PLATE VIII.

Fig. 1. Left side view of the skull of a nestling *Phaëthon flavirostris*, showing the sutures, the absence of a nasal hinge, and the large size of the anterior narial aperture. In order to expose the whole extent of the maxilla, the dentary border of the premaxilla has been removed.

Fig. 1 *a*. Ventral view of the same skull. The pterygoids, palatines, and vomer have been removed, in order to show clearly the schizognathous nature of the palate.

Fig. 2. Left side view of the skull of a very young nestling *Sula leucogastra*, showing the sutures and the large size of the anterior narial aperture.

Fig. 3. Left side view of a portion of the cranio-facial region of the skull of *Phalacrocorax carbo*, to show the form of the maxillo-palatine processes and nasal septum when seen from behind. The lachrymal has been removed.

Fig. 4. The same view of the skull of *Fregata ariel*.

Fig. 5. The same view of the skull of *Phaëthon*. The maxillo-palatine processes are seen to have only a horizontal direction; there is no nasal septum.

Fig. 6. The same view of the skull of *Pelecanus rufescens*. Note the great vertical height of the maxillo-palatine processes, and the vestigial *septum nasi*.

2. On the Skeleton of Regenerated Limbs of the Midwife-Toad (*Alytes obstetricans*). By W. G. RIDEWOOD, D.Sc., F.L.S., F.Z.S.

[Received December 22, 1897.]

The capacity which the larvæ of the Anurous Batrachians possess of regenerating lost limbs or parts of limbs was made known to the world as long ago as 1769 by Spallanzani (**12**), and was verified by Günther[1] in 1866 (**11.** p. 567); and although the negative results obtained by Fraisse (**6**) in 1885 led this author to doubt the possibility of such regeneration, the original observation has recently received abundant confirmation at the hands of Barfurth (**2**) and Boulenger (**4.** p. 98). But whereas, as is well known, lost limbs can be developed anew at any period of life by certain Urodela, it is only in the larval stages of Anura that such phenomena are to be observed. Barfurth concludes from the results of his experiments that the capacity for reproducing lost parts diminishes in Anuran tadpoles as the development progresses, and on this hypothesis he explains the discrepancy between the results of Spallanzani and Fraisse.

With a view to following up the researches of Barfurth, Mr. G. A. Boulenger, F.R.S., seized the opportunity, when in Belgium in the spring of 1897, of procuring some fine full-grown tadpoles of the Midwife-Toad (*Alytes obstetricans*) and of repeating Barfurth's experiments upon them[2]. These tadpoles had been spawned in

[1] A mistake has evidently occurred in Owen's transcription of Dr. Günther's manuscript. The statement "If a hind limb be cut off when the larva is about two lines long it is reproduced" is meaningless, because the larva of that size has no limbs. The words "two lines long" were evidently intended to apply to the size of the limb, not of the larva.

[2] Barfurth employed tadpoles of the common frog [*Rana fusca* (*temporaria*)].

the preceding summer, and might have been of the same brood. They were collected at Maurenne, near Hastière, in the province of Namur, in May 1897, and were all treated in exactly the same way, the left hind leg, then between seven and twelve millimetres in length, being amputated at the middle of the tibial segment and left to heal. Five of the specimens completed their metamorphosis, but the sixth became arrested in its development, and although kept under exactly the same conditions of life as the other five, failed to make any progress. All six were killed in October 1897, when Mr. Boulenger very kindly handed them over to me, together with the above information as to their previous history.

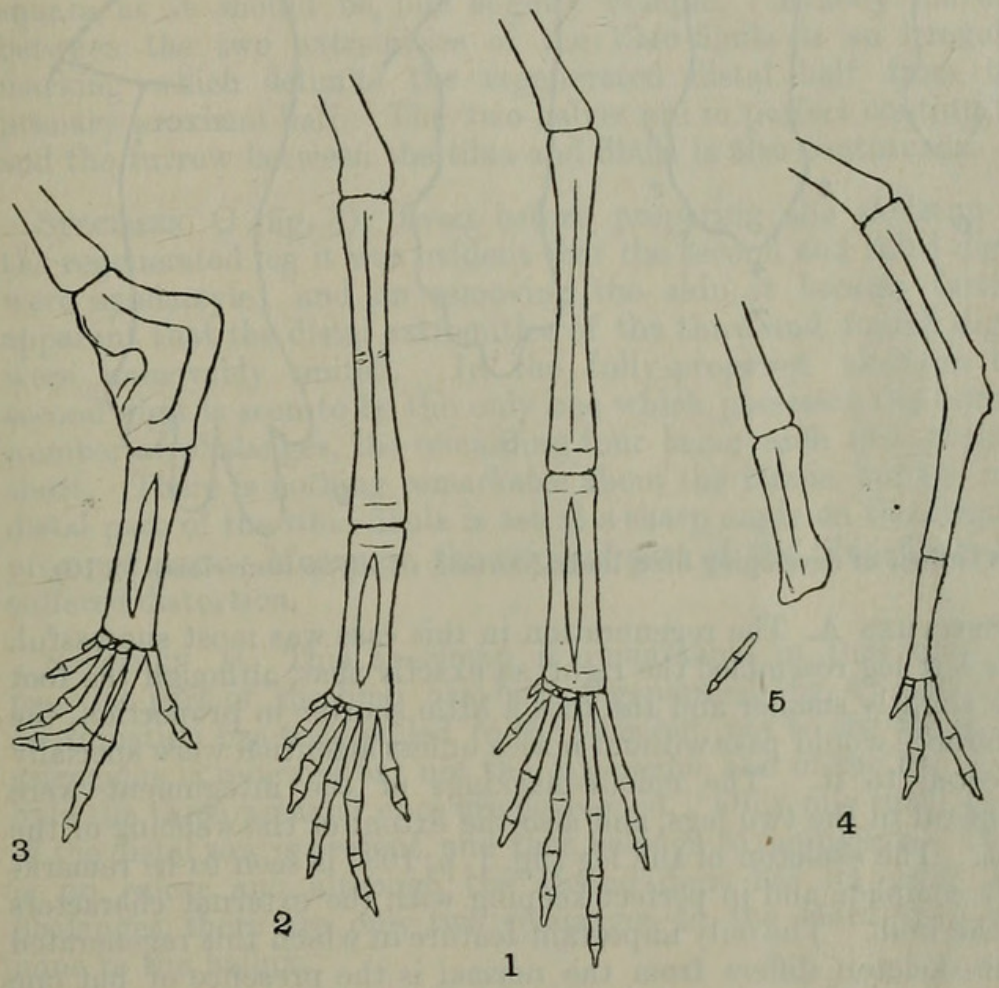
While, thanks to Götte (**10**), our knowledge of the normal and regenerated limb-skeleton of Urodela is not deficient, the skeleton of regenerated limbs of Anura does not appear to have hitherto received any attention; and it occurred to me that the best use to which the material entrusted to me could be put was the preparation and description of the regenerated cartilages. Bearing in mind the close similarity found by Götte to obtain between the regenerated and the normal limb-skeleton of Urodela, a somewhat similar correspondence was to be expected in Anura. But, having regard to the greater specialization of the Anuran limb, it was just possible that the restored skeleton might be simpler than the normal. On surveying the results of the investigation one cannot fail to be impressed by the closeness with which the skeletal parts of the newly-developed limb approach those of the normal.

While in animals other than Anura structural differences between the regenerated and the normal limb may be explained as phenomena of atavism [as claimed by Giard (**7** and **8**), Barfurth (**1**. p. 113 (6)), and Bordage (**3**)], there is no evidence of such phylogenetic reversion in the regenerated limb-skeleton of the Anura under consideration. The astragalus and calcaneum are elongated and are confluent with one another at both their proximal and distal extremities. The remaining tarsalia are disposed exactly as in the normal limb of the same age. Although in specimen C four of the five digits have each one phalanx less than the normal, there is abundant evidence in specimens A and B to show that the typical number of phalanges for each digit can be reproduced. And, lastly, the experiments throw no light whatever on the morphology of the calcar, although one might fully have expected atavism to be apparent here if anywhere.

Mr. Boulenger has also communicated to me the very interesting fact that, if the first appearance of the new limb be watched carefully, a single digit is first seen to grow out from the healed stump, then another digit at its side, then a third, and so on in succession. The tarsus and the distal half of the tibial segment of the leg appear to be intercalated afterwards between the digits and the stump. The chief interest of the successive appearance of the digits lies in the fact that this mode of development is characteristic of the Urodele limb. In the newts and salamanders,

as Götte (**10**) and Strasser (**13**) have shown, the first digit to develop is the second ; the inner digit follows and then the remaining digits in succession, the third, the fourth, and, in the hind limb, the fifth. The digits of the normal Anuran limb, however, develop simultaneously, as Götte (**9**) has remarked in the case of *Rana* and *Hyla*, and as Dugès has figured in the case of *Pelobates* (**5**. pl. additionnelle, figs. 11–13). Four figures of the

Figs. 1–5.

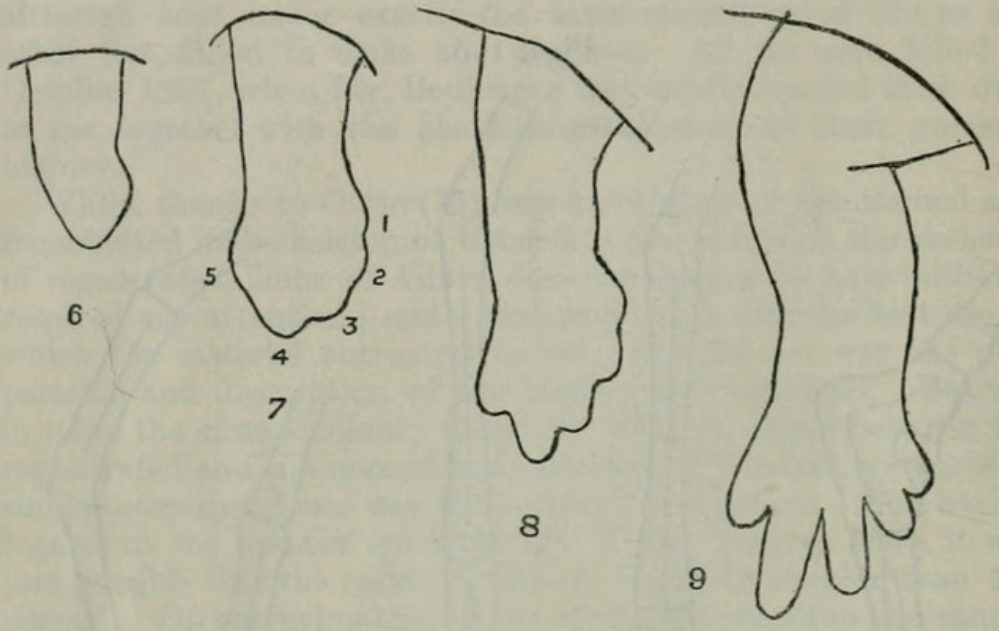


Skeleton of regenerated left hind limbs of *Alytes obstetricans* (×5).

budding normal limb of *Alytes* are here given (figs. 6–9, p. 104) to illustrate this point farther, and it will be noticed that, so soon as any digitation at all can be made out in the differentiating bud, all five digits can be counted. The explanation usually given for the exceptionally rapid development and the great length of the first-formed digits in the newts is that these are larval digits, of special functional importance to the larva. But in the Anuran tadpole the paired limbs are not used as a means of progression ; they simply develop passively and slowly in anticipation of the approaching metamorphosis. It is curious, therefore, to find that in the regenerated limb of Anuran tadpoles the Urodele mode of digit-development should be adopted.

It not infrequently happens that the full complement of digits is not developed in the regenerated limb. Barfurth (2) has figured cases in which only one, two, three or four digits are present; and of the five[1] specimens now under consideration two possess only one and three digits respectively.

Figs. 6–9.



Outlines of developing hind limbs (normal) of *Alytes obstetricans* (×10).

Specimen A. The regeneration in this case was most successful. The left leg resembled the right so exactly that, although the foot was slightly smaller and the toes a little shorter in proportion, the difference would pass without notice unless attention were specially directed to it. The colour-markings of the integument were identical in the two legs, and also the extent of the webbing of the foot. The skeleton of the leg (fig. 1, p. 103) is seen to be remarkably complete and in perfect keeping with the external characters of the limb. The only important feature in which this regenerated limb-skeleton differs from the normal is the presence of but one phalanx to the hallux and the slenderness of the hallux metatarsal. The remaining digits, the calcar, and the whole of the tarsus present no differences. The distal end of the tibio-fibula is in perfect continuity with the proximal portion, and there are no markings to indicate the limits of the secondary and primary portions of this bone.

Specimen B. In this specimen the regenerated left leg was considerably shorter than the right or normal. The femoral joint was of the same size as in the right, but the remaining parts of

[1] That is, the five specimens which completed their metamorphosis. The development of the sixth appears to have been completely arrested, and the regenerated limb at the time of death had the form of a mere non-digitate bud, too small to allow of a macroscopic examination of the skeleton. This sixth specimen will, therefore, not be referred to again.

the limb were all dwarfed. The proportion of the web of the foot was normal, but the five toes were disproportionately short, so that the foot had a stunted appearance. In the skeleton (fig. 2, p. 103) the tarsus and metatarsus call for no remark except that the ratio between length and thickness is less than in the normal limb. The fifth digit has only two phalanges; and in the fourth digit, which suffers from an unnatural curve towards the postaxial side of the foot, the antepenultimate phalanx is short and nodular. The joint between the tibio-fibula and the proximal tarsals is not square, as it should be, but slightly oblique. Exactly halfway between the two extremities of the tibio-fibula is an irregular marking which delimits the regenerated distal half from the primary proximal half. The two halves are in perfect continuity, and the furrow between the tibia and fibula is also continuous.

Specimen C (fig. 3). Even before preparing the skeleton of the regenerated leg it was evident that the second and third digits were syndactyle; and on removing the skin it became further apparent that the distal extremities of the third and fourth digits were immovably united. In the fully-prepared skeleton the second digit is seen to be the only one which possesses the normal number of phalanges, the remaining four being each one phalanx short. There is nothing remarkable about the tarsus, but the new distal part of the tibio-fibula is set at a sharp angle on the original proximal part. Moreover, the *original* part of the tibio-fibula has suffered distortion.

Specimen D. This specimen is remarkable in that only the preaxial part of the limb has been regenerated (fig. 4). A distal continuation has been added to the tibia but not to the fibula, the astragalus is renewed but not the calcaneum, and of the five digits only the three preaxial ones are developed. Only one small tarsal of the distal row is present, and that belongs to the hallux. There is no calcar, and, although the second digit has its usual two phalanges, there are only two phalanges to the third digit, and none to the hallux.

Specimen E. The regenerated parts in this specimen consist merely of a single digit, supported by three skeletal cartilages. No attempt has been made to complete the tibio-fibula, and there is no tarsus. There is an interval between the tibio-fibula and the skeleton of the digit (see fig. 5), and the axis of the latter makes an angle of about 55° with the tibio-fibula. This case appears to furnish a striking confirmation of the observation of Mr. Boulenger, communicated above, that in the regeneration of the limb the digits develop first, while the intermediate parts are intercalated afterwards, and also that the digits develop in succession and not simultaneously. It would seem that here, after the development of one digit, regeneration became arrested, so that we have in the young metamorphosed Batrachian the persistence of a very early phase of limb-regeneration.

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3. Description of a new Sea-Snake from Borneo.

By G. A. BOULENGER, F.R.S.

[Received January 8, 1898.]

(Plate IX.)

HYDROPHIS FLOWERI, sp. nov. (Plate IX.)

Head very small; anterior part of body very slender, its diameter about one third the depth of the posterior part. Rostral broader than deep; frontal once and a half as long as broad, as long as its distance from the rostral, much shorter than the parietals; one præ- and one postocular; a single anterior temporal; six or seven upper labials, third and fourth entering the eye; two pairs of