Syndactyly in *Bufo maculatus* Hallowell (Amphibia: Anura: Bufonidae)

A.J.L. Lambiris
Harare, Zimbabwe

Syndactyly in five specimens of *Bufo maculatus*, all from a small area 25 km west of Harare, Zimbabwe, is described. In three cases only one pair of digits was involved (two of the hand, one of the foot); in a fourth, two pairs of digits on one foot were involved; and in the fifth case, all digits of one hand were involved together with ectrodactyly and marked deformity.

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Sindaktilie in vyf eksemplare van *Bufo maculatus*, almal vanaf 'n klein gebied 25 km wes van Harare, Zimbabwe, word beskryf. In drie gevalle was net een paar vingers betrokke (twee van die hand, een van die voet); in 'n vierde was twee pare tone aan een voet betrokke; en in die vyfde geval was al die vingers van een hand betrokke saam met ektrodaktilie en aansienlike misvorming van die hand.

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A.J.L. Lambiris
34 Van Praagh Avenue, Milton Park, Harare, Zimbabwe

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Syndactyly appears to be a rare condition in Anura (Lynch 1965). In May 1981, five *Bufo maculatus* of various sizes, showing fusion of two or more digits, were found at the Atlantica Ecological Research Station, 25 km west of Harare, Zimbabwe. Three were preserved for detailed examination and are now in the author's collection (AJL 1544 – 1546). The specimens were fixed in 4% formal-saline and drawings of the feet were made. The specimens were then cleared and stained with Alizarin Red Sulphonate using Dawson's method (Peacock 1966) and osteological details were studied using a dissecting miscroscope.

Definitions of terms

Aplasia: Arrested development; failure of a structure to develop.
Ectrodactyly: Failure of one or more digits to develop.
Microdactyly: Reduction in the length of a digit.
Osteoporosis: Reduction in the density of bone matrix due to the loss of mineral salts.
Synarthrosis: Fusion of the articulating surfaces of a joint; initially fibro-cicatricial, subsequently ossified.
Syndactyly: Fusion, wholly or partially, of two or more adjacent digits.
Synostosis: Fusion of two or more adjacent bones into a single mass.

Descriptions

AJL 1544: Not sexed. Snout-vent length 13,0 mm. Collected 23 May 1981. Multiple syndactyly, microdactyly and phalangial aplasia of the left pes, involving digits two and three, and four and five (Figure 1).

The two pairs of digits are fused for the greater part of their length, with only the terminal phalanges free; there is a slight amount of webbing between the free portions of digits four and five. Microdactyly is especially pronounced in the third and fourth digits.

The skin on the dorsum of the pes is smooth. Ventrally, the outer and inner metatarsal tubercles retain their normal size, shape and position, but the other tubercles on the sole of the foot and the subarticular tubercles are considerably modified in number, appearance and distribution (Figure 1a, b).

Examination of the skeleton reveals the following (Figure 1c): The tarsals are unossified and appear to be fused into a single body. The second and third metatarsals are reduced in length (especially the second), while the

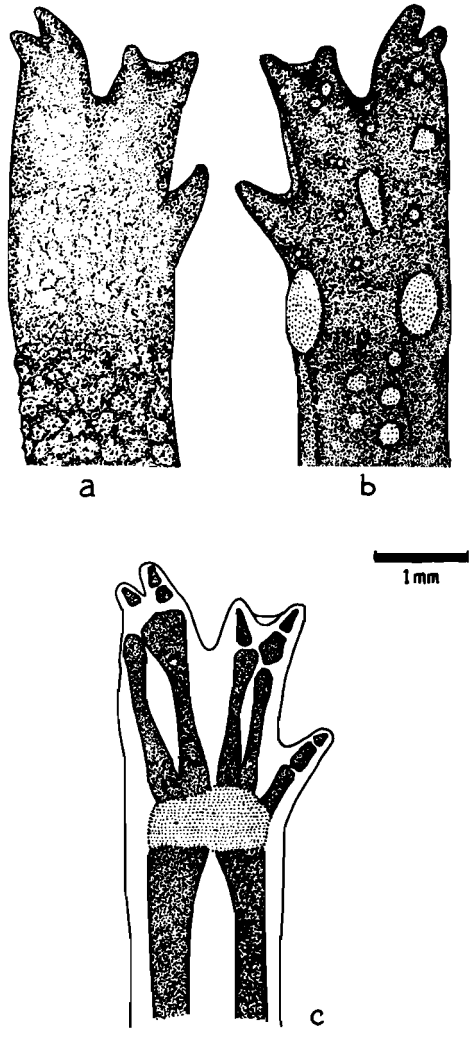

Figure 1 Syndactyly in *Bufo maculatus*. AJL 1544. (a) Dorsal aspect, (b) ventral aspect and (c) skeleton of left pes. In (c) heavy stipple denotes bone, light stipple denotes cartilage.

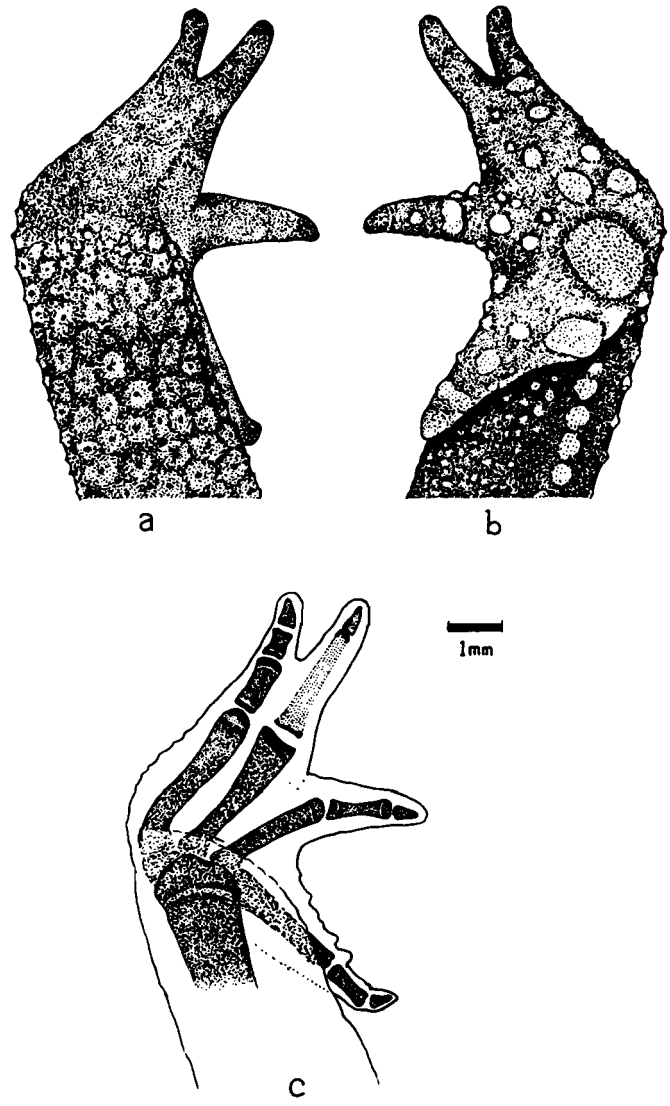

Figure 2 Syndactyly in *Bufo maculatus*. AJL 1545. (a) Dorsal aspect, (b) ventral aspect and (c) skeleton of left manus. Stipple convention as Figure 1.

fourth and fifth are of approximately normal length. The fourth tarsal is decidedly clavate distally; the phalanges of the fourth and fifth digits seem to be associated with it alone, the fifth metatarsal being somewhat laterally displaced. The fourth and fifth metatarsals appear to be partially fused proximally.

With the exception of the first digit, which appears to be normal, the phalanges show a number of abnormalities. The second digit has two phalanges (the normal number), but the proximal one is greatly shortened and thickened, and is elongately pentagonal. The third digit has one phalanx only, which appears to be a single bone and not derived from three fused phalanges. The fourth digit has two very short phalanges instead of the normal four; the distal element appears to be a normal terminal phalanx, but the derivation of the proximal element is in doubt. The fifth digit has a single phalanx, more closely associated with the fourth rather than the fifth metatarsal; the proximal and middle phalanges are completely absent.

AJL 1545: Male. Snout-vent length 29,5 mm. Collected 28 May 1981. Partial syndactyly of the left manus, involving the third and fourth digits. Localized osteoporosis (Figure 2).

The digits are fused proximally for slightly more than half their length and the skin texture is more normal than in the first case although (especially associated with the third digit) there are some aberrations in the subarticular tubercles (Figure 2a, b).

Osteologically, the third digit is markedly abnormal. What should be the middle and proximal phalanges consists of an elongate element that appears to be a single entity, with no macroscopic evidence of synarthrosis. Furthermore, this element is cartilaginous throughout except for an extremely thin cap of slightly ossified tissue at each end. The phalanges of the fourth digit appear to be normal. There is no fusion of the bones of the syndactylous digits at any point (Figure 2c).

AJL 1546: Female. Snout-vent length 33,0 mm. Collected 28 May 1981. Multiple syndactyly; ectrodactyly; localized osteoporosis; imperfect development of the left manus. (Figure 3).

The manus has the form of a dorsoventrally compressed club with smooth skin above and below. There is no external differentiation into a palm and digits, although the dorsum bears three slightly raised ridges which subsequently proved to indicate the position of three digits in-

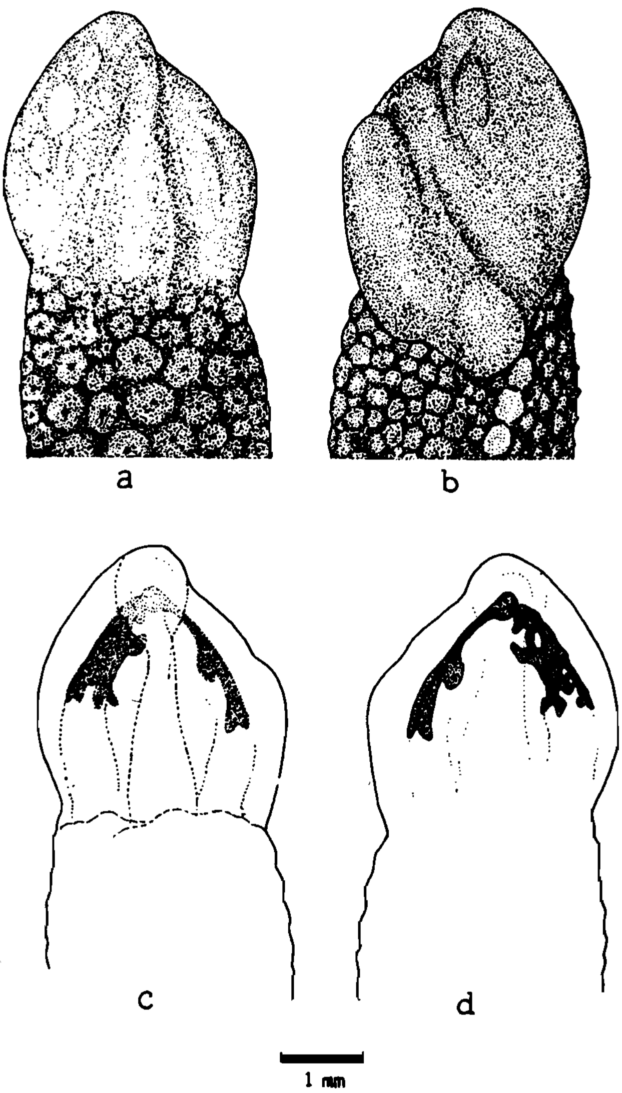

Figure 3 Syndactyly and ectrodactyly in *Bufo maculatus*. AJL 1546. (a) Dorsal aspect and, (b) ventral aspects of left manus. (c) Dorsal and (d) ventral aspects of skeletal malformation; stipple denotes calcification, dotted lines show outline of cartilage.

ternally; these are even less clearly indicated on the ventral surface, which bears only one poorly defined tubercle in the region overlying the carpals (Figure 3a, b).

Staining and clearing indicated a remarkable series of abnormalities (Figure 3c, d). The digits are completely invested in a thick sheath of skin and soft tissue. There is no evidence whatever of discrete bony elements in any of the three digits, each possessing merely a single rod of rather thin cartilage. Carpal bones could not be found, and it is presumed that they are either aplastic or exist as cartilage that does not show up in the preparation. The radio-ulna is slightly thicker than that of the right limb, but otherwise of normal appearance.

Examination of the stained and cleared manus from the dorsal aspect reveals the faint outlines of a relatively large median digit with a very clavate tip. Arising on each side of it, and curving inwards and ventrally to meet below it, are what appear to be two lateral digits. That which occupies the position of the pollex is probably a single entity, but the structure which takes the place of the third and fourth digits is less easy to interpret. It is probably a single digit, not two fused ones, with either the third or fourth being absent.

The relationship of the two lateral digits can be seen more clearly from the ventral aspect. Their origins and relations with the carpal area cannot be determined at all, the tissues here being completely transparent. Distally, they can be seen to meet, and possibly to be fused, below the tip of the median digit. They are also surrounded distally by very incomplete, rather thinly ossified, sheaths that appear to be better defined on the ventral surfaces.

Discussion

The two cases not preserved and described above agreed (externally at least) with that reported by Lynch in most respects: fusion of the third and fourth digits of a hind foot for almost their entire length, with a slight reduction in the length of the fused digits, but otherwise essentially normal superficially.

The cases described here differ more radically in many respects, particularly osteologically, and it appears on the basis of the present material that there may be several anatomically distinct types of syndactyly. It is felt, however, that there is not yet sufficient information available to propose specialized terminology for these types. Nevertheless, the present author does not agree with Lynch's differentiation between 'real' and 'apparent' syndactyly according to whether the bones of the digits involved are fused together or not. Syndactyly, strictly referring to a union of two or more digits as a whole, is by no means synonymous with synostosis and can occur independently of it.

Teratology

Localized osteoporosis is an interesting feature of two of the cases described here. The condition was not noted by Lynch, who examined the skeleton of his specimen radiographically, but '. . . somewhat between a quarter and half of the bony matrix must be lost before the radiographic appearance is altered' (Montgomery 1965). It may rarely occur without any apparent cause or, more commonly, as the result of '. . . rigid splinting or mechanical fixation of an extremity' (Bennett 1957). Montgomery (1965), states that 'Muscular movement and the continuous alternation of stresses and strains are believed to be the main stimuli to osteoblastic activity and to the maintenance of normal bone density; conversely, in immobilization bone formation stops . . .'

Reference to Figures 2 and 3 show that the unossified elements are effectively immobilized to a lesser or greater extent by the surrounding tissues. In the case of AJL 1545 the degree of immobilization of the third digit might not seem sufficient to cause demineralization of the bone, but the unusual length of this element may be a contributing factor.

In the case of AJL 1546, where the digits are completely immobilized by a thick layer of investing tissue, the splinting effect is much more obvious and much more profound. The formation of an ossified layer is readily explained by the observation that it was this portion of the manus that was in contact with the ground during locomotion, and consequently subject to stresses stimulating localized osteoblastic activity. It may be mentioned parenthetically that during removal of excess Alizarin from this toad, only a few thin, poorly defined, randomly distributed

muscle fibres could be seen in the manus; these were manifestly functionless and the consequent reduction in mechanical stresses undoubtedly contributed to the high degree of osteoporosis.

Aplasia tends to occur more in the bones of the extremities than elsewhere (Bennett 1957) and is a congenital anomaly. It is demonstrated especially clearly in AJL 1544, but the author knows of no other record of aplasia associated with syndactyly in Anura. Similarly, ectrodactyly in association with syndactyly does not seem to have been reported previously.

The incidence of so many cases of a supposedly rare condition, within such a short period of time and within a very small area (all the toads were collected within one 100-m survey square), strongly suggests that syndactyly is a genetically controlled anomaly. This belief is reinforced by consideration of the fact that the toads, which were collected during the course of an intensive marking/recapture programme, represent 5% of the recorded population of *Bufo maculatus* and that no other amphibian or reptile species collected showed any sign of syndactyly. There was no evidence, even under high magnification, of acquired trauma and subsequent fusion of the tissues. The author feels that these points tend to argue against environmental factors, such as lacerations or chemical pollution, as a cause of syndactyly in this area at least.

Locomotion

It was apparent, when observing the living toads, that even extensive syndactyly does not materially impair locomotion. In all cases both the walking gait and hopping were not significantly different from those of normal toads and it is assumed that the condition should not be considered as seriously maladaptive where only one limb is involved. Even if more than one limb is involved, the consequences are not necessarily disastrous. A dwarf chamaeleon *(Bradypodion v. ventrale)* from Grahamstown, South Africa, which exhibited multiple syndactyly of all four feet, was still capable of climbing trees though with some difficulty (Lambiris 1973); and yet another *Bufo maculatus* from the same site at Atlantica with amely of the left hind limb (AJL 1552) was also able to move without much difficulty.

Acknowledgements

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