SHORT NOTES

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NOTES ON THE DISTRIBUTION AND ECOLOGY OF *PHRYNOCEPHALUS CLARKORUM* ANDERSON & LEVITON 1967 AND *PHRYNOCEPHALUS ORNATUS* BOULENGER 1887 IN AFGHANISTAN

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P. clarkorum and *P. ornatus* are two of the six species of toad-headed agamid lizards that inhabit the desert and semi-desert wastes of southern Afghanistan. The other species are *P. euptilopus* Alcock & Finn 1896, *P. lutteoguttatus* Boulenger 1887, *P. m. maculatus* Anderson 1872 and *P. scutellatus* (Olivier 1807). All these are adapted to the varying ecological conditions which range from large sand seas with massive dune formation, firm sand spits and ridges contiguous with or separate from the sand desert, gravel plains and stony wastes. The abrupt juxtaposition of these ecosystems in some instances allows for a degree of sympatry. Other reptiles are similarly dependant on micro-environmental differences resulting in a rich spectrum of species. The greatest abundance of any given species is often to be found on the margins of its ecological zone.

The two species here considered were originally confused by Boulenger as a composite species: *P. ornatus*, type locality between Nushki and Helmand Afghanistan. Material collected by the present author in 1964 from near Kandahar and Girishk was examined by Steven Anderson and Alan Leviton who recognised that two species were involved and that Boulenger's type series was composed of two distinct taxa. These species were first separated and defined by Anderson & Leviton in 1967 based on the author's 1964 material, specimens collected by John Gasparetti in Afghanistan, animals from Chagai District in West Pakistan and a part of Boulenger's original material amounting to 13 examples of *P. clarkorum* and 24 of *P. ornatus*. Anderson & Leviton (1967) remarked: "whether or not these two similar forms inhabit the same habitats and to what extent their distributions overlap are questions necessitating further investigation". Clark *et al.*(1969) stated: "it would be interesting to know what ecological and behavioural differences may distinguish these two similar and previously confused species". At the time the only field data available from Afghanistan was that made by the present author in 1964. *P. clarkorum* had been taken from near Kandahar and *P. ornatus* from Girishk. In 1968 the author revisited Afghanistan and collected larger samples of both species amounting to 38 *P. clarkorum* and 90 *P. ornatus*. Evaluation of the field data from the trip reveals that these two species can indeed be sympatric and that they demonstrate certain behavioural differences even though they live essentially under the same conditions.

Distribution. Both species have a distribution that is known to include the sandy deserts of southern Afghanistan with some extension into the adjoining regions of West Pakistan and, in the case of *P. ornatus* at least, Iran (Leviton & Anderson, 1970; Welch, 1983). To this region they seem to be endemic along

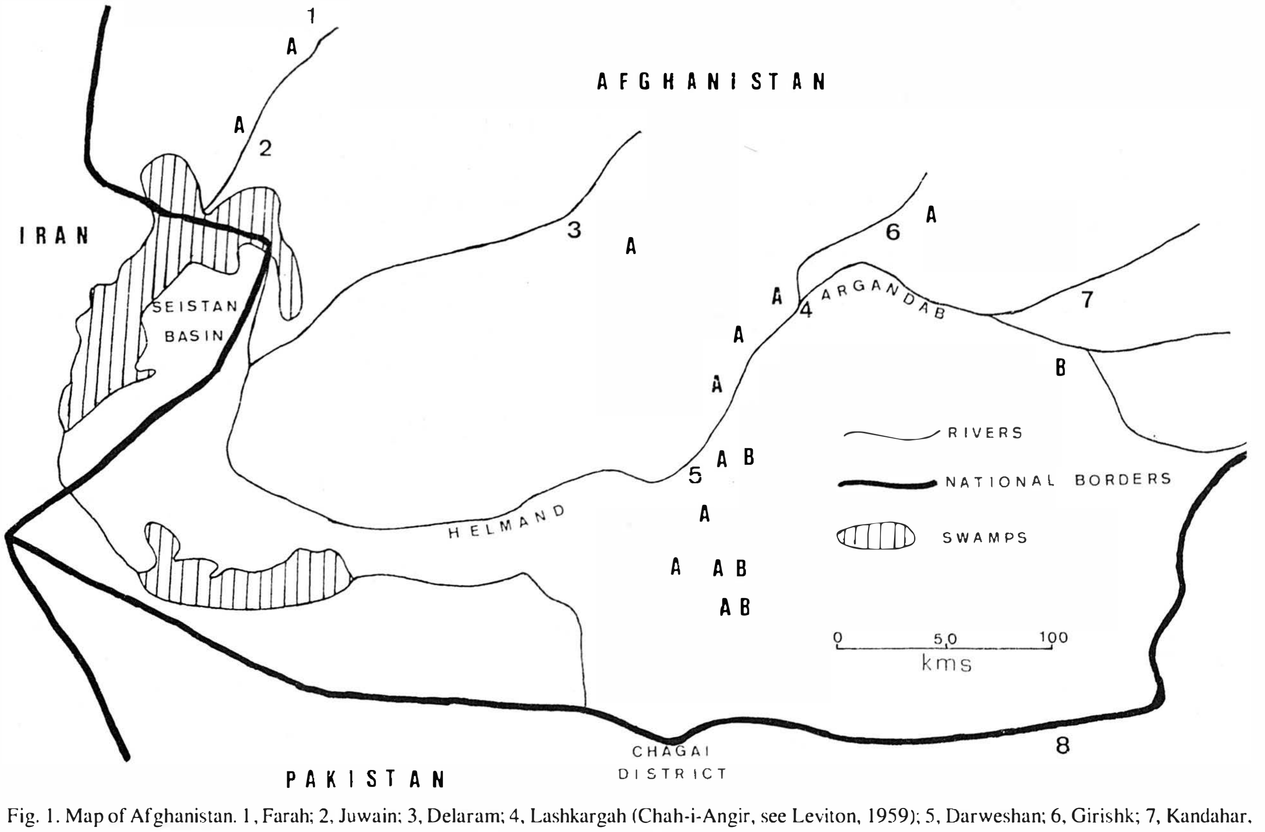

Fig. 1. Map of Afghanistan. 1, Farah; 2, Juwain; 3, Delaram; 4, Lashkargah (Chah-i-Angir, see Leviton, 1959); 5, Darweshan; 6, Girishk; 7, Kandahar, 8, Nushki. A, locality records for *P. ornatus*; B, locatity records for *P. clarkorum*.

with the other species referred to above with the exception of *P. m. maculatus* which occurs also in Syria and Iraq (Welch, 1983). Locality records of *P. clarkorum* and *P. ornatus* are few due to the lack of observations in a region that is difficult to research. These localities are shown on Fig. 1. Bearing in mind the known range parameters it is certain that both species occur widely through the area although this remains to be proven. The range of *P. clarkorum* is defined by the Argandab and Helmand river systems which contain the main sand desert in southern Afghanistan. However *P. ornatus* is to be found outside this defined zone, the explanation being that it has followed sand migration patterns which occur as a result of wind action (Clark, 1990). Sizeable though localised sand accumulations from east of Delaram to Kandahar contained populations of *P. ornatus* as well as west of the Helmand river at Lashkargah, Farah and Juwain. At a location 16 km west of Delaram and another 40 km south east of Kandahar none were found. In the former case it could be argued that the site was too far removed from the main sand desert but this does not hold true for the Kandahar station. Altitude may however be significant. *P. ornatus* was not found above 880 m. at Girishk. The altitude at Kandahar was 1100 m. and here *P. clarkorum* occurred. Within the confines of the sand desert itself the two species were sympatric in two areas: 10-20 km north east of Darweshan at 830 m altitude and 55-70 km southeast at 790 m. At the aforementioned Darweshan location *P. clarkorum* was mostly seen in a single broad depression amongst the dunes, the ground being covered with coarse-grained sand. Fewer were observed on the firmer, finer sand on the surrounding sand hills. From the other stations the impression gained was of small well-separated colonies comprised of just a few lizards. Other places visited in the Darweshan area, which was researched extensively over the period 13 March to 4 April, yielded populations of *P. ornatus* but no further *P. clarkorum*. With regard to relative abundance it was the locality near Kandahar that produced most *P. clarkorum*: 21 out of the total of 38 on a single day, 7 April. The remaining 17 examples were caught over a 4 day period. The largest number of *P. ornatus* taken from a single site on a single day was 45 km south of Lashkargah on 13 March when 23 were obtained. This station is isolated from the main desert. On available evidence it seems that whereas *P. ornatus* is more opportunistic and less territorially restricted than *P. clarkorum* both species are more successful where they are not sympatric. Where sympatry occurs both live in reduced numbers and roughly equal population densities. Although no difference in general biotope could be determined, within the limitations already mentioned, the way these species behaved and reacted was at variance. This cannot be adequately discussed without first considering the morphological characters of these two lizards.

Morphology and behaviour. The reader is referred to Anderson & Leviton (1969) for a detailed account of these species and the characters separating them. The most obvious and distinctive features are here given. *P. clarkorum* has a more slender habitus than *P. ornatus* which is rather plumper in body form. *P. clarkorum* has a prominently striped pattern: a broad dorso-lateral and lateral white band bordered with black, the dorso-lateral band extending down the tail. *P. ornatus* lacks these features. *P. clarkorum* has a sandy-grey ground colour with two rows of dark spots down the dorsal aspect; *P. ornatus* has a more brown ground colour with dark spots encircled with orange. In *P. clarkorum* the underside of the tail is lemon-yellow with five transverse black bands; *P. ornatus* has four such bands. In a recent paper (Clark, 1990) it was erroneously stated that both species had up to four black bands. This was a typing error which was overlooked in proof-reading. The black-banding is more striking in *P. clarkorum* not only because there are more bands but due to the fact that they are broader than in *P. ornatus* and that the tail is shorter in proportion to the body length with the interspaces correspondingly reduced. These differences are of great significance in relation to habitat and behaviour. The habitat requirements have already been mentioned: firm sand accumulations or sand-strewn alluvium. In such situations a certain amount of vegetative cover is often present: grassy tussocks, stunted bushes, degraded tree trunks, low xerophytic shrubs. *P. clarkorum* would invariably seek the shelter of any vegetation present when alerted and the striped patterning rendered it inconspicuous when motionless due to the sunshine/shadow factor. Where loose sand was present it would tend to partially bury its hind quarters though never completely covering itself with sand. *P. ornatus* seldom sought such protection preferring to stop in its tracks and remain motionless in the open where its mottled pattern blended with the granular texture of the background sand. It was also noted that *P. clarkorum* would run in shorter dashes and often change direction when pursued whereas *P. ornatus* ran faster and straighter. There was a tendency for *P. ornatus* to seek vegetative cover in places where *P. clarkorum* was not present but never to the same degree of persistence. When under threat both species would raise the tail and lash it from side to side but in flight *P. ornatus* would run with the tail raised whereas *P. clarkorum* never did. This can perhaps be attributed to the fact that in motion a striped or banded pattern creates an illusionary impression which makes it difficult for a potential predator or enemy to follow the movement. Since *P. clarkorum* has a striped pattern it does not need to raise the tail to delude the pursuer. *P. ornatus*, lacking body striping, raises the tail to create the same effect and when the animal suddenly halts in its tracks the tail is lowered rendering the animal invisible at a distance from its pursuer that is hard to determine. The two species under discussion are not alone in 'tail display' which is a characteristic of the genus as a whole and a feature of all Afghan species. This has been discussed by the author recently (Clark, 1990). It can further be construed as a warning/threat gesture as well as a recognition signal during courtship. Nikol'skii (1911) gives a full and vivid description of tail display in the Central Asian *P. sogdianus* (=*P. interscapularius*). This species is also found in northern Afghanistan and closely parallels both *P. clarkorum* and *P. ornatus* though would seem to have closer affinities to the latter. He concludes that "the bending of the tail is important only as a countermimic adaptation". Clearly more research is needed in this field and the reasons why different species adopt, dissimilar display patterns.

Reproduction: With regard to the reproductive cycles of *P. clarkorum* and *P. ornatus* we have little data. Anderson & Leviton (1967) state that ovarian eggs were present in both species in animals examined by them which had been collected between May and October. Two *P. clarkorum*, taken on May 15th. 1962 in Chagai District in Baluchistan had oviducal eggs implying that egg deposition had not yet begun or that it was at any rate not completed. Of the present author's material collected early in April a greater number of *P. clarkorum* contained oviducal eggs than did *P. ornatus*,in proportion to the total collected. This suggests that the breeding season is perhaps staggered by a month or so with *P. ornatus* completing egg deposition by around the middle of April and *P. clarkorum* a month or so later. It was also found that *P. ornatus* was active at lower environmental temperature than *P. clarkorum*, the former being found on 26 February near Girishk around midday with air and ground temperatures of 15.5°C and 26°C respectively. *P. clarkorum* was never found with an air temperature lower than 24°C. This suggests that *P. clarkorum* is more sensitive to low temperatures with a longer period of hibernation which would result in it breeding later. Clearly, these conclusions are based on limited information and await confirmation by more detailed studies.

Conclusions: *P. clarkorum* and *P. ornatus* are sand-dependent lizards with preferred habitats of firm sand and sand-strewn alluvium. *P. clarkorum* is intimately connected to the main desert sand formations, *P. ornatus* ranges more widely following migratory sand accumulations. Where sympatric both occur in stable and compatible populations neither showing dominance but are less abundant than in areas where either one or the other species is found. Behaviour, escape methods and detection avoidance can be related to morphological differences. *P. clarkorum* seems to breed later than *P. ornatus* and is probably more sensitive to lower temperatures.

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VARIATION IN VIABILITY DURING DEVELOPMENT AND HATCHING SUCCESS IN EMBRYOS OF THE TOAD *BUFO CALAMITA*

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Many authors have dealt with embryo hatching success in anurans as failures in fertilization efficiency (Davies & Halliday, 1977; Gerhardt *et al.*, 1987; Ryan, 1985; Robertson, 1990). However, other sources may contribute to additional embryo mortality throughout development: these include failures or abnormalities in development, fungal infestations prior to hatching, etc. (Herreid & Kinney, 1966; Woodruff, 1976; Seigel, 1983; Travis *et al.*, 1987; Banks & Beebee, 1988). Therefore, any attempt to separate fertilization efficiency from later factors governing mortality is an important matter that ultimately relates to sexual selection and fitness, since Licht (1976) proposed that an optimal male/female body size ratio might enhance fertilization rate.

Little information is available regarding embryonic development and viability of the next generation, and non-proximate factors such as female body size and age. Other factors such as egg size may affect some components of offspring fitness such as embryo size at hatching (Kaplan, 1980; Crump, 1984). However, no information is available concerning embryo survival and egg size. Finally, external fertilization in anurans may result in a lower rate of successful insemination at higher clutch sizes.

The present study examines the variation in embryo viability during development from fertilization to hatching in the natterjack toad, *Bufo calamita*. Fertilization success is analyzed as a function of body size ratio (defined as relative male body length/female body length). Likewise, both fertilization efficiency and hatching success are studied as a function of female body size, age, and clutch and egg size.

The study was conducted in central Sierra Morena, Córdoba Province, Spain, from January to April of 1987 and 1988. Naturally-occurring pairs of natterjack toads in amplexus were captured in the breeding area; 71 in 1987 and 44 in 1988. The pairs were isolated in glass aquaria (30 x 20 x 20 cm) filled with 3 l of pond water and some vegetation. The aquaria were placed at the site where the pair had been captured until oviposition occurred. Then the individuals were measured for body length and toe-clipped. Toes were frozen for skeletochronological study in order to determine successive resting lines, providing an estimate of the age of each individual (Tejedo, 1989). All clutches were photographed to estimate clutch size and were then carefully released into the pond. The absolute number of eggs for each clutch was counted from the resulting photographs. Average egg size was determined by measuring the diameter of ten eggs from samples randomly selected in each clutch, to the nearest 0.02 mm, using an ocular micrometer. Estimates of embryo viability were obtained from samples taken sequentially from individual clutches. Embryos were staged according to Gosner (1960). In 1987, four samples were taken at 3-4 day intervals: (1) late cleavage, stages 9-10, taken about 12 hr after oviposition. This sample was used as an estimate of fertilization efficiency; (2) late gastrula or early neurula, stages 12-13; (3) neurulation, stages 14-16; and, (4) hatching, stages 17-19. During 1988, only two samples were taken, spaced about 10 days apart: (1) stages 9-10, taken about 12 hr after oviposition (fertilization success estimate); and (2) stages, 16-18. The final samples from both years were used to estimate total number of viable embryos and percent of hatching success. Additionally, collections were taken from non-manipulated clutches, those laid freely, not in aquaria (N = 10 in 1987 and N = 6 in 1988), to ascertain if manipulation affected total number of viable embryos. Manipulated clutches did not differ from control ones in clutch size or average egg size (Mann-Whitney U-test, $P > 0.05$). The average sample size ($\bar{x} \pm$ SD) was 71.2 ± 33.2 embryos, n = 246, in 1987, and 85.4 ± 37.4 embryos, n = 100, in 1988. Each sample was immediately examined with a dissecting microscope. Embryos were counted and scored as non-viable or dead when they were grey and swollen. Dead