Acanthodactylus opheodurus Arnold, 1980 in the Levant revisited, and the striped patterns of Levantine *Acanthodactylus*

(Reptilia: Lacertidae)

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Abstract. The distribution of the Arabian desert lizard *Acanthodactylus opheodurus* Arnold, 1980 in the Levant is re-examined. West of Jordan it is almost limited to the 'Arava Valley, absent from most of the Negev and from Sinai. This correction of an earlier report derives from re-identification of specimens, relying on the colour pattern difference from the syntopic sibling *A. boskianus asper* (Audouin, 1829). The vertebral dark stripe is simple in *A. opheodurus* but forked in *A. boskianus*. The vertebral stripe is forked but light-colored in two geographically adjacent related taxa, *A. b. boskianus* (Daudin, 1802) of northern Egypt and *A. schreiberi syriacus* Boettger, 1878 of coastal Israel.

Key words. Colour-pattern, distribution, Egypt, Israel, Sinai.

Introduction

The syntopic occurrence of related lizard species – sibling species (sensu MAYR 1965), congeners or merely family members – usually raises two challenges for both the species involved and the investigator. First, identification of individuals as to their specific affiliation (although this is sometimes aided by behavioral signals). Second, resource partitioning, particularly food. Both may be moderated by character displacement, as exemplified in the geckos *Ptyodactylus guttatus* von Heyden, 1827 and *P. hasslelquistii* (Donndorff, 1798), which are easier to distinguish where they coexist in Sinai (WERNER & SIVAN 1993, 1994). Certain morphological differences may imply also a divergence in diet but this is more laborious to prove. Sometimes mere identification is difficult.

Before 1980 the four *Acanthodactylus* species then known in Israel, *A. beershebensis* Moravec et al., 1999 (then within *A. pardalis* (Lichtenstein, 1823)), *A. boskianus asper* (Audouin, 1829), *A. schreiberi syriacus* Boettger, 1878 and *A. scutellatus* (Audouin, 1829), sympatric but mostly not syntopic were easily identified (BARASH & HOOFIEN 1956). In 1980, *A. opheodurus*, a sibling species of *A. boskianus*, albeit much smaller, was described from Arabia and the 'Arava Valley of Israel (ARNOLD 1980), and thus was added to Israel's fauna. Its discovery explained how some "*A. boskianus*" from Israel could be conspicuously sexually mature at a "juvenile" body size. It became necessary to examine whether the museum material of "*A. boskianus"* from the Negev desert of southern Israel and the contiguous Sinai desert of Egypt actually included some similarly striped *A. opheodurus*. In this context, "striped" means that the dorsal body coloration of, at least, the juveniles comprises alternate contrasting very dark and very light longitudinal stripes (Fig. 1).

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The surest difference between these two species was said to be the shape of the clavula in the hemipenis (ARNOLD 1983), requiring dissection. WERNER (1986) dissected the tail bases of several individuals from Israel and concluded that the alleged differences in the pectination of toes and eyelids (DISI et al. 2001) were unreliable. The best external character, applicable also to females, appeared to be head shape (Fig. 2). On average the snout tends to be flat-topped in *A. boskianus* and conical in *A. opheodurus*. Hereupon all "*A. boskianus*" specimens from Israel and Sinai in the National Collections of Natural History at the Hebrew University of Jerusalem were identified mainly by head shape. The results showed wide sympatry of the two species in most areas of the Negev and Sinai (WERNER 1986). Such indeed is the situation in Arabia (ARNOLD 1980) and Jordan (DISI et al. 2001, DISI 2002, 2011).

However, BAHA EL DIN (2006) denied the occurrence of *A. opheodurus* in Sinai. Without detailing his criteria, he reported that "out of over 250 *Acanthodactylus* specimens examined from all parts and habitats of South Sinai … none were referable to *A. opheodurus*, but rather to *A. boskianus* s.l. Daudin 1802…" (This obviously excluded the not-striped *A. scutellatus* group). Therefore we report here a re-examination of the relevant material in the collection at the Hebrew University. To gain better perspective we consider also other geographically adjacent taxa of striped *Acanthodactylus*.

Material and methods

Material examined: Alcoholic museum specimens (Museum codes follow LEVITON et al. 1985) and photographs of free individuals as follows:

Acanthodactylus cf. *boskianus asper* (including *A. opheodurus*): Egypt: unknown locality (N=2): MNHN 8293, 1999.8220. – Egypt: Non-coastal (N=29): HUJR 1344, 6151, 6153; SMF 21354-5, 39154-39176, 86886. – Israel and Sinai (N=386): between catalogue numbers HUJR-1336 and 19307 (from Israel, N=208; from Sinai, N=178). Additionally, 111 photographs of live *Acanthodactylus* cf. *boskianus* from Israel, from the files of Amos BOUSKILA and Roy TALBI and (N=1) Yehudah WERNER. – Jordan (N=11): HUJR 1335, 1338, 1341, 1661, 5041-3, 5046, 5053, 10542, 10649. – Syria (N=7): HUJR 2418-9, 10426, 10430-1, 10645, 10647. – *Acanthodactylus boskianus boskianus:* Egypt: unknown locality (N=2): MNHN 2762 (holotype), 2767. – Egypt: Mediterranean-coastal region (N=3): SMF 75242, 13631-2. Additionally, photographs provided by Alan RESETAR (N=5) of FMNH 78949, 167874-5, 167955,167964; and by Patrick CAMPBELL (N=1) of BMNH 1927.8.13.52. – *Acanthodactylus schreiberi syriacus:* Israel (N=24): HUJR 2590, 2726, 2853, 2969, 6925, 7022, 7318, 12751, 12782, 13291-2, 13508, 13675, 13841, 14381, 14399, 14400, 17568-17570, 17819, 17822, 18004, 19241).

We primarily identified all specimens and photographs of "*Acanthodactylus* cf. *boskianus asper"* by the chief key character provided by ARNOLD (1986) for Arabia: the dark vertebral line (distinct in juveniles, females, and younger males) is simple, evenly wide, in *A. opheodurus* (Fig. 3) but forked craniad in *A. boskianus* (Fig. 4).

Results

Only 14 specimens, all of them from Israel, were referable to *A. opheodurus* (Fig. 3). Thirteen of the *A. opheodurus* were from the 'Arava Valley, between latitudes approximately 29°N and 30°45'N (HUJR 1899, 2661-2, 2893, 5789, 5962, 6205 13339 (juv.), 13340 (juv.), 17959, 19149, 19189-90). The 14th specimen was catalogued from elsewhere: HUJR

Fig. 1 (left). *Acanthodactylus boskianus asper*. The striped coloration of the juvenile fades in the adult male (both from Mishor Yamin, Negev, Israel, 6 March 1973). Scale bar, 10 mm, in all photographs. – Fig. 2 (right). Comparison of characteristic head shapes in dorsal view of A [right] adult male *Acanthodactylus opheodurus* (HUJR 2893, southern ha-'Arava Valley, Israel) and B [left] subadult *Acanthodactylus boskianus asper* of equal trunk length (HUJR 11474, Sinai, Egypt). Head shape varies ontogenetically, sexually and individually but these examples show the principle.

1583 from Mamshit ("Kurnub", approximately 31°01'30"N, 35°03'E), 17 March 1947, Coll. RUBINSTEIN. In this case identification was verified by hemipenial dissection.

In addition, 13 photographs were assignable to *A. opheodurus*: One was photographed in the field in the same area as HUJR 1583, viz. Mishor Yamin: 4 km S of Rotem Jnct. (approximately 31°01'N, 35°05'E), on 28 March 1990, by Y. L. WERNER (Film No.1-089, frames 4-6). Twelve were taken by R. TALBI: Three also in the same general area (TALBI 4879 in the Rotem Plain sands, approx. 31°03'N, 35°10'E and TALBI 4897, 4904 near Giv'at Zafit, approximately 31°02'N, 35°12'E). The remaining nine were from the 'Arava Valley within the above boundaries. The locality records for *A. opheodurus* are shown in Fig. 5. In at least some of these the species is syntopic with *A. boskianus asper.* All other records from Sinai, Israel and Jordan were either clearly *A. boskianus asper* (N=383 museum specimens, N=93 photographs) or photographs unidentifiable due to the angle of view, N=7, all from Israel. The museum specimens included all N=178 from Sinai.

The details of the striping pattern of *A. b. asper* are variable. The dark vertebral stripe is best identified in the posterior half of the dorsum, where it ends in the light space between the pair-members of the dorso-lateral stripes that meet near the level of the hindlimbs, forming a caudad pointing V. Its forking craniad may occur at any point between hindlimb level and the neck.

The striping-based identification was partly supported by two other variables. First, no specimens identified as *A. opheodurus* exceeded 55 mm RA (rostrum-anus length, WERNER 1971), which size was shared by two specimens. Second, among the specimens identified as *A. boskianus,* all the larger ones had a relatively long-snouted head, as is typical of this species as compared with *A. opheodurus* (Fig. 2).

The striping pattern differed also among the other striped congeners in the area extending from Egypt to Jordan. In both *A. schreiberi syriacus* from Israel and *A. b. boskianus* from Mediterranean-coastal Egypt the vertebral stripe is not a dark one but a white one, most distinct in juveniles and females (i.e., the number of dark stripes is paired). At least in some *A. s. syriacus* it forks craniad, like the dark vertebral line of *A. b. asper.* The forking may occur on the neck or more posteriorly, anywhere along the trunk (Fig. 6). We have less evidence for *A. b. boskianus*. The vertebral light stripe is less distinct than the other dorsal light

Fig. 3. *Acanthodactylus opheodurus*. The dark vertebral stripe extends simple (unforked) from hindlimbs to occiput. (HUJR 2661, gravid female, southern ha-‘Arava Valley, Israel).

Fig. 4. *Acanthodactylus boskianus asper* subadults. The dark vertebral stripe forks towards the head and encloses a short central streak from the occiput A [top], The forking occurs very near the head (HUJR 12571, Mishor Rotem, Negev, Israel). B [bottom], The forking starts behind the forelimbs (HUJR 10426, Ma’adan, Syria).

stripes. In adult males the pattern is faded and the vague light vertebral stripe appears to somehow disintegrate and fan out towards the occiput. In female FMNH 167964 the vertebral light stripe is distinct (though less conspicuous than the others) from between the hindlimbs to behind the forelimbs. There it is broken up into a series of speckles and thence it forks towards the occiput as a pair of solid lines.(Fig. 7). In the juvenile MNHN 2762 (holotype) the white vertebral line is not forked.

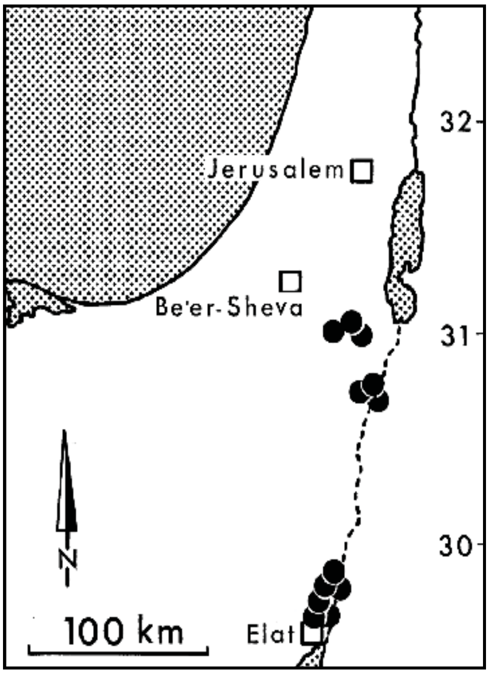

Fig. 5. Locality records of *Acanthodactylus opheodurus* in the study area. For comparative data of *Acanthodactylus boskianus asper* see WERNER (1977) and for the distribution of main sand areas see WERNER (1987).

Discussion

We note that in contrast with the abundance of *A. boskianus asper* throughout the Negev (WERNER 1977) and Sinai (BAHA EL DIN 2006), we have records (specimens and photographs) of *A. opheodurus* only from sandy areas (WERNER 1987) of the northern and southern 'Arava Valley and the Mamshit-Mishor Yamin – Mishor Rotem area. Therefore we conclude that the distribution of *A. opheodurus* in Israel is mainly limited to the 'Arava Valley (including tributaries), bordering Jordan's Arabian desert but with at least a local distal population in the Mishor Yamin plain. This distribution resembles those of several other Arabian reptiles, e.g., the geckos *Bunopus blanfordii* and *Stenodactylus doriae* and the snake *Platyceps elegantissimus* (WERNER 1987) but differs in the extension to Mishor Yamin. This presumed absence of *A. opheodurus* from most of Israel's Negev desert accords with the contention of BAHA EL DIN (2006) that the species is absent from Egypt's Sinai desert, as the two areas are contiguous as one geophysical unit.

Using the striped pattern for distinguishing *A. opheodurus* from *A. b. asper* seems justified by the additional inter-taxon pattern differences in the region, i.e., the "inversion" of the pattern in *A. b. boskianus* and *A. s. schreiberi.* But the striped pattern and its variation, intra- and inter-taxonic, require some elucidations. First, can either the dark or the light stripes be regarded as the background colour, against which the other stands out; do we say the lizard has light stripes, or that it has dark stripes? In the case of *A. b. asper* BOULENGER (1921) says "Young with … white streaks…" This interpretation was shared by BLANC (1979) in his analysis of pattern variation in Tunisian *Acanthodactylus*. In contrast, SALVADOR (1982) says, "In the youngest specimens … there are seven black bands…" ARNOLD (1980), too (in the similar *A. opheodurus*), considers the dark stripes as the pattern on a light background. This view is adopted by DISI (2002). Some authors take one or another interpretation for

Fig. 6. *Acanthodactylus schreiberi syriacus* juvenile. The vertebral stripe is white and in this case forks behind the head. (HUJR 13291, Nizzanim, coastal plain, Israel).

Fig. 7. *Acanthodactylus boskianus boskianus* adult female. The vertebral stripe is white and in this case forks between the forelimbs (FMNH 167964, Kafr el Sheikh, Egypt).

granted, and speak of conspicuous stripes without specifying whether these are light or dark (e.g., DISI et al. 2001). But actually as the juvenile grows, the dark stripes expand, fade and attain the hue that matches the substratum. From this aspect, they represent the lizard's background color, and the lizard is adorned with whitish stripes. Nevertheless one needs to discuss the black stripes as a dynamic pattern unit, as follows.

SALVADOR (1982) explains the variation in the location of the point of bifurcation of the vertebral dark stripe as an ontogenetic process. In the young the point of bifurcation is near the head, and with growth it migrates caudad so that in adults the vertebral stripe is represented by a pair of stripes. This description is probably realistic, as we saw no juveniles with a paired number of complete stripes. But apparently in some populations or individuals the process is delayed or absent, because the bifurcation is very anterior also in many adults (e.g., fig. 1 in SEIFAN et al. 2009).

Very interestingly, in the taxa whose juveniles have a white vertebral stripe, *A. schreiberi* and *A. b. boskianus*, this stripe morphologically "behaves" like the black vertebral stripe of *A. b. asper*. But in these, too, it is the dark component of the pattern that during growth expands, fades and colour-matches the substrate.

In summary, in these three sister taxa (HARRIS & ARNOLD 2000), the vertebral stripe splits during growth into two stripes. As a result, the stripes of larger individuals are not much wider, in mm, than those of smaller individuals. This may well have some image-functional aspect that remains to be explored. It does not happen in the smaller *A. opheodurus*. Furthermore, in the *boskianus* group, regardless whether the vertebral stripe is light or dark, the dark stripes represent the ground color while the white stripes constitute the adorning pattern, in agreement with the usage of BOULENGER (1921) and BLANC (1979). Some other species of lizards appear to be polymorphic with respect to stripe number and the colour (light or dark) of the vertebral stripe. This was recently reported In *Aspidoscelis burti* (Teiidae) where so far no ontogenetic shift or correlation to body size could be demonstrated (WALKER & CORDES 2011).

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