VI. ADAPTATION IN CAUDAL MUSCULATURE*

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The present study began with a kangaroo which was given to the Department of Zoology of the University of Oklahoma by W. M. Newton of Ada. For the purpose of anatomical study the tail of this animal was given to me by Doctor A. Richards, with the suggestion that it might furnish the basis for research work on caudal musculature.

Referring to the literature it was found that very little morphological research had been done on the caudal region of vertebrates. According to H. H. Wilder (History of the Human Body. 1909) in long tailed animals there are two extensor muscles on each side of the mid dorsal line; on the side two abductors, and ventrally a single pair of flexors.

The kangaroo gives a fine illustration of these muscles and since it is a marsupial, the muscles will be described more in detail than the others. From the available animals the following were in addition selected to represent as far as possible, the other mammalian groups and the musculature worked out with a

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view of finding some possible adaptation to environment: as representative o. the Ungulata, the horse and ox; of the Carn.vora, the domestic cat and dog; of Rodentia, the rabbit and mouse; an l of the Primates, man.

The tail of this kangaroo was composed of thirty segments and was thir.y inches long. The circumference tapered from nine to one and three-fourth inches. The dorsal ventral and lateral surfaces were flat, giv.ng the tail a rectangular from with a width at the body end of three and one-fourth inches and depths of three inches. The hair on the ventral surface was worn off of the last three-fourths of the tail. The connective tissue was very thick and tough. The general impression was that it was an organ of great strength. On the ventral surface of the ta l, between the muscles with their tendons and the skin, beginn.ng with the tenth vertebra and extending to the tip was a layer of fat one and one-half inches thick and of very tough texture. It was the thickest at the enh verebra and from here apered to a thin layer at the tip.

The muscles of the tail of the kangaroo were as follows: (The nomenclature used is from Wilder and in parenthesis is that adopted by the American Veterinary Associat.on).

1. Extensor Caudae Medialis (Sacrococcygeus). This muscle extends the length of the tail, meeting its fellow in the mid dorsal line. It has many insertions, being attached at each articular process ,thus giving the appearance of many short muscles, each with one origin and two insertions. The function of this muscle is to extend the tail.

2. Extensor Caudae Lateralis (Sacrolateralis). This mus le is found just lateral to the medialis and lies below the articular process. It is a continuation of the Longissimus dorsi and ex.ends the length of the tail. It has the appearance, when in place, of one long round muscle inserted by many strong tendons to the dorsal surface of the articular process. Its function is to extend the tail.

3. Intertransversales Caudae. This is composed of bundles, each attaching to a lateral process, passing ventral to the second and attaching to the third. This is a series of muscles whose function it is to flex the tail laterally.

4. Flexor Caudae Longus (Sacrococcygeus ventralis.) This is a long muscle on the ventral side, so closely united with the next muscle (Brevis) that at first they appear as one. Its origin is in the lumbar vertebrae, the sacrum and the caudal vetebrae.

It is inserted by long flat tendons to the chevron bones. Its function is to flex the tail.

5. Flexor Caudae Brevis (Sarcrococcygeus ventralis). The origin is in the medial dorsal side of the ileum and the dorsal surface of the sacrum. It is inserted by strong tendons to the transverse processes. Its function is to flex the tail.

6. Iliocaudalis (Coccygeus). This is a thick flat muscle whose origin is in the sacrum. It spreads like a fan and acts as a support for the viscera.

The adaptations shown in the kangaroo are, first, its great size, and second, strength, due to the large tendons. These two features enable it to use its tail as a weapon of defense. Third, the thick layer of fat on the ventral side just under the skin is a pad so that the tail may be used as a third leg of a tripod in resting. Fourth, in running the tail of the kangaroo is carried horizontally so that the center of the pull of the tendons is in the region of the tenth caudal vertebra, the center of gravity of the tail. And fifth, the fan-like form of the Iliocauda is muscle is an adaptation to the upright position of the animal, serving as a support for the viscera.

Ungulata-Horse and Ox

All six muscles were present in the horse. The tendons were very short and there was far less specialization shown; that is, each muscle appeared to have lateral flexion equally. This would account for the circular motion. The Iliocaudalis is very small and aids in flexion of the tail. The center of the strength is in the first four or five vetebrae. At the end the muscles seem to have no function except to give shape to the tail. All this, we see, is adaptation to the horse's mode of life. The tai is the only free appendage, movement is always in the long axis of the body and with the exception of the well developed skin muscles, that move the skin on any part of his body, the tail must protect him from the insects.

The ox has the six muscles but the Iliocaudalis muscle is of still less use and is hard to separate from the other ventral muscles. The center of the pull is at the body end and the muscles and vertebrae are lost three or four inches in front of the end of the tail. The best adaptation shown in the tail of the ox is in the hair arrangement, causing a curl at the end. This is caused by the spiral growth from the skin and not, as in other anima's, by the form of the hair itself. Since the cow has far less move-

ment than the horse she compensates by the force of the blow she can deal.

Carnivora-Dog and Cat

Five muscles were present in all dogs although there was a great variety of tendon arrangement shown as a result of man's selective breeding. In long-tailed dogs, the collie, for example, the tail acts as a rudder, helping them to turn corners. In all dogs any emotion is shown by the movement of the tail and this wagging is due to the tendon connection between the Extensor Caudae Medialis and Lateralis muscles. They seem to be attached to each other directly by tendons, this is not found in other animals.

In the cat two additional muscles were found. One a Lateral muscle we will call the Sacro Coccygeus Accesorius, and the other the same that was found in the kangaroo, the Iliocaudalis, which is spread out fan shaped, to act as a support for the viscera as the cat jumps and climbs. All muscles are about the same size, the length of the tail and this with the help of the extra lateral muscle explains the ease with which a cat can move its tail.

Rodents-Rabbit

In the rabbit there were only four muscles. The Extensor Medialis is the only well developed muscle. This is the muscle that holds the tail up. The tail is small and seems to be of no value to the animal. The flexor muscles are very short and of little value. The tail falls because of its own weight and must be pulled up and held in place by the one well developed muscle. The Iliocaudalis is spread out fan shaped and acts as a support for the viscera.

Primate-Man

In man there is a great reduction of caudal vertebrae and muscles but the intertransversales are fairly constant.

The Levator Ani of man is the muscle that runs transversely across the pelvic opening as a support for the viscera. This is the Iliocaudalis of the kangaroo, the cat and the rabbit.

Conclusion

There are typically five caudal muscles, two extensors, one abductor and two flexors and these are fairly constant except where adaptations have taken place. The muscles in which adaptations are most apt to take place are Intertransversales and the Iliocaudales. No two species were found with either of these two muscles the same. The greatest variation was found in the Iliocaudalis. In animals that have an upright (man), or a semi-

upright (rabbit) position or stand upright at least a part of the time (the cat), this muscle acts as a support for the viscera. Differences may occur between animals of the same, as well as different species, as for instance, in the dog. In general, then, the muscles tend to remain constant, but are subject to differentiation as the iliodacaudalis and intertransversales of kangaroo and man; they may be lost as in the rabbit and in man, or they may be added as in the cat.