

SHORTER CONTRIBUTIONS: HERPETOLOGY

Copeia, 1994(2), pp. 533-535
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OBSERVATIONS ON THE AFRICAN DWARF CROCODILE, *OSTEOLEAEMUS TETRASPIS*.—The African dwarf crocodile (*Osteoleaemus tetraspis*) is endemic to the equatorial rain forest belt of central and West Africa, where it inhabits small streams (Kofron, 1992). Forty percent of Liberia is covered with primary rain forest (C. P. Kofron and A. Chapman, unpubl.), comprising the largest blocks remaining in West Africa (Allport, 1991). Although Liberia was believed to be a stronghold of the species (Poolley, 1982), a recent survey of crocodiles in Liberia revealed depleted populations with only scattered individuals because of hunting and deforestation (Kofron, 1992). Although large numbers still persist in the Congo, thousands are killed there annually for food (Behra, 1990). The African dwarf crocodile is now one of the most critically endangered crocodylians in the world, but it has never been studied in the wild. The available sparse knowledge of the species was reviewed by Groombridge (1982), Waitkuwait (1989), and Thorbjarnarson (1992); and breeding of captive individuals in zoos was reviewed by Bustard (1980). The purpose of this paper is to provide additional information about reproduction of the species.

There are seven individuals of the African dwarf crocodile in the Monrovia Zoo on the Mesurado River. The four females range from 102–134 cm total length and the three males from 122–129 cm. In 1989, the smallest female nested at the beginning of the wet season, on 6 April (Fig. 1). Eleven eggs were laid in a cavity in the ground and covered with several cm of sandy soil. Although the female remained in the vicinity of the nest and guarded it for several weeks, none of the eggs hatched because of invasion by ants.

Similarly, nesting of the dwarf crocodile in the Ivory Coast occurs from March through June (Waitkuwait, 1989), also at end of the dry season/beginning of the wet. The nest is usually a mound of vegetation (Waitkuwait, 1989), but vegetation was not readily available in the Monrovia Zoo pen. The reproductive female (102 cm) is considerably smaller than the 150–160 cm reported for mature females by Waitkuwait (1989). The clutch of 11 eggs agrees with the small clutch sizes of 6–17 eggs recorded previously for the species (Groombridge, 1982; Waitkuwait, 1989).

In an effort to assess the reproductive cycle, a blood sample (15 ml) was drawn by needle and syringe from the inferior jugular vein (Kofron and Trembath, 1987) of the reproductive fe-

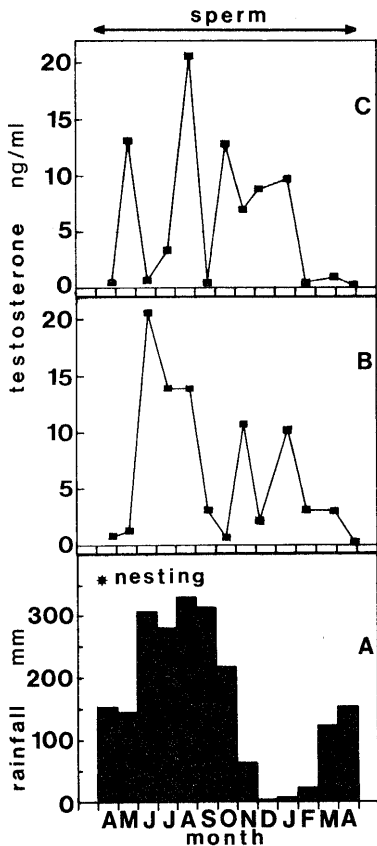


Fig. 1. (A) Monthly rainfall (mm) recorded in Liberia (Chapman, 1991). The asterisk indicates the time of nesting for a female African dwarf crocodile (*Osteoleaemus tetraspis*) in the Monrovia Zoo, Liberia. (B, C) Levels of plasma testosterone (ng/ml) in two adult males of the African dwarf crocodile in the Monrovia Zoo. The times of sperm production for the two males are also indicated.

male during every month of the following 13 months. Plasma estradiol 17-B and plasma calcium were measured by radioimmunoassay and atomic absorption spectrophotometry, respectively (Kofron, 1990). However, neither showed any pattern, presumably because the captive female did not reproduce again during the sampling period. Plasma estradiol 17-B ranged from 86–354 pg/ml and plasma calcium from 2.6–3.7 mM/ml.

During April, the three male crocodiles were examined for the presence or absence of spermatozoa in the penile groove (Kofron and Trembath, 1987), and all three were found to be mature and actively producing spermatozoa. Two of the males were examined monthly over the next 12 months, and sperm were always present. This is in contrast to the seasonal production of spermatozoa by Nile crocodiles during winter in southern Africa (Kofron, 1990), which has a more temperate climate. Monrovia is only 6° north of the equator, with only wet and dry seasons.

Blood samples were also drawn from the same two males on a monthly basis to measure plasma testosterone. There was a similar cyclic pattern in both males, with two periods of low levels, one period of high levels, and one period of intermediate levels (Fig. 1). During April 1989, both males had low levels at 1 ng/ml. From May through Aug., both attained levels as high as 21 ng/ml, which fell to 1–3 ng/ml during Sept. From Oct. to Jan., plasma testosterone increased to 10–13 ng/ml and then during Feb. fell to 1–3 ng/ml. During the following April (1990), both males again had low levels at 1 ng/ml.

During the time of female nesting (April), the male dwarf crocodiles had low levels of plasma testosterone, which then were followed by high levels (May through Aug.). Although this study was conducted with only a small sample of captive dwarf crocodiles, nonetheless the pattern is similar to that for Nile crocodiles (*Crocodilus niloticus*) in southern Africa (Kofron, 1990) and American alligators (*Alligator mississippiensis*) in Louisiana (Lance, 1989). In both Nile crocodiles and American alligators, the high levels of plasma testosterone represent a postmating increase.

Acknowledgments.—CPK was in Liberia under the auspices of the Fulbright program. The United States Educational and Cultural Foundation in Liberia provided a short-term grant, and the services of J. J. Martin are especially appreciated. D. Thompson, Jr., measured the plasma hormones. A. Chapman, G. C. Grigg, S. C. Ma-

nolis, and G. J. W. Webb also rendered assistance.

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Copeia, 1994(2), pp. 535–537
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ROLE OF WRAPPING BEHAVIOR ON EGG SURVIVAL IN THREE SPECIES OF *TRITURUS* (AMPHIBIA: URODELA).—Old World newts are terrestrial Salamanders that reproduce in water. Oviposition behavior corresponds to Salthe's (1969) Mode I, i.e., many eggs (100–500) are laid singly on supports such as aquatic plants over a period of 1–3 months (Bell, 1977; Bell and Lawton, 1975; Miaud, 1990). There is no postoviposition parental care. Oviposition is characterized by egg-wrapping behavior: a female grasps a support (e.g., a plant leaf) and bends it around her vent with her hind legs. One egg is deposited, and the female tightens this fold on the egg for several seconds. When the salamander leaves the oviposition site, the adhesion substances of the egg membranes secure it to the site. All of the eggs are deposited in this way, dispersed on aquatic plants at the breeding site (Bell and Lawton, 1975; Diaz-Panigagua, 1986; Miaud, 1990).

Duration of embryo development increases when water temperature decreases (Moore, 1939). A 6:1 difference in developmental rates between embryos raised at 25 C and 10 C could usefully be considered alongside data on the actual temperatures at which *Triturus* embryos normally develop in the wild (Horner and MacGregor, 1985). Hatching takes place about 15 days after egg deposition in *Triturus helveticus* at 18 C (Gallien and Bidand, 1959), about 12 days in *Triturus alpestris* at 22 C (Epperlein and Junginger, 1982), and about nine days in *Triturus carnifex* at 20 C (Horner and MacGregor, 1985).

Egg survival in the laboratory is variable between species: in subgenus *Neotriton* (*Triturus marmoratus*, *T. cristatus*, and *T. carnifex*) a particular embryonic mortality, called developmental arrest syndrome (MacGregor and Horner, 1980), causes the death of 50% of their eggs. In contrast, the species of *Mesotriton* (*T. alpestris*) and *Palaeotriton* (*T. helveticus* and *Triturus vulgaris*) show nearly 100% successful de-

velopment of fertile eggs (Sims et al., 1984; Horner and MacGregor, 1985; Sessions et al., 1988). In natural conditions, egg survival strongly decreases, with only 3% hatching (*T. vulgaris*: Bell and Lawton, 1975; *T. helveticus*, *T. alpestris*, and *T. cristatus*: Miaud, 1990). Most deaths in the field are presumably caused by predation, aquatic insects, and newts eating eggs (Bell and Lawton, 1975; Joly, 1987).

During a study of oviposition behavior in *T. helveticus*, *T. alpestris*, and *T. cristatus*, interspecific differences in egg-wrapping behavior were observed (Miaud, 1990). All eggs laid by *T. cristatus* (n = 100) were wrapped, and 10% (n = 307) and 25.4% (n = 168) of *T. alpestris* and *T. helveticus* eggs, respectively, adhered unwrapped to the substrate. The aim of this paper is to compare survival of wrapped and unwrapped eggs in the field.

Materials and methods.—Five females and two males of each of the three species, *T. helveticus*, *T. alpestris*, and *T. cristatus*, from a pond in southeast France were placed on 10 May 1990 in three aquaria (60 × 60 × 40 cm). Twenty long, thin strips of transparent PVC (40 × 0.5 cm), imitating a plant often used for oviposition (*Glyceria fluitans*), were provided as oviposition sites in each aquarium. Such artificial supports, used previously in several experiments, provide a favorable oviposition substrate (Miaud, 1990). Newts, fed every 48 hours with living chironomid larvae, laid their eggs on these strips. Water temperature fluctuated from 18–23 C. From one to 10 eggs were laid on each strip, but each egg was wrapped individually. On 18 May 1990, these artificial supports were removed from the aquaria. Approximately half of the eggs were cautiously unwrapped with surgical tongs so that they were only stuck on the supports. A preliminary experiment revealed that such manipulation does not influence egg survival (survival rates of such unwrapped eggs from laying to hatching in aquaria were 0.95 (n = 40, *T. helveticus*), 0.91 (n = 33, *T. alpestris*), and 0.46 (n = 35, *T. cristatus*). The experimental plan consisted of putting these supports bearing wrapped and unwrapped eggs in a pond known to be used as a newt breeding site and to compare egg survival rates. This pond (30 m², 1 m maximum depth) is 40 km from the laboratory. Water temperature in the pond fluctuated between 18 and 24 C during the experiment. Strips covered with wrapped and unwrapped eggs were carried in plastic tanks padded with damp absorbent cotton. Eggs conveyed in this manner from the laboratory to the field and back to the laboratory developed normally in aquaria. These ar-