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Eggs and hatchlings of the Mexican salamander *Pseudoeurycea cephalica* (Caudata: Plethodontidae)

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Abstract: Eggs and hatchlings of *Pseudoeurycea c. cephalica* from Parque Nacional Lagunas de Zempoala, Morelos, Mexico are described for the first time. The eggs are similar to eggs of *P. cephalica manni* and *P. belli* in being unstranded. Egg capsules resemble *P. nigromaculata* and *P. juarezi* in having two gelatinous envelopes. The embryos have extensively webbed hands and feet with a continuous reduction in webbing during embryogenesis, supporting the hypothesis that webbing of the feet is a paedomorphic character. The hatchlings are uniform grayish-black dorsally and slightly paler ventrally. They are robust with broad heads and short tails and lack both vomerine and maxillary teeth. Lack of dentition has previously been found in juveniles of *P. belli*.

Key words: Eggs, hatchlings, *Pseudoeurycea c. cephalica*, Morelos, Mexico, Amphibia, Caudata.

The reproductive biology of the Neotropical plethodontid salamanders is generally unknown. Of about 30 species of the genus *Pseudoeurycea*, information on reproduction exists for only eight species: *P. expectata* (Stuart 1954, Salthe 1963); *P. belli* (Duellman 1961, Salthe 1963); *P. nigromaculata* and *P. juarezi* (McDiarmid & Worthington 1970); *P. brunnata*, *P. goebeli*, *P. rex* (Houck 1977b) and *P. cephalica manni* (Mendoza-Quijano & Hernández-García 1995). The information on these species has mostly dealt with egg descriptions. The only life history information appears in Houck (1977b) and descriptions of hatchlings are virtually absent.

MATERIALS AND METHODS

On July 13 1996 a clutch of 22 eggs and an attending female of *Pseudoeurycea cephalica cephalica* (Cope 1865) were found under a log at an altitude of 2850 m in Parque Nacional Lagunas de Zempoala, Morelos, Mexico. The temperature at the clutch-site was 10.4∫C with an air temperature of 20.2∫C. The area where the clutch was found is a pine-covered hillside and was, at the time of the visit, receiving heavy precipitation. On the hillside *P. cephalica* was found together with *P. leprosa* in equal abundances.

Clutch and female were kept in the laboratory at ca. 20ºC until hatching. Three eggs were preserved July 13 and five on July 31. The eggs began hatching on 27 August 1996. Six eggs hatched and the hatchlings, the remaining three eggs, and the female were all preserved in gradually increasing solutions of ethanol, ending with a 70 % solution. Several eggs, attacked by fungus during the incubation, were not preserved. All measurements (made after preservation) shown with a range were made on all eggs present in each category, the rest are on single eggs. Measurements were made using dial calipers and an occular micrometer. Specimens are deposited in the Zoological Museum of Copenhagen (ZMUC-R 03424).

RESULTS

Eggs: The eggs are slightly oval. They are not connected by strands but attached to each other by their sticky outer membranes. The clutch was ball shaped and was lying loose on the substrate in close contact with the female. The attending female had a total length of 87.9 mm with a standard length of 52.5 mm.

The eggs of July 13 had a long axis diameter of 5.5 mm (5.4-5.6 mm) and a short axis diameter of 4.5 mm (4.3-4.9 mm) (Fig. 1). Two envelopes could be discerned. First an outer sticky envelope, brown from attached soil-particles, which is easily peeled off. Then a much thicker vaguely opaque envelope is followed by the vitellin-capsule containing the embryo. The long axis diameter of the vitellin-capsule, also slightly oval in shape, is 5.2 mm (4.9-5.3 mm) with a short axis diameter of 4.1 mm (4.0-4.2 mm). The total length of the embryo is 13.2 mm with a standard length of 8.6 mm. The yolk-sac is ball shaped with a diameter of 3.1 mm, and fills up a large proportion of the vitellin space. The eye is exposed with a diameter of 0.8 mm. The iris is pigmented with a pale dead white pupil with a diameter of 0.3 mm. The extremities are well developed. The forelimbs are 1.6 mm long and the hindlimbs are 1.8 mm long. The forefeet are extensively webbed with the webbing covering the toes entirely. The webbing of the hindfeet is not quite as extensive as on the forefeet but still covers ca. 90 % of the toe-lengths. The embryo has a starshaped pigmentation covering ca. 40 % of the dorsal surface. The gills are large and flat and heavily branched. The gill-area has a diameter of ca. 2.0 mm with the longest branch length of 1.3 mm. The nasolabial grooves are very distinct dividing the snout in three. Neither mouth nor nostrils are present. Ten costal folds can be discerned.

The eggs of July 31 are slightly larger with a long axis diameter of 6.3 mm (5.6-6.9 mm) and a short axis diameter of 4.9 mm (4.7-5.2 mm). The vitellin-capsule has a long axis diameter of 5.5 mm (5.1-5.9 mm) and a short axis diameter of 4.6 mm (4.3-5.1 mm). No difference from the early eggs in constitution of egg capsules was found. The total length of the embryo is 14.2 mm with a standard length of 9.4 mm. The yolk sac is slightly oval with a

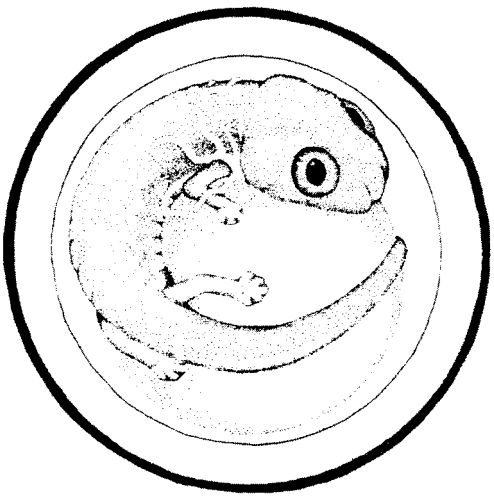

Fig. 1. Egg of *Pseudoeurycea c. cephalica* of July 13 1996 from Parque Nacional Lagunas de Zempoala, Morelos, Mexico, showing the two gelatinous envelopes outside the vitellin-capsule and the position of the embryo.

diameter of ca. 3.5 mm. No difference in eye size was found but the eyes are no longer exposed but encapsulated with both upper and lower eyelids present. The iris is more heavily pigmented. The extremities are of the same size as in the early embryos but some reduction in the webbing of both the fore- and hindfeet is evident. The dorsal side of the embryo is pigmented to a degree of close to 100 % coverage. The parts of the ventral side free from the yolk sac is still largely unpigmented. In comparison with the early embryos the gills are of fairly equal size with a gill-area-diameter of ca. 2.7 mm and the longest branch length of 1.3 mm. The nasolabial grooves are well developed but inconspicous giving the snout a more homogeneous appearence. The mouth is slit and the tongue is present, but it has not yet obtained its bolitoid structure. There is no change in number of costal folds. The anus is pierced.

The three eggs of August 27 are in the stage just before hatching and it is assumed that they, if not preserved, would have hatched in 1-2 days. The eggs are not firm in comparison with the earlier eggs and their shape is, therefore, not quite consistent. They have a long axis diameter of 7.3 mm (7.1-7.8 mm) and a short axis diameter of 6.1 mm (5.9-6.3 mm). The envelopes appear very thin and the central, formerly thick, envelope is almost completely dissolved. The vitellin-capsule has a long axis diameter of 6.7 mm (6.5-6.9 mm) and a short axis diameter of 5.9 mm (5.7-6.0 mm). The total length of the embryo is 14.9 mm with a standard length of 10.3 mm. No yolk is present except for a small slit in the belly of the embryo. No change in eye size or morphology from the embryos of July 31 could be discerned. The extremities are larger. The forelimbs have a length of 3.4 mm and the hindlimbs have a length of 3.6 mm. The toes now show even more reduced webbing than the earlier embryos. There is no change in pigmentation. Of the gills only one branch is present on each side of the head with a length of 1.2 mm.

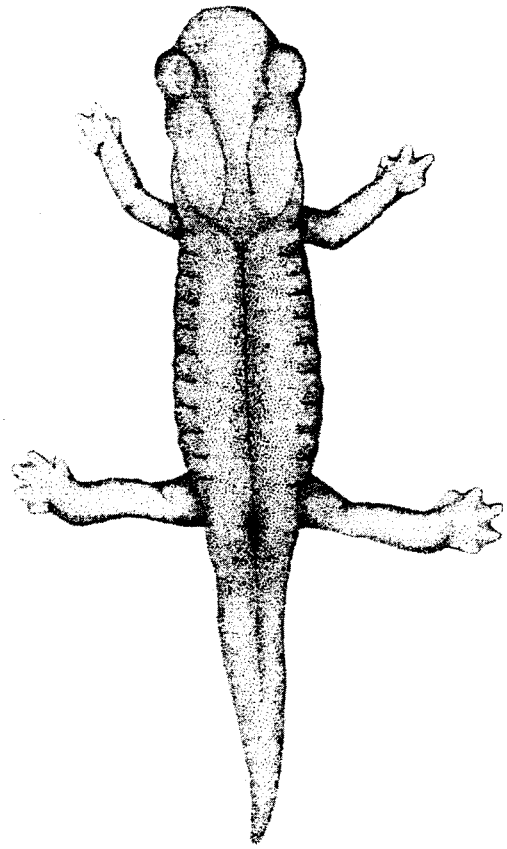

Fig. 2. Hatchling of *Pseudoeurycea c. cephalica* of August 27 1996.

Nostrils can now be discerned and the tongue has obtained its boletoid structure.

Hatchlings: The hatchlings are robust with short rounded tails showing no constriction at base (Fig. 2). They have a total length of 14.7 mm (14.2-15.1 mm) with a standard length of 10.2 mm (9.8-10.5 mm). The dorsal side is uniform grayish black with slightly paler venter. The belly is slit showing the remnants of the yolk sac. The head is broad with a short truncate snout. The eyes are highly protuberant. On each side of the head a white spot is present showing the attachment site of the gills. Neither vomerine nor maxillary teeth are present. Hands and feet show more extensive webbing than in adults with webbing

coverage of about 3/4 of toe-lengths. The feet show slightly less webbing than hands. Very little variation was found in morphometrics (mean ± 1 S.E., N=6): Standard length 10.2 mm ± 0.11; tail length 4.5 mm ± 0.06; axilla-groin 4.4 mm ± 0.15; head width 2.9 mm ± 0.02; snout-gular fold 3.3 mm ± 0.04; fore limb length 2.6 mm ± 0.04; hind limb length 3.0 mm ± 0.03.

DISCUSSION

Previously, *Pseudoeurycea* clutches have mostly been found in winter or early spring but this *P. cephalica* clutch was collected in July. The severe winter of 1995/96 with heavy snowfall and prolonged subzero temperatures in the central highlands of Mexico might explain the discrepancy as just a case of late breeding.

The clutch size of 22 is consistent with other *Pseudoeurycea* species, which range from 19-34 eggs. Capsules resemble *P. nigromaculata* and *P. juarezi* in having two gelatinous envelopes outside the vitellin-capsule (McDiarmid & Worthington 1970). *P. expectata* has three envelopes whereas *P. belli* has four envelopes (Salthe 1963), although Duellman (1961) only found two envelopes in *P. belli*. No information on constitution of egg capsules exists for *Pseudoeurycea brunnata, P. goebeli, P. rex* or *P. cephalica manni*, respectively (Houck 1977b, Mendoza-Quijano & Hernández-García 1995). McDiarmid & Worthington (1970) attributed the differences in number of envelopes to differences in developmental stages. This might also be the case in *P. c. cephalica.*

The eggs were not stranded, as has been the case with most *Pseudoeurycea*-clutches, but instead attached to each other by a sticky outer membrane. This has previously been reported only for clutches of *P. belli* (Duellman 1961) and *P. cephalica manni* (Mendoza-Quijano pers. comm.). This character appears to be relatively common among the neotropical *Bolitoglossini*, though, being reported for *Bolitoglossa* (Smith *et al.* 1968, Vial 1968, Houck 1977a, Hanken 1979), *Chiropterotriton* (Hanken 1979), *Nototriton* (McCranie & Wilson 1992) and *Parvimolge* (Duellman 1959). No information exists, as to whether the eggs of *P. brunnata, P. goebeli* and *P. rex* are stranded or not. It is interesting, that now two species of *Pseudoeurycea*, out of the five for which such clutch data exists, have unstranded eggs more similar to *Bolitoglossa* or *Chiropterotriton* than to the other *Pseudoeurycea.*

The gills of *Lineatriton lineola* (Sessions 1977) are very similar to the gills found in *P. c. cephalica.* In comparison, the gills of *P. juarezi* have a more complex structure with more extensive branching (McDiarmid & Worthington 1970). The gills of *P. juarezi* are much smaller, though, and the later stage of embryogenesis of *P. c. cephalica* might explain these differences. This is in consistency with Vial (1968) who observed a rapid growth of the gills in *Bolitoglossa subpalmata* at the time when hind limb buds became present. Wake & Brame (1969) speculated that paedomorphosis had been an important factor in foot evolution in tropical salamanders. The wholly webbed feet in embryonic *P. c. cephalica* with continuous reduction of webbing during embryogenesis appears to confirm this hypothesis.

The lack of dentition has previously been observed in juvenile (snout-vent length 19 mm) *P. belli* (Taylor 1938). Lower numbers of vomerine and maxillary teeth in juveniles has been observed in *P. belli* (Taylor 1938, Duellman 1961); *P. juarezi* (Regal 1966); *P. anitae* (Bogert 1967); *P. saltator* and *P. parva* (Lynch & Wake 1989). It seems that *Pseudoeurycea* hatch with no or very few teeth, as observed in *P. c. cephalica,* and that teeth are added continuusly during ontogeny, as Regal (1966) showed that numbers of maxillary-premaxillary teeth are related to

body size in *P. juarezi* and Duellman (1961) showed that number of vomerine teeth were related to body size in *P. belli.*

The reproductive biology of the Neotropical plethodontids is still poorly understood. Although the eggs of a few species have been described it is, as yet, too early to describe patterns of reproduction for these salamanders. It can, therefore, only be urged that more attention is paid to the reproductive biology of the Neotropical plethodontids.

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RESUMEN

Se describe por primera vez huevos y recién nacidos de *Pseudoeurycea cephalica cephalica* procedentes del Parque Nacional Lagunas de Zempoala, Morelos, México. Los huevos se paracen a los de *P. cephalica manni* y *P. belli* en que no están unidos entre sí por ningún cordón. Se parecen en cuanto a constitución a los de *P. nigromaculata* y *P. juarezi* en tener dos capas gelatinosas. Los embriones tienen los pies y manos palmeados, produciéndose una reducción de la superficie palmeada a lo largo de la embriogénesis, lo cual confirma que el palmeado de pies y manos es un carácter pedomórfico. Los recién nacidos son de color gris negruzco, uniforme dorsalmente y de color más claro ventralmente. Son robustos, con cabeza ancha, cola corta y carecen de dientes tanto vomerinos como maxilares. Esta falta de dentición ya fue encontrada anteriormente en juveniles de *P. belli.*

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