

possible qualitative difference between the two species concerns the act that follows signalling. In *E. macquarii*, male and female tilt heads upward and press their barbels together (Murphy and Lamoreaux, 1978). In contrast, *E. subglobosa* males and females held a nose-to-nose orientation, but did not attempt barbel contact. The absence of barbel contact in *E. subglobosa* might be due to lower arousal levels of the females. Since, I never saw copulation in *E. subglobosa*, it is possible that unobserved female courtship patterns may occur in this species, especially if they typically follow the males' nose squirts.

Other courtship differences were quantitative. *E. subglobosa*'s observed frequency of 4.7 strokes/sec is higher than the 1–3 strokes/sec seen in *E. macquarii* (Murphy and Lamoreaux, 1978). It seems unlikely that the differences result from scaling considerations, for the individuals tested were of essentially the same size (25 cm for *E. macquarii* vs. about 20 cm for *E. subglobosa*). Neither was water temperature a variable since both tanks had water temperature averages around 26 C. If these differences are species specific, unrelated to body or leg size, then stroke rate may be of some use in sorting out disputed species and subspecies relationships. Ernst and Barbour (1989) for example, disagreed with McDowell (1983) about relationships among *E. subglobosa*, *E. australis*, and *E. krefftii*. In addition, Holmback (1987) holds that *E. australis albertisii* and *E. australis subglobosa* are synonymous.

Although eye-blinking was observed infrequently, I believe that it is indeed a part of courtship and not an incidental pattern. Blinking of the nictitating membrane was observed when the male's head was out of the water, expected since cleansing and lubricating the cornea is the acknowledged function of the nictitating membrane (Porter, 1972). However, when the male was under water, the act was never observed unless he was facing a female. The strong color contrast between membrane and eye provide additional circumstantial evidence for its being a visual signal, a component of courtship.

The eye-blinking pattern is either unique to *E. subglobosa*, or has gone unnoticed in other species. Among other papers on turtle behavior, only one mentions blinking during courtship, and that as a display performed by females of *Trachemys scripta* when orienting males were near (Lovich et al., 1990).

Acknowledgments.—I express thanks to my advisor and collaborator, D.C. Radabaugh; to Mike Goode and Ron Hatcher of the Columbus Zoo for access to, and information about the captive turtles; to Jamie Cameron, Edward H. Burt and other members of Ohio Wesleyan's Friday Afternoon Research Seminar for encouragement and suggestions; and to M. Ewert and J. Gillingham for providing advice and references. This study was partially funded by a William D. Stull award granted by the Ohio Wesleyan University's Department of Zoology.

LITERATURE CITED

- BAKER, R., AND J. GILLINGHAM. 1983. An analysis of courtship behavior in Blanding's turtle, *Emydoidea blandingi*. *Herpetologica* 39:166–173.
- CARPENTER, C., AND G. FERGUSON. 1977. Variation and evolution of stereotyped behavior in reptiles. In C. Gans and D. W. Tinkle (eds.), *Biology of the Reptilia*, Vol. 7, pp. 335–554. Academic Press, New York.
- CLAY, B. T. 1981. Observations on the breeding biology and behavior of the long-necked tortoise, *Chelodina oblonga*. *J. Royal Soc. Western Australia* 4:27–32.
- COMUZZIE, D., AND D. OWENS. 1990. A quantitative study of courtship behavior in captive green sea turtles, *Chelonia mydas*. *Herpetologica* 46:195–201.
- ERNST, C., AND R. BARBOUR. 1989. *Turtles of the World*. Smithsonian Institution Press, Washington, D.C.
- FRITZ, U., D. JAUCH, AND H. JES. 1991. Langzeit-Beobachtungen bei der Haltung und Nachzucht der Rotbauch-Spitzkopfschildkröte (*Emydura albertisii*). *Zeitschrift des Kölner Zoo* 4:131–139.
- HOLMBACK, E. 1987. Captive reproduction of the New Guinea side-necked turtle, *Emydura australis albertisii*. *Inter. Zoo Yearbook* 26:94–98.
- JACKSON, C., AND J. DAVIS. 1972. A quantitative study of the courtship display of the red eared turtle, *Chrysemys scripta elegans*. *Herpetologica* 28:59–64.
- JENKINS, J. 1979. Notes on the courtship of the map turtle, *Graptemys pseudogeographica*. *J. Herpetol.* 13:129–131.
- LEGLER, J. M. 1978. Observations on behavior and ecology in an Australian turtle, *Chelodina expansa* (Testudines: Chelidae). *Can. J. Zool.* 56:2449–2453.
- LOVICH, J., W. GARSKA, AND W. COOPER. 1990. Female participation in courtship behavior of the turtle, *Trachemys s. scripta*. *J. Herpetol.* 24:422–424.
- MCDOWELL, S. B. 1983. The genus *Emydura* (Testudines: Chelidae) in New Guinea with notes on the penial morphology of Pleurodira. In A. G. J. Rhodin and K. Miyata (eds.), *Advances in Herpetology and Evolutionary Biology*, pp. 169–189. *Mus. Comp. Zool. Harvard, Cambridge, Massachusetts*.
- MURPHY, J., AND W. LAMOREAUX. 1978. Mating behavior in three Australian Chelid turtles. *Herpetologica* 34:398–405.
- PETRANKA, J., AND A. PHILLIPPI. 1978. Observations on the courtship behavior of juvenile *Chrysemys floridana concinna* and *Chrysemys floridana hoyi*. *J. Herpetol.* 12:417–419.
- PORTER, K. R. 1972. *Herpetology*. W. B. Saunders Co. Philadelphia, Pennsylvania.

Accepted: 10 October 1995.

Journal of Herpetology, Vol. 30, No. 1, pp. 80–82, 1996
Copyright 1996 Society for the Study of Amphibians and Reptiles

Observations on Trailing and Mating Behaviors in Hognose Snakes (*Heterodon platirhinos*)

MICHAEL V. PLUMMER AND NATHAN E. MILLS, *Department of Biology, Box 2251, Harding University, Searcy, Arkansas 72143, USA.*

In the course of a radiotelemetric study of free-ranging hognose snakes (*Heterodon platirhinos*), we observed trailing and mating behaviors on several occasions in different individuals in both spring and

fall. Trailing of female snakes by male snakes has been widely reported both in the laboratory and in the field (Ford, 1986; Mason, 1992). However, our observations are of interest because, unlike most such reports on free-ranging snakes, telemetric studies allow observation of behaviors by individuals with known histories occurring over extended periods (e.g., Slip and Shine, 1988). Because it has been suggested that the process of shedding may provide chemical cues important in trailing (Mason, 1992), we provide times of the most recent shedding prior to our observations on trailing for each female.

Beginning in April 1992, we implanted Telonics (Mesa, Arizona) CHP-2P transmitters into *H. platirhinos* following the procedures of Reinert (1992) and monitored the activities of snakes daily. In early spring 1993 we had monitored female no. 1 (65.5 cm SVL, 219 g) since 10 April 1992. She overwintered 1 December 1992–8 March 1993 in a small mammal burrow near the edge of an open woodland adjacent to an approximate 0.5 ha old field in a sand/dirt quarry. From 9 March to 5 May 1993 she either was inactive under grass/surface litter or basked on warm days in an old field/woodland ecotone. On 21–23 April three untelemetered male *H. platirhinos* were found accompanying her generally staying within 1 m. On 6 May the female shed and for the next 11 d was generally more active as she moved around in the old field. On 17 May she began moving west, parallel to a narrow dirt road and away from the quarry. On 18 May she had traveled about 200 m away from the quarry. A male captured in the quarry old field and equipped with a transmitter on 10 April 1993 (no. 5, 47.5 cm, 111 g) was active in the old field until 18 April at which time it left and followed closely the path taken by the female. On 19 May the two snakes were within 100 m of each other and 500–600 m from the quarry. At 1800 h on the next day, they were found copulating at a site alongside the road 600 m from the quarry. Both snakes feigned death when disturbed, after which the larger female dragged the male with her about 65 m before they separated. The female spent the remainder of the activity season (April–September) in the general vicinity. On 9 June, after an extended inactive period which included shedding, the male began moving back east along the road. In two days he passed the quarry and then moved north about 1500 m where he spent the remainder of the activity and winter seasons. The boundaries of the 1993 summer home ranges (determined by convex polygons) of the two snakes were separated by at least 750 m.

The second set of observations began at 1700 h on 12 October 1993 when an untelemetered male (46 cm, 99 g) was found courting a telemetered female (no. 10, 68 cm, 157 g) along a fencerow of trees at the edge of a pasture. The female had been monitored since 2 July 1993 and had last shed on 30 July. The extensive tongue flicking, mounting, and intertwining of tails that we observed suggests that courtship had progressed at least to the tactile-alignment phase (Gillingham, 1987). Although we could not visually confirm copulation, on 13 October we examined cloacal fluid under magnification and found copious quantities of sperm in both snakes. The male was equipped with a transmitter (no. 13). Both snakes were active for the next several weeks in the general vicinity and overwintered in small mammal burrows within 50 m of each other.

The third set of observations also concerned snakes nos. 10 and 13 after they emerged from hibernation in 1994. At 1430 h on 19 March 1994 the male was found intertwined with the female at her hibernaculum site. Because the female had moved <1 m from her hibernaculum since emergence on 19 March, the rapid location (within 1 d) of her by the male suggests either his memory of visual landmarks from the previous fall, the detection of an old pheromone trail (Ford, 1986), or the possible detection of air-borne volatile pheromones (Weldon et al., 1992). On 20 March the female began moving on a daily basis primarily along the edge of the pasture. Each time we checked the two snakes over the next 5 d, the male was within 20 m of the female and often closer. On 25 March the snakes went their separate ways. We never observed copulation, but both snakes contained copious quantities of cloacal sperm when checked on 26 March. The last time the female had shed was 30 July 1993.

The fourth set of observations occurred in April 1994 and again concerned female no. 10 and also male no. 8 (48 cm, 98 g) which had been monitored since 6 May 1993. On 18 April the male was found coiled within <1 m of the female in an open forest-old field ecotone. The site was within the known home range of the male and about 1200 m from the site of the female's encounter with male no. 13 in early April. The male accompanied the female within several meters over the next 6 d. At 1530 h on 21 April one of us (MVP) was tracking the female when the male quickly moved within 40 cm of MVP's feet apparently unaware of his presence. The male was rapidly tongue-flicking and moved in a shallow zig-zag path toward the female which was hidden under leaf litter about 5 m away. Copulation was not observed. The last time female no. 10 had shed was 30 July 1993.

Several workers (reviewed by Platt, 1969) have encountered copulating *H. platirhinos* in the field both in the spring and fall, but this paper is the first report of trailing in this species. Our observations of accurate trailing associated with mating suggest that trailing is the mechanism by which male *H. platirhinos* locate females and that the increased frequency and distance of movement by males, especially in the spring (Plummer, unpubl. data), would increase the chance of locating the trail of a female. Because trailing occurred at various times well after shedding by the female, it does not appear that the ability of males to trail is dependent on shedding.

Most snakes appear to be polygynous with females mating with >1 male (Duvall et al., 1992). Because male snakes often accompany females for several days prior to courtship and copulation, accompaniment can serve as an index of potential mating success (Duvall et al., 1992). Two observations are consistent with the notion that female *H. platirhinos* mate with >1 male. One is that female no. 10 apparently copulated with male no. 13 and then less than two weeks later was accompanied by male no. 8 for over a week. The second is that female no. 1 was accompanied by two males over a period of several days and then copulated with a third male a month later.

Acknowledgments.—We thank J. Hollaway and S. Hensen for allowing us to work on property under their charge, N. Ford for commenting on the manuscript, and J. Demuth, B. Leung, and J. Moon for con-

tributing in various ways. This study was supported in part by summer research grants from Harding University.

LITERATURE CITED

- DUVALL, D., S. J. ARNOLD, AND G. W. SCHUETT. 1992. Pitviper mating systems: ecological potential, sexual selection, and microevolution. In J. A. Campbell and E. D. Brodie (eds.), *The Biology of Pitvipers*, pp. 321-336. Selva Publ. Co., Tyler, Texas.
- FORD, N. B. 1986. The role of pheromone trails in the sociobiology of snakes. In D. Duvall, D. Muller-Schwarze, and R. M. Silverstein (eds.), *Chemical Signals in Vertebrates*, Vol. 4, pp. 261-278. Plenum, New York.
- GILLINGHAM, J. C. 1987. Social behavior. In R. A. Seigel, J. T. Collins, and S. S. Novak, (eds.), *Snakes: Ecology and Evolutionary Biology*, pp. 184-209. McGraw-Hill, New York.
- MASON, R. T. 1992. Reptilian pheromones. In C. Gans and D. Crews (eds.), *Biology of the Reptilia*, Vol. 18, pp. 114-228. Univ. Chicago Press, Chicago.
- PLATT, D. R. 1969. Natural history of the hognose snakes *Heterodon platyrhinos* and *Heterodon nasicus*. Univ. Kansas Publ. Mus. Nat. Hist. 18:253-420.
- REINERT, H. K. 1992. Radiotelemetric field studies of pitvipers: data acquisition and analysis. In J. A. Campbell and E. D. Brodie (eds.), *The Biology of Pitvipers*, pp. 185-197. Selva Publ. Co., Tyler, Texas.
- SLIP, D. J., AND R. SHINE. 1988. The reproductive biology and mating system of diamond pythons, *Morelia spilota* (Serpentes: Boidae). *Herpetologica* 44:396-404.
- WELDON, P. J., R. ORTIZ, AND T. R. SHARP. 1992. The chemical ecology of crotaline snakes. In J. A. Campbell and E. D. Brodie, Jr. (eds.), *Biology of the Pitvipers*, pp. 309-319. Selva, Tyler, Texas.

Accepted: 10 October 1995.

Journal of Herpetology, Vol. 30, No. 1, pp. 82-85, 1996
Copyright 1996 Society for the Study of Amphibians and Reptiles

Diet of *Xenopus fraseri* (Anura, Pipidae)

L. DE BRUYN,¹ M. KAZADI² AND J. HULSELMANS,¹
¹Department of Biology, University of Antwerp (RUCA),
Groenenborgerlaan 171, 202 O Antwerpen, Belgium, and
²Station d'écologie tropicale de Masako, Faculté des sciences/UNIKIS B.P. 122, Kisangani, Zaire.

Clawed frogs (genus *Xenopus*) are widely distributed in tropical and southern warm temperate Africa (Loumont, 1984). The life history, general biology, and ecology of clawed toads have been the topic of numerous investigations, although most studies have been confined to *X. laevis* Daudin (Deuchar, 1976). All species of the genus are aquatic anurans, and this is reflected in the highly specialized behavioral and morphological adaptations to move, reproduce, and feed in aquatic environments (Deuchar, 1976). For

example, adult representatives of the family Pipidae are characterized by the lack of a tongue and use a hyobranchial pumping mechanism to carry food into the mouth (Sokol, 1969; Duellman and Trueb, 1985).

Clawed toads eat a wide variety of aquatic invertebrates (Kalk, 1960; Inger and Marx, 1961; Arnault and Lamotte, 1968; Tinsley, 1973; Simmons, 1985; Kazadi et al., 1986). Under certain circumstances, xenopods may feed on fishes, or even on conspecific tadpoles and eggs (Buxton, 1936; Savage, 1963; McCoid and Fritts, 1980). *Xenopus fraseri* is more or less confined to the belt of equatorial rain forest of West Africa (Perret, 1966; Inger, 1968). No data are available concerning the diet or feeding behavior of *X. fraseri*. We examined the diet of *X. fraseri* in a natural population to determine which types of prey were ingested and whether diets differ between individuals of different ages or sexes.

Xenopus fraseri were collected on 12 December 1984 by bailing out a small, artificial temporary pond (± 10 m²) at the 'Station d'Ecologie Tropicale' of Masako, Zaire (altitude ± 396 m). The captured toads were immediately anaesthetized with chloroform and stored in formalin. In the laboratory the toads were separated in juveniles (freshly transformed) and adults and sexed. No tadpoles were present in the pond. Juvenile toads could be distinguished by the presence of traces of gill slits and/or the remnant of a tail, and the developmental state of the internal reproductive organs. Adult females could be recognised by the presence of individualised and distinctly colored eggs (ovaries of juvenile females did not contain eggs, or when present, were clumped into an undefined mass). Adult male *X. fraseri* contained well-developed testes (≥ 1 mm); testes of juvenile males are distinctly smaller. Snout-vent length, head length, and head width of all toads were measured with a vernier calliper up to 0.1 mm.

Stomachs were excised and analyzed. Prey items were identified to family level when possible. The number of individuals of each type was recorded. For each taxon, the frequency of occurrence (number of stomachs containing that particular taxon divided by the total number of stomachs analyzed) was calculated according to Lescure (1971). Additionally, we calculated the total number of food items (percent contribution of each prey taxon to the total number of prey items found in all stomachs). A R \times C test of independence followed by an a posteriori unplanned test of homogeneity of replicates (Sokal and Rohlf, 1981) was used to test for differences in diet among the four groups (C: adult male and females, juvenile male and females) based on the 14 major food taxa (R).

A total of 91 *X. fraseri* was sampled, represented by 52 juveniles (32 males, 20 females) and 39 adults (23 males, 16 females). Examination of the general sample diet (Table 1) reveals that *X. fraseri* mainly fed on arthropods. Four major arthropod taxa were found in most of the *Xenopus* stomachs (frequency) and in high numbers (total number); branchiopods (36.98%), aquatic coleopteran larvae (19.31%), dipteran larvae (dominated by Culicidae, 14.21%, and Ceratopogonidae, 4.37%) and Formicidae (10.02%). Anisopteran larvae (4.19%) occurred relatively frequently.

Stomach contents of *X. fraseri* revealed a clear overall difference (developmental stage and sex com-