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THE EPAXIAL MUSCULATURE OF *SIREN*, *AMPHIUMA*, AND *NECTURUS* (AMPHIBIA)

WALTER AUFFENBERG [1]

SYNOPSIS: Almost all of the studies dealing with the trunk musculature of urodeles have been restricted to the hypaxial series. In this study the epaxial muscle mass of three genera (*Siren*, *Amphiuma*, and *Necturus*) have been examined. The entire dorsal muscle mass is divided into three main units on the basis of fiber attachments. Each unit is in turn provided with several distinct fiber tracts, derived from a primitive and simple myoseptal system. These minor complexities are described in regards to approximate size, direction, and attachment in the three genera studied. All three genera have a similar arrangement in the more superficial fiber tracts. In regard to the deeper tracts *Necturus* is most primitive. *Siren* and *Amphiuma* illustrate certain specializations involved in allowing these genera to bend their body vertically to a greater extent than is normally possible in members of this class. The specializations are apparently independently derived. The abandonment of myoseptal attachments and intervertebral systems more well developed are examples of such specialization.

INTRODUCTION

Studies of musculature in the urodeles have been restricted largely to the branchial, hypaxial and appendicular areas. The main reason for this is that their epaxial trunk musculature has generally been considered to be a mass of fibers which, if oriented at all, were so complex and interlaced that no serious attempt was even made to study the fiber tracts. Thus the epaxial complex is generally referred to as the "dorsal muscle mass." Certain authors (Nishi, 1916; Francis, 1934; *et al.*) recognized several subdivisions within the entire complex, but the units they described were very broad and not clearly defined in terms of fiber attachments.

During a study of Recent and fossil vertebrae of a number of salamanders it became obvious that in the Sirenidae these elements are quite distinctive. They differ markedly from other urodele vertebrae in a number of ways, and particularly in the shape of the neural arch. In no other known living amphibian is the posterior portion of the arch shaped into a horizontally-oriented V-shaped notch with its apex directed anteriorly. The two raised arms of the V have been termed

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the alliform processes (Goin and Auffenberg, 1955). These processes are presumably formed by bony outgrowths of the dorsal surface by the neural arch itself, rather than by an upturning of the posterior edge of the neural arch. As a result, the roof of the neural canal is complete and forms a "floor" between the thin vertical V-shaped alliform processes. This condition is so singular that isolated fossil vertebral elements of this group of salamanders are easily recognized, which has recently permitted the extension of the known fossil history of this group to the Lower Cretaceous (Goin and Auffenberg, 1958).

The peculiar structural features of the vertebrae of this family of salamanders led to the present study. The unusual vertebral processes of the Sirenidae suggest that the epaxial muscle fiber tracts are probably more complex than those of most other living urodeles. The complexity and yet distinctiveness of the fiber tracts suggest that much might be gleaned from a study of the "dorsal muscle mass" of other urodeles as well. For comparative purposes the epaxial muscle complex of *Amphiuma* and *Necturus* were also studied.

Most of the problems associated with a study of this kind are related to the necessity of studying only fiber direction and attachments. There are no clear demarcations between muscle masses in the nature of delimiting fascicular connective tissue. Muscles delimited by fascia are found only in the appendicular and branchial areas. In *Siren* these have been studied mainly by Wilder (1891) and Maurer (1892).

A particularly bothersome point when dealing with only fiber direction is that it is almost impossible to establish homologous relationships. For this reason the various epaxial fiber tracts are not named with respect to possible homologous structures in higher vertebrates. The entire dorsal muscle mass is easily divided into a number of units based on fiber attachments. Each unit is in turn provided with several distinct fiber tracts, derived from a primitive and simple myoseptal system. These specialized minor complexities in the fiber tracts are described in regard to approximate size, direction, and attachments, and are designated by a simple letter system. This avoids the problem of homologues for the present, and still allows for a "terminology" necessary for comparison with the epaxial system of other urodeles. The following data were obtained from the dissection and partial maceration of three adult specimens of *Siren lacertina* and one adult each of *Necturus maculatus* and *Amphiuma means.*

EPAXIAL TRUNK MUSCULATURE

Three main subdivisions of the epaxial muscle mass can be distinguished in each of the genera examined. Each division need not be of equal importance, or of equal distinctness. These are: (1) intermyoseptal fibers, (2) myoseptal-vertebral fibers, and (3) intervertebral fibers.

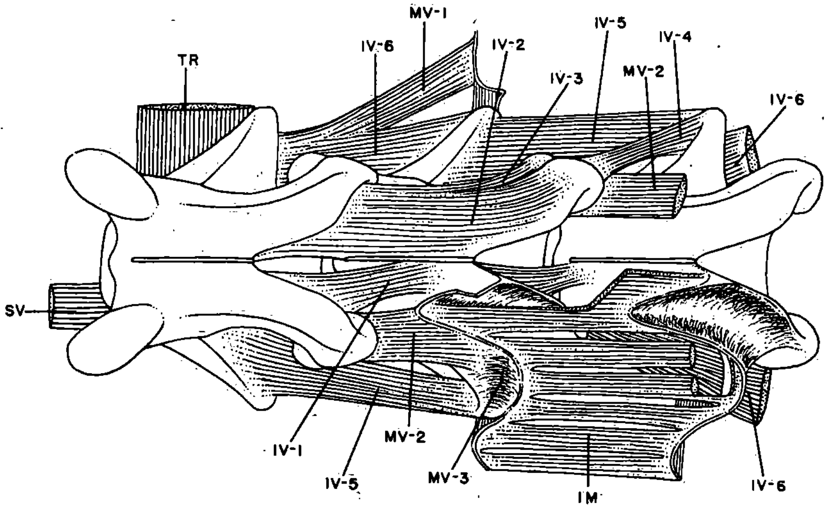

Figure 1.—Epaxial fiber tracts in *Siren lacertina.* (IM) Intermyoseptal fibers, (IV) Intervertebral fibers, (MV) Myoseptal-vertebral fibers, (SV) Subvertebralis complex, (TR) Transversus.

Intermyoseptal Fibers

SIREN.—Figure 1. This is not only the most superficial of the main fiber tract divisions in the urodeles, but the most extensive one, covering the largest part of the dorsal surface of the body. It evidently represents the most primitive group of the three divisions. Fibers from this division extent out distally to all parts of the dorsal area and attach to the inner surface of the skin, making it somewhat difficult to remove. The myotomal septa attach proximally along the upper edge of the alliform processes and distally to the skin. In the region above the vertebrae they billow out to present a surface concave posteriorly, convex anteriorly. Laterally the myotomal septa undulate in a regular pattern. Muscle fibers run longitudinally and connect adjacent septae. As a group these fibers form thick muscle segments that compose much of the subsurface musculature of the entire postcranial epaxial area. The myotomal fibers run caudocraniad and are not evenly distributed, but tend to occur in groups or tracts. These tracts are only slightly separated from one another.

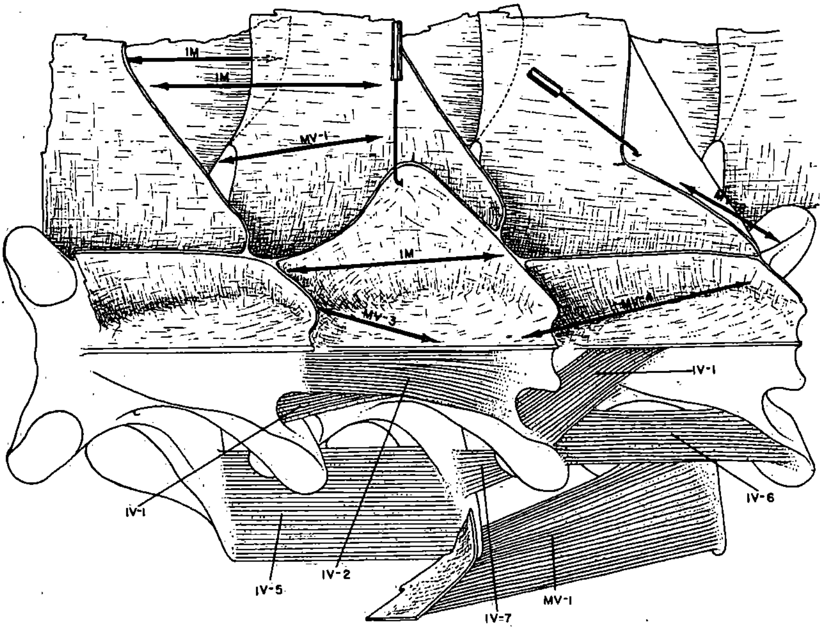

Figure 2.—Epaxial septal arrangement and fiber tracts in *Amphiuma*. Abbreviations as in Figure 1.

Amphiuma.—Figure 2. As in *Siren* the intermyoseptal fibers cover the entire external part of the epaxial complex. Fiber tracts run from septum to septum, with many fibers attaching distally to the internal surface of the skin. The myotomal septa are considerably more complex than in *Siren*. Each septum attaches anteriorly to the posterodorsal surface of a transverse process. Distally the septum attaches to the undersurface of the skin. Between these two points of attachment the septum billows out posteriorly. Medially it is attached to the sharp ridge on the dorso-lateral surface of each neural arch, a structure quite characteristic of the vertebrae of *Amphiuma* (Fig. 2). To this ridge is attached another septum, vertical in position, and close to the neural spine dorsally. Anteriorly it attaches to the laterally expanded posterior raised portion of the neural arch. Within the pocket formed between this septum and the lateral surface of the vertebra a series of fiber bundles run from one septum to another, or from the vertebra to the septum. Some of these will be discussed in more detail below. In addition to the interseptal fibers in this small pocket, other fiber bundles run between the more obvious main septae laterally. As in *Siren,* all of these fibers run antero-posteriorly.

The additional septum described above is fairly difficult to find, particularly in wet specimens. The structure is more readily observed when dry. It also becomes more obvious after a short period of maceration. After its discovery in *Amphiuma* it was searched for several times without success in both *Siren* and *Necturus.* Figure 2 shows the complex septal arrangement and fiber tract attachments in *Amphiuma.*

NECTURUS.—Of the three genera examined, the dorsal muscle mass is simplest in *Necturus.* The interseptal fibers are extensive as in *Amphiuma* and *Siren.* As fewer fibers run distally to attach to the underside of the skin in necturus, the dermis is more easily removed than in the other two genera examined. The septa are loosely attached to the underside of the skin. Medially they are attached to the posterior edge of the neural arch of one vertebra, the connection then extending posteriorly to the succeeding vertebra along the dorsal surface of its transverse process and thence distally dorsal to the rib, where it joins the main horizontal septum. Dorso-laterally the epaxial portion of the septum billows out posteriorly as in the two other genera examined. The septae and their connecting fiber tracts are more similar to those in *Siren* than in *Amphiuma.* This is particularly true of the septal system.

Myoseptal-Vertebral Fibers

Dorsal to the vertebrae, and ventral to the interseptal fibrous tracts are a more complex group of fiber tracts which are of more concern for purposes of the present study, here termed the myoseptal-vertebral fibers. It is the complexity below the interseptal fibers which is of most interest as regards the epaxial musculature of the sirenid salamanders.

SIREN.—(Figure 1.) Only three tracts have been recognized as having attachments with the myotomal septa at one end and the vertebrae at the other. These tracts are as follows:

MV-1.—The vertebral attachment for these fibers is at the postero-lateral edge of the transverse process. Here the fibers coalesce with some intervertebral fibers running from one transverse process of one vertebra to the transverse process of another vertebra. The fibers run posteriorly from the transverse process to attach near the upper edge of the septum, near its confluence with the skin, and lateral to the tip of the transverse process of the succeeding vertebra.

MV-2.—These are septal to zygapophysial fibers, running from the posterior edge of the postzygapophyses posteriorly to the myoseptum of the succeeding vertebra.

MV-3.—Fibers belonging to this group run from the superior surface of the dorsal lamina of the transverse process posteriorly to near the distal edge of the myoseptum of the same vertebra.

AMPHIUMA.—(Figure 2.)

MV-1.—The fibers of this group, as in *Siren,* run from the transverse process of one vertebra to a myoseptum. In *Amphiuma* the fiber tract runs from each septum posteriorly to the antero-dorsal surface of the transverse process of the succeeding vertebra and another set running anteriorly to the postero-dorsal surface of the transverse process of the preceding vertebra.

MV-2.—These are fibers which attach at one end to the septum, and at the other end to the zygapophyses. As in the MV-1 tract, the MV-2 tract in *Amphiuma* seems to be quite different than those found in *Siren.* The fibers are attached at one end to the dorso-anterior surface of the prezygapophysial process, but run anteriorly to the posterior surface of the preceding septum.

Amphiuma has two additional fiber tracts that apparently do not occur in *Siren.* These are:

MV-3.—This is a series of fibers running from the anterior half of the lateral surface of the neural arch to the posterior surface of the septum of the preceding vertebra.

MV-4.—Fibers from this group make up a long tract running from the lateral surface of the neural spine and the adjacent part of the neural arch to the anterior surface of the septum of the succeeding vertebra.

NECTURUS.—The myoseptal-vertebral fibers in the epaxial area of this genus are very simple compared with those in *Siren* and *Amphiuma.*

MV-1.—Of all the tracts of this division in *Necturus* this is the most well developed. The fibers run from the postero-dorsal surface of the transverse process of one vertebra posteriorly to the anterior surface of the succeeding septum, and from the posterior surface of this septum to the antero-dorsal surface of the succeeding transverse process. Thus fibers run anteriorly and posteriorly to each septum from the preceding and succeeding transverse processes, as in *Amphiuma.*

MV-2.—This tract is also fairly well developed in *Necturus.* As in *Amphiuma* the fibers run from the lateral surface of the neural arch and the neural spine, as well as from the dorsal surface of the postzygapophysial process, anteriorly to the preceding septum.

No fiber tracts corresponding to the MV-4 series could be discerned in the dissection of *Necturus.* The MV-3 group in *Necturus* is simply represented by modified, more anteriorly placed and slightly differently oriented fibers of the MV-2 series.

Intervertebral Fibers

These fibers are apparently the most important of all of the groups for comparative purposes. Some of the tracts seem closest to what might be considered homologs of epaxial muscles in the higher vertebrates. Certain functional analogs are rather obvious in some cases. It is certain that developmental homologies cannot be more than casually suggested at the present time. Several main tracts have been recognized in all three genera studied.

SIREN.—(Figure 1.)

IV-1.—The fibers of this series begin near the medio-anterior dorsal surface of the projected anterior upper edge of the neural arch. The fibers thence continue anteriorly, connecting to the posterior surface of the entire length of each of the arms of the V-shaped alliform processes (Figure 1). Apparently the increased length of this tract is involved in providing greater mechanical efficiency, presumably in moving the body up and to the side. In action the tract must be similar to the multifidus muscle of some of the reptiles with a posteriorly extended neural arch, as is found in the snakes. There is no reason to suppose that these units are homologous, since the multifidus attaches to the upper posterior surface of the neural arch, whereas the tract in *Siren* attaches at the anterior upper surface.

IV-2.—This is a rather large fiber tract connecting adjacent vertebrae by running from the dorsal part of the entire neural arch of one vertebrae, including the anterior surface of the alliform process, anteriorly to the floor of the alliform process and the posterior edge of the preceding vertebra. In action it must be very similar to the intervertebralis of higher vertebrates and is probably a true homolog of this muscle.

IV-3.—Certain fibers which become interlaced with those of the IV-2 series originate on the prezygapophysis of the next posterior vertebra, to insert with the fibers of IV-2 on the alliform process. These fibers can thus be said to span one vertebra, but the fibers are so inextricably interwoven with those of the IV-2 series that they can hardly be termed a distinct tract in themselves. Furthermore, not all of these fibers continue to the alliform process, some of them seemingly attaching to the upper surface of the adjacent vertebra cranially. In action the outer fibers of the IV-2 and those of the IV-3 series probably have an action very similar to that of longissimus complex of some of the reptiles.

IV-4.—This fiber tract is a small one, attaching at the one end to the cranio-distal end of the transverse process, in the slot between the dorsal and ventral laminae of that process, and at the other end to the caudal border of the postzygapophysis of the adjacent preceding vertebra.

IV-5.—This is a fairly large fiber tract connecting adjacent transverse processes. At one end of the fibers are attached to the cranial edge of the ventral lamina of the next posterior vertebra. From this point the fibers run anteriorly to attach along the dorsal surface of the dorsal lamina of the transverse process of the next vertebra. Other fibers run from the anterior edge of the ventral lamina of the transverse process of a posterior vertebra and run anteriorly to attach along the entire posterior edge of the transverse process of the proceeding vertebra as well as the adjacent part of the centrum of the same element.

AMPHIUMA.—(Figure 2.)

IV-1.—In *Amphiuma* this series is very much modified from the condition observed in *Siren.* The fibers are attached much more dorsally and medially, covering the lateral surface of the anterior part of the neural spine as well as the adjacent dorso-lateral part of the neural arch. From these areas the fibers run anteriorly to the posterior portion of the postzygapophysial process. The fibers run anterolaterally. They appear to be modified intervertebralis fibers, and probably function in much the same manner.

IV-2.—The fiber tract designated as the IV-2 series is very similar to the same series in *Siren.* The fiber direction is antero-posteriorly. They attach along the posterior edge of the neural spine and the adjacent arch, and extend posteriorly to along the entire lateral surface of the neural spine and the entire dorsal surface of the neural arch.

The series designated as the IV-3 and IV-4 tracts in *Siren* have not been found in *Amphiuma*. However, several other groups have been distinguished which seem to be lacking in *Siren*.

IV-5.—As in *Siren* the fibers of this tract run between adjacent transverse processes.

IV-6.—This series is not found in *Siren*. In *Amphiuma* it forms a very large group, with the fibers running from the large anterior surface of the highly keeled postzygapophysial process to the posterior surface of the vertical keel on the next vertebra anteriorly.

IV-7.—The fibers of this tract also seem to be missing in *Siren*; or are so modified that they have not been recognized as yet. They do not form a very important or large group of fibers. The tract attaches at one end to the anterior surface of the prezygapophysial buttress of one vertebra to the posterior portion of the transverse process of the preceding vertebra.

NECTURUS.—The intervertebral series in this genus of salamanders is very much simpler than that seen in *Siren* or *Amphiuma*. The IV-1 and IV-2 series are inseparable, no difference in fiber direction being observable. The entire mass of fibers run from the posterior surface of the neural spine and postzygapophysial buttresses posteriorly to attach along the entire dorsal surface of the neural arch. As discrata units the IV-3 and IV-4 seem to be completely missing in Necturus. The IV-5 series is present, running from transverse process to transverse process in a manner very similar to that found in *Siren* and *Amphiuma*. An IV-6 tract is present, but is much less obvious than in *Amphiuma*. The IV-7 series seems to be completely lacking in Necturus.

HYPAXIAL TRUNK MUSCULATURE

Maurer (1892, 1911) and others have dealt extensively with the muscles of this series. These publications will not be reviewed here. However, certain features of the details of some of these muscles have not been previously described. Maurer, Noble (1931) and others have discussed the general evolutionary and functional significance of the variability of this series in the urodeles, but the matter is obviously not as clear as might be desired. As Maurer (1911) has pointed out considerable parallel development has occurred in the evolution of certain features of the hypaxial complex. Its evolution seems dependent on body form, phylogeny and function. The importance of each of these has not been clearly delimited.

The fiber tracts composing the muscle mass immediately below the vertebrae are more complex in terms of attachments than previous workers have indicated. These tracts make up a large part of what Maurer terms the "subvertebralis complex." More specifically it is part of what he described as the M. subvertebralis medialis.

This small proximal portion of the subvertebralis complex differs considerably in the three genera examined during the course of the present study. In some cases these differences seem quite basic.

In *Siren* the deeper intervertebral fibers of this complex can be separated into two series. In one series the fibers run diagonally from the lower surface of the transverse process both anteriorly and posteriorly to the lateral surfaces of the centra of both preceding and succeeding vertebra. Another series of fibers run longitudinally from the body of one centrum to the body of another preceding or succeeding centrum. An even more superficial group of fibers extends from one septum to another. This is the group which is seen when the animal is eviscerated preparatory to dissection of the internal hypaxial muscles.

In *Amphiuma* these three groups of fiber tracts are present and as well developed as they are in *Siren*. In addition a fourth group appears as a modified intercentral fiber tract. Each tract of this group extends diagonally from the basipophysial process of one vertebra anteriorly to the antero-lateral surface of the centrum of the preceding element. This group is quite superficial and can be seen after the animal is eviscerated and without dissection.

In *Necturus* the system is generally somewhat more simple than that in *Siren* and *Amphiuma*. Diagonally directed fiber tracts extend anteriorly and posteriorly to the lateral surfaces of the centrum from both the transverse processes and the myosepta. A third series runs longitudinally from myoseptum to myoseptum.

Lateral to this immediately subvertebral medial complex in *Siren* is an almost transversely directed series of fibers which is not strongly segmented, and which covers a large part of the internal dorso-lateral wall. This has been termed the transversus (Maurer, 1892). Lateral to the large transversus in *Siren* is another series in which the fibers run more or less transversely. This is the M. obliquus internus which covers most of the area of the lateral wall. In *Amphiuma* the subvertebralis complex is more obviously split into two distinct series; i.e.: that which is immediately subvertebral in position, the medial portion of the subvertebralis, and a very large more lateral portion, the subvertebralis lateralis. The latter covers most of the area encompassed by the transversus in *Siren*. Ventro-lateral to the subvertebralis complex in *Amphiuma* is a completely unsegmented transversus, more lateral in position than in *Siren*. In *Amphiuma* the obliquus internus can only be seen by reflecting the transversus. *Necturus* is similar to *Amphiuma* in this particular regard. However, the *transversus* is located more laterally, and the lateral portion of the subvertebralis is much larger in *Necturus* than in *Amphiuma*.

Discussion

The fiber tracts of the epaxial muscle mass in urodeles are described in as much detail as is possible at this time. It is assumed that increasing complexity of fiber tracts is a condition advanced over that of less complex systems. All three of the genera studied show a similar arrangement in the more superficial intermyoseptal fiber tracts. In regards to the deeper tracts, *Siren* is quite different from the two other genera examined. It illustrates a fair complexity in the fiber tracts, particularly of the intervertebral series. Fiber tracts running from the prezygapophysial processes of one vertebra to the postzygapophysial processes of an adjacent vertebra, and tracts running from the transverse process of one vertebra to the postzygapophysial process of another vertebra are examples. Of the three genera examined *Necturus* is decidedly the most primitive in its epaxial fiber tracts. The deeper intervertebral portions of the complex are simply an extension of the metameric myotomal system onto the vertebral elements, with but very slight modification. *Amphiuma* illustrates a very specialized condition, but one quite different from that found in *Siren*. This is well shown by the great complexity of the septal arrangement medially. In addition, there are certain specializations in the intervertebral fiber tracts, such as the development of a series of fibers connecting the prezygapophysial buttress and the transverse process. Presumably the function is the same as in the specialized transverse process-postzygapophysial tract in *Siren*.

The epaxial muscle complex is one which is seemingly most important in raising certain portions of the body as a concave arc. It is probably much less important in lateral bending, which function is presumably shared (in a more primitive condition) in conjunction with the hypaxial complex. As the vertebral column became more dorsally located in the cross sectional area of the body these muscles played a less important role in lateral undulations. The more snake-like urodeles, such as *Amphiuma* and *Siren* are quite capable of bending the body vertically to a great degree. Presumably the specializations which allow these forms to bend in this plane involve specializations in the epaxial musculature. These specializations would involve at least a partial abandonment of myoseptal attachments. The intervertebral systems would become more developed. This is illustrated by the epaxial musculature of both *Siren* and *Amphiuma,* forms with a similar body form and mode of locomotion. However, certain basic differences between the two indicate that the arrangement is independently derived in the two genera. The specializations in *Amphiuma* can more easily be derived from the primitive condition in *Necturus* than can those of *Siren.*

Concerning the hypaxial musculature, the deeper portions of the subvertebralis complex is basically similar in all three genera, except for the strong basipophysial attachments in *Amphiuma.* These fibers are apparently important in bending the body down and to the side. In *Siren* a series of fibers running from the small anterior process on the ventral lamina of the transverse process to the side of the centrum of the preceding vertebra apparently function similarly.

The lateral hypaxial musculature is quite different in the three genera examined. It is simplest in *Necturus.* The muscles in this area in *Necturus* are not highly specialized for forming an arc of a short radius. In the snake-like forms, such as *Amphiuma* and *Siren,* the loss of segmentation in some of the muscles of this complex apparently provide greater mechanical efficiency in this type of movement. As has been pointed out by Maurer (1892) *Amphiuma* is most specialized in this regard since both the transversus and obliquus externus superficialis are unsegmented. In *Siren* only the transversus is unsegmented, and then only partially so. The better development of more lateral epaxial intervertebral muscles in *Siren* may take over this function. In addition, *Siren* possess a rectus lateralis, a muscle presumably very important in lateral motion in other forms. This muscle is lacking in *Amphiuma.* According to Maurer *Siren* possesses fewer muscle layers in the body than do certain primitive forms. This reduction is thought by several workers to be one of the main themes in the evolution of the hypaxial series. *Amphiuma* possesses more layers, but is specialized in other ways.

The present study on epaxial musculature and Maurer's and others' work on the hypaxial musculature show that *Amphiuma* and *Siren* have parallel development in muscle evolution probably influenced by similar modes of existence. The differences in these structures between the two genera seem to be basic and support the widely held concept of their distant relationship.

LITERATURE CITED

Francis, E. T. B.

1934. The anatomy of the salamander. Oxford: Clarandon Press, pp. i-xxxi, 1-381.

Goin, C. J., and W. Auffenberg

1955. The fossil salamanders of the family Sirenidae. Bull. Mus. Comp. Zool., vol. 113, no. 7, pp. 497-514.

1958. New salamanders of the family Sirenidae from the Cretaceous of North America. Fieldiana. Geology, vol. 10, no. 33, pp. 449-459.

Maurer, F.

1892. Der Aufbau und die Entwicklung der ventralen Rumpfmusculatur bei den urodelen Amphibien und deren Beziehungen zu den gleichen Muskeln der Selachier und Teleostier. Morph. Jahrb., vol. 18, pp. 76-179.

1911. Die ventrale Rumpfmuskulatur von *Menobranchus*, *Menopoma* und *Amphiuma*, verglichen mit den gleichen Muskeln andered Urodelen. Jena. Zeitschr., vol. 47, pp. 1-40.

Nishi, S.

1916. Zur vergleichenden Anatomic der eigentlichen Ruckenmuskeln. Morphol. Jahrb., vol. 1, pp. 168-318.

Noble, G. K.

1931. The biology of the Amphibia. New York: McGraw-Hill, pp. 1-577.

Wilder, H. H.

1891. A contribution to the anatomy of *Siren lacertina*. Zool. Jahrb., Abt. of Morph., vol. 4, pp. 653-696.

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