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POD@RCIS

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SCHNEIDER, B., 1981. *Algyroides fitzingeri* (Wiegmann, 1834) — Tyrrhenische Kieleidechse. In: BÖHME, W. (ed.). Handbuch der Reptilien und Amphibien Europas. Band 1. Echsen I: 392-401. Akademische Verlagsgesellschaft, Wiesbaden.

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Preface

WE'RE BACK

...after a long and unintended absence of several years, therefore a short explanation.

As an editorial group, most of us started with the Dutch terrarium periodical ´Lacerta´ after having been asked to help rejuvenate that journal. Our motivation was to provide amateurs and professionals alike with reliable information concerning husbandry of reptiles and amphibians. Over the years we encouraged a shift in submissions from anecdotal to more scientific material. Since most of us had biological training at university level, it was only natural that we encouraged a more professional attitude in terrarium keeping. At the same time, we intended to keep the papers accessible to the layperson. To further substantiate our ambition internationally, we founded the herpetological e-zine Pod@rcis in 2000. The emphasis is on reproduction in terraria, terrarium keeping techniques, and field observations. We also publish book reviews, travel accounts, news briefs and lighter material.
At the start Pod@rcis was the first webzine devoted to amphibian and reptile husbandry. During the first five years the webzine appeared in a bi-lingual format: Dutch and English. We aim for a world-wide audience, with reader and contributor in the unique position of no longer being restricted by political or linguistic barriers. From volume 6 onwards, the publication switched to English only, but certainly still offers the option of summaries in other languages. Rarely writers may present the text additionally in other modern languages.
Manuscripts are edited in consultation with the author(s), often with the help of external expertise. The language, flow and grammar are checked by native speakers. This ensures that our readers and authors alike receive verified information.

And then life intervened: as most of us were, and are, in more or less the same age group, we encountered similar problems – e.g., job changes, health issues and the care of (elderly) relatives. The choice between loved ones and the webzine was unavoidable but time has passed and now we are back with unbridled enthusiasm. Nevertheless, we still experience an unfortunate lack of younger enthusiasts. If you are interested in helping to address this uneven age distribution in our technical or editorial board, or as an author, please do contact us.
To avoid confusion in the numbering sequence, this volume (and the later ones) will be named Pod@rcis n.s. [new series] 10, logically following the previous volume 9 from several years ago. When applicable, each year will continue to be separated into issues 1, 2, 3…
We do not charge for the webzine. However, a small monetary contribution from any of our readers or authors would be highly appreciated to help cover the costs of running the webzine.

Back in 2000 we deposited the webzine in PDF format in various major libraries throughout the world. A recent search indicated that in some of these libraries, we seem to have disappeared. Any assistance from our readers and authors to help in depositing the journal in your institutional library, where it can be freely available to all at no costs, would be very much appreciated.

To conclude, we intend to propagate fine and thorough papers and aim to function as an appropriate medium for everyone who wishes to share fascinating information on herpetology and terrarium keeping. Do get in touch!

Herman in den Bosch
editor@podarcis.nl

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Photo: John Boonman

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.

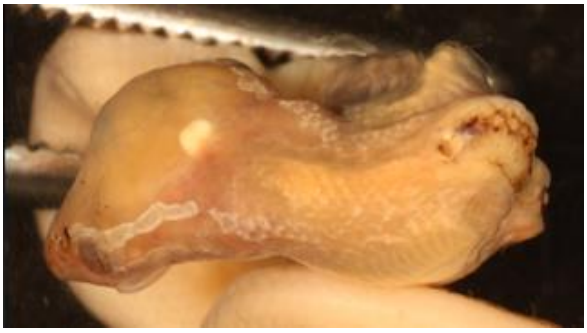

Fig 2. Photograph of anterior view of both craniodichotomous head and pseudohead.

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

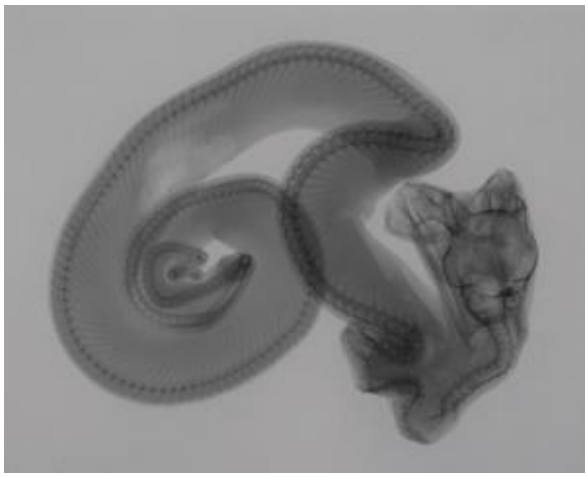

Fig 7. Radiograph of ventral surface.

Photo: Joe Martinez.

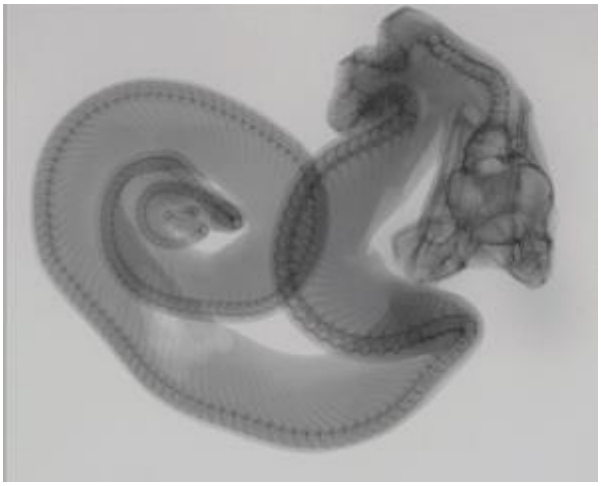

Fig 8. Radiograph of dorsal surface.

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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Forty years of Box Turtle husbandry

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All photographs by the author

INTRODUCTION

Retiring from work is the obvious moment to make all kinds of plans for the future. At the same time, it can also be the occasion to reconsider pieces of the past. Reaching that turning point in my life I came to the idea of describing my forty years of experience keeping Box Turtles**,** especially animals that have been in my possession for a considerable period of time, some for their entire life span to date. This paper is a description of my experiences with species of the genus *Terrapene* rather than a manual or prescription on how to keep these animals. As this is my personal experience, certain aspects are dealt with in a fashion that is no longer acceptable but was considered normal in the seventies. Call it a progressing insight.

THE NORTH AMERICAN BOX TURTLES OF THE GENUS *TERRAPENE*

Remarkably enough**,** in the literature an almost complete consensus prevails as to the systematics of the North American species, *Terrapene*. Our usual trusted bibles (like PRITCHARD, 1979 and ERNST & BARBOUR, 1989), as well as more recent sources, (like ZUPPA, 2003) mention two species for the US: *Terrapene carolina* and *T. ornata*, both with a number of subspecies, occasionally called races. The distribution area of two other species (*T. coahuila* and *T. nelsoni*) is restricted to some parts of Mexico. Restricting ourselves to the subjects of this paper, *T. carolina,* six subspecies are usually accepted: *T. carolina carolina, T. c. major, T. c. bauri, T. c. triunguis, T. c. mexicana* and *T. c. yucatana.* In vivarium practice, as will be shown in this article, it is often difficult to attach a subspecies name to an individual animal on the basis of external criteria. In recent years it became clear that modern genetics do not elevate the complexity to subspecies level in all cases (see e.g., MARTIN et al., 2013 as well as the response of FRITZ & HAVAŠ, 2014). In light of the large distribution area of the species and its subspecies (see below) regional variations are to be expected. On top of that numerous hybrid forms are reported (cf. LUTTERSCHMIDT et al., 2007). Taken all together it is remarkable that systematics is hardly disputed in the literature, or perhaps we simply don't know enough?
The genus is easily recognized by a) their relatively domed shells and well-developed plastral hinges, which enable the animals to close themselves off completely from the outside world, b) their terrestrial habitat, and c) that their feet are neither webbed nor elephantine. Males are easily distinguished by their plastral concavity. They often have bright red eyes and are usually slightly larger than females.

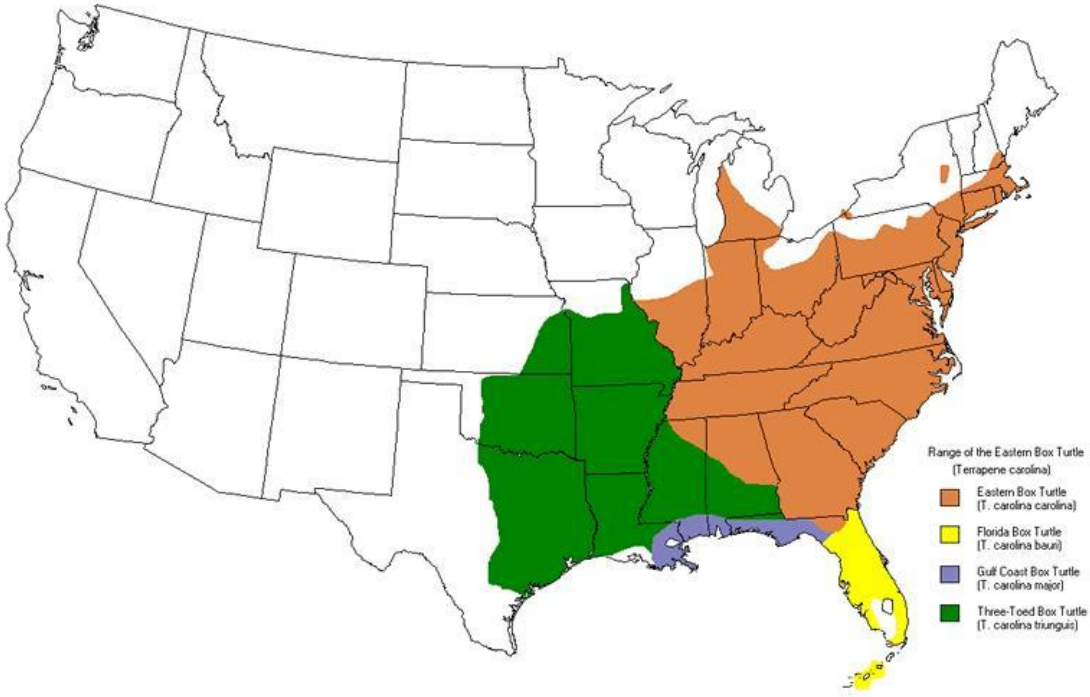
THE SUBSPECIES ACCORDING TO THE HANDBOOKS

Terrapene carolina carolina

The nominate form, the Eastern Box Turtle, is found in the US states from Massachusetts to Illinois and Georgia (see map in figure 1). The species inhabits pastures, marshy meadows as well as open woodlands and shores of rivers and lakes. Adult animals have high-domed brown or black carapaces with a variable pattern of yellowish stripes and blotches. Maximal carapace length is ca. 16 cm. The hind legs contain four toes.

Terrapene carolina major

The Gulf Coast Box Turtle inhabits the humid areas at the coasts of western Florida and South Carolina. The purest form lives in Florida. Animals in Louisiana are often



Distribution of *Terrapene carolina* in the USA. Online: https://wikispaces.psu.edu/display/Herps/Eastern++Box+turtle (last seen: 26-02-2019)

hybrids with any of the other subspecies. These are the largest *T. carolina* subspecies reaching 20 cm in length. Apart from its length, the strongly flaring rear margins are characteristic for the subspecies. Colours are not really discriminative although white head markings occur frequently in adult males as do red colours on the front legs.

Terrapene carolina bauri

The Florida Box Turtle, as the name already indicates, is predominantly found in Florida. This subspecies lives in humid areas as well. The dark carapace has a bright pattern of light radiating lines resembling *Terrapene ornata*. However, the carapace of *T. c. bauri* is much higher domed and its head is more clearly marked. In addition, *T. ornata* has a dark marking on the plastron often covering it completely. The plastron of *T. c. bauri* is usually uniformly yellow. The Florida Box Turtle reaches 15 cm maximally and the hind legs have three toes.

Terrapene carolina triunguis

The Three-toed Box Turtle is found from the valley of the Mississippi river to Texas and up to Florida in the South. This subspecies prefers clearly drier areas compared to the others. It grows to a maximum length of 16 cm and shows light markings on a tan to brown background. Males often develop red, orange or yellow markings on the head and front legs. In order to enhance confusion Three-toed Box Turtles sometimes have four-toed hind legs. Together with *T. c. bauri* it is statistically the smallest Box Turtle.

The two other subspecies *T. c. mexicana* and *T. c. yucatana* live in Mexico, in the north-eastern part of the country and Yucatan respectively. The former form has three-toed hind legs, the latter has four toes. Both are often light brown to yellow in colour with the size comparable to *T. c. carolina,* but much bigger animals, resembling *T. c. major,* can occur.

The complete species listing can be found on the IUCN Red List. All are classified as “vulnerable” (IUCN Red list, 2011) on the CITES appendix II.

THE ANIMALS

The four animals featuring in this story are still in my possession. Over the years several other specimens were kept, but for various reasons they disappeared. Some of them are also briefly mentioned here. *Terrapene carolina* experienced a pulse surge of exploitation for the international pet trade in the late 1980s and early 1990s, when the species was in demand after mass Mediterranean tortoise trade was curtailed by CITES; the genus *Terrapene* was itself included in CITES in 1994 after which exports ceased. The animals discussed here are from the "license free" period and are almost certain wild caught.

Animal 1

In May 1975 I bought a couple of Box Turtles from an, at that time, well-known pet shop. Without any doubt they were a male and a female. The female passed away after a couple of years from an infection of the respiratory tract, most probably caused by inadequate housing (draught). The male survived and is presently in perfect condition. In 1975 his carapace was 14 cm long and he weighed 640 grams. As the animal was already at least a couple of years old at the time I bought him, after almost 44 years the creature may easily be 50 years old. This is not an exceptional age for Box Turtles. Reports mention ages of more than 100 years (BELZER, 2013), but accurate recordings are mostly missing. Ages of more than 60 years are certainly not exceptional (MILLER, 2001). This specimen is a uniformly tan-coloured animal with hardly any markings, neither on the carapace nor on head and legs. The hind legs have four toes. It looks like the nominate form, *T. c. carolina*, albeit a fairly big one, measuring almost 18 cm over many years and weighing between 750 and 800 grams.

Animal 2

In August 1988 I received three small Box Turtles in very poor condition measuring about 7 cm in length. Despite serious attempts to cure the animals, two of them died. The third one is still alive and is therefore more than 30 years old. It is a female, 12.5 cm in carapace length, weighs 450 grams, is brown in colour with some

Head of male *T. c. carolina* (animal 1).

Male *T. c. major.*

yellow and orange blotches on the head and neck. With three toes on the hind legs, it is likely to be a Three-toed Box Turtle (*T. c. triunguis*).

Animal 3 and 4

In June 1990 I bought two magnificent big Box Turtles, in another pet shop, a male and a female. At that time they were already huge, weighing close to 900 grams and measuring more than 17 cm in length. In the course of time they did not grow substantially (latest measurement: 17.1 cm for the female and 18.2 cm for the male). That means that the animals are at least 35 years old, probably more. The male is dark brown in colour with some vague stripings and intense red eyes. The female is beautifully coloured**:** brown with multiple yellow markings and blotches. Since they have strongly flaring rear margins it is likely to classify them as *T. c. major.* On top of that the male is developing white streaks on its head in recent years. The hind legs have four toes.

HOUSING

In the early years my Box Turtles were floor dwelling companions to large lizards like Iguanas. Although fairly spacious**,** these types of vivaria with animals having very distinct requirements (and intestinal microflora) are not recommended. The *T. c. carolina* male (animal 1) survived these sometimes harsh conditions, with draught and fluctuating temperatures. Since 1995 housing is as it is today: the animals spend the summer in the garden and live indoors during the winter. The four animals obviously feel good under these conditions**,** not having had any significant health problems so far. The approx. 3 m^2 outdoor enclosure is situated in a fairly sheltered back yard. An area of 3 m^2 is much less than what is available in nature. STICKEL (1989) reported a 3-acres (1.2 ha) home range for *T. c. carolina* in Maryland in the period from 1944 to 1981. The north-west side is protected by a wooden fence, the other three sides are made of break-proof glass shields from scrapped railway coaches. This orientation ensures that the rising sun enters the enclosure rather early. Because of the surrounding houses, enough sunlight reaches the vivarium to warm the animals sufficiently only in the period from the beginning of May through to the end of September. The precise moment of moving the animals to or from the outdoor housing is determined by the weather and therefore changes from year to year. The chance of frost is the determining factor in spring. Lack of sunshine and increasing humidity are the key factors in autumn.

Apart from some macho behaviour between the two males (see below)**,** this limited area never caused serious problems**;** no real confrontations nor any neurotic behaviour alongside the glass fences. The enclosure is maximally overgrown with wild plants, mostly carried by wind supplemented with seeded sown ones. Four active tortoises crush the vegetation but cooler days often limit activity

The small female *T. c. triunguis* in her outdoor enclosure.

and give plants time to recover. Additional seeding often is the final touch. Logs and stones create elevated areas for warming up. A large tunnel-like area made of stones covers the complete width of the enclosure. It shelters the animals for cold and wind but also for heat. The top of that construction appears a highly appreciated place to get warm. Finally, a shallow bowl is available containing clean water.

In winter the animals are housed in open plastic containers (50x70 cm, ground area) containing a thick layer of sawdust, hay and straw. Years of experimenting have indicated that these animals immediately switch to hibernation/aestivation mode as soon they are indoors. They don't show up for months and they don't drink or eat. Apparently, the containers are large enough. The animals are housed two by two, the two *T. c. major*-type animals together. Fresh water is constantly available. Temperature never drops below 10°C but usually is somewhat higher, which has never caused any substantial activity. The animals' behaviour will be discussed below.

FOOD

Box Turtles are said to be omnivorous. In a strict sense my animals are indeed. However, that does not mean that every individual takes any food item all the time. The animals change food preference continuously and do so independently of each other. Amateurs tend to search for regularity in the pattern. After all these years I have not succeeded, and, in fact, I gave up looking. As a consequence, I try to include as much variation to their menu as possible. All animals turn out to be easy consumers although they don't eat everything all the time.

The menu consists of:
Snails. Until recently only the Common garden snail (*Cornu aspersum*), the large brown ones, sometimes called the small vine snail, was on the menu. When eaten, it is with such an enthusiasm that it almost became extinct from my 80 m^2 back yard. In an earlier version of this paper, I stated that Grove snails (*Cepaea* spec.), the yellow or rose

T. c. carolina consuming an earthworm.

T. c. triunguis eating a strawberry.

variants alike, were not eaten. However, recently animal 1 (*T. c. carolina*) did consume a couple of those creatures. You never know with Box Turtles. The shells are cracked and the content is eaten. I have never seen a slug being eaten. However, it might be possible that this happens while they are out of my sight.

Earthworms. Although this food item is something you always can rely on, it looks like the animals easily lose their skills to catch them especially after hibernation. However, after stimulation by roommates (seeing is doing), ultimately the worms (especially the wriggly ones) will be eaten by every individual.

Mealworms. Not exactly their favourite food but sometimes useful.

Meat. I used to serve chopped beef heart once in a while. Interest was always rather limited. The real fall-back option nowadays is canned cat or dog food. Notably the “paté” types are available in multiple tastes and blends. In principal I prefer complete organisms to feed, nevertheless it is always comfortable to have some alternatives available.

Fruit. Another fall-back option is bananas. It is often eaten by all animals albeit in limited quantities. Occasionally some animals are attracted to other fruits too, preferably the ruddy coloured ones. Strawberries, tomatoes but also plums, apricots or peaches are the choices. Apples or pears are not eaten. I have never seen any animal eating any vegetable or wild plant from the enclosure.

In line with my observations in nature, Box Turtles are omnivorous and highly opportunistic in their feeding behaviour (FARRELL et al., 2006). There is no evidence of major shifts between the diets of juveniles and adults. The list of foods that Box Turtles have been observed taking is vast, but includes vertebrates and invertebrates (especially snails), fungi, and a variety of plant parts, including fruits, roots, stems, and seeds. Carrion is also be taken on occasion.

BEHAVIOUR

In the summer season, when the animals are outdoors, life seems quite simple. Being lovers of the morning coolness, they are active early, especially in the fresh dew. Remarkably some 12˚C is enough to stimulate activity even for the two major animals who most likely are not used to such temperatures in the southern states of the US. Eating is not on the agenda yet, only simple strolling around. Bathing is often part of the routine. When temperature rises, activity increases. Some sunshine is appreciated at that time although it can easily become too hot for them, the animals quickly disappear in their shelters then or burrow underneath the humid grass. On warm summer nights, when the sun has left the enclosure, they reappear, certainly when a nice shower comes down. The animals prefer eating in the morning.

Weathered head of male *T. c. major.*

On a standard grey Dutch summer day activity will be much lower and is often limited to some looking around. When it is autumn-like weather the animals are often out of sight for a substantial period of time. Eating is not obvious under these conditions. Feeding frequency is limited to twice a week in order to prevent them from becoming overweight. Water is often supplied, especially during hot dry seasons. If it will become too dry animals will dig deep (occasionally up to 30 cm) holes, and disappear.

The four animals usually behave fairly decently. However, animal 1, the large *T. c. carolina* male, can be rather pushy or even aggressive. Notably directly after hibernation the old male can be a real testosterone bomb. His activity is usually directed towards the *T. c. major* female. One might worry about that but I refrain from interfering because the female does not care at all. She moves, eats, baths whenever she likes, no matter if someone is sitting on her back or not. The male snorts and sighs without any violence whatsoever. The male *T. c. major* can be treated more aggressively. In some periods biting and bumping can be slightly too emphatic. Intervention might then be necessary. Peace will usually return soon. In all the years no serious accident has occurred. In practice the impressing attitude of the animal is the most annoying. When he approaches, like a bulldozer, to the food offered, the other animals have to withdraw. The message here – keeper, take care that every individual gets his part of the cake.

The mating activity of the *T. c. carolina* male with the *T. c. major* female never resulted in eggs. Only the small three-toed animal (*T. c. triunguis*) produced eggs twice. That will be discussed in the next chapter.

Then summer comes to an end and the amount of sunshine and heat that reaches the enclosure decreases. Their active season is over, especially when nights are getting cold, usually at the end of September/beginning of October. The animals tend to dig in, often at a considerable depth (some 30 cm). I never dared to leave them outside. The literature indicates that Box Turtles are well able to cope with such conditions (see for instance CONGDON et al. 1989). However, in my opinion the winters in the Netherlands are much too precarious, with strongly fluctuating temperatures. On top of that the period of changeable weather in the Netherlands is much longer than that as described for South Carolina (October - April vs November - March).

Animals then go into hibernation, or at least winter rest, indoors. After a cool bath for cleaning and defecation, they are put in their plastic open container, two by two as described earlier. It is very remarkable that they will dig in immediately, even when the temperature is not very low (some 18˚C). Within a few moments they are out of sight, not to reappear before March. The *T. c. major*

male never digs in. He simply sits on top of the substrate for months, hardly moving. Occasionally he will drink some water but never eats. The water bowls will stay clean over the whole period so there would be evidence if any animal was secretly moving.

In the literature (e.g., PLUMMER, 2004) hibernation, including their hibernacula, for Box Turtles is extensively reviewed. Immediate stimulus to enter hibernation is likely a combination of temperature and photoperiod. Burrows may be rather deep (30 cm or more) or very superficial, depending on the temperatures of the area. Separate factors may be responsible for arousal from hibernation, including warming of the soil temperature profile, precipitation, and ground moisture. The complexity of winter rest stimuli is demonstrated by *Terrapene ornata* inhabiting drier areas. Animals are able to cope with the difficult conditions in their habitat by combining a five-month hibernation with a three-month aestivation period. Only after the monsoon do they emerge from their shelters, although they have ended their hibernation some months earlier. An inactive subterranean period of eight months is the result. Box Turtles are said to be highly successful in dealing with long lasting harsh conditions of various kinds. The reported low metabolic rates of Box Turtles allow them to rely on resource peaks for their energy, allowing them to "coast" through periods of less productive forage using stored energy. Box Turtles live at a slower pace than some other ectotherms and as such have evolved a strategy allowing them to survive in an uncertain resource environment by minimizing costs and risks (PENICK et al., 2002).

The beautifully coloured female *T. c. major.*

In early spring activity suddenly commences. Changing length of daylight seems not to be a significant factor as their artificial light (LED-light nowadays) is on for 12 hours per day every day. The temperature is, within certain limits**,** also constant so it is not clear what triggers the activation. Looking at the complexity of arousal from hibernation as described before, a combination of factors is likely to be relevant. Usually it starts at some moment in March, first there is some movement, quickly followed by bathing and drinking. A (limited) interest in food comes later. Banana and cat food are the first preference, followed by earthworms. The female *T. c. major* is always the last. Usually it is too early to transfer the animals to their outdoor housing because of the weather outside and some period has to be tided over.



Three-toad Box Turtle (*T. c. triunguis)* laying eggs.

The plastic boxes are too small to give the animals sufficient room to move, but because of the limited period of time they spend in them, it is acceptable to complete the seasonal cycle.

BREEDING

In my opinion husbandry should be aimed at breeding the animals. However, the way I keep the Box Turtles does not allow successful breeding. The group is too diverse and is living in too limited an area. Probably I would have had to split the group and provide them with separate and larger accommodations. The two *Terrapene carolina major* might be a suitable couple but they are disturbed too much by the large *T. c. carolina* male. The latter frequently courted the female *T. c. major*, but this never resulted in eggs. Mating with the small three-toed female (*T. c. triunguis*) was never observed. Because of the substantial difference in size between the animals it would be rather complicated. Nevertheless, this small female produced eggs twice, in two early consecutive years. Each time four eggs were laid and burrowed according to the handbooks. Red discs indicated that the eggs were fertilized but standard incubation methods (in incubators in humid environments at various temperatures with vermiculite as a substrate or in a bain-marie container) did not result in hatchlings. It might be possible that an earlier mating had taken place, probably with one of the other animals with which she lived together for some period of time before she came into my possession. It is known that female Box Turtles have special organs that store sperm for up to four years (GIST & FISCHER, 1993).

FINALLY

With my knowledge of today**,** I would keep Box Turtles in a completely different way than I did before, and even than I do currently. I would give them more space and pay much more attention to the formation of suitable groups or couples. In any case I would never use them as scavengers for leftovers of other animals living in the same enclosure. Longer periods of outdoor housing looks possible in the Netherlands. Prolonged hibernation or winter rest turns out to not be detrimental for at least the four animals discussed here, even when different subspecies are concerned.
In any case Box Turtles turned out to be animals that can easily survive in Dutch outdoor conditions during the warmer seasons. However**,** it is essential to pay attention to the individual requirements of the animals. These needs can change without any obvious reason. Satisfactory husbandry for over 40 years is then possible.

SAMENVATTING

In dit artikel schets ik mijn ervaringen van meer dan 40 jaar met het houden van Amerikaanse Doosschildpadden van het geslacht *Terrapene*. De drie ondersoorten die ik beschrijf, blijken geschikt te zijn om gedurende de Nederlandse zomerperiode in een buitenverblijf gehouden te worden. Ook maandenlange periodes van winterrust zijn steeds zonder problemen verlopen. De zeer individuele en in verloop van tijd variërende wensen van de verschillende dieren, evenals hun gedrag, worden besproken. Een vergelijking met literatuurgegevens wordt ook gemaakt. Om tot succesvolle voortplanting te kunnen komen, moet extra aandacht besteed worden aan de vorming van geschikte paren en moet men afzien van storende invloeden van andere dieren.

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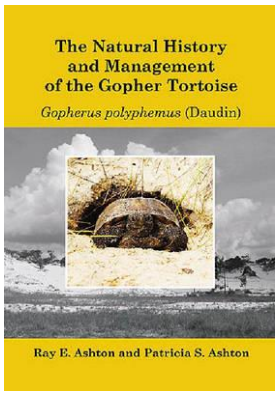
Most recent observations

On February 5, 2019, during my daily observation, I noticed that all four animals came out of hibernation simultaneously. The couple of *T. c. major* in their separate enclosure immediately started mating activities (see photo). These observations are remarkable because arousal from hibernation was earlier than in any other previous year, although conditions have not changed over the years. Most likely the complex set of conditions that promote arousal from hibernation happened to be good enough at this moment.

The female *T. c. major* usually emerged later than the other animals.

I never observed any mating activity between the two *T. c. major* animals before. Because the disturbing influence of the male *T. c. carolina* was absent (the animal is in a separate enclosure), the couple was apparently able to behave more naturally.

Book review



ASHTON, R.E. & P.S. ASHTON, 2008. The natural history and management of the Gopher Tortoise - *Gopherus polyphemus* (Daudin)
288 pages, 109 b/w photos, 1 distribution map, 13 figures, 45 tables, bound
ISBN: 1-57524-162-5
Price: $66.50

Discussing a book written by authors you know, is not easy. During several visits to the USA between 2001 and 2008 I had the privilege of meeting Ray and Pat Ashton. The first time I met them at a meeting on relocation and translocation of tortoises held at the Ashton Biodiversity Research & Preservation Institute in Florida. I found them to be dedicated and motivated tortoise specialists with a passion for Gopher tortoises. I have followed their numerous publications on Gopher tortoises, and I consider them to be Mr. and Mrs. Gopher tortoise.

A background of many years of Gopher tortoise conservation does not automatically mean that writing a book on the species is a "piece of cake". Apart from the authors, the editor, publisher, and printer play a role in the process between writing and publishing. Not being a Gopher tortoise specialist myself, although well acquainted with turtles in general during my now 31 years in the Rotterdam zoo, examining a book on this particular species is complicated. Questions arise such as "is all this information true, are all fourteen pages of cited references relevant and were they actually used?" After reading this book, and to be honest this took me a few weeks, I became a bit confused. This book is based on many years of experience, practical as well as theoretical, but in particular it shows the couple's passion and devotion to the species. The book contains in-depth detailed instructions of how to succeed in the field with respect to searching, excavating burrows and handling the tortoises. The volume also provides very detailed information on the species' natural history and biology, habitat, nutrition, and reproduction. Furthermore, land management and conservation of the species is discussed and advice is given to land owners, researchers, law enforcement officers and state authorities on improvement to these topics.

This book occasionally gives the impression that it is written for dummies because of the amount of detail included for many of the issues discussed. As well, on a number of topics an overload of irrelevant information is given. A few examples: "courtship and mating was caught on videotape by one author and photographed by the other author, p. 22"; "the videotape ran out and part of the courtship was not recorded or seen because another tape had to be obtained, p.22"; "time periods of bobbing behaviour was measured by using a wrist watch, p. 23"; "plan your location carefully. Have a place close by, near restaurants, and where you can renew fuel, ice and drinks, p. 177". There are many such examples found in the book, and it looks as if the authors intended to write an extremely detailed protocol for all sorts of workers on how to carry out field research in relation to protection and conservation of the Gopher Tortoise. But again, this certainly illustrates the immense experience, extensive knowledge, motivation and passion of the authors.

With respect to the contents and text, I encountered quite a large number of mistakes, outdated information and errors. On page 8 the old names *Geochelone elephantopus* (currently *G. nigra*) and *Geochelone gigantea* (currently *G. dussumieri*) are used. On page 21 the information on courtship

gathered by the authors is not in table 1.6 where such data are summarized. On page 24 nest temperatures of 27-31°C are mentioned without referring to the phenomenon of temperature dependent sex determination during incubation, which is extremely important to know when resorting to artificial hatching – resulting in males at low and females at high temperatures. On pages 26-28, a large number of predators are listed in the text as well as in table 1.7; a bit of overkill in my opinion. Numerous photos, unfortunately all in black-and-white presumably for financial reasons, are included. Many photos are of a poor quality and lack focus thus not illustrating the associated text. On pages 38 and 45 the same photo is printed. On page 15 in photo 1.13 the egg tooth mentioned, can hardly be distinguished because the photo lacks focus. On page 19, photo 1.19, carapaces of dead tortoises are used to explain the gender distinction – why not use live specimens? On page 17 the text saying, "a more dome shaped carapace replaces the flattened carapace of the juvenile" refers to photo 1.16 in which this cannot be seen. In chapter 5 the numbering of tables and figures is swapped, thus both item types are incorrectly numbered. Quite a lot of text on specific topics is also included in tables on the same pages, causing information to be presented twice; in my view it would have been better to mention specific, limited information in the text and give a more extended overview in the tables.
The book includes 368 references. An appendix lists 1103 species (376 genera in 83 families) on which the Gopher Tortoise forages. The volume further contains 45 tables and 13 figures. The management techniques discussed in this book regarding a number of issues such as translocations of wild populations can certainly be used for other tortoise conservation projects elsewhere in the world. Captive breeding, however, is not discussed, so the reader will not find breeding recipes. Regarding behaviour, health and veterinary issues and nutrition in the wild much attention is paid.
For those readers interested in conservation of *Gopherus polyphemus* the text contains a huge number of recommendations, tips and information with respect to field research. The information overload sometimes makes it difficult to shift the relevant from the irrelevant. The large number of errors, textual duplication, typos, and flawed photos, take away from the readability of this book. For these aspects the authors are probably not to blame. With some extra attention to editing, photos and layout, this book certainly would have increased in value as a scientific resource.

The general conclusion: for those working with the species in the field or in captivity, or active in protection and conservation or planning to do so, this book is certainly a must-read. Through the in-depth discussion of a large number of issues a positive impression of the complexity of the status of the species in the wild, and the need for proper management and protection of the species and its habitat is gained. Until now I have not read a detailed book such as this on tortoise conservation in all its aspects.

Henk Zwartepoorte
Former Assistant Curator Reptiles and Amphibians Rotterdam Zoo

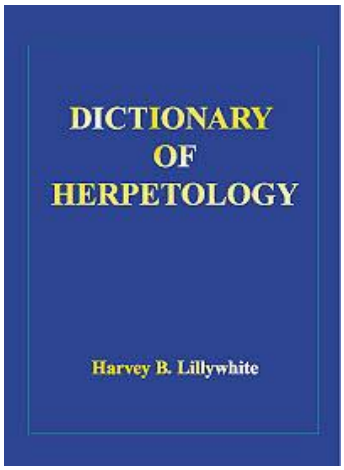
As this review was written a considerable time ago, nomenclatural changes occurring in the intervening years could not be taken into consideration by the author. To respect the integrity of the text, we publish the original phrasing.

In memory of Henk Zwartepoorte

In 2016, just after arriving in Australia for a herpetological trip, the author very unexpectedly died. Almost all of the Pod@rcis editors knew Henk, some of us for a considerable time, and several on occasion had the pleasure of co-authoring his papers. He was very open to all interested in herps, professionals and amateurs alike, and well-respected internationally for his extensive knowledge of especially the Testudines. We all miss him and extend our condolences to his partner Mary.

Herman in den Bosch, for the editorial team.

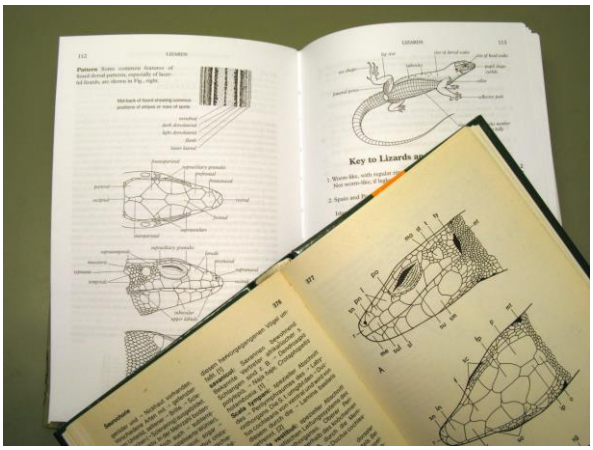
Book review



LILLYWHITE, H.B., 2008. Dictionary of herpetology. Krieger Publishing Company, Malabar (Fl), USA.
ISBN 1-57524-023-8
384 pages, 41 b&w figures, 3 tables
Price: €112.50

Any author's working day will not pass without consulting a lexicon in some form. A herpetologist's life is no exception and would include dictionaries like PETERS (1964), and the more recent book of KABISCH (1990) for those who understand German. The latter includes more illustrations than the former and a list of references, which is completely absent from PETERS (1964). The work being reviewed here falls somewhere between these two dictionaries as there are some references in-text, as well as Peters'-like outlined drawings. A simplistic comparison of the three dictionaries would be to count and compare the number of entries in each. Lillywhite certainly wins with over 11,000 entries, with the other two averaging 3,500 – although the reality is that what really matters is the kind of terms included. Peters is certainly the purest as it focuses primarily on herpetological terms, while Kabisch incorporates a fair number of (mainly European) genera and species names plus some terms useful to the vivarium keeper. To a lesser extent, KABISCH (1990) also integrates general morphological terminology. LILLYWHITE (2008) adds even more non-herpetological terminology related to anatomy, physiology, systematics, evolution, and other disciplines. Even our webzine is included with its URL (thank you!), although the journal's name should be spelled with an @.

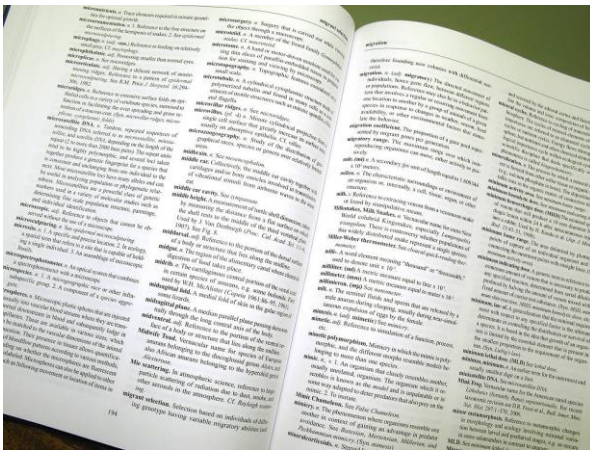
I could not resist testing the *Dictionary of herpetology* with some terms that have either confused me over the years, or that seem to have different meanings to different people. The terms I chose to use were pileus and gular fold. 'Pileus' in European, certainly in German, herpetology denotes the top of the head of especially the Squamata, commonly referring to its pholidosis, the constellation of the scales. According to Lillywhite, pileus is "A black, cap-like marking on top of the head". Although the head scalation in lizards is fairly similar to those in snakes, it would have been good to include drawings with explanatory terms as in, e.g. ARNOLD (2002: 112-113) or KABISCH (1990: 377) (see figure below), which would immediately



Examples of ARNOLD (2002) and KABISCH (1990) respectively.

clarify the placement of the occipital scale (which is not the interparietal in lizards), frontoparietal (which is not necessarily "Syn. Interparietal"), and supraciliary granules (absent in LILLYWHITE (2008) although his fig. 16 shows "superciliaries").
As I explained in an earlier paper (IN DEN BOSCH, 2005: 11) a 'gular fold' is not necessarily "a fold of skin running transversely

across the throat immediately anterior to the insertion of the forelegs"**,** the definition given by Lillywhite, because in Lacertidae that is where we find the collar. A gular fold in this family would automatically become syntopic with the collar. More logically, the 'gular fold' is the transverse fold found under the throat of many lacertids running more or less from ear opening to ear opening. KABISCH (1990) employed 'sulcus gularis'. Alternatively, the term 'jugular fold' could be used in this context.



LILLYWHITE (2008: 194-195).

The format of the present work is somewhat surprising as it not only is a fairly large tome (22x28.5 cm) and thus bulky on one's desk – PETERS (1964) and especially KABISCH (1990) were more pocket book-sized – but it exists solely as a book. The dictionaries that I use each day, range from modern languages to etymology, and are almost all available in electronic form, even the rarer etymological ones – some of which are over a century old. My herp ones, an ethological lexicon, and two classical dictionaries are all well-printed and within easy reach, but used much more sparingly, I reluctantly confess, only because they are not immediately under one's fingertips. Apart from economic motives (fear of illegal copying), it is incomprehensible that Krieger did not also publish the *Dictionary of herpetology* in digital format in this computer age.

Should one buy the book? I am undecided. For around $30 - $40 Peters' dictionary is readily available second-hand, as is Kabisch's for half that price. If you do not also have access to anatomical or medical lexicons, or do not want to clutter your desk, and money is not an object, you certainly should. If in future the publisher decides to include a CD or DVD, I would then recommend that we all order it immediately.

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