

Resumen por el autor, H. S. Colton.

La anatomía de una rana con cinco patas

El presente trabajo es una descripción de un miembro que surjía en una cintura escapular accesoria situada en el extremo esternal del coracoides y precoracoides derecho. El miembro en cuestión, compuesto de húmero, radio-ulna y una mano reduplicada con ocho dedos, carecía de pigmento y músculos, excepto sobre la cabeza humeral, y aparentemente carecía de sensibilidad. El músculo pectoral del lado derecho presenta su origen en el húmero accesorio y la cintura escapular accesoria, insertándose sobre estas estructuras y no sobre el esternón, como ocurre en el lado izquierdo, que es normal. A causa de la curiosa musculatura, el autor llega a la conclusión de que la anormalidad fué causada por una lesión del esternón.

Translation by José F. Nonidez
Cornell Medical College, New York.

THE ANATOMY OF A FIVE LEGGED FROG

HAROLD SELLERS COLTON

University of Pennsylvania

FOUR FIGURES

In December 1921 I purchased from a collector of frogs a specimen of *Rana pipiens* with an extra fore limb protruding from the region of the right coracoid. Since it is by studying the abnormal structures which sometimes appear in animals that we are able to shed light on normal conditions, I thought it worth while to study the relation of this limb to the body of the animal.

While polymely is fairly common in the hind limb of the frog¹ it is much rarer in the fore limb. Why this difference exists is perfectly clear. The limb buds of the fore limb, growing as they do in the protected opercular chamber, are not subject to accident as are the buds of the hind limbs, exposed at all times to external conditions. Nevertheless, as can be seen from the table (page 248), polymely of the fore limb is not uncommon.

The frog in question, a small male (five cm. long) was kept alive in an aquarium. During the winter he fed upon spiders, meal worms and beetles. On April 20th he died from some unknown cause, perhaps by the water becoming too hot as the aquarium stood in a sunny place. While he was alive I had abundant opportunity to observe the actions and reactions of the supernumerary limb.

This limb armed with eight digits he kept folded across his chest (fig. 1). Except for the region on the proximal end of the limb no sign of pigment nor any musculature was visible. Indeed, pinching the limb with forceps showed that it was without sensation—no reaction could be observed. Indeed, so numb was

¹ Bateson, W. 1894 Materials for the study of variation. Lond. Macmillan.

TABLE 1
Cases of polymely of the fore limbs of Anura

AUTHOR	DATE	SPECIES	SYMMETRY	REGION	NUMBER OF DIGITS	SHOULDER-GIRDLE SUPERNUMERARY
Superville ¹	1740	?	Right	Scapular	?	?
Gervais ¹	1864	<i>Pelobates cultripes</i>	Left	Scapular, posterior	3	Coracoid and scapula
Lunel ¹	1868	<i>Rana viridis</i>	Left (pair)	Scapular (?)	4+4	
Royal College of Surgeons ¹	1872 ²	?	?	Sternal	?	?
Mazza ¹	1888	<i>Rana esamelica</i>	Left (pair)		?	Scapula and coracoids
Bland Sutton ¹	1889	<i>Rana temporaria</i>	Left	Scapular	3	Coracoids
Bergendal ¹	1889	<i>Rana temporaria</i>	Left	Scapular	2	None
Tornier	1898	<i>Rana esculenta</i>	Right (pair)	Scapular, one ventral, one anterior	4	Coracoids
					4	None
Washburn ¹	1899	<i>Buffo columbiensis</i>	Left	Scapular anterior	7	?
Johnson ¹	1901	<i>Rana palmipes</i>	Left and Right	Scapular	4	?
"					? destroyed	?
Ergerman and Cox	1901	<i>Rana halicinum</i>	Right (pair)	Scapular (ventral)	?	?
O'Donoghue	1910	<i>Rana pipiens</i>	Right, ventral	Scapular	5	?
"	1910	<i>Hyla aurea</i>	Left, dorsal	Scapular	Destroyed	Scapula
		<i>Rana temporaria</i>	Right, dorsal	Scapular	1	None
Wagner	1913	<i>Rana pipiens</i>	2 right 1 left	Sternal	4+4+4	?

¹ O'Donoghue, Chas. H. 1910 Instances of polymely in two frogs. Zool. Anz., vol. 35, pp. 759.

the limb that small pond snails attacked it. At times, they covered the limb, apparently feeding upon the epidermis and causing abrasions. The striking characteristics of the supernumerary limb were its position on the ventral side, the lack of musculature, the lack of pigment, and the lack of sensation.



Fig. 1 Photograph of frog, ventral surface. In the dark area anterior to the extra limb there is no muscle layer between the skin and the peritoneum; one looks directly into the body cavity.

The attack of the snails indirectly led to the frog's death. To protect him from the snails I removed him to an aquarium standing before a south window, and without land upon which to crawl. The next morning I found him dead. After his death I preserved him and dissected the arm. The shoulder

girdle proved quite normal on the left side and quite abnormal on the right. The right fore limb was normal, but the coracoid and precoracoid, instead of reaching to the sternum, were very short and supported a mass of cartilage with three centers of ossification. Of the three parts two, in their relationships, suggested coracoid and precoracoid, while the third, a forked structure which slid back and forth on a process from the sternum (fig. 2), could hardly be homologized with the scapula. Attempts to homologize these three parts with the normal shoulder girdle have proved unsatisfactory. With a glenoid cavity in the supernumerary shoulder girdle the extra humerus is articulated. On the distal end of this humerus is an indication of a joint, but no movement is possible. At this point the radio-ulnar is stiffly joined to the humerus. At the distal end of the radio-ulnar a mass of cartilage represents the carpals. From this mass eight digits extend, forming a reduplicated hand. The first digit is present as one, the metacarpal of the second is split on the end, the other three digits are all paired. Figure 3 shows the palmar surface of the double hand. Symmetrical reduplications of a similar sort have been reported by Harrison ('21) in his transplanted limb buds in Salamanders.

While the osteology is interesting the musculature throws more light on the origin of the limb. As I mentioned earlier, the only muscles present in the limb were found at its proximal end, the hand, the forearm and three quarters of the upper arm showed no trace of musculature that I could observe. Four muscles were concerned with the accessory shoulder girdle and the accessory humerus. Three of these muscles (fig 4 *A*, *B*, and *C*) were inserted in the crista deltoidea of the normal right humerus in the position of the normal three portions of the pectoralis muscle, which was absent. The anterior of these three muscles (*A*) had its origin on the accessory shoulder girdle, on the sternum, and on the supernumerary humerus. The second muscle (*B*) had its origin on the accessory shoulder girdle, while the third or posterior muscle (*C*) had its origin on the humerus of the supernumerary limb. A fourth muscle (*D*), in position a continuation of the second (*B*), had its origin on the accessory shoulder girdle

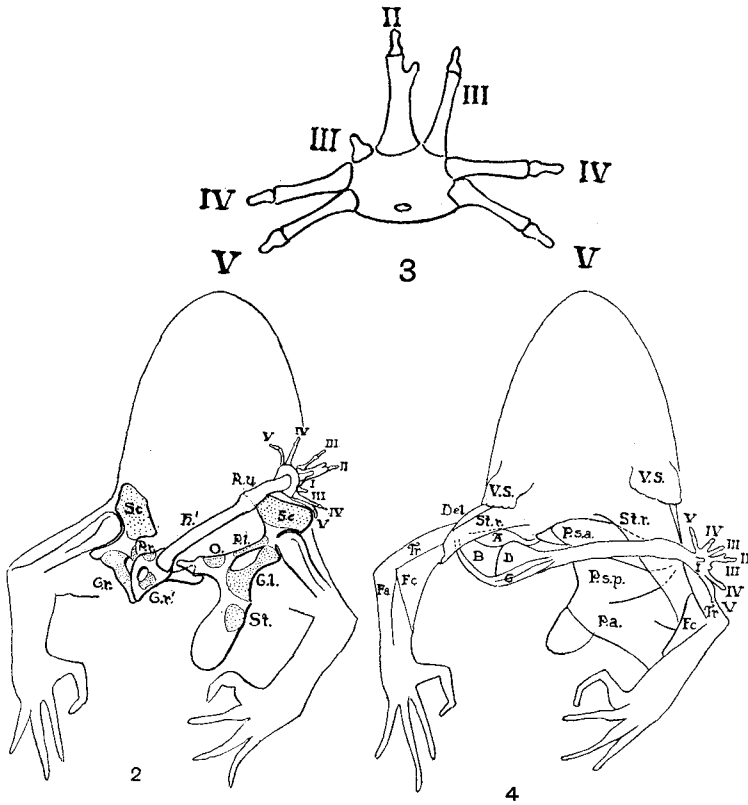


Fig. 2 Osteology of supernumerary limb, twice natural size.

C.l. Left coracoid
C.r. Right coracoid
C.r' Supernumerary coracoid
H. Humerus
H' Supernumerary humerus
O. Omosternum
P.l. Left precoracoid
P.r. Right precoracoid
R.u. Radio-ulnar
Sc. Scapula
St. Sternum

Fig. 3 Palmar surface of hand of supernumerary limb. This shows a twinning on an axis through the first and second digits. The first digit is hidden by the second. Four times natural size.

Fig. 4 The musculature of the forelimbs of the five legged frog. Twice natural size. *A*—Anterior muscle of the accessory limb. *B*—Median muscle of accessory limb. *C*—Posterior muscle of accessory limb. *D*—Muscle connecting supernumerary limb and shoulder girdle. *Del.*—Deltoid. *F.a.*—Flexor antibrachii. *F.c.*—Flexor carpi. *P.a.*—Pectoralis portio abdominalis. *P.s.a.*—Pectoralis portio sternalis anterior. *P.s.p.*—Pectoralis portio sternalis posterior. *St.r.*—Sterno-radialis. *Tr.*—Triceps. *V.S.*—Vocal Sack.

and passing over the head of the supernumerary humerus inserted on that bone. A comparison between the right or abnormal half of the frog with the left or normal half shows that the supernumerary limb is served by muscles homologous to the three portions of the normal pectoralis muscle,—portio sternalis anterior (fig. 4, *P.s.a*), portio sternalis posterior (*P.s.p.*), and portio abdominalis (*P.a.*). Ecker ('89). Supporting this view I found that on the right side the normal pectoralis muscle was lacking,—a fact which in life gave the frog a very peculiar appearance. In front of the supernumerary limb a dark patch was visible; there being no layer of muscle between the skin and the peritoneum, one looked directly into the coelom.

A review of cases of fore limb duplication (table 1) shows that the most common type arises in the scapular region and seems to be caused by a split in the limb bud. In two cases, in which, however, the anatomy was not studied, the limb is reported on the ventral side in the region of the sternum. Supernumerary fore limbs then in the Anura may be found in two regions, in the scapular region and in the sternal region.

Speculations on the possible origin of sternal limbs may be based on three sets of evidence; on the osteology, on the musculature and on the nerve supply. The limb may have been caused by a split in the limb bud involving the coracoid and pre-coracoid or it may have been due to an injury to the sternum. The osteology of our limb favors both hypotheses (fig. 2). Since the pectoralis muscle is normally innervated through the brachial nerve, were it possible to trace out the nerve to the pectoralis muscle, it would also favor both hypotheses, therefore a choice between the hypotheses depends upon the musculature. Since the origin of the pectoralis muscle is normally on the sternum, it would seem that the accessory limb has in some way been derived from the sternum. How this may take place is left for experimental analysis.

LITERATURE CITED

- BATESON, W. 1894 Materials for the study of variation. Lond. Macmillan.
- ECKER, A. 1889 Anatomy of the frog. Oxford.
- EIGERMAN, C. H. & COX, U. O. 1901 Some cases of saltatory variation. Am. Naturalist, vol. 35, pp. 33.
- HARRISON, R. G. 1921 Symmetry in transplanted limbs. Jour. Exper. Zool., vol. 32, pp. 1.
- JOHNSON, R. H. 1901 Three polymelous frogs. Am. Naturalist, vol. 35, pp. 25.
- O'DONOGHUE, CHAS. H. 1910 Instances of polymely in two frogs. Zoologischer Anz., vol. 35, pp. 759.
- TORNIER, V. G. 1898 Polymely. Zool. Anz., vol. 21, pp. 372.
- WAGNER, G. 1913 On a peculiar monstrosity of a frog. Biol. Bull., vol. 25, pp. 313-317.
- WASHBURN, F. L. 1899 A peculiar toad. Am. Nat., vol. 33.