FLYING ABILITY AND THE ANTERIOR INTERMUSCULAR LINE ON THE CORACOID

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THE student of functional osteology working with either Recent or fossil material often times must attempt to reconstruct the myological pattern by study of the muscle scars on the various bones. In birds, the coracoid is one of the elements most frequently encountered in the fossil record. To complete a phylogenetic picture of flight in a family which includes fossils, it frequently is desirable to speculate on the evidence furnished by the coracoid.

In 1931, Lambrecht (Proc. VIIth. Internat. Ornith. Congress, Amsterdam, 1930: 79–81) noted in fossil and Recent cormorants a difference in the position and configuration of the anterior intermuscular line on the coracoid. Medial to this line is M. supracoracoideus (M. pectoralis secundus); lateral to it is M. coracobrachialis posterior (M. pectoralis tertius) (Text-fig. 1). Lambrecht inferred that the line separated parts of the origins of the two muscles and stated that shifting of the line laterally indicates increased size of M. supracoracoideus and consequent better "flying ability." His corollary to this thesis was that M. coracobrachialis posterior decreases in size as M. supracoracoideus increases.

Several objections may be raised to this interpretation of the significance of this particular intermusclar line. First, the main origin of M. supracoracoideus is from the sternum and not the coracoid; in the cathartid vultures at least, there is very little coracoidal origin. The medial edge of the origin of M. coracobrachialis posterior is, however, defined by the line. Secondly, M. supracoracoideus in many birds becomes tendinous in the region of the proximal part of the coracoid; thus the width of the coracoid covered by it varies with the width and the length of the tapered tendon, rather than with the development of the fleshy part of the muscle in which resides the actual power-potential. Thirdly, there is no reason to believe that increase or decrease in one of these muscles must necessarily result in decrease or increase in the other muscle. M. coracobrachialis posterior is free to expand laterally, and it does not always occupy all of the area lateral to the muscular line. M. supracoracoideus may and often does extend its origin medially and anteriorly on to the furculum. Ventrally, both are covered by M. pectoralis superficialis. In the Cathartidae, M. supracoracoideus overlaps the medial edge of M. coracobrachialis posterior and thus can expand without causing any corresponding change in the intermuscular line.

Still another criticism is that the line on the coracoid does not in all cases agree with the line on the sternum as to the lateral extent of the origin of M. supracoracoideus. In *Diomedea nigripes,* for example, the line on the sternum is much farther laterally than the coracoidal line when the two elements are articulated.

Miller (Univ. Calif. Publl. Zoöl., 42: 51, 1937) has voiced well-

TABLE I

STERNAL WIDTH OF IMPRESSION OF M. SUPRACORACOIDEUS ON CORACOID*

	Number of specimens	*Average*	*Range*
Diomedea nigripes	3	43.8	41.8–46.4
Gavia pacifica	4	33.9	31.9–35.9
Gavia stellata	7	33.8	32.1–35.9
Gavia immer	3	33.6	32.9–34.7
Cathartes aura	9	32.5	30.5–33.6
Sarcoramphus papa	2	31.7	31.1–32.4
Elanus leucurus	4	31.6	28.2–33.4
Cygnus columbianus	4	31.0	28.1–32.4
Gymnogyps californianus	5	30.2	28.9–31.2
Anas carolinensis	9	29.8	27.7–32.4
Anas platyrhynchos	7	29.7	28.2–31.7
Buteo borealis	7	29.5	26.7–31.3
Falco mexicanus	10	29.1	26.1–31.3
Anas cyanoptera	5	29.0	26.8–30.7
Branta c. minima	5	29.0	27.7–30.4
Falco peregrinus	4	28.6	28.0–29.2
Coragyps atratus	5	28.5	27.8–29.4
Branta c. canadensis	2	28.5	28.3–28.7
Branta c. hutchinsi	3	27.8	27.0–28.8
Falco sparverius	7	27.2	25.4–28.8
Falco columbarius	5	25.8	24.4–27.5
Accipiter gentilis	7	25.2	24.2–26.1
Ardea herodias	4	24.9	21.7–26.9
Oreortyx picta	5	23.8	22.0–25.9
Accipiter cooperi	5	23.2	22.0–24.5
Corvus corax	9	22.3	20.2–23.2
Phalacrocorax auritus	4	22.1	21.2–23.8
Corvus brachyrhynchos	9	21.6	20.4–22.6
Accipiter velox	8	19.7	18.4–21.6
Colinus virginianus	3	19.0	18.4–19.9
Anhinga anhinga	1	18.4	
Pelecanus occidentalis	4	15.4	14.7–16.6

* Expressed in per cent of coracoidal length.

founded suspicions as to the accuracy of our knowledge of the intricate functions of M. coracobrachialis posterior and its relationship to the action and relative development of M. supracoracoideus.

With these thoughts in mind, I examined the coracoids of a number of birds, and to obtain a mathematical expression of the position of the anterior intermuscular line measured the total length of the coracoid, the greatest sternal width of the coracoid and the sternal width of the coracoid medial to the muscular line in some 32 species. These species were selected to demonstrate different types of flight.

The width of the space supposedly occupied by M. supracoracoideus is expressed in per cent of coracoidal length in Table 1 and in per cent of the sternal width of the coracoid in Table 2. Admittedly, the measurements may not in all cases portray the exact situation, since the line may be in a different position farther anteriorly on the coracoid. However, as discussed previously, the more proximal part

TABLE 2

STERNAL WIDTH OF IMPRESSION OF M. SUPRACORACOIDEUS ON CORACOID*

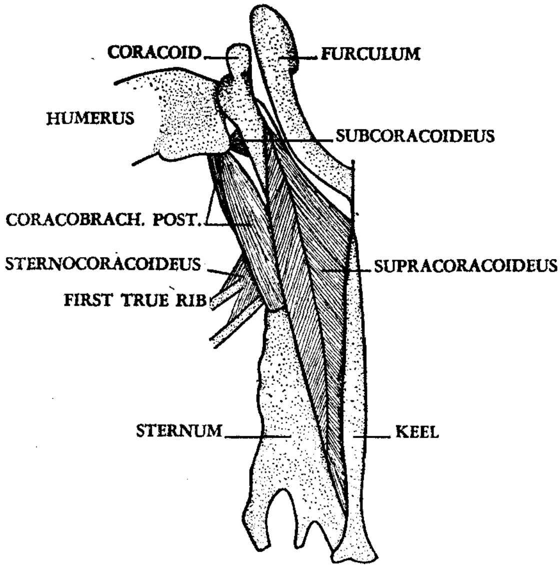
	Number of specimens	*Average*	*Range*
Sarcoramphus papa	2	79.4	77.8–80.9
Corvus corax	9	77.6	71.0–80.2
Falco mexicanus	10	77.1	72.0–83.3
Corvus brachyrhnychos	9	76.0	70.4–80.0
Cathartes aura	9	75.7	72.8–77.7
Falco sparverius	7	75.2	71.0–78.3
Coragyps atratus	5	72.5	70.7–73.9
Falco peregrinus	4	72.3	70.1–75.4
Cygnus columbianus	4	71.9	69.4–73.8
Falco columbarius	5	71.6	68.3–75.3
Anas cyanoptera	5	71.6	68.8–74.4
Gymnogyps californianus	5	71.2	70.2–72.0
Branta c. minima	5	71.1	68.7–74.7
Anas carolinensis	9	70.9	67.5–73.8
Anas platyrhynchos	7	70.7	66.8–75.9
Oreortyx picta	5	70.7	68.0–72.4
Branta c. hutchinsi	3	70.3	69.0–70.9
Branta c. canadensis	2	69.6	68.7–70.3
Elanus leucurus	4	68.1	64.7–70.5
Buteo borealis	7	65.6	60.3–69.8
Colinus virginianus	3	64.7	60.3–68.8
Ardea herodias	4	64.6	62.2–67.0
Gavia stellata	7	62.3	60.2–65.6
Gavia immer	3	61.8	61.3–62.3
Accipiter gentilis	7	59.8	56.9–62.1
Gavia pacifica	4	59.5	52.4–64.1
Accipiter cooperi	5	58.4	56.8–59.5
Phalacrocorax auritus	4	54.8	53.8–58.2
Accipiter velox	8	52.0	48.7–55.2
Diomedea nigripes	3	51.1	48.8–53.3
Anhinga anhinga	1	49.0	
Pelecanus occidentalis	4	35.4	34.6–36.6

* Expressed in per cent of greatest sternal width of coracoid.

of the area is a more reliable indicator of the development of M. supracoracoideus because the muscle has not yet become attenuated and has not formed its tendon of insertion. Except for the crow and raven, no passerines were measured because their small size makes too great the error in measurement.

In examining the coracoids and in reviewing the data furnished by the measurements, I found no correlation between the position of the anterior intermuscular line and any type of flight, size, or phylogenetic position. One might expect similarities in the ratios within a closely related group because of similarities in width and configuration of the sternocoracoidal articulation. A glance at the tables shows no such correlation among the various genera of the Cathartidae or among the species of *Falco* and *Accipiter.*

The wide separation in the ratios of such a notably soaring family as the Cathartidae by such forms as *Elanus, Falco, Anas carolinensis,* and *Cygnus,* and the disparity in the ratios of the various species of *Falco* negate any correlation with either soaring or swift, flapping flight. Also note the dissimilarity between *Pelecanus* and *Diomedea* and between the species of *Accipiter.*



TEXT-FIGURE 1.—Ventral view of the deep breast musculature in *Coragyps atratus* (× ¼).

Apparently the position is not correlated with speed of flapping flight, either, for *Ardea* and *Pelecanus,* both relatively slow, laborious flappers, are separated in the tables by such forms as *Oreortyx, Accipiter gentilis, Accipiter velox,* and *Anhinga.* Comparisons of two species within a genus, such as *Corvus corax* and *Corvus brachyrhynchos,* show no significant differences although the raven uses a slower wing beat. Likewise, the differences between *Anas carolinensis,* a fast flyer, and *Anas platyrhynchos* are negligible.

The fast, whirring flight of the quail as it gets off the ground is well known, yet *Oreortyx* and *Colinus* rank relatively low in the series as indicated by the ratios, and their ratios are separated by those of forms like *Branta, Elanus,* and *Phalacrocorax.*

The volumes of M. supracoracoideus and M. coracobrachialis posterior were measured in all the genera of the Cathartidae. Expressed in per cent of total volume of the wing musculature, the volumes of M. supracoracoideus are: *Vultur,* 7.3; *Coragyps,* 6.5; *Sarcoramphus,* 5.8; *Gymnogyps,* 5.1; and *Cathartes,* 4.4. Judging from the ratios of Table 1, the series in order of decreasing development of M. supracoracoideus would be *Cathartes, Sarcoramphus, Gymnogyps,* and *Coragyps.* From Table 2, the same series is *Sarcoramphus, Cathartes, Coragyps,* and *Gymnogyps* (no coracoids of *Vultur* were available). Thus it appears that in the New World vultures the position of the line on the coracoid is not an index to the volume of the muscle which, in turn, is the best gross index to its power. The volumes of M. coracobrachialis posterior, expressed in per cent of total volume of wing musculature, vary between 0.93 per cent in *Sarcoramphus* and 1.16 per cent in *Gymnogyps,* a negligible range of some 0.2 per cent. These figures indicate that M. coracobrachialis posterior does not vary inversely in its developments with M. supracoracoideus.

Consequently, it seems necessary to discard the anterior intermuscular line on the coracoid as an index to the ability to fly. There are too many complications in the form of synergistic actions of the muscles and in the stimuli supplied to them through the nervous system for any such simple criterion to be significant.

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SOME CHANGES IN THE BIRD LIFE OF CHURCHILL, MANITOBA

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On May 1, 1934, P. A. Taverner and G. M. Sutton published a carefully prepared, annotated list (1) of the birds that had been recorded from Churchill, Manitoba, up to July, 1933. In 1934, I spent the month of June at Churchill studying ptarmigan (2) in the interest of the American Game Association and found this list most useful, while my observations on the relative abundance of the various species checked rather accurately with those reported by Taverner and Sutton. Ten years later, 1944, I spent most of the month of June again at Churchill, under the auspices of the National Geographic Society, this time with my son David, and since the status of certain species seems to have changed in this interim and since the area will probably undergo additional changes, it seems advisable to report our observations at this time.