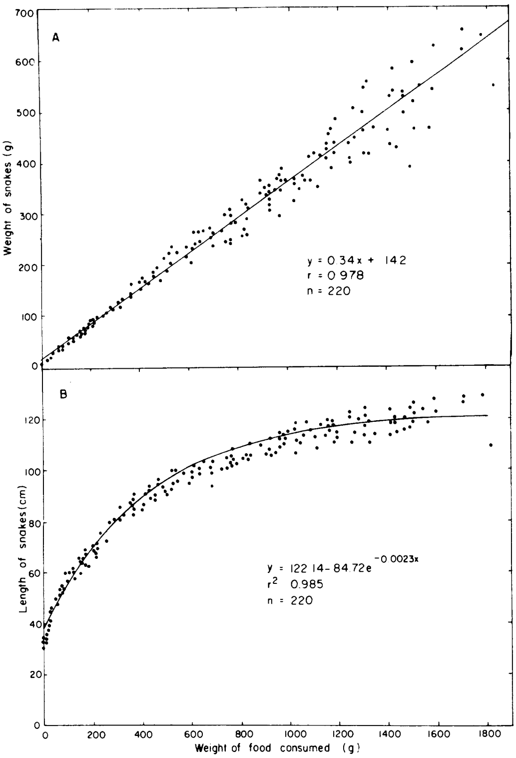

Fig. 3. The relation between weight (A) or length (B) of snakes and the total weight of food consumed.

is avoided with the asymptotic regression analysis. The values of the constants in the asymptotic regression analysis are fairly accurately established with data based on 600 g of food consumption and these values changed only slightly as the amount of data increased. We conclude that although both types of analyses reflect the established pattern of growth, the asymptotic regression analysis is more useful for predicting biological growth because it models underlying biological processes.

Acknowledgments.—We greatly appreciate the assistance of R. W. Simons and the constructive criticism received from L. H. S. Van Mierop of the University of Florida during this study and during the preparation of this manuscript. R. L. Carter suggested the use of the asymptotic regression curve and fit it to our data using the facilities of the N.E. Regional Data Center of the State University System of the State of Florida in Gainesville.

Literature Cited

Burkett, R. D. 1966. Natural history of the cottonmouth moccasin, *Agkistrodon piscivorus* (Reptilia). Univ. of Kansas Publ. Mus. Nat. Hist. 17:435–491.

Carpenter, C. C. 1952. Growth and maturity of the three species of *Thamnophis* in Michigan. Copeia 1952:237–253.

Dmi'el, R. 1967. Studies on reproduction, growth, and feeding in the snake *Spalerosophis cliffordi* (Colubridae). Copeia 1967:332–346.

Fitch, H. S. 1960. Autecology of the copperhead. Univ. Kansas Publ. Mus. Nat. Hist. 13:85–288.

———. 1963. Natural history of the black rat snake *Elaphe o. obsoleta* in Kansas. Copeia 1963:649–658.

Ford, N. B. 1974. Growth and food consumption in the yellow rat snake, *Elaphe obsoleta quadrivittata.* Herpetologica 30:102–104.

Gibbons, J. W. 1972. Reproduction, growth and sexual dimorphism in the canebreak rattler (*Crotalus horridus*). Copeia 1972:222–226.

Kaufman, G. A., and J. W. Gibbons. 1975. Weight-length relationships in thirteen species of snakes in the southeastern United States. Herpetologica 31:31–37.

Klauber, L. M. 1956. Rattlesnakes: Their habits, life histories and influence on mankind. Vol. 1. Univ. of Calif. Press, Berkeley.

Myer, J. S., and A. P. Kowell. 1973. Effects of feeding schedule and food deprivation on the growth of neonatal garter snakes (*Thamnophis sirtalis*). J. Herp. 7:225–229.

Platt, D. R. 1969. Natural history of the hognose snakes *Heterodon platyrhinos* and *Heterodon nasicus.* Univ. Kansas Publ. Mus. Nat. Hist. 18:253–420.

Smith, G. C. 1976. Ecological energetics of three species of ectothermic vertebrates. Ecology 57:252–264.

Wharton, C. H. 1966. Reproduction and growth in the cottonmouths, *Agkistrodon piscivorus* Lacepede, of Cedar Keys, Florida. Copeia 1966: 149–161.

S. M. Barnard, T. G. Hollinger and T. A. Romaine, *Department of Anatomy, College of Medicine, University of Florida, Gainesville, Florida 32610.* Accepted 19 Oct. 1978.

Copeia, 1979(4), pp. 741–744

EGG DEVELOPMENT TIME AND CLUTCH SIZE IN TWO NEOTROPICAL SALAMANDERS.—The reproductive biology of most neotropical salamanders (Plethodontidae) is unknown. McDiarmid and Worthington's (1970) summary of available information dealt with only 10 species. Houck (1977a, b, c) studied reproduction in 11 species from western Guate-

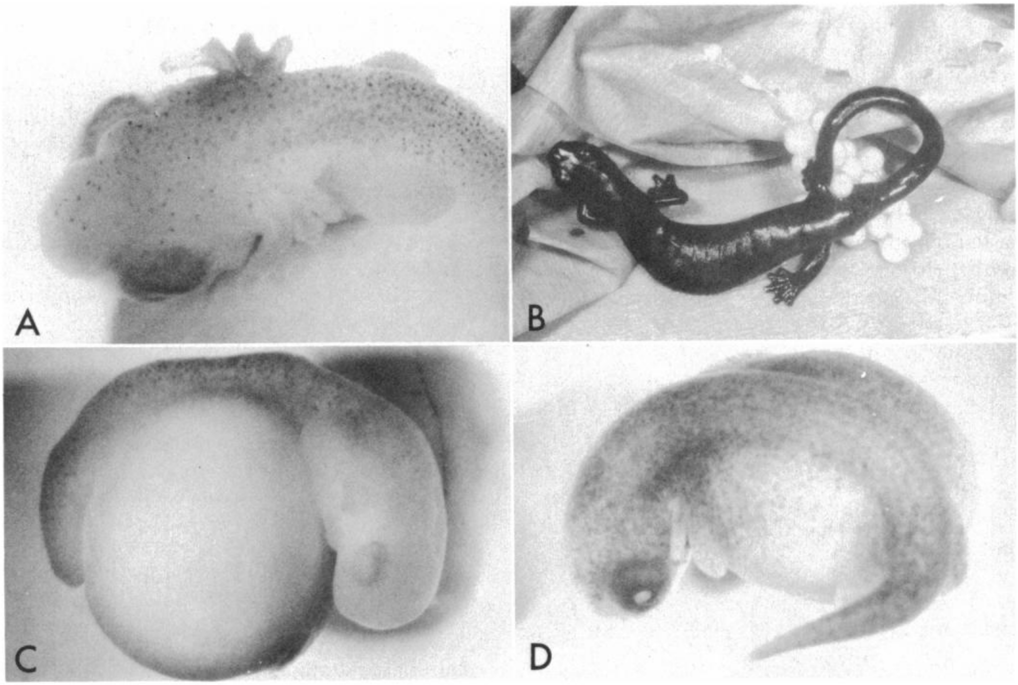

Fig. 1. A) Anterior portion of embryo of *Chiropterotriton magnipes.* Note tribranchiate pattern of gills, undifferentiated anterior limbs, and dorsal pigmentation. B) Adult *Bolitoglossa compacta* (MVZ 128635) depositing eggs. C) Embryo of *B. compacta,* preserved 115 days after oviposition. Note slightly lobed gill and slight pigmentation. Anterior limb bud rudimentary. D) Embryo of *B. compacta,* preserved 158 days after oviposition. Note dense pigmentation and well-developed eye.

mala in detail. Recently, Sessions (1977) described a clutch of *Lineatriton lineola.* Here, I present information concerning the clutch size of two additional species, *Chiropterotriton magnipes* and *Bolitoglossa compacta,* the development time of eggs of *B. compacta,* and the first descriptions of developing embryos of both species.

Forty-one adult *C. magnipes* (MVZ 129008–129048) were collected from the walls, ceiling and crevices of the Cueva de la Iglesia, Ahuacatlan, San Luis Potosi, Mexico on 4 May 1975. One adult female (MVZ 129021), 51.2 mm SVL, was guarding a clutch of 26 eggs attached to the ceiling. The eggs were attached in a bead-like fashion that is characteristic of most *Pseudoeurycea* (McDiarmid and Worthington, 1970). The eggs were preserved in 10% neutral buffered formalin. Egg diameter, including surrounding capsules, taken perpendicular to the axis of the egg strand ranges from 4.9–5.6 mm ($\bar{x}$ = 5.3) after preservation.

All embryos were preserved at approximately the same stage of development (Fig. 1A), which corresponds most closely to the "early pigmentation" stage of Vial (1968, Fig. 17). Fore and hind limbs are present but undifferentiated. Costal folds are indistinct. Gills are tribranchiate, closely resembling those of *P. juarezi* (McDiarmid and Worthington, 1970). Melanophores are scattered dorsally beginning behind the level of the eyes and continuing posteriorly to the anterior part of the tail (the venter and hind limbs are unpigmented). Heavily pigmented optic cups show a trace of the choroid fissure ventrally.

An adult female *B. compacta* (MVZ 128635), measuring 84.7 mm from snout to posterior end of vent (SVL), was collected beneath a log on the southern flank of Cerro Respingo, 5.0 km (airline) east of Cerro Punta, Prov. Chiriqui, Panama, elev. 2,710 m, on 12 August 1975. The live animal was returned to the laboratory where it was placed in a plastic shoebox with moist paper towels and maintained at a constant temperature of 13 C with a light:dark cycle of 14:10 hours. On 24 October 1975 the salamander deposited a clutch of eggs on crumpled paper towels in the box (Fig. 1B). The total of 39 eggs formed an adherent clump typical of other *Bolitoglossa* (McDiarmid and Worthington, 1970). After one day the female had made no noticeable attempt to brood the clutch or disturb it in any way. The eggs were then removed from the box and placed in a covered glass petri dish on a layer of paper toweling moistened with distilled water.

After 2–3 weeks an extensive fungal growth had developed on the eggs. Fungal mycelia were removed with forceps, and the eggs bathed in a 0.5% hydrogen peroxide solution for several minutes and rinsed several times in distilled water. They were then returned to the petri dish with fresh toweling. Thereafter, the eggs were washed in peroxide baths every 2–4 days until hatching. Embryos that ceased development were removed and preserved. Similar treatments have proven effective in retarding fungal growth in other salamander eggs (Lynne Houck, pers. comm.). The effect, if any, of the baths on the subsequent development time is unknown. However, aside from partial erosion of the surface of the embryonic membrane there was no noticeable physical harm to the eggs, embryos or hatchlings ascribable to the treatments.

Descriptions of two *B. compacta* embryos are presented below. Ages were estimated from the elapsed time between oviposition and preservation dates. These ages are only approximate since the exact date of death is unknown (embryos were preserved only when it appeared certain that they had ceased development).

The first embryo (Fig. 1C) was preserved 115 days after oviposition. It most closely resembles the "early limb bud" stage of Vial (1968:Figs. 15, 16). The embryo is flexed dorsoventrally about the yolk including an arc of ~270° about the perimeter from head to tail. Fore and hind limb buds are present but undifferentiated. No trace of a mouth or nostrils is evident. Gills appear rudimentary, broader (anteroposteriorly) than long and slightly trilobate from front to back. Melanophores are lightly scattered dorsally from behind the eyes to midtail, barely extending onto the yolk sac. An optic cup is distinguished by its slightly denser pigmentation.

The second embryo (Fig. 1D) was preserved 158 days after oviposition. The fore and hind limbs are flexed slightly at the presumptive elbow and knee joints, and are expanded distally giving a paddlelike appearance. A mouth and gular fold are visible. Nostrils are suggested by small paired areas of the snout devoid of pigment. The left gill is stumplike, approximately two-thirds of the length of the left anterior limb bud, while the right gill is reduced but retains a trace of the tribranchiate pattern. Melanophores are present dorsally and laterally on the trunk, limbs, tail and yolk sac, and ventrally on the tail and throat anterior to the gular fold. Pigment is lacking on the undersides of the feet. The heavily pigmented optic cup is distinct, and the lens is visible behind the pupil. No choroid fissure is evident.

Two additional *B. compacta* embryos survived to hatching, emerging 249 and 251 days (more than 8 months) after oviposition. After approximately 8 weeks, during which time no change in total length was observed, the hatchlings were preserved and then measured. SVL and tail lengths, respectively, for the two hatchlings are (in mm): 13.4, 3.8; 11.4, 3.0.

The laboratory temperature of 13 C closely approximates both the 11.8 C reading observed for a nonbrooding adult female *B. compacta* from the same locality as the gravid female reported above, and the mean temperature of 12.8 C for nest sites of *B. subpalmata* at comparable elevations (2,300–3,200 m) in Costa Rica (Vial, 1968). Therefore, the development time reported here may accurately reflect that occurring in natural situations.

Incubation period of temperate plethodontids with direct development range from 2 months [*Plethodon vehiculum,* Peacock and Nussbaum (1973), *Batrachoseps attenuatus,* Anderson (1958)] to 4 months [*Ensatina eschscholtzii,* Stebbins (1954)]. For neotropical species, inferred durations include 4–5 months [*Bolitoglossa subpalmata,* Vial (1968)] and 5–6 months [*B. rostrata,* Houck (1977c)]. The development time from oviposition to hatching for the single clutch of eggs of *B. compacta* maintained under laboratory conditions greatly exceeds that previously reported for any plethodontid, but agrees with the general pattern of longer development times for neotropical species relative to temperate counterparts.

Lastly, both species discussed in this report demonstrate a timing of oviposition consistent with the existing hypothesis that, for neotropical salamander species with distinct annual reproductive cycles, egg deposition occurs in the dry season with subsequent hatching at the beginning of the wet season, the period most suitable for hatchling survival (McDiarmid and Worthington, 1970; Houck, 1977a, b, c).

Acknowledgments.—I thank Gloria Wurst for sharing the onerous task of bathing salamander eggs twice a week for 8 months. Samuel S. Sweet, Allen Greer, Phlyp Greer and James F. Lynch participated in collecting salamanders in the field. Lynne D. Houck, Raymond B. Huey, Sally E. Susnowitz, David B. Wake and Marvalee H. Wake made valuable criticisms of drafts of this manuscript. This research was supported in part by NSF grant DEB 74-20922.

Literature Cited

Anderson, Paul K. 1958. Induced oviposition in *Batrachoseps attenuatus* and incubation of eggs. Copeia 1958:221–222.

Houck, Lynne D. 1977a. Reproductive biology of a neotropical salamander, *Bolitoglossa rostrata*. Copeia 1977:70–82.

———. 1977b. Reproductive patterns in neotropical salamanders. Unpubl. Ph.D. Diss., Univ. Calif., Berkeley.

———. 1977c. Life history patterns and reproductive biology of neotropical salamanders, p. 43–71. *In*: The reproductive biology of amphibians, D. H. Taylor and S. I. Guttman (eds.). Plenum, N.Y.

McDiarmid, Roy W., and R. D. Worthington. 1970. Concerning the reproductive habits of tropical plethodontid salamanders. Herpetologica 26:57–70.

Peacock, R. L., and R. A. Nussbaum. 1973. Reproductive biology and population structure of the western red-backed salamander, *Plethodon vehiculum* (Cooper). J. Herp. 7:215–224.

Sessions, Stanley K. 1977. Egg-capsules and embryos of the bolitoglossine salamander, *Lineatriton lineola* (Cope). Herpetologica 33:452–454.

Stebbins, Robert C. 1954. Natural history of the salamanders of the plethodontid genus *Ensatina*. Univ. Calif. Publ. Zool. 54:47–124.

Vial, James L. 1968. The ecology of the tropical salamander, *Bolitoglossa subpalmata*, in Costa Rica. Rev. Biol. Trop. 15:13–115.

James Hanken, *Department of Zoology and Museum of Vertebrate Zoology, University of California, Berkeley, California, 94720.* Accepted 23 Oct. 1978.

Copeia, 1979(4), pp. 744–745

PRODUCTION OF AN EMBRYO BY AN *ACROCHORDUS JAVANICUS* ISOLATED FOR SEVEN YEARS.—Production of young by isolated individuals has been reported for many reptiles. Some reptiles produce young only by parthenogenesis and many reptiles store sperm for long periods (Fox, 1977). Bergman (1958) in his study of reproduction in acrochordids, found no evidence of sperm storage or parthenogenesis. This note reports a gravid *Acrochordus javanicus* that had been isolated for seven years, six months.

A female *A. javanicus* was given to the author in January 1970. It had been captured in the Northern Territory, Australia, approximately three months previously. The snake was maintained isolated from contact with other *Acrochordus* until it died in July 1978. It was then 130 cm (S-V) long. Dissection showed 7 eggs in the right oviduct and 3 eggs in the left oviduct. Nine eggs appeared to consist only of congealed yolk, whereas the tenth contained a fully formed embryo.

The embryo was 37.5 cm (TL) long and had no obvious deformities. Its scale development and color pattern were similar to those of the adult. The internal organs of the embryo were badly decomposed, suggesting that it had died some time before the adult. Because the internal organs were poorly preserved the sex of the embryo could not be determined but since there were no everted hemipenes as are typical of male embryos at this stage of development (Alan Greer, pers. comm.) it was probably female.

The adult (Serial No. R75103) and juvenile (Serial No. R75104) are lodged with the Australian Museum, Sydney, Australia.

The longest recorded period of sperm storage by a snake is five years by *Leptodeira annulata polysticta* (Haines, 1940). Only one species of snake, *Typhlops braminus*, is thought to be parthenogenetic (McDowell, 1974). There is insufficient evidence to determine whether the embryo reported in this note was produced as a result of sperm storage or parthenogenesis. However, this record indicates that the possibility of sperm storage or parthenogenesis in the Acrochordidae warrants further research.

Acknowledgments.—I thank Alan Greer for his help with sexing the embryo and Gordon Grigg