Axial bifurcation and duplication in snakes. Part VII. Axial bifurcation with pseudoquadritomy in *Boaedon capensis* Duméril, Bibron & Duméril, 1854

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INTRODUCTION

The first synoptic review of axial bifurcation in snakes (CUNNINGHAM, 2007) listed 225 cases representing 48 species. More recently WALLACH (2007) surveyed 950 cases comprising 169 species in 93 genera. Currently there are 1850 authentic cases of axial bifurcation involving 254 species and subspecies in 111 genera and 13 families, culled from more than 3500 publications, citations and internet postings (WALLACH, 2018). This total includes progeny from four hybrid crossings (*Boaedon fuliginosus* x *B. lineatus, Lystrophis pulcher* x *L. mattogrossensis, Lampropeltis alterna* x *L. mexicana,* and *L.mexicana* x *L. ruthveni*). An indication of newly recorded cases can be seen by a comparison of current statistics vs. those summarized by WALLACH (2007): type 1 – voucher specimens (327 vs. 306), type 2 – physical evidence (589 vs. 374), type 3 – reliable reports (849 vs. 216), and type 4 – anecdotal reports (48 vs. 54). Note that the number of anecdotal cases has been reduced as additional information allowed some cases to be upgraded in their reliability.

There are four previous records of dicephalism in *Boaedon capensis,* the South African brown house snake. *Boaedon capensis* was previously a synonym of *Lamprophis fuliginosus* or *L. lineatus* but is currently recognized as a distinct species (WALLACH *et al.,* 2014). MAPHUMULO (2009) reported a captive bred prodichotomous specimen by Max Harris of “Northlands Pets”, Springfield Park, South Africa, born on 10 April 2009 after a two month incubation period. Another specimen was captive bred in Liverpool, U.K. by a breeder known as Slangman (African House Snake website, 21 April 2009). A third record, captive bred by Niki Chinn, occurred in 2011 in Liverpool, U.K. This prodichotomous specimen pipped the egg but was unable to emerge and drowned in the egg. Lastly, in 2013 Steven Ray of “From Cute to Creepy”, Swords Creek, Virginia captive bred a 150 mm prodichotomous dicephalic from a pair of captive bred heterozygous albino parents.

The most common type of axial bifurcation is prodichotomy, which is the complete separation and development of two heads (SMITH & PÉREZ-HIGAREDA, 1987). Prodichotomy occurs in 62% of the present sample. If the two heads are not entirely separated, a condition known as craniodichotomy, the resulting snake normally has two snouts and may have either three or four eyes, depending upon the separation of the heads. This condition occurs in 28% of the current sample. The other 10% of axial abnormalities include proarchodichotomy (two heads with extremely long necks), amphidichotomy (two heads and two tails), opisthodichotomy (one head with two bodies and two tails), and urodichotomy (two tails). Occasionally one of the two heads may be incompletely developed: it may be smaller than the other head, have abnormal ossification of bones, or lack internal soft tissues. This is called a parasitic head and it is usually non-functional.
Initial external observation suggests that the present specimen has two heads, the left one incomplete or parasitic, and that each head has a bifurcated snout.

MATERIALS AND METHODS

This report deals with the fifth known captive bred specimen of *Boaedon capensis*, the brown house snake of South Africa. It was bred by Scott Powley of "Powley Exotic Reptiles", Laguna Niguel, California. The specimen was subsequently donated to the first author by Christopher Marley of "Pheromone Design", Salem, Oregon, who preserved it on alcohol.
Digital radiographs were taken with a Thermo Kevex X-ray machine (model PXS10) using a PaxScan 4030R system with ViVA software.

RESULTS

Catalogued as VWABC 20 (Figs. 1–3) in the axial bifurcation collection of the first author, is a 123 mm specimen (SVL 103 mm, tail 20 mm) with relative tail length 16.2%, 25 midbody and 19 precloacal scale rows, 168 ventrals, 61 subcaudals, entire cloacal shield, 8 supralabials with 4th and 5th in the orbit, 1 preocular, 2 postoculars, and 1 + 2 temporals. The dorsal coloration consists of orange stripes formed by linear rows of small spots over a pale yellow background, ventrolateral scale rows mostly devoid of pigment and silvery-white, venter uniformly light silver. The head exhibits a broad white chevron, bordered above and below in orange, extending from the snout through the eyes and across the temporal region onto the side of the neck, supralabials are light.

The classification of VWABC 20 is problematic. It appears to be craniodichotomous with a well-developed right head (Figs. 4–5), and an apparent incompletely developed ectopic left head with supralabials and infralabials (Fig. 6). However, the right head has subsequently bifurcated into a craniodichotomous condition (see fig. 8), the left one did not although it has two knobs, each one showing infra- and supralabials. Consequently, one cannot use the term quadritomy and therefore we use the more appropriate pseudoquadritomy. Such a condition has not been observed, to our knowledge, not only in any snake, but also among any vertebrates. Quadrifurcation is known to occur in soft tissues such as blood vessels (aorta; coronary, carotid, renal, celiac and internal iliac arteries; portal veins) and the trachea but has not been reported in osseous tissue.

Fig 1. Photograph of ventral view of body.

Photo: Christopher Marley.

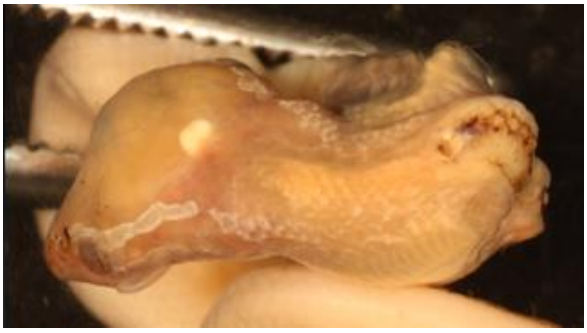

Fig 2. Photograph of anterior view of both craniodichotomous head and pseudohead.

Photo: Joe Martinez.

Fig 3. Photograph of ventral view of both craniodichotomous head and pseudohead.

Photo: Joe Martinez.

Even though the scalation of the developing knobs on the left externally resembles the labials of two developing ectopic heads, radiographs reveal, however, that the apparent left ectopic head is actually a pseudohead formed from an extreme-shaped kinking of the spinal column. A search for cranial

Fig 4. Photograph of left craniodichotomous head.

Photo: Joe Martinez.

Fig 5. Photograph of right craniodichotomous head.

Photo: Joe Martinez.

Fig 6. Photograph of anterior view of pseudohead.

Photo: Joe Martinez.

musculature or brain tissue in that region to demonstrate an incipient head development via CT Scan, was inconclusive.

DISCUSSION

As previously pointed out (WALLACH, 2007) there are numerous probable causes of mutations that lead to axial bifurcation in snakes. However, the most common cause (at least in captive bred specimens) appears to be the resulting loss of genetic fitness due to inbreeding depression. Captive breeders routinely mate snakes to their siblings and parents (and occasionally to other species) in order to produce desired or anticipated colors and patterns. This inbreeding, crossbreeding, and back-breeding has resulted in a dramatic increase, nearly 12 times, in the mutation rate of captive born progeny (1/60–1/25,000, $\bar{x}$ = 1/3,530, n = 43) when compared with wild population estimates (1/1,500–1/116,667, $\bar{x}$ = 1/41,330, n = 22).

Segmentation of the axial skeleton from the somatic mesoderm occurs prior to any ossification. There are probably multiple processes occurring here. The primary heads on the right appear to be classic dicephalism but the posterior snouts then are ectodermal only. So

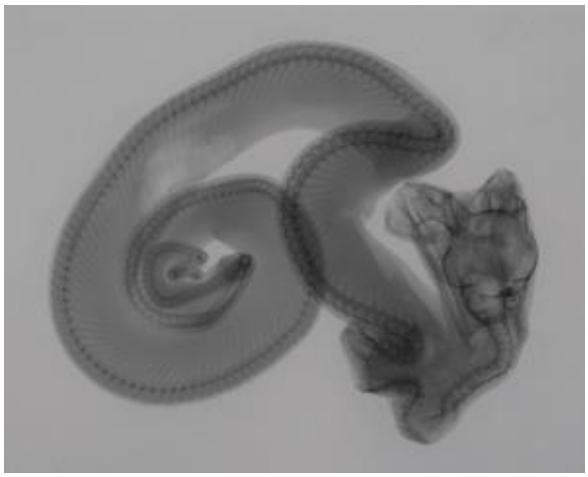

Fig 7. Radiograph of ventral surface.

Photo: Joe Martinez.

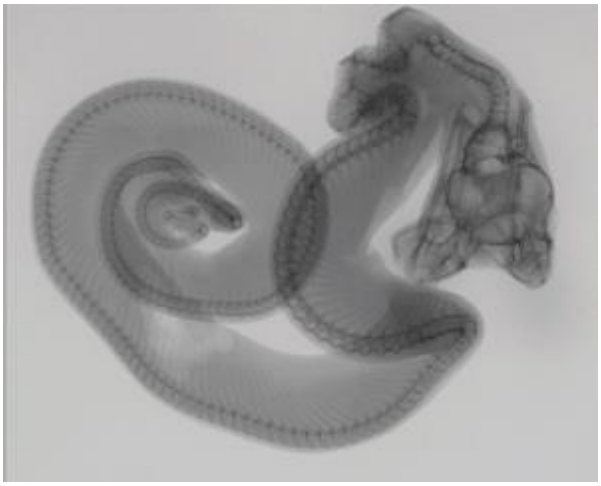

Fig 8. Radiograph of dorsal surface.

Photo: Joe Martinez.

there must have been a second zone of ectopic head induction that occurred.
Considering the usual embryonic pathway in forming the oral region, where entodermal tissue touching the ectoderm (membrana buccopharhyngea) starts the development of the (entodermal) mouth and the (ectodermal) lips and labials – one could hypothesize that the ´pseudohead´ resulted from a process gone awry in a region where normally no mouth is formed (the region of the later oesophagus) as a consequence of a kinked neural tube and inductional effects from underlying entodermal tissue on the ectoderm, analogous to embryonic developmental patterns.

ACKNOWLEDGMENTS

For the procurement of this unusual specimen we thank the breeder Scott Powley and the donor Chris Marley. For assistance with the radiographs and photographs We thank Jose Rosado and Joe Martinez. Zachary Lewis and Elizabeth Sefton performed a CT Scan of the specimen.

SUMMARY

We report on the fifth known case of somatodichotomy in *Boaedon capensis.* However, this most unusual captive bred specimen is a superficially double dichotomous individual and therefore represents the first record of axial pseudoquadritomy in Vertebrata. The apparent left ectopic head is actually a pseudohead formed from an extreme-shaped kinking of the spinal column.

SAMENVATTING

Het vijfde bekend geworden geval van somatodichotomie bij *Boaedon capensis* wordt gemeld. Dit nakweekdier is echter een bijzonder geval want in elke kop blijkt (eenmaal bij de echte kop) dan wel lijkt (bij de pseudokop), nóg een splitsing zichtbaar. De pseudokop blijkt evenwel een complexe dubbele kronkel van de wervelkolom te zijn; in de andere kop zijn twee schedelvormingen zichtbaar.

Fig 9. Adult of a normally developed *Boaedon capensis*. Photos: Courtney Hundermark

LITERATURE

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