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First captive breeding of *Lacerta* (*Omanosaura*) *cyanura* ARNOLD, 1972, with comments on systematic implications posed by the reproductive pattern and the juvenile dress
(Squamata: Sauria: Lacertidae)

Gefangenschafts-Erstnachzucht von *Lacerta* (*Omanosaura*) *cyanura* ARNOLD, 1972, mit Bemerkungen zur Einbeziehung ihrer Fortpflanzungsstrategie und ihres Jugendkleides in systematische Überlegungen
(Squamata: Sauria: Lacertidae)

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KURZFASSUNG

Die seltene südostarabische *Lacerta cyanura* ARNOLD, 1972 wurde an zwei weiteren (zu den sieben bislang bekannten: GRUBER & al. 1993) Fundpunkten nachgewiesen, beide auf der Musandam-Halbinsel, Oman. 2 Männchen und 1 Weibchen werden in Gefangenschaft gehalten. Das Weibchen, nur mit einem der Männchen vergesellschaftet, produzierte bislang 6 Gelege von je 3 Eiern, in etwa 3-wöchigem Rhythmus. Dieses Fortpflanzungsmuster und das auffallende Jugendkleid werden, auch im Hinblick auf die systematische Stellung der Art, diskutiert.

ABSTRACT

The rare Southeast Arabian lizard *Lacerta cyanura* ARNOLD, 1972 has been found at two additional localities (seven being actually known: GRUBER & al. 1993), which are both situated on the Musandam Peninsula, Oman. Two males and one female are kept in captivity. The female, associated with only one of the males, so far produced 6 clutches of 3 eggs each in intervals of roughly 3 weeks. This reproductive pattern and the juvenile dress are discussed, also in respect to the systematic relationship of this species.

KEYWORDS

Reptilia, Sauria, Lacertidae, *Omanosaura*, *Lacerta cyanura*; habitat, captive breeding, reproductive strategy, systematics, distribution, ecology, new record; Oman

INTRODUCTION

The Oman Mountains which stretch from the Musandam Peninsula and Ruus al Jibal southeastward to Hajar ash Sharqi, including a small part of the United Arab Emirates (fig. 1), harbour two remarkable, endemic lacertid lizards: *Lacerta jayakari* BOULENGER, 1887 and the much smaller *L. cyanura* ARNOLD, 1972. Both are regarded as sister species (ARNOLD 1972; MAYER & BENYR 1994) and have been placed in a separate subgenus - *Omanosaura* - by LUTZ & al. (1986). This subgenus, however, was not erected "on the basis of typical joint, partly synapomorphic characters", as claimed by GRUBER & al. (1993), but on the genetic distance of *L. jayakari* from the rest of the collective genus *Lacerta* (LUTZ & al. 1986). The inclusion of *L. cyanura* in this "chemosystematically" defined taxon was made merely on morphological grounds, as was already done by ARNOLD (1972, 1973). *L. cyanura* was only recently studied biochemically (MAYER & BENYR 1994), and the relatively short immunological distance of 16.5 units between *L. jayakari* and *L. cyanura* corroborated their rather close relationship.

MATERIAL AND RESULTS

During several excursions of the senior author (R. L.) to the Oman Mts. in the United Arab Emirates (UAE) and to the Musandam Peninsula (Oman) special attention was paid to the blue-tailed Arabian *Lacerta*. While the big species *L. jayakari* proved to be rather widespread and common, capture or even the sighting of *L. cyanura* was always restricted to single individuals. Today, nine localities are known where *L. cyanura* is found (fig. 1), but it is likely that the disjunctions between the localities reflect lack of faunistic knowledge rather than a patchy distribution or real scarcity. Shortly after the discovery of two populations in the J. Akhdar region by GRUBER & al. (1993, see fig. 1) we here report on two hitherto unknown populations in the Musandam Peninsula of Oman. One is located 20 km north of Dibba on the road to Al Khasab, the other one more northwards, approx. 5 km behind the first checkpoint of the road to Al Khasab. These two localities bridge the distributional gap of 80 km of aerial distance between Al Khasab (Wadi Qidah, ARNOLD 1972) and the UAE locality Wadi Uyaynat (GRUBER & al. 1993).

It was difficult to approach the lizards in the field, because they spent most of their time on steep rocky slopes at least 3 m above the ground, never resting but continuously moving or foraging. The home ranges appeared to be very large, and the lizards did not seem sedentary in terms of constant hiding or basking places. It was hardly possible to observe one specimen twice in the same place, not even under nearly identical conditions such as time of day, weather, position of the sun, etc.

In May 1992 the senior author collected two robust adult males of about 60 mm snout-vent length and 150 mm tail length at Tayybha, UAE. They were placed in a terrarium equipped with elements of the natural habitat and did not behave aggressively towards each other. In April 1993 a female was collected 20 km north of Dibba, North Oman, out of a group of two females and a male sighted. This female was added to the two males which started to attack each other from that moment on. One of them repeatedly suffered injuries (skin ruptures) from flank bites by the superior male, and hence, was kept separately.

The remaining couple is kept in a terrarium (90 cm x 40 cm x 60 cm) containing a sand layer 10 cm deep, a big stone on which *Caralumma arabica* is growing, and several slabs of slate forming hollow crevices on the hind wall. The sand layer is covered with some smaller stones for climbing, an *Aloe* sp. and a small drinking cup are hidden in the soil. The soil is heated to about 30 °C day and night. During the day the temperature is increased for several hours up to 60 °C by means of an 80 W spotlight. The whole terrarium is illuminated by a fluorescent lamp for 12 hours per day. Approximately half of the soil is kept moist, when egg deposition is to be expected.

The lizards have lost their shyness, but are always very attentive and almost only seen when searching for food. After the spot light is being switched on, they sometimes leave their hiding-places, bask atop a stone just a few centimetres from the lamp and seem to be inattentive. However, if some insects are released in the terrarium, they seize them immediately. No individual ever tried to retrieve an insect which was already caught by another lizard.

The lizards are fed with small crickets (*Gryllus, Acheta*), various Saltatoria and *Tenebrio molitor* larvae and pupae. All food items are powdered with Korvimin ZVT R. Twice a week Tricrescovit R is added to the drinking water (2 ml per 1/4 l).

Apparently, the female always lays three eggs per clutch (table 1). In one case, only two eggs were found, but it is well possible that a third one was simply overlooked in the substratum because the clutch was deeply buried underneath a stone. Copulations were never observed. On the average the eggs measured 9 mm x 4 mm when laid and 15 mm x 9 mm immediately prior to hatching. The eggs were incubated artificially at a temperature of 28 °C. The size of the hatchlings was about 25 mm snout-vent length and 55 mm tail length.

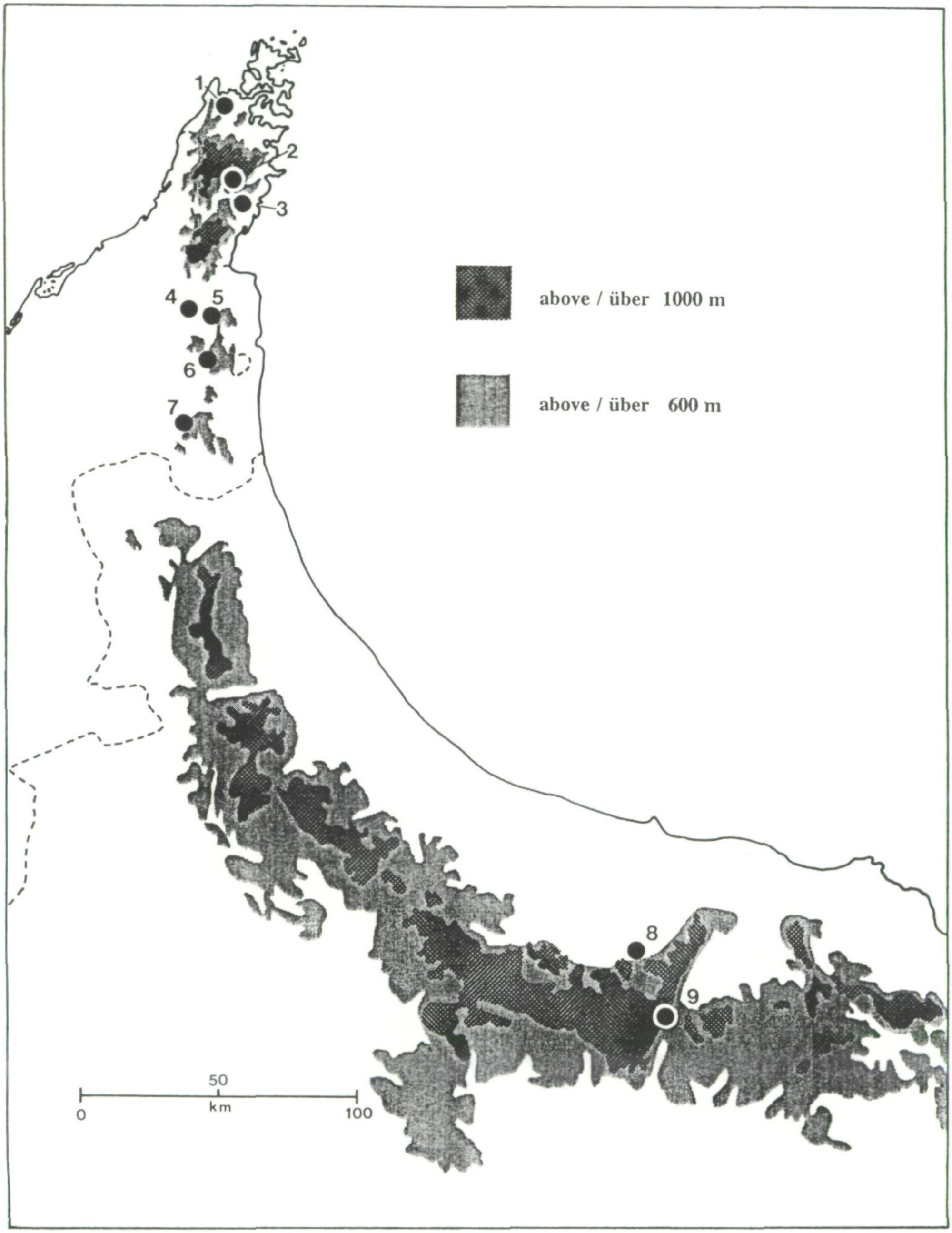

Fig. 1: Map of the Oman Mountains showing the nine localities from which *Lacerta cyanura* is known. 1 - Wadi Qidah near Al Khasab; 2 - 5 km N of the 1st checkpoint on the road to Al Khasab; 3 - 20 km N of Dibba, road to Al Khasab; 4 - Wadi Uyaynat; 5 - Tayybha; 6 - Wadi Siji near Masafi; 7 - Wadi Shawkah (= type locality); 8 - Wadi Mistal; 9 - Wadi near Al Hammah. - (Drawing: U. BOTT).

Abb. 1: Karte des Oman-Gebirges mit den neun bekannten Fundorten von *Lacerta cyanura*. 1 - Wadi Qidah bei Al Khasab; 2 - 5 km N des ersten Kontrollpunktes auf der Straße nach Al Khasab; 3 - 20 km nördlich Dibba, Straße nach Al Khasab; 4 - Wadi Uyaynat; 5 - Tayybha; 6 - Wadi Siji bei Masafi; 7 - Wadi Shawkah (= Locus typicus); 8 - Wadi Mistal; 9 - Wadi bei Al Hammah. - (Graphik: U. BOTT).

Table 1: Egg deposition of *Lacerta cyanura* in the terrarium of the author (R. L.).
Tab. 1: Eiablagen einer *Lacerta cyanura* im Terrarium des Verfassers (R. L.).

Clutch no.	Date of egg deposition	No. of eggs	No. of hatchlings (Date of hatching)	Remarks
1	01. 07. 1993	3	0 (-)	Eggs laid hidden behind a stone plate, dried out when discovered.
2	22. 07. 1993	3	0 (-)	Eggs laid hidden behind a stone plate, destroyed by crickets.
3	14. 08. 1993	3	3 (12. 10. 1993)	
4	01. 09. 1993	2	2 (02. 11. 1993)	
5	23. 09. 1993	3		
6	15. 10. 1993	3		

Their colour and pattern consisted of yellow-whitish longitudinal stripes separated by dark, blackish bands, the tail was bright blue. The dress of a live juvenile is documented here for the first time by a colour photograph (fig. 3).

DISCUSSION

Although a preserved juvenile paratype of *L. cyanura* had already been pictured in a black-and-white plate by ARNOLD (1972: pl. 1), the important systematic characters of this juvenile dress were only briefly used by ARNOLD (1972: 127) to support his hypothesis of a closer relationship between *L. cyanura*, *L. jayakari* and *L. cappadocica*: "... the dorsal pattern of the juvenile paratype has some similarity to that of *L. cappadocica wolteri*". This phenetic hypothesis has been clearly falsified in the meantime by LUTZ & al. (1986) and MAYER & BENYR (1994) on the basis of biochemical evidence. Phenetically the conspicuous, striking juvenile dress of *L. cyanura* also resembles that of certain *Acanthodactylus* and *Eremias* species, which evolved such patterns independently as they belong to different phyletic lineages. Since they all, like *L. jayakari*, live in arid or even desert environments a selective advantage may be connected with this kind of juvenile dress. However, one has to distinguish between the contrasting, striped body pattern and the striking bright blue tail. The latter is common in various other lacertids, e. g. most *Archaeolacerta*, *Teira* (e. g. *perspicillata*) and a few *Podarcis* (e. g. *hispanica*), most intensive in juveniles and persisting after maturity, if at all, mostly in females. As discussed by ARNOLD (1984, 1988), most species showing this tail colouration are active foragers, adapted to open, often exposed rocky habitats, where the attention of their predators is obviously distracted from the vulnerable head and body and directed towards the regeneratable tail. Disappearance of this bright tail colouration at maturity has been explained by the assumption, that the small young individuals are generally more vulnerable to predators than the bigger, adult ones (ARNOLD 1984, 1988). This may be true for the above mentioned lacertids, as well as for other active foragers of the scincomorph families as scincids (e. g. *Ophiomorus, Eumeces, Emoia*), teiids (*Tretioscincus*), cordylids (*Platysaurus*), gerrhosaurids (*Cordylosaurus*) and others. In *L. cyanura*, however, the blue tail colouration persists in both adult males and females (see ARNOLD 1972; GRUBER & al. 1993: 16; figs. 2 & 3 in this paper). This could be explained by the fact, that *L. cyanura*, particularly when compared with its presumed adelphotaxon *L. jayakari*, is an especially tiny and delicately built lizard. It may be a related phenomenon that persistence of the striped juvenile dress e. g. in *Eremias* occurs in the smallest species of the genus, viz. *E. fasciata, lineolata, scripta,* and *pleskei* forming the subgenus *Rhabderemias* (SZCZERBAK 1974). It is questionable, however, whether the presence or absence of a juvenile dress in closely related (sister?) species can be explained exclusively by ecological and selective influences, respectively. *L. jayakari* does not have a specific juvenile pattern, apart from a blackish tail colouration which

Fig. 2: Adult male of *Lacerta cyanura* from 20 km N of Dibba, Oman. - (Photo: R. LEPTIEN).
Abb. 2: Adulte männliche *Lacerta cyanura* von 20 km nördlich Dibba, Oman. - (Photo: R. LEPTIEN).

Fig. 3: Hatchling of *Lacerta cyanura*, one day old. - (Photo: R. LEPTIEN).
Abb. 3: Frisch geschlüpfte *Lacerta cyanura*, einen Tag alt. - (Photo: R. LEPTIEN).

obviously does not work as a predator-directed signal as assumed for the bright blue tails. Therefore phylogenetic constraints on these colour and pattern characteristics may be underestimated.

Another inconsistency in the argumentation of a sister species relationship in the two Arabian *Lacerta* species is the shape of their hemipenial spiny epithelium, which consists of simple, recurved spines in *L. jayakari*, but of multi-spined crowns in *L. cyanura* (ARNOLD 1972, 1973). Although the latter type of this cuticular differentiation has evolved several times within the Lacertidae (ARNOLD 1973; BÖHME 1993), and independently of the question, which of both cell types is regarded the derived one (MAYER & BENYR 1994) it is less parsimonious to assume that two different types occur just in sister species.

A third, even more important difference between *L. jayakari* and *L. cyanura* can be found in their reproductive strategies. *L. cyanura* females seem to produce multiple clutches of three eggs each in relatively regular intervals of more or less three weeks, as inferred from the female reported on here (table 1). In contrast, *L. jayakari* is known to produce (likewise from one captive female) 5 fertile clutches per year with intervals from 6 to 21 weeks, the clutches consisting of 7-9 eggs each (BISCHOFF 1982). In both species the peak of reproductive activity seems to be in autumn. This argues for an Ethiopian (Saharo-Sindian) reproductive cycle rather than a Palaearctic one, so that in this life history aspect there seem to be "southern" rather than "northern affinities" (cf. ARNOLD 1972).

PETERS (1962, 1964) was the first to point out, that life history data in lacertids can also be of systematic significance. He showed that the different reproductive strategy of *Lacerta parva* as compared with the so-called "green lizards" (*Lacerta* s. str.) was not a function of its small body size but constitutes a sound argument against its close relationship with the latter group (PETERS 1962: 422). On the contrary, its life history characteristics are shared by *Eremias* and *Ophisops* (PETERS 1964: 465). This cannot be explained simply by convergent ecological adaptation.

For the same reason it seems unlikely that two presumed Arabian sister species living sympatrically in the same area should have evolved such different reproductive strategies just as a function of their different size, i. e. as a means of niche segregation. According to our admittedly still fragmentary data, *L. cyanura* underwent a strong reduction of its clutch size down to three, which "minimizes the handicapping of the gravid female; the eggs are well dispersed in time and space, and the hatchling is larger than it would be if the egg were crowded by others in the female's body" (FITCH 1970: 203). *L. jayakari*, in contrast, achieves its relatively big hatching size by means of a prolonged incubation period of about four months (BISCHOFF 1982: 142), maintaining a bigger clutch size (see above). The rapid sequence of the *L. cyanura* clutches reduced to three eggs in three-week-intervals even argues for an alternating ovulation of both ovaries which would mean that at any time only one oviduct contains eggs. A similar phenomenon as hypothesized here for *L. cyanura* has been found in various *Anolis* species (FITCH 1970). This is of great relevance for the most actual question of alternating hemipenis use in multiple copulations, to supply both oviducts separately and alternately with sperm (see BÖHME & SIELING 1993 and references herein).

These comments and suggestions may suffice to demonstrate that the case of the small *L. cyanura* and the big *L. jayakari* is an excellent model for a comparative study of their life histories, in the laboratory as well as in the field. Such a study will better allow to judge the ratio of ecological and phylogenetic constraints that influenced the evolution of these two remarkable species.

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