ARTICLES

Intraspecific Oophagy In Reptiles

Reptilian behavior has been the subject of voluminous reviews which summarize the abundant anecdotal literature. For instance, Carpenter and Ferguson (1977) reviewed the massive literature on mating, courtship, aggression, and social communication. Greene (1988) reviewed antipredator behaviors. Somma (1990) reviewed parental care. Published reports on oophagy range from brief notes of its occurrence to full descriptions of the behavior. In this paper we provide an updated review of the literature on oophagy in reptiles, a review of the hypotheses proposed to account for this behavior, and suggestions for reporting future observations.

Oophagy (technophagy – Hamilton 1958; prolicide – Auffenberg 1981; cannibalism – Heimlich and Heimlich 1947; Martof 1956; Fitch and Henderson 1978; Christian and Tracy 1982) has been used to refer to two different behavioral acts: 1) predation of the eggs of other vertebrate species by, for example, *Dasypeltis* of Africa (Gans 1952) and *Pituophis melanoleucus* in North America (Wright and Wright 1957) (interspecific oophagy), and 2) consumption of a female's own eggs, embryos, or extraembryonic membranes, or the consumption of the eggs of a conspecific female by other females or by males (intraspecific oophagy). The published literature reflects these two definitions.

The following list catalogs published and unpublished observations of intraspecific oophagy known to us through 1992. Details are provided when available to differentiate between consumption of the individual's own eggs and the consumption of them by a conspecific. Additional information is included if pertinent. Some of the reports noted only that the behavior occurred in the species; these are indicated as "captive" or "field" observations to distinguish between these two environments. A primary aim of this review is to stimulate additional reports of such behavior so that a more complete database is available for analyses of causes and benefits. Higher order taxonomy follows Zug (1993). Observations by us are noted by our initials.

Lacertilia

Anguidae: *Elgaria coerulea* – Females ate extraembryonic membranes (J. R. Stewart *in* Guillette and Hotton 1986; Somma 1990). *Gerrhonotus liocephalus* – A nest-guarding female apparently removed spoiled eggs from the nest (H. W. Greene *in* Tinkle and Gibbons 1977). *Ophisaurus attenuatus* – Brooding females sometimes eat their own eggs (Fitch 1970, 1989). A captive female consumed her own freshly-laid eggs (Vogt 1981). *Ophisaurus ventralis* – A field-collected specimen contained two conspecific eggs (Hamilton and Pollack 1961). A captive female consumed her entire clutch (Villiard 1969).

Gekkonidae: *Ailuronyx seychellensis* – captive (Slavens 1987). *Cosymbotus platyurus* – field (Church 1962). *Gehyra mutilata* – field (Church 1962). *Gekko petricolus* – Zaworski (1987) observed captive females consume infertile eggs and empty eggshells. *Hemidactylus brookii* – Bustard (1957) observed a male eating eggs of conspecific females in captivity. *Hemidactylus frenatus* – captive (Miller 1979); field (Church 1962). *Hemidactylus turcicus* – Captive females guarding their eggs were "overpowered" by conspecifics who ate their eggs (L. A. Somma, pers. comm.). *Lepidodactylus lugubris* – captivity (Miller 1979). JDG observed a wild female on Guam eat two eggs after she was disturbed. *Phelsuma dubia, P. laticauda,* and *P. madagascariensis* – Captive females of these species will eat empty egg shells after neonates hatch, ingest inviable eggs, and consume freshly-laid eggs when their diet is deficient in calcium (Osadnik 1984). *Phelsuma sundbergi* – One wild-caught individual contained an egg shell, "probably gecko," in its stomach (Evans and Evans 1980). *Ptychozoon kuhli* – captivity (JDG). *Ptyodactylus hasselquistii* – One egg was found in a wild-caught female (Perry and Brandeis 1992).

Helodermatidae: *Heloderma horridum* – captive (R. E. Honegger, pers. comm.; JDG). *Heloderma suspectum* – captive (R. E. Honegger, pers. comm.; JDG).

Iguanidae: *Anolis equestris* – A male dug up and ate the eggs of a female with which he had mated (Miller 1979). *Conolophus pallidus* – Field observation of a female eating eggs of conspecifics (Christian and Tracy 1982). *Conolophus subcristatus* – Captive males ate eggs of conspecific females (H. K. Snell, pers. comm.). *Ctenosaura similis* – field (Fitch and Henderson 1978).

Lacertidae: *Lacerta agilis* – Darevsky (1946) described oophagy by captive males. *Lacerta lepida* – captivity (Laferrere 1970). *Lacerta viridis* – captivity (Street 1979).

Scincidae: *Corucia zebrata* – Captive females ate extraembryonic membranes of their offspring (Honegger 1985; Wright 1991). Consumption of extraembryonic membranes was observed on several occasions at the Philadelphia Zoo (JDG). *Egernia cunninghami* – Females ate extraembryonic membranes (Niekisch 1975, 1980). *Eumeces anthracinus* – A captive female ate four of her eight eggs (Hamilton 1958). *Eumeces callicephalus* – An egg of a captive female was eaten by her or a conspecific cagemate (Zweifel 1962). *Eumeces egregius* – A captive female *E. e. onocrepis* ate one of her four eggs and a captive female *E. e. insularis* ate all five infertile eggs (L. A. Somma, pers. comm.). *Eumeces fasciatus* – One of 25 females consumed all of her eggs after being brought into captivity (Cagle 1940). A captive female consumed two of her own eggs (McCauley 1945). Fitch (1954) found two eggs in field-collected females. Groves (1982) described the oophagic behavior of this species and found that 20 of 21 eggs were eaten by their attendant captive females; the last egg was eaten by a conspecific female. Vitt and Cooper (1986) observed ingestion of both dead and live eggs by captive females but gave no data. *Eumeces inexpectatus* – A field-collected female contained one of her own eggs in her stomach (Hamilton 1958). Vitt and Cooper (1986) observed ingestion of both dead and live eggs by captive females but provided no specifics. A captive female ate an infertile egg of a clutch she was brooding (L. A. Somma, pers. comm.). *Eumeces laticeps* – A female brooding 15 eggs consumed twelve of them after being placed in a terrarium (Martof 1956). Among 15 females with broods in the laboratory, seven ate 1-3 of their own eggs and three consumed their entire clutches (Vitt and Cooper 1985). These authors also provided circumstantial evidence that a wild female consumed two of her 12 eggs in a nine day period. *Eumeces obsoletus* – A captive female consumed her own eggs (Burt 1928). *Eumeces okadae* – 19 of 272 eggs in natural nests were eaten by the attending females (Hasegawa 1985). *Eumeces septentrionalis* – Frequently-fed, captive females consumed their inviable eggs (Somma 1989a,b). *Eumeces skiltonianus* – Tanner (1957) provided circumstantial evidence that a wild female had consumed one of her eggs. *Leiolopisma otagense* – Females ate extraembryonic membranes (Smithells *in* Sharrell 1966). *Leiolopisma smithii* – Females ate extraembryonic membranes (Somma 1990). *Mabuya capensis* – Females were observed eating extraembryonic membranes (FitzSimons 1943; Rose 1929, 1950). *Mabuya macrorhyncha* – A captive female ate the extraembryonic membranes of her neonates (Reboucas-Spieker and Vanzolini 1978). *Scincella lateralis* – Captive females were frequently observed to eat eggs of conspecifics (L. A. Somma, pers. comm.). *Sphenomorphus quoyii* – Females tore extraembryonic membranes and presumably swallowed them (Shine 1988). *Tiliqua (Trachydosaurus) rugosa* – Captive females ate the extraembryonic membranes of their neonates (Hitz 1983; Mertens 1960).

Teiidae: *Ameiva corvina* – A captive female was observed carrying a slit and flaccid egg in her mouth (JCM). *Cnemidophorus sexlineatus* – A captive female dug up and ate two eggs of a conspecific (L. A. Somma, pers. comm.). *Cnemidophorus tesselatus* – Captive females were observed to dig up and eat eggs of conspecifics (L. A. Somma, pers. comm.). *Cnemidophorus uniparens* – On three occasions conspecifics consumed eggs of cagemates (Crews et al. 1983).

Varanidae: *Varanus bengalensis* – Deraniyagala (1953) mentioned this species eats the eggs of conspecifics. A male ingested eggs during two breeding seasons in captivity (W. Auffenberg *in* Slavens 1982). *Varanus exanthematicus* – Cissé (1972) found conspecific eggs in the stomach of a single field-collected specimen. *Varanus indicus* – 20 eggs of a female collected on Guam were ingested by a male or the female or both in captivity (JDG). *Varanus komodoensis* – Captive adult females ate eggs of conspecifics (Lederer 1942). Auffenberg (1981) observed this behavior in captive adult males. Other reports of oophagy in captives are in Brongersma (1932), Oesman (1967), and Galstaun (1973). *Varanus prasinus* – One of four eggs laid in captivity was eaten by an adult male (J. B. Murphy, pers. comm.). *Varanus salvator* – Captive males and females have been recorded eating conspecific eggs (R. E. Honegger, pers. comm.). A captive female consumed one of her own eggs at the Philadelphia Zoo (JDG).

Xantusiidae: *Xantusia henshawi* – A captive female ate the extraembryonic membranes of her neonate (Shaw 1949). *Xantusia vigilis* – Females ate extraembryonic membranes in captivity (Cowles 1944; Miller 1954).

Serpentes

Boidae: *Corallus enydris* – Captive females ate their own eggs after deposition (Jes 1984; Miller 1983). *Epicrates cenchria* – A captive female ate an undeveloped ovum (Boos 1976). A captive female ingested a dead neonate and its foetal membrane after nudging it with her snout (Groves 1981). *Epicrates striatus* – Captive females ate dead neonates and their membranes (Hanlon 1964; Huff 1980; Slavens 1987). Captive females have been observed to eat undeveloped ova, extraembryonic membranes, and dead neonates (Groves 1981). *Eryx colubrinus* – captive (Ross and Marzec 1990). *Eunectes murinus* – Neill and Allen (1962) described the feeding behavior of a captive female which ate 15 of 19 aborted embryos; the four live-born neonates were not eaten. Holstrom and Behler (1981) described the ingestion of extraembryonic membranes and an undeveloped egg in captive females. *Eunectes notaeus* – Captive females have been observed to eat infertile eggs (Holmstrom 1981; Slavens 1985, 1988; Townson 1985).

Colubridae: *Ahaetulla nasuta* – captive (Reippel 1970). *Cemophora coccinea* – Ditmars (1907) observed a captive female consume seven of eight eggs containing near-term embryos. Palmer and Tregembo (1970) observed one captive female swallow three eggs laid by a conspecific. *Elaphe scalaris* – captive (Leferrere 1970). *Heterodon nasicus* – captive (M. J. Kowak, pers. comm.). A captive female ate several of her own eggs on two separate occasions (Hammack 1991). *Lampropeltis triangulum* – An entire clutch was eaten by the resident captive male (J. B. Murphy, pers. comm.). A captive female was observed to regurgitate one of her eggs (Groves and Sachs 1973). *Leptodiera annulata* – A captive female consumed her entire clutch (Wehekind 1955). *Oligodon taeniolatus* – A recently captured female ate three eggs less than one hour after laying them (Minton and Anderson 1963).

Elapidae: *Naja naja* – Oophagy was presumed to occur based on Hindu scriptures dating to 600 B.C. (Rao 1957).

Pythonidae: *Python molurus* – A female was observed removing infertile or undeveloped ova from her clutch (Griehl 1984).

Viperidae: *Agkistrodon bilineatus* – A captive female ingested two dead neonates (and their extraembryonic membranes) of her own litter (JDG).

Testudines

Emydidae: *Clemmys muhlenbergii* – captive (Robotham 1963). Arndt (1977) noted that a captive female ate one of her own eggs after oviposition. *Terrapene carolina* – captive (Ernst and Barbour 1972; W. B. Love, pers. comm.).

Testudinidae: *Gopherus agassizii* – A captive female dug up and ate the eggs of a conspecific who had just completed nesting (Nichols 1953).

Crocodylia

Alligatoridae: *Alligator mississippiensis* – field (Kushlan and Simon 1981). Kellogg (1929) recorded three partially digested eggs in the stomach of a Louisiana specimen.

Crocodylidae: *Crocodylus niloticus* – Females were observed to pick up and eat eggs from nests, egg fragments were found in feces, and stomachs of several females killed contained eggs (Modha 1967; Welman and Worthington 1943). Cott (1961) found 87 conspecific eggs in the stomach of one individual.

Discussion

Intraspecific oophagy has been reported to occur in 58 species of lizards, 16 snakes, three turtles, and two crocodilians. In lizards, 59 observations (number of literature and personal observation records) occurred in captivity and 15 in the field, whereas all observations of snake and turtle oophagy were of captive specimens.

Oophagy is a specialized behavior not involving the active killing of another conspecific or consumption of carrion. Consumption of unhatched, late-term embryos might be considered cannibalism, but unhatched juveniles are unable to utilize defensive behaviors, whereas newly hatched neonates and those newly freed from embryonic membranes may possess innate defensive strategies, or visual or other cues that modify the predatory behavior of adult conspecifics. The hatching event is an adequate distinction between when the behavior should be called cannibalism or oophagy.

Intraspecific oophagy is probably a form of parental care when performed by females on their own eggs. Several hypotheses have been proposed to explain the causes of this behavior in brooding females.

Hunger/thirst hypothesis: Oophagy by the parental female may be caused by hunger (Cagle 1940) or a combination of hunger and thirst (Vitt and Cooper 1986). Fitch (1954) thought this behavior occurred in order to satisfy hunger without the female having to leave the nest.

Mistaken food hypothesis: Decomposing eggs may have a different odor than healthy eggs and females may mistake them for prey items (R. B. Huey *in* Shine 1988 p. 292).

Hygiene hypothesis: Oophagy by the brooding female may minimize the transfer of bacteria, fungi, and other harmful microorganisms from dead or infected eggs to viable eggs (Groves 1981, 1982; Shine 1988; Somma 1989, 1990; Tinkle and Gibbons 1977).

Predator avoidance hypothesis: Consumption of dead eggs by the female may reduce detection of the nest and attendant female by predators, presumably because of chemical cues released by rotting eggs and aborted ova (Groves 1982; Neill and Allen 1962; Somma 1990; Tinkle and Gibbons 1977).

Captive females of several species of *Phelsuma* ingested their own eggs after they were damaged experimentally, and when these animals were kept on a calcium deficient diet, they ate their eggs immediately after laying them (Osadnik 1984). Brooding captive female *Eumeces septentrionalis* will ingest mechanically killed or introduced rotten eggs and eggs swabbed with the contents of a rotten egg (Somma 1989). Brooding female *Eumeces fasciatus* will eat rotting eggs, even after consumption of insect prey (Groves 1982). These observations suggest that the hygiene and predator avoidance hypotheses may explain the causes of oophagy in brooding females of some species. However, dietary deficiencies may cause oophagy in other species. Data are lacking to more completely differentiate among the existing hypotheses. Oophagic behavior in brooding females may have multiple causes.

In addition to being a form of parental care, intraspecific oophagy is a form of predation when performed by conspecifics.

Hypotheses advanced to explain the causes of infanticide (Huntingford and Turner 1987) may also apply to the causes of oophagy. These are, as modified from Jenssen et al. (1989), (1) exploitation of eggs and aborted neonates in egg membranes as food, (2) elimination of potential population members as competitors for limited resources, (3) improved breeding opportunities for conspecific predators by removing non-related offspring in the embryo stage from prospective mates, and (4) improved inclusive fitness of parents by their selective killing of non-related offspring. In addition, intraspecific oophagy may be a method of density-dependent population regulation, as suggested for some cannibalistic lizards (Badir 1968; Jenssen et al. 1989; Mitchell 1986). None of the observations listed above, however, allows us to distinguish among these potential causes of oophagy by conspecifics.

Observations of oophagic behavior should be reported, but they should contain the circumstances within which the behaviors were performed, if they occurred in the field or in captivity, and whether a single individual (e.g., female parent) or a conspecific was involved. Consistent information and experiments on a variety of species could provide insights into the causes and benefits of these behaviors.

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Literature Cited

Arndt, R. G. 1977. Notes on the natural history of the bog turtle, *Clemmys muhlenbergi* (Schoepff), in Delaware. Chesapeake Sci. 18:67–76.

Auffenberg, W. 1981. The Behavioral Ecology of the Komodo Monitor. Univ. Press of Florida, Gainesville. x + 406 pp.

Badir, N. 1968. The effect of population density on the embryonic mortality in the viviparous lizard *Chalcides ocellatus* (Forsk.). Anat. Anz. Bd. 122:11–14.

Boos, H. 1976. Behavioral information needed. AAZPA Newsltr. 17:13.

Brongersma, L. D. 1932. Über die Eiablage und die Eier von *Varanus komodoensis* Ouwens. Zool. Garten Leipzig 5:45–46.

Burt, C. E. 1928. Insect food of Kansas lizards with notes on feeding habits. J. Kansas Entomol. Soc. 1:50–68.

Bustard, H. R. 1957. Observations on zonures and geckos in captivity. British J. Herpetol. 2:71–75.

Cagle, F. R. 1940. Eggs and natural nests of *Eumeces fasciatus*. Am. Midl. Nat. 23:227–233.

Carpenter, C. C., and G. W. Ferguson. 1977. Variation and evolution of stereotyped behaviors in reptiles. *In* C. Gans and D. W. Tinkle (eds.), Biology of the Reptilia, Vol. 7, Ecology and Behavior A, pp. 335–554. Academic Press, New York.

Christian, K. A. and C. R. Tracy. 1982. Reproductive behavior of Galapagos land iguanas (*Conolophus pallidus*), on Isla Santa Fe, Galapagos. *In* G.M. Burghardt and A. S. Rand (eds.), Iguanas of the World, Their Behavior, Ecology, and Conservation, pp. 366–379. Noyes Publ., Park Ridge, New Jersey.

Church, G. 1962. The reproductive cycles of the Javanese house geckos, *Cosymbotus platyurus*, *Hemidactylus frenatus*, and *Peropus mutilatus*. Copeia 1962:262–269.

Cissé, M. 1972. L' alimentation des varanidés au Sénégal. Bull. de 1'1 F.A.N., Ser. A 34:503–515.

Cott, H. B. 1961. Scientific results of an inquiry into the ecology and economic status of the Nile crocodile (*Crocodilus niloticus*) in Uganda and northern Rhodesia. Trans. Zool. Soc. London 29:211–356.

Cowles, R. B. 1944. Parturition in the yucca night lizard. Copeia 1944:98–100.

Crews, D, J. E. Gustafson, and R. R. Tokarz. 1983. Psychobiology of parthenogenesis. *In* R. B. Huey, E. R. Pianka, and T. W. Schoener (eds.), Lizard Ecology, Studies of a Model Organism, pp. 205–231. Harvard Univ. Press, Cambridge, Massachusetts.

Darevsky, I. S. 1946. On the biology of *Lacerta agilis*. Priroda [Nature], Moscow, 9:52–54. (in Russian).

Deraniyagala, P. E. P. 1953. A Colored Atlas of Some Vertebrates from Ceylon Vol. II. Tetrapod Reptilia. Government Press, Ceylon (Sri Lanka). 101 pp.

Ditmars, R. L. 1907. The Reptile Book. Doubleday, Page & Co., Garden City, New York. xxxii + 472 pp.

Ernst, C. H., and R. W. Barbour. 1972. Turtles of the United States. Univ. Press of Kentucky, Lexington. x + 347 pp.

Evans, P. G. H., and J. B. Evans. 1980. The ecology of lizards on Praslin Island, Seychelles. J. Zool., London 191:171–192.

Fitch, H. S. 1954. Life history and ecology of the five-lined skink, *Eumeces fasciatus*. Univ. Kansas Publ. Mus. Nat. Hist. 8:1–156.

_____. 1970. Reproductive cycles in lizards and snakes. Univ. Kansas Mus. Nat. Hist. Misc. Publ. (52):1–247.

_____. 1989. A field study of the slender glass lizard, *Ophisaurus attenuatus*, in northeastern Kansas. Occ. Pap. Mus. Nat. Hist. Univ. Kansas (125):1–50.

_____, and R. W. Henderson. 1978. Ecology and exploitation of *Ctenosaura similis*. Univ. Kansas Sci. Bull. 51:483–500.

FitzSimons, V. F. 1943. The Lizards of South Africa. Transvaal Mus. Mem. (1):1-528.

Galstaun, B. 1973. Eiablagen des Komodowarens (*Varanus komodoensis*) im Zoolgischen und Botanischengarten Jakarta. Zool. Garten Leipzig 43:136–139.

Gans, C. 1952. The functional morphology of the egg-eating adaptations in the snake genus *Dasypeltis*. Zoologica, N.Y. 37:208–244.

Greene, H. W. 1988. Antipredator mechanisms in reptiles. *In* C. Gans and R. B. Huey (eds.), Biology of the Reptilia, Vol. 16, Ecology B., pp. 1–152. Alan R. Liss, Inc., New York.

Griehl, K. 1984. Snakes, Giant Snakes and Non-venomous snakes in the Terrarium. First English Version, Barron's Educ. Series, Inc., Woodbury, NY. [Original title: Schlangen, 1982. Grafe und Unzer GmbH, Munich, Germany].

Groves, J. D. 1981. Observations and comments on the post-parturient behaviour of some tropical boas of the genus *Epicrates*. British J. Herpetol. 6:89–91.

_____. 1982. Egg-eating behavior of brooding five-lined skinks, *Eumeces fasciatus*. Copeia 1982:969–971.

_____, and P. S. Sachs. 1973. Eggs and young of the scarlet king snake, *Lampropeltis triangulum elapsoides*. J. Herpetol. 7:389–390.

Guillette, L. J., Jr., and N. Hotton, III. 1986. The evolution of mammalian reproductive characteristics in therapsid reptiles. *In* N. Hotton, III, P. D. MacLean, J. J. Roth, and E. C. Roth (eds.), The Ecology and Biology of Mammal-like Reptiles. pp. 239–250. Smithsonian Inst. Press, Washington, D.C.

Hamilton, W. J., Jr. 1958. Technophagy in the Florida five-lined skink. Herpetologica 14:28.

_____, and J. A. Pollack. 1961. The food of some lizards from Fort Benning, Georgia. Herpetologica 17:99–106.

Hammack, S. H. 1991. Life history: *Heterodon nasicus kennerlyi*. Herpetol. Rev. 22:132.

Hanlon, R. W. 1964. Reproductive activity of the Bahaman boa (*Epicrates striatus*). Herpetologica 20:143–144.

Hasegawa, M. 1985. Effect of brooding on egg mortality in the lizard *Eumeces okadae* on Miyaki-Jima, Izu Islands, Japan. Copeia 1985:497–500.

Heimlich, E. M., and M. G. Heimlich. 1947. A case of cannibalism in captive *Xantusia vigilis*. Herpetologica 3:149–150.

Hitz, R. 1983. Pflege und Nachzucht von *Trachydosaurus rugosus* Gray, 1827 im Terrarium (Sauria: Scincidae). Salamandra 19:198–210.

Holstrom, W. F., Jr. 1981. Observations on the reproduction of the yellow anaconda *Eunectes notaeus* at the New York Zoological Park. Int. Zoo Yrbk. 21:92–94.

_____, and J. L. Behler. 1981. Post-parturient behavior of the common anaconda, *Eunectes murinus*. Zool. Garden N.F., Jena 51:353–356.

Honegger, R. 1985. Additional notes on the breeding and captive management of the prehensile-tailed skink, (*Corucia zebrata*) (Sauria: Scincidae). Herpetol. Rev. 16:21, 23.

Huff, T. A. 1980. Captive propagation of the subfamily Boinae with emphasis on the genus *Epicrates*. *In* J. B. Murphy and J. T. Collins (eds.), Reproductive Biology and Diseases of Captive Reptiles, pp. 125–134. Soc. Study of Amph. Rept., Contrib. Herpetol. No 1. Athens, Ohio.

Huntingford, F. A., and A. K. Turner. 1987. Animal Conflict. Chapman and Hall, London. 488 pp.

Jenssen, T. A., D. L. Marcellini, K. A. Buhlmann, and P. H. Goforth. 1989. Differential infanticide by adult curly-tailed lizards, *Leiocephalus schreibersi*. Anim. Behav. 38:1054–1061.

Jes, H. 1984. Beobachtungen an einigan ovovivipar gebärenden Riesenschlangen (Boidae). Salamandra 20:268–269.

Kellogg, R. 1929. The habits and economic importance of alligators. U.S. Dept. of Agric., Tech. Bull. 147:1–36.

Kushlan, J. A., and J. C. Simon. 1981. Egg manipulation by the American alligator. J. Herpetol. 15:451–454.

Laferrere, M. 1970. Observations erpétologiques. Rivieria Scient. 1970:89–90.

Lederer, V. G. 1942. Der Drachenwaran (*Varanus komodoensis* Ouwens). Zool. Gart. Leipzig (n.s) 14:227–244.

Martof, B. 1956. A contribution to the biology of the skink *Eumeces laticeps*. Herpetologica 12:111–114.

McCauley, R. H., Jr. 1945. The Reptiles of Maryland and the District of Columbia. Privately published, Robert H. McCauley, Jr., Hagerstown, Maryland. 194 pp.

Mertens, R. 1960. The World of Amphibians and Reptiles. English translation. McGraw-Hill Book Co., New York, NY. 207 pp.

Miller, M. J. 1979. Oviphagia in the mourning gecko, *Lepidodactylus lugubris*. Bull. Chicago Herpetol. Soc. 14:117–118.

Miller, M. R. 1954. Further observations on reproduction in lizard *Xantusia vigilis*. Copeia 1954:38–40.

Miller, T. J. 1983. Life history: *Corallus enydris enydris*. Herp Rev. 14:46–47.

Minton, S. A., Jr. and J. A. Anderson. 1963. Feeding habits o Kukri Snake, *Oligodon taeniolatus*. Herpetologica 19:147.

Mitchell, J. C. 1986. Cannibalism in reptiles: A worldwide rev Soc. Stud. Amphib. Rept., Herpetol. Circ. 15:1–37.

Modha, M. L. 1967. The ecology of the Nile crocodile (*Croco niloticus* Laurenti) on Central Island, Lake Rudolf. E. Afr Wildl. J. 5:74–95.

Neill, W. T. and R. Allen. 1962. Parturient anaconda, *Eunectes* (Latreille), eating its own abortive eggs and foetal membr Quart. J. Florida Acad. Sci. 25:73–75.

Nichols, U. G. 1953. Habits of the desert tortoise, *Gopherus sizii*. Herpetologica 9:65–69.

Niekisch, M. 1975. Plege und Nachzucht von *Egernia cunning* (Sauria, Scincidae). Salamandra 11:130–135.

_____. 1980. Terraristische Beobachtungen zur Biologie von *nia cunninghami* (Reptilia: Sauria: Scincidae). Salamandra 16: 176.

Oesman, H. 1967. Breeding habits of *Varanus komodoensis* at Jogjakarta Zoo. Int. Zoo Yrbk. 7:10–11.

Osadnik, G. 1984. An investigation of egg laying in *Phels* (Reptilia: Sauria: Gekkonidae). Amphibia-Reptilia 5:125–1

Palmer, W. M., and G. Tregembo. 1970. Notes on the natural his of the scarlet snake, *Cemophora coccinea copei* (Jan), in N Carolina. Herpetologica 26:300–302.

Perry, G., and M. Brandeis. 1992. Variation in stomach conten the gecko, *Ptyodactylus hasselquistii guttatus* in relation to age, season and locality. Amphibia-Reptilia 13:275–282.

Rao, H. S. 1957. History of our knowledge of the Indian fa through the ages. J. Bombay Nat. Hist. Soc. 54:251–280.

Reboucas-Spieker, R., and P. E. Vanzolini. 1978. Parturitio *Mabuya macrorhyncha*, 1946 (Sauria, Scincidae), with a not the distribution of maternal behavior in lizards. Pap. A Zool. 32:95–99.

Rieppel, O. 1970. Nachwuchs bei *Dryophis nasutus* (Lacépède) Aqua Terra 7:85–88.

Robotham, G. R. 1963. The bog turtle, a gift of responsibi Philadelphia Herpetol. Soc. Bull. 11:68–70.

Rose, W. 1929. Veld and Vei. An Account of South African Fr Toads, Lizards, Snakes & Tortoises. Specialty Press of S Africa, Cape Town. xiii + 240 pp.

_____. 1950. The Reptiles and Amphibians of Southern Africa. Maskew Miller, Cape Town, South Africa. xxv + 378 pp.
ROSS, R. A., and G. MARZEC. 1990. The Reproductive Husbandry of Pythons and Boas. Instit. Herpetol. Research, Stanford, California. 270 pp.
SHARRELL, R. 1966. The Tuatara, Lizards, and Frogs of New Zealand. Collins, London, England. 94 pp., 52 color plates.
SHAW, C. E. 1949. Notes on two broods of xantusiids. Herpetologica 5:23–26.
SHINE, R. 1988. Parental care in reptiles. *In* C. Gans and R.B. Huey (eds.), Biology of the Reptilia, Vol. 16, Ecology B, pp. 275–329. Alan R. Liss, Inc., New York.
SLAVENS, F. L. 1982. Inventory of Live Reptiles and Amphibians in Captivity Current January 1, 1982. Privately published, Frank L. Slavens, Seattle, Washington. 197 pp.
_____. 1985. Inventory of Live Reptiles and Amphibians in Captivity Current January 1, 1985. Privately published, Frank L. Slavens, Seattle, Washington. 341 pp.
_____. 1987. Inventory of Live Reptiles and Amphibians in Captivity Current January 1, 1987. Privately Published, Frank L. Slavens, Seattle, Washington. 345 pp.
_____. 1988. Inventory, Longevity, & Breeding Notes – Reptiles and Amphibians in Captivity Current January 1, 1988. Privately published, Frank L. Slavens, Seattle, Washington. 401 pp.
SOMMA, L. A. 1989a. Oophagous behavior in brooding prairie skinks, *Eumeces septentrionalis*. Herpetol. Rev. 20:3–4.
_____. 1989b. Brooding behaviour of the prairie skink, *Eumeces septentrionalis*, and its relationship to the hydric environment of the nest. Zool. J. Linnean Soc. 95:245–256.
_____. 1990. A categorization and bibliographic survey of parental behavior in lepidosaurian reptiles. Smithsonian Herpetol. Infor. Serv. (81):1–53.
STREET, D. 1979. The Reptiles of Northern and Central Europe. B. T. Batsford, Ltd., London, England. 268 pp.
TANNER, W. W. 1957. A taxonomic and ecological study of the western skink (*Eumeces skiltonianus*). Great Basin Nat. 17:59–94.
TINKLE, D. W. and J. W. GIBBONS. 1977. The distribution and evolution of viviparity in reptiles. Misc. Publ. Mus. Zool. Univ. Michigan (154):1–54.
TOWNSEN, S. 1985. The captive reproduction and growth of the yellow anaconda (*Eunectes notaeus*). *In* S. Townsen and K. Lawrence (eds.), Reptiles, Breeding, Behavourial and Veterinary Aspects, pp. 33–45. British Herpetol. Soc., London.
VILLIARD, P. 1969. Reptiles as Pets. Doubleday & Co., Garden City, New York. 188 pp.
VITT, L. J., and W. E. COOPER, JR. 1985. The relationship between lipid cycling in the skink *Eumeces laticeps* with comments on brooding ecology. Herpetologica 41:419–432.
_____, and _____. 1986. Skink reproduction and sexual dimorphism: *Eumeces fasciatus* in the southeastern United States with notes on *Eumeces inexpectatus*. J. Herpetol. 20:65–76.
VOGT, R. C. 1981. Natural History of Amphibians and Reptiles in Wisconsin. Milwaukee Pub. Mus., Milwaukee. 205 pp.
WEHEKIND, L. 1955. Notes on the foods of the Trinidad snakes. British J. Herpetol. 2:9–13.
WELMAN, J. B., and E. B. WORTHINGTON. 1943. The food of the crocodile. Proc. Zool. Soc. London 113:108–112.
WRIGHT, A. H., and A. A. WRIGHT. 1957. Handbook of Snakes of the United States and Canada. Comstock Publ. Co., Ithaca, New York, 2 vols. xviii + 1105 pp.
WRIGHT, K. 1991. The Solomon Island skink. Reptile & Amphibian Mag. (March/April):10–19.
ZAWORSKI, J. P. 1987. The captive maintenance and propagation of *Gekko petricolus*. Bull. Chicago Herpetol. Soc. 22:129–130.
ZUG, G. R. 1993. Herpetology, An Introductory Biology of Amphibians and Reptiles. Academic Press, Inc., San Diego, California. xv + 527 pp.
ZWEIFEL, R. G. 1962. Notes on the distribution and reproduction of the lizard *Eumeces callicephalus*. Herpetologica 18:63–65.

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Observations Of Autohemorrhaging In *Tropidophis haetianus, Rhinocheilus lecontei, Heterodon platyrhinos,* And *Nerodia erythrogaster*

In a recent review of reptilian defense mechanisms, Greene (1988) noted the occurrence of ocular hemorrhage commonly observed in *Phrynosoma* spp. and cited an observation of nasal and oral hemorrhage in *Tropidophis pardalis* (Hecht et al. 1955). In this note we present original observations of autohemorrhage in *Tropidophis haetianus, Rhinocheilus lecontei, Heterodon platyrhinos,* and *Nerodia erythrogaster,* and review the literature concerning autohemorrhage in snakes.

Dwarf boas of the genus *Tropidophis* have often been observed to respond to capture or handling with autohemorrhage in the vicinity of the eyes, mouth, and/or nose. This behavior has been noted in *T. greenwayi* (Iverson 1986), *T. maculatus* (Campbell 1951; Underwood 1952), *T. melanurus* (Mertens 1946; Stull 1928), *T. pardalis* (Hecht et al. 1955; Petzold 1969), *T. parkeri* (Campbell 1951), *T. pucisquamis* (Carvalho 1951), and *T. semicinctus* (Darlington 1927). On 5 March 1990 we collected a female *T. haetianus* (SVL 554 mm) (Bobby Witcher Memorial Collection, Avila College BWMC 4174) from under a rock beside a stream 6.1 km W of the junction of highways (Hwy) 44 and 46, along Hwy 46, Provincia de Barahona, República Dominicana. This specimen was placed in a collecting bag immediately after capture. Upon removal, some 10 min later, it was coiled in a tight ball and began bleeding profusely from the mouth and both eyes. An estimated 6-8 large drops of blood were expressed before the snake was returned to the sack where it continued to bleed for several minutes. No musk was exuded.

On 8 March 1990 another female (SVL 440 mm) was captured, again under a rock beside a stream, on the south edge of Paraiso, Provincia de Barahona. This snake responded similarly to the first by coiling into a tight ball. After a few minutes of further rock turning while the snake was still held in one hand, the collector noticed his hand was smeared with blood. A large drop was observed on the left side of the face of the snake, along the line of the mouth. No further bleeding was observed with handling on subsequent days.

During a field trip to the Provincia de Barahona during June 1991, simultaneous oral and ocular bleeding was observed in three of four captured *T. haetianus*. The behavior was observed in both males and juveniles of the species.

Cloacal hemorrhage has been noted in *Rhinocheilus l. lecontei* (Hanley 1943), and observed in 7 of 27 (26%) *R. l. tesselatus* taken in Eddy Co., New Mexico, and Culberson and Hudspeth Counties, Texas (McCoy and Gehlbach 1967). McCoy and Gehlbach also recorded cloacal hemorrhage in four other specimens of *R. l. tesselatus* and one incidence of nasal hemorrhage (epistaxis) in snakes from western Texas and Coahuila, México. They concluded that hemorrhaging may be confined to females of this species, and that epistaxis is observed less commonly than cloacal hemorrhage. We here report cloacal hemorrhage in a female *R. l. tesselatus* (SVL 470 mm) (BWMC 1251) taken in Clark Co., Kansas, and 4 of 10 *R. l. lecontei* taken in Clark and Nye Counties., Nevada.

The Kansas specimen was found on 21 April 1979, under a rock on a dry hillside, 24.1 km N of Ashland at ca. 1400 h. Prior to any attempt to pick it up, the snake began writhing and expressing blood from the cloaca. No oral or nasal bleeding was observed. During subsequent handling the specimen went limp and bleeding stopped. On the assumption that the snake may have been injured, it was monitored carefully for several weeks in captivity, during which time it behaved normally and consumed two lizards.

The four specimens from Nevada were all taken on the road at night, between 31 May 1970 and 13 August 1973. One individual exhibited oral and cloacal bleeding. Of the four, it reacted most violently with much writhing, and production of considerable quantities of musk. Two of these specimens (both females) were preserved (KU 176894, LACM 133966). The other two were released without determination of sex.

Platt (1969) noted that snakes of the genus *Heterodon* sometimes exhibit oral hemorrhaging during the death-feigning (letisimulation) phase of defensive behavior. We have observed cloacal hemorrhaging twice in specimens of *Heterodon p. platyrhinos* from Missouri. The first occurrence was not associated with letisimulation. On 18 August 1978 a male (SVL 489) (BWMC 1022) was collected crossing a road at ca. 0600 h in eastern Jackson Co. When grasped, the snake coiled quickly and produced two or three drops of blood from the cloaca. It rapidly calmed, at which time the bleeding stopped. It did not release any musk. The specimen was maintained alive for several months before preservation.

On 16 June 1984 at ca. 2100 h, the second *H. p. platyrhinos* was observed crossing a gravel road, 12.8 km NE of Climax Springs, Camden Co. When grasped, the snake first writhed, forcefully exuded several large drops of blood from its vent accompanied with the sound of escaping flatus, and after a few seconds went limp in the collector's hand, apparently feigning death. There were no apparent signs of trauma other than the rather considerable bleeding. This specimen was released near the site of capture, and was gone the next morning.

To our knowledge autohemorrhage has never been reported in snakes of the genus *Nerodia*. On 26 March 1991 a male *Nerodia erythrogaster transversa* (SVL 604 mm) was collected in Cherokee Co., Oklahoma. When grabbed it thrashed wildly, defecating, and squirting musk from its cloacal glands. As the head was grasped the snake opened its mouth and several drops of blood oozed from the gums of the lower jaw.

McCoy and Gehlbach (1967) point out (in *Rhinocheilus*) that although autohemorrhage in snakes is often associated with defensive behavior, it is difficult to attribute operational defensive function to the bleeding. Frye (1981) indicates the causes of hemorrhage in reptiles are the same as those in higher vertebrates, and that spontaneous extravasation can result from a relative or absolute deficiency of thrombocytes. Spontaneous nasal bleeding is not an uncommon occurrence in young thoroughbred horses during extreme physical exertion (Kelly 1974) and it is possible both oral and cloacal autohemorrhage of the colubrids described here is similarly "exertion-related." In almost all cases, bleeding is subsequent to bouts of thrashing, writhing, or rapid coiling.

The autohemorrhaging observed in *Tropidophis* spp., however, may represent a different phenomenon. It differs from that observed in colubrids by being preceded, generally, by the described "balling" behavior, and by the presence of repeatedly observed nasal and orbital bleeding. This indicates more extensive involvement than that of superficial vessels of the oral or cloacal mucosae. Indeed the source of orbital bleeding could be the sinus orbitalis as associated with orbital blood spurting in *Phrynosoma* (Burleson 1942), although in *Tropidophis* the blood simply flows across the eye under the ocular and is not forceful
it is difficult to assign defensive significance to this
a defensive mechanism can be attributed to autoh
least in snakes, it seems prudent to consider it a ph
product of increased blood pressure associated wi
violent exertion and/or a "fright, fight, or fligh
response.

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LITERATURE CITED

BURLESON, G. L. 1942. The source of the blood ejecte
by horned toads. Copeia 1942(4):246–248.
CAMPBELL, D. G. 1951. Notes on snakes near Malve
Notes Nat. Hist. Soc. Jamaica 51:54–56.
CARVALHO, A. L. DE. 1951. Observacoes sobre "*Tr
cisquamis*" (Muller, 1901). Revista Brasil. Biol. 11(
DARLINGTON, P. J. 1927. Autohemorrhage in *Tropidoph*
Bull. Antivenin Inst. 1(2):59.
FRYE, F. L. 1981. Biomedical and Surgical Aspect
Reptile Husbandry. Vet. Med. Publ. Co., Edwards
456 pp.
GREENE, H. W. 1988. Antipredator mechanisms in r
Gans and R. B. Huey (eds.), Biology of the Reptili
Ecology B: Defense and Life History, pp. 1–152. Ala
New York.
HANLEY, G. H. 1943. Terrarium notes on California rep
1943:145–147.
HECHT, K., V. WALTERS, and G. RAMM. 1955. Observa
natural history of the Bahaman pigmy boa, *Tropido*
with notes on autohemorrhage. Copeia 1955(3):24
IVERSON, J. B. 1986. Notes on the natural history o
Islands dwarf boa, *Tropidophis greenwayi*. Carib.
4):191–198.
KELLY, W. R. 1974. Veterinary Clinical Diagnosis. W
Wilkins Co., Baltimore, Maryland. 374 pp.
MCCOY, C. J., and F. R. GEHLBACH. 1967. Cloacal hem
the defense display of the colubrid snake *Rhinoch*
Texas. J. Sci. 19(4):349–352.
MERTENS, R. 1946. Die Warn- und Droh-Reaktionen d
Abh. Senckenberg. Naturf. Ges. 471:1–88.
PETZOLD, H-G. 1969. Zur Haltung und Fortpflanzu
einiger kubanischer Schlangen im Tierpark Berlin.
5(3):124–140.
PLATT, D. W. 1969. Natural history of the hognose snak
platyrhinos and *Heterodon nasicus*. Univ. Kansas Pub
Hist. 18(4):253–420.
STULL, O. G. 1928. A revision of the genus *Tropidophis*.
Mus. Zool. Univ. Michigan 195:1–52.
UNDERWOOD, G. 1952. Introduction to the study of Ja
tiles (part X). Serpentes. Nat. Hist. Notes Nat. Hist. S
53:97–105.

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