías, Cordillera de Nahuelbuta, Angol, Chile. Voucher specimens are housed at the collections of the Instituto de Herpetología, Fundación Miguel Lillo, under the number FML 03694, and the material employed for comparison is listed in the appendix.

For the descriptions, bones and cartilages were stained with alizarine red S and Alcian blue 8GX, respectively, as described by Wassersug ('76). The muscles were stained temporarily with lugol (Bock and Shear, '72). Thus, it was possible to differentiate easily tendons, ligaments and fasciae from the skeletal support.

RESULTS

Muscles with exclusive character states in Rhinoderma darwinii

Fourteen muscles from diverse regions of the body (Figs. 1, 2) are included in this section. Each muscle description is followed by a brief discussion of the muscle in other anurans for which the information is available. This information has been derived from Beddard ('08), Duellman and Trueb ('86), Dunlap ('60), Ecker (1889), Gaupp (1896), Noble ('22; '31), Trewavas ('33) and Tyler ('79). Our discussion of the m. pelvocutaneus and the apical element of m. intermandibu-

Address reprint requests to Dr. Adriana S. Manzano, Instituto de Herpetología, Fundación Miguel Lillo, Miguel Lillo 251, 4000 Tucumán, Argentina.

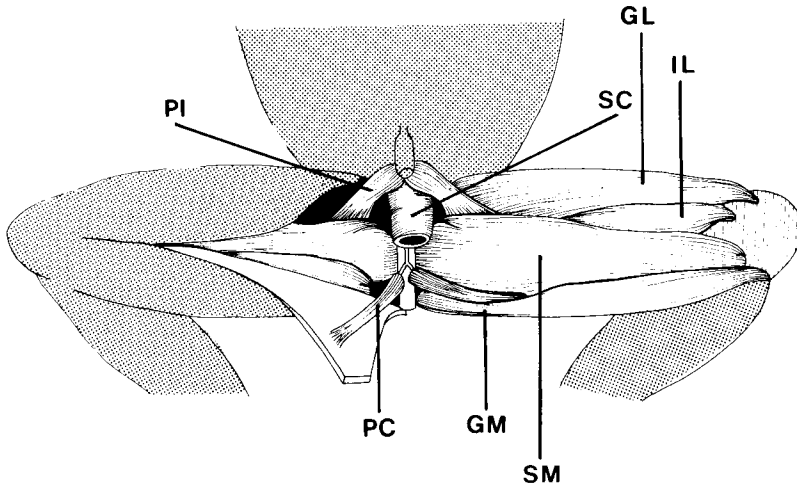


Fig. 1. *Rhinoderma darwinii*. Ventral view of muscles of the thigh. GL, glutaeus magnus; GM, gracilis major + gracilis minor; IL, iliofibularis; PC, pelvocutaneus; PI, piriformis; SC, sphincter anni cloacae; SM, semimembranosus.

laris is based on examination of at least two individuals of 14 species that represent six families (listed in the appendix). "Other anurans," as cited in the following analysis, are those species treated in the literature cited, plus those listed in the appendix.

M. deltoideus scapularis

This is the shortest and most posterior of the three deltoideus. It has a single origin at the

base of the scapula, and inserts on the inner side of the distal end of the humerus.

In other anurans, the scapular branch of the deltoideus has three points of origin: one from the scapula, a second from the distal end of the clavicle, and a third from the procoracoid cartilage.

M. coracoradialis

This muscle has three branches; two thin lateral branches flank the medial superficial branch, which is wide and fan shaped. The m. coracoradialis has three points of origin: (1) from the superior half of the clavicle and epicoracoid horn, (2) from the external half of epicoracoid cartilage, and (3) at base of the epicoracoid cartilage. The muscle has three points of insertion. The medial branch terminates in a thick tendon that inserts on the proximal region of radius; each lateral branch ends in a thin tendon joined to the thicker tendon of the medial branch. In other anurans, the m. coracoradialis is single and extends from the omosternum to the epicoracoid cartilage.

M. coracobrachialis brevis

This muscle is connected laterally to the distal end of the m. omohyoideus by a sheet of connective tissue. This condition has not been reported in other anurans in which these muscles are not associated.

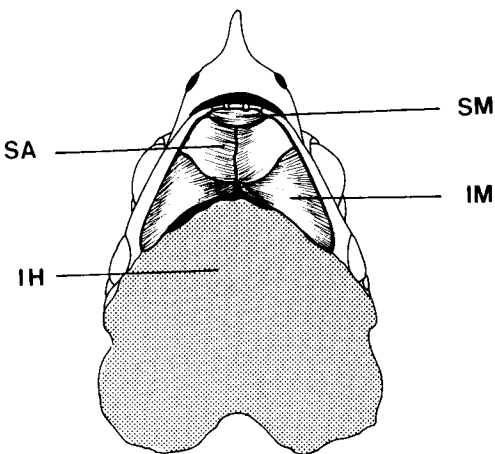


Fig. 2. *Rhinoderma darwinii*. Ventral view of muscles of the throat region. IH, interthyroideus; IM, intermandibularis; SA, apical element of the intermandibularis; SM, submental.

M. omohyoideus

This long, thin muscle has two points of origin—one from the base of the scapula and the other from the inner side of the distal end of the coracoid. It inserts on the ventral margin of the hyoid, between the posteromedial and posterolateral processes. Its distal end is connected to the m. coracobrachialis brevis by connective tissue.

In other anurans, this muscle is variably present or absent. When present, it has a simple origin from the scapula and is not connected to the m. coracobrachialis brevis.

M. cucularis

This long, thick muscle extends obliquely from the dorsal edge of the operculum to the middorsal edge of the scapula.

In other anurans, the m. cucularis originates from the prootic bone and inserts on the suprascapula. The m. cucularis described by Beddard ('08) in *Rhinoderma darwinii* may correspond to the superior part of the m. longissimus dorsi.

M. interhyoideus

The m. interhyoideus is composed of one or two thin bands that lie deep to the m. intermandibularis (slightly differentiated). The muscle originates from the quadratojugal and inserts on the omosternum. In males, this muscle, along with the m. intermandibularis, forms the gular sac. The m. interhyoideus is sexually dimorphic. In males, the muscle is double, whereas in females it is represented by a single thin strip.

The m. interhyoideus was described by Beddard ('08) as m. subhyoideus, but the intraspecific variation has not been reported previously.

M. levator mandibular posterior externus

This short, wide muscle originates from the quadratojugal and inserts on the distal end of the lower jaw. In other anurans, this muscle originates on the zygomatic ramus of the squamosal.

M. levator mandibular posterior articularis

This short, wide muscle lies at the jaw articulation deep to the m. levator mandibular posterior externus and m. l. m. p. subexternus. It originates from the distal end of the zygomatic ramus of squamosal and inserts on the posterior end of the dentary.

The m. levator mandibular posterior articularis was termed m. massetero by Ecker

(1889); in other anurans, it originates from the quadratojugal.

M. levator mandibular posterior longus

This nonbranching muscle originates from the dorsolateral surface of the fused prootic and exoccipital and has a nontendinous insertion on the distal lingual angulosplenic. It extends under the zygomatic ramus of squamosal.

The muscle was termed the m. temporalis by Ecker (1889). In most anurans for which the muscle is described, it is branched and the different branches are joined by one tendon that inserts on the lower jaw.

M. geniohyoideus lateralis

Each of the two branches of the m. geniohyoideus lateralis is long and single. Each branch originates by means of a short tendon from the inner surface of dentary and inserts on the posteromedial process of the hyoid.

See comments under m. geniohyoideus medialis.

M. geniohyoideus medialis

This wide muscle covers the remaining muscles of the hyoid. It has a single origin from the dorsal surface of the mentomeckelian bone, and is divided into two branches that have a common insertion surface on the hyoarytenoid membrane (*sensu* Trewavas, '33).

In other anurans, the m. geniohyoideus has three branches: two laterals (m. g. lateralis) that usually are divided, and a single medial slip (m. g. medialis). In *Rhinoderma darwinii*, the condition is reversed; the lateral branches are single and the medial one is divided.

M. intermaxillaris

This wide muscle is located on the anterior and terminal region of the head; it is attached to the anterolateral edge of the premaxilla, the nasal capsule, and the anterior edge of the nasal bone on each side, and it is structurally involved with the nasal appendage characteristic of *Rhinoderma darwinii*.

In other anurans, the attachment of the muscle is restricted to the premaxilla.

M. iliofibularis

This long, thin muscle extends along the external surface of the femur. It has a nontendinous origin from the base of the ilial shaft and a tendinous insertion on the ventral region of the fibular condyle. In other anurans,

the muscle has a tendinous origin from the ilium and inserts on the aponeurosis of the knee.

M. iliofemoralis

This short, thin muscle lies deep to, and separate from, the m. iliofibularis. It originates via a tendon in the acetabulum and inserts on the proximal femur. In other anurans, the m. iliofemoralis has a dual origin from the ilium and the tendon of origin of the m. iliofibularis.

Characterization of the m. pelvotaneus (nobis)

In the ventral thigh region of anurans, two muscles are attached to the skin—the m. gracilis minor and the m. abdominal crenator. The m. gracilis minor is variable in its presence and configuration. If present, the muscle may be connected with the skin or not, and if attached, the connections vary; an interesting synthesis was presented by Dunlap ('60).

Rhinoderma darwinii lacks the m. abdominal crenator (described for several species of *Bufo* by Winokur and Hillyard, '92), and in this species, the m. gracilis minor lacks connections with the skin (although Beddard, '08, reported it under the name of m. rectus internus minor). Nevertheless, *Rhinoderma* has a paired ribbon-shaped muscle that is thin and short and located in the posterodorsal region of the thigh. The muscle originates from a common tendon from the dorsal end of the ischium, and each branch inserts on the skin (Fig. 1). Because this muscle has an independent origin from the m. gracilis minor and a novel topology, we consider it to have been unreported. With reference to its origin and insertion, we term the muscle m. pelvotaneus.

Eupsophus roseus (Leptodactylidae: Telmatobiinae) is the only species, among those employed for comparisons (see appendix), that has a m. pelvotaneus. Lower telmatobines were proposed as a sister group of rhinodermatids by Barrio and Rinaldi de Chieri ('71), based on the number of chromosomes ($2n = 26$). The presence of the m. pelvotaneus in *Eupsophus roseus* supports the idea.

The apical element of the m. intermandibularis

The apical element of the m. intermandibularis (Fig. 2) was reported in *Rhinoderma darwinii* as the m. genioglossus (?) (Beddard,

'08) and m. intermandibularis posterior (Trewavas, '33). In this species, this element originates from the anterior end of the lower jaw and inserts on a median raphe. It is short, small, and fan shaped and is joined with its lateral counterpart at the midline. The apical slip lies over the principal element of the m. intermandibularis and is completely free from it.

The apical element is known in ascaphids, discoglossids, bufonids, hylids, centrolenids, leptodactylids, myobatrachids, dendrobatids, microhylids, and ranids (Emerson, '76; Trewavas, '33; Trueb and Tyler, '74; Tyler, '71; '79). The structure is present in *Telmatobius laticeps*, *Batrachyla antartandica*, *Hylorina sylvatica* (Leptodactylidae), *Phyllomedusa savagii*, and *Phrynohyas venulosa* (Hylidae) among the materials used for comparison. It is interesting that *Eupsophus roseus* (Leptodactylidae) and *Dermatonotus muelleri* (Microhylidae) have anterolateral elements of the m. intermandibularis, and *Phyllomedusa savagii* also has posterolateral elements of this muscle (in the sense of Tyler, '71); however, in all these cases, the supplementary fibers are connected to the raphe and at the same level as those of the principal element of the m. intermandibularis. The independent condition of the fibers of the apical element, which in *Rhinoderma darwinii* overlie the m. intermandibularis and are completely free from it, raises some question about its homologies with the structures of the same name in other anurans.

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APPENDIX

Material employed for comparisons

Leptodactylidae

FML 03957—*Telmatobius laticeps*. Tafí del Valle, Tucumán, Argentina.

FML 03280—*Pleurodema borellii*. Santa Victoria, Salta, Argentina.

FML 03785—*Pleurodema cinerea*. Tilcara, Jujuy, Argentina.

FML 03910—*Hylorina sylvatica*. Chaitén, Palena, Chile.

FML 03708—*Eupsophus roseus*. Con-tulmo, Chile.

FML 03762—*Batrachyla antartandica*. Pirehueico, Chile.

FML 04664—*Pseudopaludicola falcipes*. Laguna Paiva, La Capital, Santa Fé, Argentina.

Microhylidae

FML 04491—*Elachistocleis bicolor*. Guay-colec, Formosa, Argentina.

FML 03593—*Dermatonotus muelleri*. 40 km S de Monte Quemado, Santiago del Estero, Argentina.

*Bufo*nidae

FML 04438—*Bufo rubropunctatus*. Fundo María Ester, 15 km W Victoria, Chile.

FML 02502—*Melanophryniscus rubriventris rubriventris*. Abra de Cañas, Valle Grande, Jujuy, Argentina.

Dendrobatidae

FML 01722—*Dendrobates auratus*. 4 m. N de Limón, Prov. Limón, Costa Rica.

Hylidae

FML 04899—*Phyllomedusa sawagii*. Lucio V. Mansilla, Tulumba, Córdoba, Argentina.

Pseudidae

FML s/n—*Pseudis paradoxa*. No data.