

The "Sternum" in *Necturus*

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Recently, in order to arrive at a satisfactory answer to a moot question on the anatomy of the urodele, *Necturus*, I dissected 8 males and 5 females (varying in length from 25 to 39 centimeters). The problem involved was the existence or non-existence of cartilaginous *inscriptiones tendineae* in the myocommata of the ventral pectoral region; and the further question as to whether these cartilaginous elements, if generally found, are to be considered metamerized rudiments or sternebrae that have been arrested in their development (or, more loosely, constitute an ontogenetically-arrested sternum).

In the literature we have conflicting reports. Many workers have reported these inscriptions; a few have denied their presence. A note of uncertainty concerning the presence of a "sternum" is evident in the early mention of this structure in *Necturus* by W. Kitchen Parker in 1868:

My figures of the shoulder-girdle of this South [sic] American amphibian have been made from Professor Hyrtl's dry skeleton of an adult male, and I have no sternum to speak of, although I am not certain of its non-existence . . .

Prior to Parker's notice, Mayer (1835) and Stannius (1856) had noted the presence of chondrifications in the intermuscular septa in the region of the pectoral girdles. Gegenbaur (1865) used *Necturus* as one of his type-animals, but made no mention of a sternum's being present, although he treated of the sternum in some detail in his other types. Mivart (1869, 1870) denied the presence of a sternum. In subsequent reports, many investigators (Fuerbringer 1873; C. K. Hoffman in Bronn 1873-78; Huxley 1874; Wiederseim 1892; Wiederseim & Parker 1897; Gegenbaur 1901) noted the presence of chondrifications in the myosepta in the region of the pectoral girdles in *Necturus*, and referred to them as *inscriptiones tendineae*, *sternebrae*, or simply as the sternum. Goette (1877) discussed the chondrifications in the belly-muscles of several urodeles, including *Necturus*. He decided that they might be considered as a first or second step in the development of sternal reinforcements, which however, he considered to be not homologous with a true sternum as it is identified in the amniote animals. Lavocat (1889) described the branchial arches of the peren-

nibranchiate Amphibia as thoracic ribs, and the basibranchial cartilages (by inference) as a costal sternum. He said that the Amphibia lacked any abdominal ribs or abdominal sternum.

H. H. Wilder (1902) claimed to be the first to observe the chondrifications in the myosepta in *Necturus*:

Sternum. The several cartilaginous rudiments which represent this part in *Necturus* are somewhat difficult of detection and thus entirely escaped the attention of the earlier investigators. They consist of thin cartilages found in several successive myocommata of the pectoral region and confined mainly to the area covered by the overlapping epicoracoids. As will be seen by text figure 6 [here omitted], which represents the sternal elements of six normal individuals, the cartilaginous pieces show great individual difference in shape and size, and are capable of some variation in the myocommata involved. The largest segmental portion or sternebrium is that of the 4th myocomma which is in general an irregularly triangular or often bat-shaped piece. It lies just posterior to the epicoracoids in the angle formed by their overlapping edges, and is sufficiently large and superficial to give rise to a part of the fibers of the pectoralis muscle. This muscle attachment as well as its position relative to the shoulder girdle fixes its identity as the homologue of the rhomboidal sternal plate of the higher Urodela, and it would seem probable that this latter has resulted from the development of this piece alone. The sternebrium associated with the 3rd myocomma forms a long and slender open V, which may or may not be continuous with the sternebrium of the 4th. Sternal elements are often found both in the 2d and in the 5th myocomma, usually as a pair of cartilages, or as a unilateral piece. Of these, the one associated with the 5th myocomma is much more frequent, being found in rather more than half of the specimens thus far examined, either upon one side or both. Sternal elements in the 2d myocomma are rarely seen.

Wilder was obviously in error in his claim of priority, but since his publication, the majority of authors who have touched upon this subject in *Necturus* have followed the pattern set by him, and have referred to the chondrification as sternal. Whipple (1906) and Wilder (1925) mention the "sternebrae" of *Necturus*; Engler (1929) refers to the chondrification as a sternum. Many of the current text-books of comparative anatomy refer to the chondrifications as a sternum; there is little significant variation in their descriptions.

On the other hand, Hoffman (1930) said that in *Necturus* the "problematic chondrifications of the inscriptions tendineae are totally absent"; and later (1936) again said there is no sternum and that the inscriptions tendineae are absent in *Necturus*. In the latter paper Hoffman noted that there is in the sternal region a thick band of connective tissue which he thought might represent an ontogenetically arrested sternum. Senning (1937) also stated there is no sternum present in *Necturus*.

Hanson (1919) reviewed many of the theories of the origin of the sternum in the light of the results of his own research. He concluded that the chondrifications in the myosepta of *Necturus* are simply chondrifications of the outer part of the connective tissue of the intermuscular septa, and that they have no relation whatever to the formation of a sternum as it occurs in "higher" forms. Hanson thought of them as intermuscular splints, homologous with the inscriptions tendineae of other forms, and possibly also with abdominal ribs such as occur in certain reptiles. He noted the simultaneous presence in many animals of both inscriptions tendineae and sternal and costal elements, and questioned whether all would be present if one were derived from the other. I believe Hanson is probably correct in his interpretation of the significance of the chondrifications in the myosepta in *Necturus*.

It is an interesting fact that some *Necturus* have the inscriptions tendineae, while other lack them. Previous records have not included any information on the size of the animals in which the cartilages were (or were not) found. It is evident from the data presented in the table below that specimens of length greater than 32 cm. have the inscriptions tendineae, while shorter specimens generally lack them.

Length (cm.)	Sex	Inscriptions	
		Absent	Present
25.0	f	X	
26.5	f	X	
27.5	m	X	
28.0	f		X
28.3	f	X	
29.2	m	X	
30.5	m	X	
32.0	m	X	
33.5	m		X
33.5	m		X
33.7	m		X
37.5	f		X
39.0	m		X

I made no attempt to discover the age of my specimens by an examination of the parasphenoid bone (Senning 1940). If it can be assumed that my specimens have the same age-length relationships as did those studied by Senning, a good estimate of age can be made. On this basis, my last five individuals in the table above are at least twenty years old. It is possible that chondrification of the myosepta may be a mark of senility in *Necturus*.

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