

AMPHIBIA: CAUDATA

Catalogue of American Amphibians and Reptiles.

SALTHE, STANLEY N. 1973. Amphiumidae, *Amphiuma*.

Amphiumidae Gray

Congo eels

Amphiumidae Gray, 1850:54. Type genus *Amphiuma* Garden 1773, published by Smith, 1821.

Muraenopses Fitzinger, 1843:34. See comment.

Amphiumidae Cope, 1875:25. Cope regarded himself as the author of this family, disregarding Gray.

Amphiumidae Gray, 1825; Kuhn, 1962:361. See comment.

• CONTENT: One fossil genus, *Proamphiuma*, and one genus, *Amphiuma*, both recent and fossil.

• DEFINITION. The premaxillaries are coossified, premaxillary spines being produced posteriorly dorsally, separating the nasals, ventrally in the roof of the mouth. An "atlas"-mandibular ligament passes over the parietal. The occipital condyles are stalked. Vomerine teeth form a row on each side, paralleling the maxillary teeth. The internal choanae are bounded by bone laterally but not posteriorly. The columella is fused to the operculum and is attached to the periotic by a narrow isthmus. The first epibranchial is fused to the first ceratobranchial; the second ceratobranchial is absent, even in hatchlings. The vertebrae are amphicoelous with the centrum somewhat compressed and with the foramen chordae in the upper quarter of the glenoid cavity, which is more ellipsoid than round in outline. There is no ypsiloid apparatus, even though lungs are present.

• DESCRIPTIONS, ILLUSTRATIONS. See *Amphiuma*. The vertebrae of *Proamphiuma* are illustrated and described by Estes (1969).

• DISTRIBUTION. At present restricted to the Austroriparian biotic province of Dice (1943) in North America. See fossil record, and also species accounts.

• FOSSIL RECORD. *Proamphiuma cretacea*, of late Cretaceous age, has been described by Estes (1969) from the Hell Creek Formation in McCone County, Montana. *Amphiuma* (which see) also has a fossil record, ranging from the late Paleocene to the late Pleistocene.

• PERTINENT LITERATURE. All references are cited elsewhere in this account, or in the genus or species accounts.

• REMARKS. The earliest workers, probably including Linnaeus, thought that *Amphiuma* was a metamorphic stage in the transformation of *Siren* into some unknown giant salamander (Rusconi, 1821; Duméril, Bibron, and Duméril, 1854), a notion dispelled by Cuvier (1827). After this it was for a time treated as if it was related to *Cryptobranchus* because both possess four limbs and an open gill slit without external gills, an idea attacked successfully by Tschudi (1838). Cope, during his entire herpetological career (1866, 1886, 1889) felt that the amphiumids were a link from the salamanders to the caecilians, also noting the similarity to *Desmognathus* in the "atlas"-mandibular ligament and the stalked occipital condyles. After being considered as a completely separate group (Davison, 1895) for some years, Dunn (1922) suggested placing the amphiumids with the salamandrids in the Salamandroidea, mainly on the basis of skull and palatal features, an arrangement followed by subsequent workers (Noble, 1931; Brame, 1967). He also, however (Dunn, 1923), noted that Reed's (1920) study of the otic region formed a basis for allying the amphiumids with plethodontids. Regal (1966) argued that the posterior projection of the vomer reflects a general narrowing of the head and that it may be derived from any larval condition, and proposed removal of the amphiumids from the Salamandroidea, and, on the basis of ear structure and chromosome number ($2n = 28$ is elsewhere found only in plethodontids), that they be allied to the plethodontids. In that same year, Salthe and Kaplan (1966) found that antigenic determinants on the muscle-type lactate dehydrogenase of *Amphiuma* are more like those of plethodontids than those of any other group of salamanders.

COMMENT

The family name Amphiumidae was first used in 1825 by Gray for a taxon including both *Amphiuma* and *Cryptobranchus*. It was not until 1850 (again by Gray) that this name was used for a taxon including only amphiumids, that is, for the taxon as it is now constituted. Therefore, use of Amphiumidae Gray 1825, for example by Kuhn (1962), is incorrect. Tschudi (1838) noted the relationship between *Andrias* and *Cryptobranchus* and also that the living representative of the former does not have open gill slits. He therefore broke apart the old family Amphiumidae and gathered the cryptobranchids into a family Tritonides. Apparently being unwilling to erect a monotypic family (there are none in his work of that year), he erected a new family Proteidae, based largely on shared larval characters, to include *Amphiuma* along with the axolotl, *Proteus*, *Necturus*, and the sirenids. It was Fitzinger (1843) who first placed the amphiumids in a family of their own, the Muraenopses, for which he supplied no definition or details of any kind (see comment under *Amphiuma*). If it were not for this deficiency, his name would under present rules be the family name today. As it was, Gray (1850) took the tack of ejecting the cryptobranchids from his old family, thereby retaining its name.

Amphiuma Garden
Congo eel

Amphiuma Garden, 1821. ["1773"] p. 599. In Smith, Correspond. of Linn. Type species *Amphiuma means* Garden, 1773, by monotypy.

Siren Linnaeus 1821 ["?1772"] p. 599. In Smith, Correspond. of Linn. Refers to an apparently lost letter from Linnaeus to Garden.

Chrysodonta Mitchill, 1822:503. Type species *Chrysodonta larvaeformis* Mitchill, 1822, by monotypy.

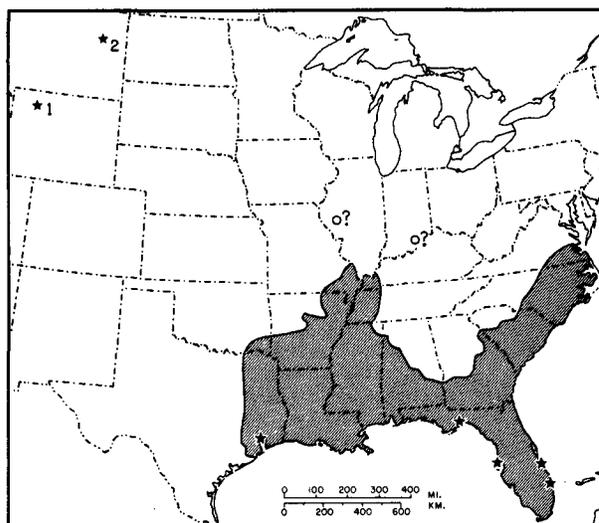
Amphiumina: Bonaparte, 1837:22. Emended name.

Sirenoidis Fitzinger, 1843:34. Substitute name for part. See comment. Type species *Amphiuma tridactylum* Cuvier, 1827.

Muraenopsis Fitzinger, 1843:34. Substitute name for part. See comment. Type species *Amphiuma didactylum* Cuvier, 1827.

Amphiuma Linn.: Gray, 1850:162. New combination.

• CONTENT. One fossil species, *A. jepseni*, and three recent species, *A. means*, *A. tridactylum*, and *A. pholeter*, one or two of which have Pleistocene fossil records.



MAP. Shaded area and questioned extra-limital spots indicate distribution of three Recent species of *Amphiuma*, unnumbered stars mark Pleistocene records for *Amphiuma*. Star 1 marks locality of *Amphiuma jepseni* (late Paleocene); star 2 marks locality of *Proamphiuma cretacea* (Cretaceous).

• **DEFINITION.** The body is elongated, cylindrical, eel-shaped, with costal grooves. The tail narrows to a point, is compressed, and occupies from $\frac{1}{6}$ to $\frac{1}{4}$ of the body length. Four ossified limbs are present, very small relative to body size and with few digits, the same number on both fore- and hind-limbs. The head is narrow and more pointed than is usual for urodeles, depressed, and occupying about a tenth of the total length of the body. The eyes are small, without lids, covered with a cuticle continuous with the skin, and are flush with the skin of the head. The lips are thick and extensive, the upper overhanging the lower anteriorly. External gills are absent, but one (vertical) gill cleft remains open on each side; there are four branchial arches. The tongue is flat, indistinct, adherent. Lateral nasal glands are present. Prefrontal and nasal bones are present. The parietals meet in a low sagittal crest, and each has a prominent temporal flange. The vertebrae have prominent muscle crests and two anteriorly-directed hypapophyses (basapophyses) at the anterior ventral extremity of the centrum.

• **DESCRIPTIONS, ILLUSTRATIONS.** These papers refer to aspects of anatomy that do not differ in the living species. General anatomical studies are Cuvier (1827), Cope (1889), Davison (1895), and Baker (1945). Musculature is described by Davison (1894), Drüner (1904), Maurer (1911), Bruner (1914a), Dunn (1941), Eaton (1936a; 1936b), Auffenberg (1959), Hilton (1959; 1962). The skull and branchial arches are described by Cope (1866), Wiedersheim (1877), Schuffeldt (1883), Cope (1886; 1889), and Davison (1895). The nasal region is described by Wilder (1892), Higgins (1919), and Hilton (1951a). The ear region is described by Cope (1888), Norris (1901), Kingsbury and Reed (1909), Reed (1920), Dunn (1922; 1941), Dempster (1930), and Hilton (1950). The teeth are described by Röse (1895), Oltmanns (1952), and Hilton (1951b). Glands in the head are described by Wilder (1909), Bruner (1914b), Wilder (1929), and Seifert (1932). The skeleton is described by Cope (1866), Parker (1868), and Whipple (1906), while the vertebrae are described by Mivart (1870), Cope (1886), Davison (1897), Hilton (1947b), and Auffenberg and Goin (1959). The lateral line system is described by Norris (1907; 1911), Kingsbury (1896), Escher (1925), Chezar (1930), and Hilton (1947a). The vascular system is described by Lahti and Churchill (1938), the aortic arches by Baker (1949) and Darnell (1949), the vascularization of various respiratory surfaces by Noble (1925), Elkan (1958), and Czopek (1962a), and the heart and cardiovascular dynamics by Johansen (1962; 1964) and Toews (1971a). The lungs have been described by Hilton (1952), Czopek (1962b), Stölk (1962), Willnow (1964), and Tenney and Tenney (1970).

• **DISTRIBUTION.** See fossil record, and the familial and specific accounts.

• **FOSSIL RECORD.** *Amphiuma jepseni* has been described from the late Paleocene (Tiffanian) Polecat Bench Formation in Park County, Wyoming (Estes, 1969). This is apparently a somewhat less neotenic form than any of the recent species. For late Pleistocene records see *A. means*. *Amphiuma norica* from the Pleistocene of Germany (Brunner, 1956) was shown to be spurious by Estes (1969).

• **PERTINENT LITERATURE.** Spermatogenesis is described by McGregor (1899) and Baker (1962). The former has described the chromosomes, as have Donnelly and Sparrow (1963; 1965) and Dodson (1948). Mirsky and Ris (1957) give the amount of DNA per cell. These papers provide data on cell size, as do Smith (1925), Szarski and Czopek (1965; 1966), and Hartman and Lessler (1964). The thyroid gland and its activity form the subject of papers by Versluys (1925), Baker and Stoudemayer (1951), Kobayashi and Gorbman (1962), Kerkof *et al.* (1963), Moule and Nace (1964), and Prahla (1970). Hemoglobin kinetics are discussed by Scott (1931), McCutcheon and Hall (1937), and Lenfant and Johansen (1967). Oxygen consumption is discussed by Smith (1925) and Morgan *et al.* (1967), while glycogen utilization in anoxic conditions is studied by Rose *et al.* (1965) and Rose and Zambarnard (1966). The structure and function of the pancreatic islets is studied by Herman and Sato (1970), while the influence of this tissue on glucose metabolism is discussed by Nace and Fucikovsky (1962), Oguri and Nace (1964), and Nace and Blair (1970). Gas tensions in various portions of the blood stream are reported by Toews (1971c). Control of the breathing cycle is the subject of Toews (1971b), while the actual mechanism of obtaining air is discussed by Bruner (1914a, b). Salthe (1965) discusses the ecological and physio-

logical implications of the kinetic properties of the lactate dehydrogenases.

• **KEY TO THE LIVING SPECIES.** Numbers in parentheses indicate the account numbers for the species in this catalogue.

1. Dark ventral coloration 2
Light ventral coloration with dark throat patch; three toes on limbs *A. tridactylum* (149)
2. Two toes on most limbs; to 890 mm total length
..... *A. means* (148)
Not more than one toe on limbs; to 305 mm total length *A. pholeter*

• **REMARKS.** See remarks under *A. tridactylum* for a discussion of the possibility of that taxon being a subspecies of *A. means*.

• **ETYMOLOGY.** Garden did not supply an etymological explanation for *Amphiuma*. Duméril, Bibron, and Duméril (1854) noted that other workers were puzzled as to the meaning of this name (evidently Garden was not a strong Greek scholar), and suggested *amphi*, around, and *hyma*, rain, or *amphi*, double, and *hymen*, membrane. The first possibility would presumably refer to the fact that during heavy rains these animals are sometimes caught on roads and other accessible places, the second is obscure and the authors did not elaborate.

COMMENT

Fitzinger's unexplained introduction of two new generic names in 1843 can possibly be explained as a device by which he could escape having a monotypic family. As noted above, Tschudi in 1838 had broken up Gray's old Amphiumidae, and had himself avoided a monotypic family by placing *Amphiuma* in a family together with several other salamanders that had larval or neotenic traits. The trouble with this suggestion is that Fitzinger does use monotypic families in his classification of 1843, and it also does not take account of his strange treatment of amphiumids in 1826. On page 42 of the Neue Classification he has both *Cryptobranchus* and *Amphiuma* as genera making up his family Cryptobranchioidea. On page 66 of that work we find only *Cryptobranchus* remaining in that family, and *Amphiuma* has disappeared without comment, to reappear, again without comment, only in the names of the type species of the two new genera in 1843. The name *Sirenoidis* for the two-toed form did not catch on, but subsequent authors did adopt *Muraenopsis* for the three-toed form until Ryder (1880) reported specimens with mixed numbers of digits and suggested synonymy of *Muraenopsis* because that name appeared to be based solely on digit number.

LITERATURE CITED

- Auffenberg, W. 1959. Epaxial musculature of *Siren*, *Amphiuma* and *Necturus*. Bull. Florida State Mus. 4:253-265.
- and C. J. Goin. 1959. The status of the salamander genera *Scapherpeton* and *Hemitrypus* of Cope. Amer. Mus. Novit. (1979):1-12.
- Baker, C. L. 1945. The natural history and morphology of Amphiumae. Rep. Reelfoot Lake Biol. Sta. 9:55-91.
- 1949. The comparative anatomy of the aortic arches of the urodeles and their relation to respiration and degree of metamorphosis. J. Tennessee Acad. Sci. 24:12-40.
- 1962. Spermatozoa of Amphiumae: spermatoleosis, helical motility and reversibility. *Ibid.* 37:23-36.
- and M. B. Stoudemayer. 1951. The influence of thyroxine, epinephrine, and x-rays on metamorphosis of some neotenic urodeles. *Ibid.* 26:32-41.
- Bonaparte, C. L. 1837. Synopsis vertebratorum systematis. Soc. Linn. Exhibiti, Septima. Nov., 1837(1):1-40.
- Brame, A. H., Jr. 1967. A list of the world's recent and fossil salamanders. J. Southwestern Herp. Soc. 2:1-26.
- Bruner, H. L. 1914a. The mechanism of pulmonary respiration in amphibians with gill clefts. Morphol. Jahrb. 48: 63-82.
- 1914b. Jacobsen's organ and the respiratory mechanism of amphibians. *Ibid.* 48:75-100.
- Brunner, G. 1956. Nachtrag zur Kleinen Teufelshöhle bei Pottstein (Ober-franken). Ein Übergang von der letzten interglaziale Riss-Würm-Warmfauna zur Würm I-Kaltfauna. Neues Jahrb. Geol. Pal. Monatsh. 1956:75-100.
- Chezar, H. H. 1930. Studies on the lateral line of Amphibia. II comparative cytology and innervation of the lateral line organs in the Urodela. J. Comp. Neurol. 50:159-176.

- Cope, E. D. 1866. On the structure and distribution of the genera of the arceriferous Anura. *J. Acad. Nat. Sci. Philadelphia* n.s. 6:67-112.
- 1875. Check list of North American Batrachia and Reptilia. *Bull. U. S. Nat. Mus.* (1):1-104.
- 1886. On the structure and affinities of the Amphiumidae. *Proc. Amer. Philos. Soc.* 23:442-444.
- 1888. On the relations of the hyoid and otic elements of the skeleton in the Batrachia. *J. Morphol.* 2:297-306.
- 1889. The Batrachia of North America. *Bull. U. S. Nat. Mus.* (34):1-515.
- Cuvier, G. J. L. F. 1827. Sur le genre de reptiles batraciens, nommé *Amphiuma*, et sur une nouvelle espèce de ce genre (*Amphiuma tridactylum*). *Mem. Mus. Hist. Nat. Paris* 14:1-14.
- Czopek, J. 1962a. Vascularization of respiratory surfaces in some Caudata. *Copeia* 1962:576-587.
- 1962b. Smooth muscles in the lungs of some urodeles. *Nature* 193:798.
- Darnell, R. M. 1949. The aortic arches and associated arteries of the caudate Amphibia. *Copeia* 1949:18-31.
- Davison, A. 1894. The arrangement of muscle fibers in *Amphiuma tridactyla*. *Anat. Anz.* 9:332-336.
- 1895. A contribution to the anatomy and phylogeny of *Amphiuma means*. *J. Morphol.* 11:375-410.
- 1897. A preliminary contribution to the development of the vertebral column and its appendages. *Anat. Anz.* 14:6-12.
- Dempster, W. T. 1930. The morphology of the amphibian endolymphatic organ. *J. Morphol.* 50:71-126.
- Dice, L. R. 1943. The biotic provinces of North America. Univ. Michigan Press, Ann Arbor, 78 p.
- Dodson, E. O. 1948. A morphological and biochemical study of the lampbrush chromosomes of urodeles. *Univ. California Publ. Zool.* 53:281-314.
- Donnelly, G. M. and A. H. Sparrow. 1963. Karyotype and revised chromosome number of *Amphiuma*. *Nature* 199:1207-1208.
- 1965. The mitotic and meiotic chromosomes of *Amphiuma*. *J. Hered.* 56:91-98.
- Drüner, L. 1904. Studien zur Anatomie der Zungenbein-Kiemenhaken und Kehlkopfmuskeln der Urodelen. II Theil. *Zool. Jahrb. Anat.* 19:361-690.
- Duméril, A. M. C., G. Bibron, and A. H. A. Duméril. 1854. *Erpétologie générale ou histoire naturelle complète des reptiles*. Vol. 9, Paris. 440 p.
- Dunn, E. R. 1922. The sound-transmitting apparatus of salamanders and the phylogeny of the Caudata. *Amer. Nat.* 56:418-427.
- 1923. The breeding habits of salamanders and their relation to phylogeny. *Copeia* 1923:25-27.
- 1941. The "opercularis" muscle of salamanders. *J. Morphol.* 69:207-215.
- Eaton, T. H., Jr. 1936a. The myology of salamanders with particular reference to *Dicamptodon* (Eschsholtz). *J. Morphol.* 60:31-75.
- 1936b. The gularis muscle in the Urodela. *Ibid.* 60:317-324.
- Elkan, E. 1958. Further contributions on the buccal and pharyngeal membrane in urodeles. *Proc. Zool. Soc. London* 131:335-355.
- Escher, K. 1925. Das Verhalten der Seitenorgane der Wirbeltiere und ihrer Nerven beim Übergang zum Landleben. *Acta Zool.* 6:307-414.
- Estes, R. 1969. The fossil record of amphiumid salamanders. *Breviora* (322):1-11.
- Fitzinger, L. I. 1826. Neue Classification der Reptilien nach ihren natürlichen Verwandtschaften. Vienna, 66 p.
- 1843. *Systema reptilium*. I. Ambyglossae. Vienna, 106 p.
- Gray, J. E. 1825. A synopsis of the genera of reptiles and Amphibia, with a description of some new species. *Ann. Philos.* n.s. 10:193-217.
- 1850. Catalogue of the specimens of Amphibia in the collection of the British Museum. Pt. II. Batrachia Gradientia, etc. London, 72 p.
- Hartman, F. A. and M. A. Lessler. 1964. Erythrocyte measurements in fishes, Amphibia, and reptiles. *Biol. Bull.* 126:83-88.
- Herman, L. and T. Sato. 1970. Correlative light and electron microscopic studies of the islets of Langerhans of an amphibian *Amphiuma tridactylum* (Congo eel). *J. Microscop.* (Paris) 9:907-922.
- Higgins, G. M. 1919. The nasal organ in Amphibia. *Illinois Biol. Monogr.* 6:7-90.
- Hilton, W. A. 1947a. Lateral line sense organs in salamanders. *Bull. So. California Acad. Sci.* 46:97-110.
- 1947b. The skeleton of *Amphiuma*. *J. Ent. Zool.* 39:14-16.
- 1950. The ear of salamanders. *Bull. So. California Acad. Sci.* 49:41-54.
- 1951a. The olfactory system of tailed Amphibia. *Ibid.* 50:119-127.
- 1951b. Teeth of salamanders. *Herpetologica* 7:133-136.
- 1952. The pulmonary respiratory system of salamanders. *Ibid.* 8:87-92.
- 1959. Review of the head muscles of salamanders. Pt. I. *Bull. So. California Acad. Sci.* 58:133-137.
- 1962. Shoulder and upper arm muscles of salamanders. *Ibid.* 61:205-216.
- Johansen, K. 1962. Double circulation in the amphibian *Amphiuma tridactylum*. *Nature* 194:991-992.
- 1964. Cardiovascular dynamics in the amphibian *Amphiuma tridactylum* Cuvier. *Acta Physiol. Scand.* 60(supp. 217):1-82.
- Kerkof, P. F., W. Tung, and T. L. Chaikoff. 1963. I^{131} utilization by salamanders: *Taricha*, *Amphiuma*, and *Necturus*. *Endocrinology* 73:185-192.
- Kingsbury, B. F. 1896. The lateral line system of sense organs in some American Amphibia and comparison with the dipnoans. *Trans. Amer. Microscop. Soc.* 17:115-146.
- and H. D. Reed. 1909. The columella auris in Amphibia. *J. Morphol.* 20:550-628.
- Kobayashi, H. and A. Gorbman. 1962. Thyroid function in *Amphiuma*. *Gen. Comp. Endocrin.* 2:279-282.
- Kuhn, O. 1962. Die vorzeitlichen Frösche und Salamander, ihre Gattungen und Familien. *Jahrb. Ver. Vaterl. Naturkde. Württemberg* 117:230-450.
- Lahti, V. and E. P. Churchill. 1938. The circulatory system of the amphiuma. *Proc. South Dakota Acad. Sci.* 18:61-64.
- Lenfant, C. and K. Johansen. 1967. Respiratory adaptations in selected amphibians. *Resp. Physiol.* 2:247-260.
- Maurer, F. 1911. Die ventrale Rumpfmuskulatur von *Menobranchus*, *Menopoma* und *Amphiuma*, verglichen mit den gleichen Muskeln anderer Urodelen. *Jenaische Z. f. Naturwiss.* 47:1-40.
- McCutcheon, F. H. and F. G. Hall. 1937. Hemoglobin in the Amphibia. *J. Cell Comp. Physiol.* 9:191-197.
- McGregor, J. H. 1899. Studies on the spermatogenesis of *Amphiuma*. *J. Morphol.* 15(suppl.):57-104.
- Mirsky, A. E. and H. Ris. 1957. The desoxyribonucleic acid content of animal cells and its evolutionary significance. *J. Gen. Physiol.* 34:451-462.
- Mitchill, S. L. 1822. Description of a batracian animal from Georgia, different from the reptiles of that order hitherto known. *Amer. Med. Recorder* 5:499-503.
- Mivart, St. George. 1870. The axial skeleton of the Urodela. *Proc. Zool. Soc. London.* 1870:260-278.
- Morgan, L. R., R. Singh, and R. J. Fiset. 1967. Relationship of oxygen consumption and cytochrome oxidase-succinic dehydrogenase activities in *Amphiuma means*. *Comp. Biochem. Physiol.* 20:343-349.
- Moule, J. W. and P. F. Nace. 1964. Radioiodide metabolism in *Amphiuma* after its intraperitoneal administration. *Canadian J. Physiol. Pharm.* 42:623-626.
- Nace, P. F. and M. Blair. 1970. Pancreatic alpha cell hyperplasia in insulin-treated *Amphiuma*. *Fed. Proc.* 29:357.
- and L. A. Fucikovsky. 1962. Blood "sugar" and pancreatic structure of the salamander *Amphiuma*. *Anat. Rec.* 142:261.
- Noble, G. K. 1925. The integumentary, pulmonary, and cardiac modifications correlated with increased respiration in Amphibia: a solution of the "hairy frog" problem. *J. Morphol.* 40:341-416.
- 1931. *The biology of the Amphibia*. McGraw-Hill, N. Y. 557 p.
- Norris, H. W. 1901. The morphology and function of the amphibian ear. *Proc. Iowa Acad. Sci.* 8:76-78.
- 1907. The innervation of the lateral line system of *Amphiuma*. *Ibid.* 14:273-278.
- 1911. The innervation of the lateral line organs in *Amphiuma* and *Siren*. *Science* 33:266-267.
- Oguri, M. and P. F. Nace. 1964. Nuclear material in *Amphiuma* cytoplasm. *Rev. Canadien Biol.* 23:17-20.
- Oltmanns, E. 1952. Zur Morphologie der Zähne rezenter Amphibien. *Anat. Anz.* 98:369-389.

- Parker, W. K. 1868. A monograph on the structure and development of the shoulder girdle and sternum in the vertebrates. Ray Society, London, 237 p.
- Prahlad, K. V. 1970. Circulating iodotyrosines and iodothyronines in amphibians. *Trans. Illinois State Acad. Sci.* 63:370-372.
- Reed, H. D. 1920. The morphology of the sound transmitting apparatus in caudate Amphibia and its phylogenetic significance. *J. Morphol.* 33:325-387.
- Regal, P. J. 1966. Feeding specializations and the classification of terrestrial salamanders. *Evolution* 20:392-407.
- Röse, C. 1895. Beiträge zur Zahnentwicklung der Schwanzmolche. *Morphol. Arb.* 4:178-192.
- Rose, F. L. and J. Zambarnard. 1966. Cardiac glycogen depletion in *Amphiuma means* during induced anoxia. *J. Morphol.* 120:391-396.
- and G. S. Pogany. 1965. Hepatic glycogen depletion in *Amphiuma* during induced anoxia. *Science* 147:1467-1468.
- Rusconi, M. 1821. *Les amoures des salamandres aquatiques.* P. E. Giusti, Milan, 73 p.
- Ryder, J. A. 1880. Morphological notes on the limbs of the Amphiumidae, as indicating a possible synonymy of supposed genera. *Proc. Acad. Nat. Sci. Philadelphia* for 1879:14-15.
- Salthe, S. N. 1965. Comparative catalytic studies of lactic dehydrogenases in the Amphibia: environmental and physiological correlations. *Comp. Biochem. Physiol.* 16:393-408.
- and N. O. Kaplan. 1966. Immunology and rates of enzyme evolution in the Amphibia in relation to the origins of certain taxa. *Evolution* 20:603-616.
- Schufeldt, R. W. 1883. The habits of *Muraenopsis tridactylum* in captivity; with observations on its anatomy. *Science* 2:159-163.
- Seifert, H. 1932. Untersuchungen über die Mundhöhlen der urodelen Amphibien. *Morphol. Jahrb.* 70:173-216.
- Scott, W. 1931. Oxygen and carbon dioxide transport by the blood of the urodele *Amphiuma tridactylum*. *Biol. Bull.* 61:211-222.
- Smith, H. M. 1925. Cell size and metabolic activity in Amphibia. *Ibid.* 48:347-378.
- Smith, J. E. 1821. A selection of the correspondence of Linnaeus and other naturalists. Longman, Hurst, Rees, Orme, & Brown, Vol. I London, 630 p.
- Stölk, A. 1962. Occurrence of smooth muscles and leiomyoma of the lung in the three-toed amphiuma (*Amphiuma tridactylum*). *Proc. Akad. Wet. Amsterd.* 65C:459-468.
- Szarski, H. and J. Czopek. 1965. Liver cell size in some species of Amphibia. *Zool. Polon.* 15:51-64.
- 1966. Erythrocyte diameter in some amphibians and reptiles. *Bull. Acad. Pol. Sci.* 14:433-437.
- Tenney, S. M. and J. B. Tenney. 1970. Quantitative morphology of cold-blooded lungs: Amphibia and Reptilia. *Resp. Physiol.* 9:197-215.
- Toews, D. P. 1971a. A mechanism for the selective distribution of blood in the Amphibia. *Canadian J. Zool.* 49:957-959.
- 1971b. Factors affecting the onset and termination of respiration in the salamander, *Amphiuma tridactylum*. *Ibid.* 49:1231-1237.
- 1971c. Gas tensions in the lungs and major blood vessels of the urodele amphibian, *Amphiuma tridactylum*. *J. Exp. Biol.* 55:47-61.
- Tschudi, J. J. 1838. Classification der Batrachier, mit Berücksichtigung der fossilen Thiere dieser Abteilung der Reptilien. *Petitpierre, Neuchatel*, 102 p.
- Versluys, J. 1925. On the thyroid glands and the phylogeny of the perrenibranchiate and derotremous salamanders. *Proc. Konink. Akad. van Wetensch. Amsterd.* 28:50-62.
- Whipple, I. 1906. The ypsiloid apparatus of urodeles. *Biol. Bull.* 10:255-297.
- Wiedersheim, R. 1877. Das Kopfskelet der Urodelen, ein Beitrag zur vergleichen der Anatomie des Wirbelthierschädels. *Morphol. Jahrb.* 3:352-459.
- Wilder, H. H. 1892. Die Nasengegend von *Menopoma* und *Amphiuma tridactylum*. *Zool. Jahrb. Anat.* 5:155-176.
- Wilder, I. W. 1909. The lateral nasal glands of *Amphiuma*. *J. Morphol.* 20:143-170.
- Wilder, M. 1929. The significance of the ultimobranchial body: a comparative study of its occurrence in urodeles. *J. Morphol.* 47:283-332.
- Willnow, I. 1964. Die Lunge von *Amphiuma means means*. I. Mitteilung: Morphologie. *Zool. Beitr.* 10:29-84.
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