Mosimann, J.E. and J.R. Bider. 1960. Variation, sexual dimorphism, and maturity in a Quebec population of the Common Snapping Turtle, *Chelydra serpentina*. *Canadian Journal of Zoology* 38:19–38.

Pearse, A.S. 1923. The abundance and migration of turtles. *Ecology* 4:24–28 (corrected by Petokas 1981).

Petokas, P.J. 1981. A.S. Pearse's density estimates for turtles: The correction of a long-standing error. *Bulletin of the Maryland Herpetological Society* 17:68–70.

Reehl, M., J. Thompson, and J.K. Tucker. 2006. A three-year survey of aquatic turtles in a riverside pond. *Transactions of the Illinois State Academy of Science* 99:145–152.

Smith, G.R., J.B. Iverson, and J.E. Rettig. 2006. Changes in a turtle community from a northern Indiana lake: A long-term study. *Journal of Herpetology* 40:180–185.

Stone, P.A., S.M. Powers, and M.E. Babb. 2005. Freshwater turtle assemblages in central Oklahoma farm ponds. *Southwestern Naturalist* 50:166–171.

Tucker, J.K. and J.T. Lamer. 2004. Another challenge in snapping turtle (*Chelydra serpentina*) conservation. *Turtle & Tortoise Newsletter* 8:10–11.

Yntema, C.L. 1979. Temperature levels and periods of sex determination during incubation of eggs of *Chelydra serpentina*. *Journal of Morphology* 159:17–28.

Some Natural History Notes on the Brooding Behavior and Social System of Two Oklahoma Skinks, *Plestiodon fasciatus* and *Plestiodon obtusirostris*

Cybil N. Cavalieri and Stanley F. Fox

Department of Zoology, Oklahoma State University, Stillwater, Oklahoma 74078, USA

Photographs by the senior author.

The purpose of this study was to quantify the social and reproductive behavior of *Plestiodon fasciatus* and *P. obtusirostris*. We conducted laboratory experiments with brooding behavior and field experiments to test for mate-guarding and territoriality. To determine the use of space by both species, we conducted a mark-recapture study. We constructed two permanent 1-ha trapping grids of can pitfall traps and cover-boards, with an inter-trap distance of 10 m. One was in a mixed woodland-grassland habitat and one in a grassland habitat. We manipulated the hydric environment to determine parental behavior of brooding female *P. obtusirostris*. We size-matched male *P. fasciatus* and *P. obtusirostris* for dyadic encounters with and without females and both on and off home ranges in order to determine social behavior. Change in hydric conditions did not induce female *P. obtusirostris* to move eggs to more suitable nest sites in our experiments. *Plestiodon fasciatus* exhibited behavior associated with mate-guarding. *Plestiodon obtusirostris* did not display behavior associated with territoriality, and our experiment examining mate-guarding calls for a more intensive study.

Natural history is ultimately the foundation of all research at the organismal level. Without a basic understanding of a species' natural history, conclusions regarding the toxicology, population genetics, developmental biology, or physiology of that species cannot be drawn, nor can any knowledge in these fields or others be placed in proper context. Yet the study of natural history has increasingly become less popular in lieu of more specialized fields. The bloom of natural history studies dealing with herpetofauna in the United States mostly took place in the 1940s and 1950s. These days, natural history information on U.S. herpetofauna is still gathered, but usually subsidiary to other main objectives, such as conservation status, ecological genetics, or phylogeography. The herpetofauna of the United States is arguably the most well known in the world. Despite this and the fact that *Scincella lateralis*, for example, is one of the most common lizards in the southeastern United States, little is known of its ecology (most of which is anecdotal), and what research has been done is contradictory (Fitch and Greene 1965, Lewis 1951, Fitch 1970, Collins and Conant 1998).

Much of our current knowledge of skink natural history is built upon anecdotal evidence based on single observations without regard to the rigor of the account; very little of our knowledge is based on detailed field studies or experimental work. The recent taxonomic elevation of *Plestiodon septentrionalis* subspecies into the full species *P. septentrionalis* and *P. obtusirostris* (Powell et al. 1998) raises the question of whether these two species might differ in their natural history and behavior. *Plestiodon obtusirostris* reportedly exhibits coiling around and brooding of eggs, manipulation or retrieval of eggs, communal care of eggs or young, and, because it is a close relative of *P. septentrionalis*, possibly shows hydroregulation and thermoregulation of the nest site, oophagy of bad or unfertilized eggs, parental assistance and

Cover-board being checked for skinks at the grassland site near Stillwater, Oklahoma.

grooming of neonates during hatching, and care of neonates (Somma 1985, Somma 2003).

In recent years, some skink taxa, for example *P. laticeps,* have been shown to exhibit mate-guarding (Cooper and Vitt 1993, Cooper 1999). Mate-guarding is the social system in which a male associates with a female after copulation in order to prevent rival males from obtaining subsequent copulations via intrasexual selection (Cooper and Vitt 1993, Birkhead and Møller 1998). On the other hand, territoriality is the social system exhibited most commonly in lizards. Territoriality is a system of space use in which a defined area and the resources within (including mates) are defended from conspecifics (Stokes 1974). We do not know if mate-guarding, territoriality, or some other form of social organization is present even in the common North American skinks that often occur in close proximity to humans and their yards and gardens. This is especially true of the recently-elevated *P. obtusirostris. Plestiodon obtusirostris* males and females often are found in the same refuge and most of the species' ecology resembles that of *P. fasciatus* (Breckenridge 1944). However, the social system of even the more intensely studied *P. fasciatus* is ambiguous. Fitch (1954) suggested that *P. fasciatus* could not exhibit territoriality due to the habitat constraint of visual obscurity, preventing the detection of intruders into the territory, but this was never tested. *Plestiodon fasciatus* females have been reported to breed with multiple males in a matter of just a few days (Fitch 1970), an observation that argues against mate-guarding.

The purpose of this study was to quantify the social and reproductive behavior of *P. fasciatus* and *P. obtusirostris.* We conducted laboratory experiments to test for brooding behavior and field experiments to test for mate-guarding and territoriality.

Methods and Results

We constructed two permanent 1-ha trapping grids of can pitfall traps and cover-boards, with an inter-trap distance of 10 m, near Oklahoma State University in Payne County, Oklahoma: One in a mixed woodland-grassland habitat and one in a grassland habitat. Can traps were 978-ml metal cans buried in the soil so the lid of the can was flush with the surface. Traps had perforated bottoms and the cavities beneath the cans were lined with gravel to facilitate drainage. Wooden lids supported above can-traps furnished shade for trapped animals. Traps were checked every other day. At each site, we also had 100 cover-boards (1.22 x 0.61 m) placed between the can traps. Skinks were captured by hand under cover-boards on the sites, under debris, or moving in the litter. Sex, mass, head-body (SVL) and tail length, and age class of skinks captured for the first time were recorded and they were toe-clipped and implanted with a PIT tag (see below). Date, time, and location were also recorded for these first-time subjects, and for subsequent relocations. Animals were released 3 m from the trap in a random direction, or at the point of capture if captured by hand. Can traps were closed during inclement weather or when not in use.

Skink after being implanted with a PIT-tag. Notice the small incision site.

Table 1. Behavior exhibited by *Plestiodon* during dyadic interactions.

Behavior	Weighted Score
Approach	1.0
Bite	1.0
Supplant	1.0
Superimposition	1.0
Tail wag low to ground	0.5
Tongue flick	0.5
Flee	-1.0

Individual skinks were uniquely marked by toe clipping and those >40 mm in SVL and in good body condition were also implanted with a 8.5 x 2.12-mm PIT tag (Passive Integrated Transponder — a miniature transponder that emits a unique number when activated by a radio signal in the portable antenna). Subjects with PIT tags survived as well as those marked in other ways and appeared to show normal behavior in all respects. Skinks are small and delicate and repeated handling can be detrimental, causing stress, tail autotomy, or other injuries. The PIT tags were used to identify skinks that escaped into litter or were hidden under the cover-boards, without the stress of hand capture (Cavalieri and Fox, in review).

Egg-brooding.—The goal of this laboratory experiment was to describe egg-brooding in *P. obtusirostris* and to test for increased egg survival under induced suboptimal moisture conditions through parental care by the mother. If the mother moves the eggs from a suboptimal nest site to an optimal nest site, this is evidence of parental care. Anecdotal accounts report that female *P. laticeps* and *P. fasciatus* will move a nest when flooded by a natural rain event (Vitt and Copper 1989). We wanted to determine if female *P. obtusirostris* would do the same.

During spring 2008, we made multiple relocations of a female *P. obtusirostris* under a single cover-board. She was first captured on 19 May 2008. All subsequent relocations of this individual were made by using the PIT-tag reader to scan the cover-board. She was relocated six times at cover-board 81 on the grassland site. On 26 May, the female was found in a cavity under that cover-board. On 26 June 2008, the female, 16 eggs, and natal soil were excavated and removed to the laboratory. The nest was placed inside a plastic shoebox within a 37.9-l aquarium, with the natal soil spread over the bottom of the shoebox. The eggs were placed at one end within a depression and lightly covered with soil. A semi-transparent red glass tile was placed over the soil to act as a cover object but allow viewing of the female and eggs without disturbance. The female was placed in the shoebox and she had freedom to move from the shoebox to the surrounding aquarium space. The laboratory was maintained at 22–25 °C and was illuminated by normal overhead fluorescent ceiling lighting, supplemented by 40-watt Vitalites© over racks of aquaria. In addition, we mounted a 40-watt incandescent bulb for added warmth 20 cm over the shoebox in the aquarium containing the lizard. The female was fed crickets in the aquarium space and given water every other day. After one week, the female had rearranged the eggs and was brooding them. At this point, we added deionized water to one end of the shoebox to induce an excessively hydric state without standing water. We kept the soil moisture high by adding 200 ml of water as needed, usually every other day. The opposite end of the shoebox soil remained at the same moisture level as the excavated natal soil by means of a vertical waterproof cardboard divider that extended to just below the surface of the soil, thereby giving the female opportunity to move her eggs from the over-wetted end to the other end with optimal con-

Hatchling *Plestiodon obtusirostris* emerging from eggs.

Hatchling *Plestiodon obtusirostris.*

ditions. However, the female did not move her eggs. The eggs hatched six days later. Between 1700 h on 8 July and 1500 h on 9 July, five hatchlings emerged from the eggs over a 2-day period. They were lethargic and sickly. None survived past the 24th day after hatching.

The following summer, while monitoring cover-boards, we found 17 small, freshly laid eggs on top of the ground near a shallow depression under a cover-board at 1215 h on 11 June 2009. We first believed them to be *Aspidoscelis* eggs, because they were small, oblong, and lying on top of the ground; *Aspidoscelis* was the second-most common lizard in the area next to skinks. We carefully replaced the cover-board, and when we returned at 1535 h, the eggs were buried in the depression and covered. As we carefully excavated the chamber, an adult skink bolted from the chamber. We carefully replaced the cover-board, backed up several paces, and waited about 10 min before quickly lifting the cover-board and capturing the adult, which was readjusting the disturbed nest. It was an adult female *P. obtusirostris,* which we placed in a cloth bag and stowed in an ice chest for transport. We also carefully removed the nesting chamber, including the eggs and natal soil, and took them directly to the laboratory. We placed the natal soil in a three-chambered nesting box within a 37.9-l aquarium. As above, we placed the eggs in one end chamber of the nesting box in a cavity of natal soil covered lightly with soil and the overlaid semi-transparent red glass tile. The area surrounding the nesting box was filled with moistened peat moss so that it was level with the nesting box. We released the female into the aquarium, and maintained her under the same conditions as described above. The female skink and eggs were left undisturbed for one week to allow the female to start brooding the eggs once more. At that time, the female had clearly rearranged the eggs and was actively brooding. Again, the side of the nest box with the eggs was flooded by adding 200 ml of deionized water and kept excessively moist by periodic addition of water. After 21 days, when it became apparent that the eggs had died and that the female had abandoned brooding, the trial was stopped. As in the previous trial, the female did not move the eggs.

Mate-guarding.—At least one species of North American skink (*P. laticeps*) is not territorial. Instead, males move around an area in search of receptive females, with which they mate and then guard against rival males (Cooper 1999). We wanted to test for mate-guarding in *P. fasciatus* and *P. obtusirostris.* If mate-guarding were exhibited, we expected: (1) Males attending females to act more aggressively toward introduced males than males not attending, and (2) territoriality would not be in evidence (see below).

Plestiodon fasciatus.—Once home ranges were established by multiple locations of identified individuals on the study site, size-matched male skinks were paired for dyadic encounters. We introduced a resident male *P. fasciatus* without a female into an arena (0.75 x 0.75-m hardware cloth cage with 6.4-mm mesh) overnight, positioned the arena on the ground at the cover-board of last capture, and put the cover-board on top of the arena for shade. The resident was allowed 24 h to acclimate to the arena before an intruder male *P. fasciatus* from at least 20 m distant was placed in the arena. After a 10-min acclimation period, we conducted a 30-min trial. Behavior was scored by using pre-assigned weighted values for specific types of behav-

Three-chambered nest box used in the second experiment with the brooding female *Plestiodon obtusirostris.*

ior (Table 1), and level of aggression followed Fox and Baird (1992) and Husak and Fox (2003). After the trial, the intruder was removed and the resident was left in the arena overnight with a female collected from no more than one cover-board away from the resident (within the resident's home-range and thus presumably a mate). The intruder was kept in the laboratory for 24 h. The following day, the intruder male was introduced to the resident male and female. Again, after a 10-min acclimation period and a 30-min trial, behavior was scored as above. A sum of the weighted scores was calculated for each pair of males, and then compared in a pairwise fashion.

Our intent obviously was to conduct paired trials with a sizeable set of males, but inclement weather within a narrow time frame of opportunity to conduct these trials in the field worked against us. In the end, we managed to complete a paired trial with only one resident. The resident *P. fasciatus* showed more aggression toward the intruder with a female (resident, 8.0; intruder, 5.5) than without a female (resident, 1.5; intruder, 0.5). The resident male exhibited both aggressive and submissive behavior.

Plestiodon obtusirostris.—We size-matched males for dyadic encounters as above. A resident male *P. obtusirostris* and a female *P. obtusirostris* collected from no more than one cover-board away from the resident (within the resident's home-range, presumably a mate) were allowed to acclimate in the arena as above. An intruder male *P. obtusirostris* was introduced after 24 h and a 30-min behavioral trial was conducted after a 10-min acclimation period. At the end of the trial, we removed the female from the arena and released her. We kept the intruder male in the laboratory and the resident male in the arena overnight. After 24 h, the intruder male was reintroduced to the resident male and a behavioral trial was conducted as above. The sum of the weighted scores (Table 1) was calculated for each pair of males, and then compared in a pairwise fashion.

Unfortunately, for the same reasons as listed above, we completed one paired trial also for only one resident. The resident *P. obtusirostris* showed no aggressive behavior either with or without a female (both scores were 0). The intruder *P. obtusirostris* showed slightly more aggressive behavior with the female present (8 with female and 6 without female). The only aggressive behavior exhibited was approach and superimposition. No submissive behavior was exhibited.

Territoriality.—Many species of lizards are territorial (Martins 1995). Territoriality is indicated if home ranges are mutually exclusive with little overlap (i.e., defended home ranges). As such, residents in their own territories are more aggressive than when the same individuals become intruders in another lizard's territory. Additionally, under territoriality, residents in their home range are expected to exhibit similar levels of aggression toward an intruder whether they are in consort with a female or not.

Arena at the woodland site near Stillwater, Oklahoma.

Female *Plestiodon obtusirostris* and nesting experiment set-up. Eggs are visible beneath the semi-transparent red glass tile.

We conducted three paired field trials to test for territoriality in *P. obtusirostris* between 4 June and 11 June 2009. We placed a resident male into an arena (0.75 x 0.75-m hardware cloth cage with 6.4-mm mesh) at the cover-board where it was collected for a least an hour to acclimate before introducing a size-matched intruder male from at least 20 m away. After a 10-min acclimation period, we conducted a 30-min trial. Behavior was scored by using pre-assigned weighted values as before (Table 1), and level of aggression followed Fox and Baird (1992) and Husak and Fox (2003). At least an hour of recovery time was given to both males after each trial. After this time, the male that was the intruder in the earlier trial was placed in the arena on its home range, thereby becoming the resident. An hour for acclimation was allowed. The resident male from the previous trial was introduced into the arena, thereby becoming the intruding male in this second trial. Trials were conducted and scored as above and an aggressive score was calculated for each individual (aggressive score = number of aggressive motor patterns minus number of submissive motor patterns). Aggressive scores as an intruder and as a resident for each individual were a pair for the Wilcoxon signed-rank test. No hint of territoriality was evident ($Z = -0.52$, $P = 0.60$, 6 pairs).

Discussion

As a consequence of logistical problems, mostly associated with unsuitable weather and a very short window of opportunity for field and laboratory experiments, our sample size is extremely limited. Nevertheless, because so little is known about the brooding behavior and social organization of *Plestiodon obtusirostris* and *P. fasciatus*, we feel that our studies have done a little, at least, to advance our understanding of the natural history of these two skinks. Our experiments confirmed what Somma (2003) stated in his literature review, namely that *P. obtusirostris* coils around and broods eggs, as well as manipulates and retrieves eggs. Both females rearranged the eggs after we placed them in the nesting chambers; however, we were unable to determine from our experiments if *P. obtusirostris* exhibits supplemental parental care as reported in sister taxa, such as communal care of eggs or young, hydroregulation and thermoregulation of the nest site, oophagy of bad or unfertilized eggs, parental assistance and grooming of neonates during hatching, and care of neonates (Somma 1985, 2003). We did not see any evidence that female *P. obtusirostris* will move eggs to a more hydrologically suitable nest site as other congeners are reported to do, but our sample size was too small to draw conclusions. We suspect that the first female did not move her eggs in response to the treatment of her nest site with excess moisture because the eggs were too close to hatching (hatching six days after treatment). On the other hand, we expected that the second female would

Male *Plestiodon obtusirostris* before dyadic interaction.

move her eggs in response to the same treatment because these eggs were much younger and the benefit of moving the eggs to a better site would seem to outweigh the risk of damaging developing embryos (i.e., moving them would have greater impact on their survival since they had to remain in the nest longer). Other studies have suggested that brooding behavior increases survival of eggs in changing hydric environments (Fitch 1954, Telford 1959, Fitch and Fitch 1974). Somma (1985) noted a significant difference in female *P. septentrionalis* contact with eggs and behavior three days after ovipositing, depending on soil moisture conditions. Lang (1990) showed that female *P. septentrionalis* will move eggs away from overly warm or cold temperatures to more favorable sites. We suggest that more effort should be placed into quantifying the brooding behavior of *P. obtusirostris*. The natural history of *P. obtusirostris* and its relatives has been neglected despite the fact that these lizards exhibit active parental care, a behavior rare in reptiles (Somma 2003). We would certainly benefit from knowing whether all of the skink species in North America exhibit egg-brooding, if some have developed it to a greater extent than others, and, indeed, if egg-brooding independently evolved more than once (De Fraipont and Barbault 1996).

With respect to social organization, our single trial with *P. fasciatus* showed some evidence for mate-guarding: the resident male was more aggressive with a female present than without. Further study obviously is needed, but this one trial suggests that mate-guarding might be part of the social system in this species. The interaction with *P. obtusirostris* showed no strong evidence of mate-guarding, but a little more aggression was shown when a female was present. Nevertheless, we do not believe that this one interaction says much about the mating system of *P. obtusirostris*. On the other hand, *P. obtusirostris* showed no hint of territoriality. This is not surprising given that the better-studied congener, *P. laticeps,* exhibits mate-guarding (Cooper and Vitt 1993), not territoriality. For future studies, we again suggest that efforts focus on mate-guarding in these species.

Formal natural history studies in the field are often difficult to conduct properly because they require the coordination of many different free-ranging animals and a bit of luck, but the knowledge gained is invaluable. Secretive animals compound the problem, and the natural history of these secretive skinks has been neglected. To offset the difficulty of field experiments, we suggest that laboratory experiments first be conducted, such as the rich set of laboratory experiments conducted by Jaeger and his students on salamander aggression (e.g., Jaeger 1984, Gabor and Jaeger 1995, Kohn et al. 2005). Subsequently, one can take the knowledge and experience gained from the laboratory to the field and verify the behavior in a more natural setting. Our collective knowledge and technology has advanced since the yesteryear bloom of natural history. We should finish what we started then and take a second look at what we think we know through new eyes.

Literature Cited

Birkhead, T.R. and A.P. Møller. 1998. *Sperm Competition and Sexual Selection*. Academic Press, San Diego, California.

Breckenridge, W.J. 1944. *The Amphibians and Reptiles of Minnesota*. University of Minnesota Press, Minneapolis.

Conant, R. and J.T. Collins. 1998. *A Field Guide to Reptiles & Amphibians: Eastern and Central North America*. Third edition, expanded. Houghton Mifflin Company, Boston, Massachusetts.

Cooper, W.E., Jr. 1999. Tradeoffs between courtship, fighting, and antipredatory behavior by a lizard, *Eumeces laticeps*. *Behavioral Ecology and Sociobiology* 47:54–59.

Cooper, W.E., Jr. and L.J. Vitt. 1989. Maternal care in skinks (*Eumeces*). *Journal of Herpetology* 23:29–34.

Cooper, W.E., Jr. and L.J. Vitt. 1993. Female mate choice of large male Broad-headed Skinks. *Animal Behaviour* 45:683–693.

De Fraipont, M. and C.R. Barbault. 1996. The evolution of oviparity with egg guarding and viviparity in lizards and snakes: A phylogenetic analysis. *Evolution* 50:391–400.

Fitch, H.S. 1954. Life history and ecology of the Five-lined Skink, *Eumeces fasciatus*. *University of Kansas Publications, Museum of Natural History* 8:1–156.

Fitch, H. S. 1970. Reproductive cycles in lizards and snakes. *University of Kansas Museum of Natural History Miscellaneous Publication* (52):1–247.

Fitch, H .S. and A.V. Fitch. 1974. Preliminary experiments on physical tolerances of the eggs of lizards and snakes. *Ecology* 48:160–165.

Fitch, H.S. and. H.W. Greene. 1965. Breeding cycle in the Ground Skink, *Lygosoma laterale*. *University of Kansas Publications, Museum of Natural History* 15:565–575.

Fox, S.F. and T.A. Baird. 1992. The dear enemy phenomenon in the collared lizard, *Crotaphytus collaris*, with a cautionary note on the experimental methodology. *Animal Behaviour* 44:780–782.

Gabor, C.R. and R.G. Jaeger. 1995. Resource quality affects the agonistic behavior of territorial salamanders. *Animal Behaviour* 49:71–79.

Husak, J.F. and S.F. Fox. 2003. Spatial organization and the dear enemy phenomenon in adult female collared lizards, *Crotaphytus collaris*. *Journal of Herpetology* 37:211–215.

Jaeger, R.G. 1984. Agonistic behavior of the Red-backed Salamander. *Copeia* 1984:309–314.

Kohn, N.R., R.G. Jaeger, and J. Franchebois. 2005. Effects of intruder number and sex on territorial behavior of female Red-backed Salamanders (*Plethodon cinereus*: Plethodontidae). *Journal of Herpetology* 39:645–648.

Lang, J.W. 1990. Behavioral thermoregulation of eggs by Prairie Skinks [abstract]. *American Society of Zoologists* 30:108A.

Lewis, T.H. 1951. The biology of *Leiolopisma laterale* (Say). *American Midland Naturalist* 45:232–240.

Martins E.P. 1995. Phylogenetic perspectives on the evolution of lizard territoriality, pp. 117–144. In: L.J. Vitt and E.R. Pianka (eds.), *Lizard Ecology: Historial and Experimental Perspectives*. Princeton University Press, Princeton, New Jersey.

Powell, R., J.T. Collins, and E.D. Hooper, Jr. 1998. *A Key to the Amphibians and Reptiles of the Continental United States and Canada*. University Press of Kansas, Lawrence.

Somma, L.A. 1985. Brooding behavior of the Northern Prairie Skink, *Eumeces septentrionalis septentrionalis* (Baird) and its relationship to the hydric environment of the nest substrate. Unpublished M.A. Thesis, University of Nebraska at Omaha.

Somma, L.A. 2003. *Parental Behavior in the Lepidosaurian and Testudinian Reptiles: A Literature Survey*. Krieger Publishing Company, Malabar, Florida.

Stokes, A.W. 1974. *Territory*. Dowden, Hutchinson & Ross, Stroudsburg, Pennsylvania.

Telford, S.R., Jr. 1959. A study of the Sand Skink, *Neoseps reynoldsi* Stejneger. *Copeia* 1959:110–119.