

The Pelvic Musculature of *Necturus*

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The musculature of the pelvis and hind-limb of salamanders as a group has received but little attention (Francis, 1934). The myology of *Necturus* has been studied even less than in certain other genera. It is true that many standard manuals of comparative anatomy list certain of the muscles of *Necturus*, but the descriptions made and names used in many cases are so variable as to be of little value. Mivart (1869) dissected one specimen of *Necturus* and sketchily presented his findings. Wilder (1908, esp. 1912, and 1923) did especially valuable work on the limb-muscles of *Necturus*; his descriptions will be referred to many times. Francis (1934) tabulated the various synonyms for and described each of the muscles of *Salamandra*. I have adopted his terminology for this report on the musculature of the pelvis of *Necturus*.

Pubo-ischio-tibialis (PIT) ("puboischiotibialis" of Wilder).

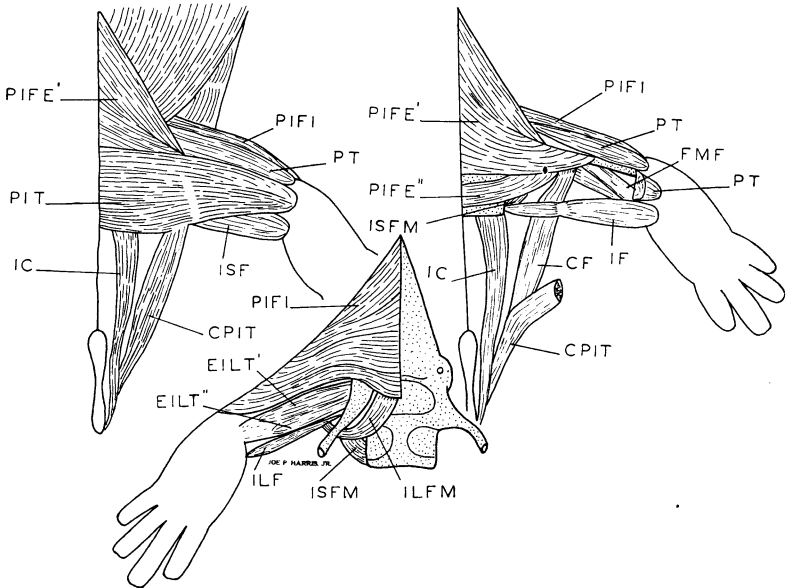
Origin: along the crista muscularis of the ventral surface of the ischium. *Insertion*: along the anterior surface, proximal half of the length of tibia.

This, the most superficial ventral muscle of the pelvic girdle of *Necturus*, covers the posterior half of the girdle, and originates solely on its ischial portion. Because of this feature of its origin, the name "ischiotibialis" would be more exact, but the name pubo-ischio-tibialis is retained. The muscle is reasonably broad and thin at its origin, but at the lateral margin of the pelvic girdle it becomes narrower and thicker, almost cylindrical, then tapers slightly as it passes down along the femur to its insertion on the tibia.

At the level of the lateral margin of the pelvic girdle the fibers are interrupted by a deep tendinous inscription ("raphe" of Wilder) which begins at the posterior border of the muscle and goes forward about two-thirds of the width of the muscle. The tendinous inscription is not described for *Salamandra*. Many authors have described the portion of the pubo-ischio-tibialis distal to the tendinous inscription as the "gracilis" muscle, but that designation seems unnecessary.

Wilder (1912) says a tendon marks the antero-lateral boundary of the pubo-ischio-tibialis. This tendon he describes as being variable, sometimes appearing broad and thick, at other times thread-like, sometimes forming a union with the pubo-tibialis, etc. Francis (1934) also describes the tendon in *Salamandra*. I have been unable to find the tendon in the specimens which I have examined.

Slightly median to the tendinous inscription the pubo-ischio-tibialis receives the caudali-pubo-ischio-tibialis mus-



cle. Wilder describes its insertion as being on the tendinous inscription, but in all my specimens the insertion was as described above.

The pubo-ischio-tibialis overlaps the posterior portion of the pubo-ischio-femoralis externus muscle.

Pubo-ischio-femoralis externus (PIFE' and PIFE'') ("pubo-ischiofemoralis externus" of Wilder).

This muscle arises all along the median line of the ventral surface of the pelvic girdle. The fibers converge to insertions on the proximal portions of the femur. The arrangement of the muscle is such that it outlines the shape of the pelvic girdle. The pubo-ischio-femoralis externus is readily divisible into two portions, on the basis of origins and insertions, direction of fibers, and innervation.

ANTERIOR PORTION (PIFE') ("obturator anterior" of Appleton)

Origin: along the crista muscularis of the anterior two-thirds of the ventral surface of the pelvic girdle. The pubo-ischio-tibialis muscle overlaps the back part of the "obturator anterior" along the ventral surface of the crista ventralis and the distal continuation of the ridge of the crista ventralis on the proximal half of the femur. The fibers of the muscle run caudo-laterad.

Wilder says this anterior portion of the pubo-ischio-femoralis externus muscle is "further subdivided, though not very definitely, into three branches; a) anterior superficial, b) posterior superficial, c) anterior deep. Of these portions a) is the most anterior and arises from the median line of the plate for about its anterior half, inserting into the crista ventralis of the femur and the distal elongation of this process. Portion b) is a narrow slip, arising from the median line in the ischiadic region and inserting into the crista ventralis proximal to the insertion of a), and closely associated with that of c). Portion c) is perhaps a little the largest, slightly exceeding a). It arises from the median line along its middle three-fifths, and is overlapped anteriorly by a). It inserts into the crista ventralis".

I have not been able to recognize the posterior superficial portion b) described by Wilder. Quite frequently natural divisions of the anterior portion of the pubo-ischio-femoralis externus muscle are possible at its insertion on the femur, but the body of the muscle is divisible only on the most arbitrary basis. The innervation for all the anterior portion appears to be from the obturator nerve. It seems that the divisions recognized by Wilder are unnecessary.

POSTERIOR PORTION (PIFE'') ("obturator posterior" of Appleton)

Origin: along the crista muscularis of the posterior third (ischium) of the pelvic girdle. The fibers of this portion run cranio-laterad to their insertions on the crista ventralis of the femur. *Insertion*: on the crista ventralis of the femur, deep (dorsal) to the fibers of the obturator anterior. The pubo-ischio-tibialis completely covers the obturator posterior.

Pubo-tibialis (PT) (“pubotibialis” of Wilder)

Origin: by a tendon from the lateral surface of the pelvic girdle anterior to the acetabulum (Wilder’s “pre-acetabular process”). *Insertion*: on the proximal end of the tibia proximal to the insertion of the pubo-ischio-tibialis muscle. This is a slender cylindrical or oval muscle which forms the anterior-ventral border of the thigh. The tendon of its origin is frequently coupled with the tendon of insertion of the rectus abdominis muscle.

Ischio-femoralis (ISFM) (“ischiofemoralis” of Wilder)

Origin: on the concave lateral surface of the posterior part of the ischium, and on its ischial tuberosity. *Insertion*: on the posterior face of the head of the femur on a slight projection named the crista lateralis. The muscle runs dorsal to the post-acetabular process of the pelvic girdle to reach its insertion point. It is a short stout muscle, strongly attached to the head of the femur. It aids in anchoring the head of the femur in the acetabulum.

Ischio-flexorius (IF) (“posterior portion of puboischiotibialis” of Wilder).

This muscle is exposed when the pubo-ischio-tibialis and the attached caudali-ischio-pubo-tibialis muscles are removed. *Origin*: Posterior lateral margin of the ischium, on the ischial tuberosity. *Insertion*: by a tendon on the fibular side of the shank. The tendon joins the plantar aponeurosis of the flexor primordialis communis muscle. The ischio-flexorius is quite thin at its origin, and weakly joined to the ischium. As a consequence, it is easily pulled free from the ischium. Also the muscle is sharply scored by a tendinous inscription a short distance lateral to the ischium; the inscription is very nearly dorsal to the tendinous inscription of the pubo-ischio-tibialis muscle. Distal to the tendinous inscription, the ischio-flexorius becomes thicker and stronger as it goes down along the leg to its insertion on the plantar aponeurosis. Francis recognizes in *Salamandra* a similar division of the ischio-flexorius, and names the proximal portion the “pars propria”, and the distal segment the “pars plantaris”. The ischio-flexorius lies dorsal (deep) to the insertion of the caudali-pubo-ischio-tibialis and ventral (superficial) to the body of the caudali-femoralis muscle.

The next three ribbon-like muscles are in a pocket formed

by the ventral mass of the trunk muscles. The pocket is divided into right and left sides by the cloaca. All three pairs of muscles may be hidden by the enlarged cloacal glands, which must be removed to expose them. The three muscles are evidently derived by modification of the ventral caudal myotomes, as stated by Wilder.

Caudali-pubo-ischio-tibialis (CPIT) "caudalipuboischiotibialis" of Wilder).

Origin: ventral to, but with the caudali-femoralis, from the sides of the haemapophyses of the first one, two or three caudal vertebrae that have haemal arches (usually the fourth, fifth, and sixth caudal vertebrae). Since the haemal arches slant caudo-ventrad, the origin of the caudali-pubo-ischio-tibialis and caudali-femoralis muscles appears as a broad sheet extending over three vertebral segments. *Insertion*: by a flat tendon on the posterior surface of the pubo-ischio-tibialis slightly median to the tendinous inscription (not on the tendinous inscription as described by Wilder). The caudali-pubo-ischio-tibialis muscle is lateral to the ischio-caudalis, and ventral to the caudali-femoralis muscle. (Caudali-ischio-pubo-femoralis muscle should be called "caudali-ischio-tibialis", because in *Necturus* the pubo-ischio-tibialis muscle is, strictly speaking, an ischio-tibial only, since it lacks any point of attachment on the pubic portion of the pelvic girdle.)

Caudali-femoralis (CF) ("caudalifemoralis" of Wilder).

Origin: dorsal to, but with the caudali-pubo-ischio-tibialis, as described above. *Insertion*: runs dorsal (deep) to the caudali-pubo-ischio-tibialis to insert on the crista ventralis (Wilder) ("external trochanter" of Francis) of the femur by a strong tendon. In its course it passes dorsal to the ischio-flexorius, which thus lies between the caudali-femoralis and the caudali-pubo-ischio-tibialis muscle. This is the strongest of the three "caudali-" muscles.

Ischio-caudalis (IC) ("ischio-caudalis" of Wilder).

Origin: first or second haemal spine (usually on fourth or fifth caudal vertebra). The origins of this and the two preceding muscles are sometimes impossible of separation. *Insertion*: on the posterior margin of the ischium at the ischial tuberosity.

It is evident that the origins and insertions for the pre-

ceding three muscles are listed according to the usual scheme in which the end attached to the axial skeleton is designated as *origin*, with the *insertion* on the appendicular skeleton. Functionally, the origin and insertions may be reversible. When the pelvic girdle is held rigid, contraction of these three muscles will move the pelvic girdle and appendage. On occasion both ends may move, since *Necturus* in walking swings its tail and moves its legs in such fashion that the left leg moves backward as the tail swings to the left, etc. Furthermore, the ischio-caudalis, the weakest of the three muscles considered here, may not be for locomotion at all. It may be used solely for compressing the cloacal glands. These glands lie between the two ischio-caudal muscles, and are to a small degree separated into dorsal and ventral portions by the position of these muscles. For *Salamandra*, Francis says that the ischio-caudal muscle together with the caudali-ischio-pubo-tibialis muscle "must have a special function in the male by compressing the glandular tissue around the cloaca. It is probably for this reason that the tail is strongly flexed during copulation". [In *Necturus*, copulation does not take place.] Whether strong flexion of the tail, with resultant pressure on the cloacal glands, is necessary for the manipulation of spermatophores in *Necturus* has not yet been reported.

Pubo-ischio-femoralis internus (PIFI) ("anterior portion of puboischiofemoralis internus" of Wilder).

Origin: along the dorsal (upper) surface of the anterior three-fifths of the pelvic girdle. Its origin extends from the front end of the girdle posteriad to a point between the iliac processes, originating in part from the anterior half of the pubo-ischiadic fossa. *Insertion*: along most of the anterior face of the femur. This is a broad muscle, the most powerful of the dorsal surface of the pelvic girdle and limb. It is broad at its origin, but becomes narrower as it runs along the anterior surface of the femur. However, its insertion on the femur is about as extended as its origin on the pelvic girdle. In its course the muscle curves up over the edge of the pelvic girdle and the pre-acetabular process to reach the femur.

Ilio-femoralis (ILFM) ("posterior portion of puboischiofemoralis internus" of Wilder).

Origin: side and bottom of the puboischiadic fossa beneath (ventral to) the fibers of the pubo-ischio-femoralis internus muscle. *Insertion*: on the posterior face of the femur, slightly distal to the crista ventralis. The fibers of this muscle begin at nearly right angles to the fibers of the pubo-ischio-femoralis internus and in their course rise up over the postacetabular process and curve around behind the ilium dorsal to the ischio-femoralis muscle, to their strong insertion on the femur. Nowhere do the fibers of this muscle and the pubo-ischio-femoralis internus muscle "blend into an inseparable mass" as described by Wilder. The insertion of the ilio-femoralis is on the femur posterior to the insertion of the pubo-ischio-femoralis internus. The muscles are discrete throughout their courses. They have different innervations. Their separate origins, insertions, functions and innervations seem sufficient reason for separating the two muscles in name. Francis describes the origin of the ilio-femoralis in *Salamandra* on the postero-lateral face of the ilium and to some extent on the inner face of the ischium. In *Necturus*, the origin is on the inner face of the ischium; seldom do any fibers originate on the ilium. "Ischio-femoralis" would therefore be a better name in *Necturus*; but since that name is already used for another muscle, the name ilio-femoralis is retained.

Pubo-femoralis.

Francis describes this muscle in *Salamandra* as arising from the antero-ventral surface of the pubo-ischium, anterior to the pubo-ischio-femoralis externus, and inserting along the ventral face of the femur. This muscle is not present in *Necturus*.

Pubo-extensorius.

This muscle is described by Francis in *Salamandra* as a component of the pubo-ischio-femoralis internus. It is said to originate along the antero-dorsal edge of the pubis, to pass lateral along the antero-dorsal aspect of the thigh to a tendinous insertion on the capsule of the knee. Francis says that though it is closely associated with the pubo-ischio-femoralis internus proximally, it still retains a separate insertion on the knee, and that the muscles can be readily separated, beginning at the knee. The same general description is apt for *Necturus*. An anterior portion of the pubo-

ischio-femoralis internus can be peeled away beginning at the knee; but proximally no separation can be recognized, and splitting of the muscle becomes most arbitrary. Moreover, I have not yet found separate innervations for the two portions named here. Francis quotes Low as saying that this muscle (pubo-extensorius) is more distinct in the larva. The absence of the pubo-extensorius in *Necturus* may be additional evidence of the "specialized-larval" state of the animal.

Extensor ilio-tibialis (EILT) ("iliotibialis" and "ilioextensorius" of Wilder).

Origin: antero-lateral surface of the ilium. *Insertion*: by a wide tendinous aponeurosis which covers the knee, forming part of the knee capsule; it extends to the proximal end of the tibia. The extensor ilio-tibialis is of nearly uniform width from its origin to its insertion, but in thickness is wedge-shaped, being thickest at its origin.

The extensor ilio-tibialis is of variable appearance. Usually it is superficially divided into two parallel muscles by a deep groove; sometimes it shows no such division. Even when the belly of the muscle is superficially divided, there is a common origin on the ilium, and both divisions end in the common aponeurosis at the knee. Both slips are innervated by the same nerve.

Wilder recognizes two divisions in this muscle. He used the name "iliotibialis" for the anterior division, and the name "ilioextensorius" for the posterior division. Appleton (1928) in one place uses Wilder's terminology, but in another uses the names "pars anterior" (EILT') and "pars posterior" (EILT''). Because of the common innervation, I think the names "pars anterior" and "pars posterior" are appropriate.

Ilio-fibularis (ILF) ("iliofibularis" of Wilder).

Origin: by a slender tendon from the outer surface of the ilium, posterior to the extensor ilio-tibialis. *Insertion*: on the proximal end (epiphysis) of the fibula, posterior surface. This muscle is relatively slender, fusiform, and is of slightly larger diameter distally than proximally. It lies parallel with and posterior to the extensor ilio-tibialis muscle.

Femoro-fibularis (FMF) ("femerofibularis" of Wilder).

Origin: median ventral surface of femur near the insertion of the caudal-femoralis and ischio-femoralis. *Insertion*: by a tendon to the postero-lateral surface of the fibula at about the middle of its length. The muscle crosses the popliteal surface of the knee.

SUMMARY

A brief description of each of the muscles of the pelvis of *Necturus* is presented. The muscles are named in accordance with the terminology used by Francis (1934) in his descriptions of the muscles of *Salamandra*. Names used by Wilder (1912) in his descriptions of the muscles of *Necturus* are listed as synonyms of the names used by Francis. With but one exception (pubo-femoralis) the muscles listed for the pelvis of *Salamandra* are found in *Necturus*. Wilder's descriptions are found inadequate in respect of five muscles, namely, the pubo-ischio-femoralis externus, the pubo-ischio-femoralis internus, the ischio-flexorius, the ilio-femoralis, and the extensor ilio-tibialis. It is suggested that the pubo-extensorius muscle may furnish additional evidence of the specialized larval state of adult *Necturus*. A possible function of the ischio-caudalis muscle in compressing the cloacal glands is also suggested.

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Collecting Mosses in East-Central Africa

Eula Whitehouse

On February 19, 1952, I left Dallas for Kenya and Tanganyika to collect mosses and to photograph and study flowers and animals of the region. My nephew went along to help with the photography. We spent about 38 hours in the air and covered a distance of some 9300 miles in reaching Nairobi, capital and largest city of Kenya, the center from which we expected to make our forays. On our way, we had to spend two days in New York and six days in London acquiring visas and hotel accommodations. We arrived in Nairobi after 8 p.m., too late to see much of the city.

Our flight from London had carried us over the Alps at night so that we reached Cairo in the early morning hours. We had a view of north Africa as we flew to Nairobi *via* Khartoum, the course following the Nile River most of the way. It took nearly an hour to go through customs. A representative of Cook's Travel Agency drove us seven miles out of Nairobi to the "Spread Eagle Hotel", there to spend the