OVOVIVIPARITY IN SALAMANDRA SALAMANDRA (L.) (AMPHIBIA, URODELA) FROM NORTHERN ISRAËL

M.R. Warburg, G. Degani, I. Warburg

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OVOVIVIPARITY IN *SALAMANDRA SALAMANDRA (L.)* (AMPHIBIA, URODELA) FROM NORTHERN ISRAEL

by M.R. Warburg, G. Degani & I. Warburg
Biology Dept., Technion, Haifa

ABSTRACT

1. Larvae were born alive, singly or in small batches, generally wrapped in their embryonic sac.
2. The duration of spawning was 1-4 days, numbers of larvae ranged between 30-200 per batch.
3. Larvae weighed 0.13-0.40 g when born and were 2.5-4.0 cm long; an exponential relationship was found between length and weight of the newly born larvae.
4. Number of larvae per batch and their dimensions were compared in three populations.

I. — INTRODUCTION

In Europe various subspecies of *Salamandra* are found from Spain north to Poland and Russia and south to Turkey. In the Middle East this salamander reaches south to the northern parts of Israel where it occurs in three disjunct localities. The northern population is located in the upper Galil extending to Mt. Hermon. The main population is found in the central and western Galil and the southernmost location is on Mt. Carmel.

The local subspecies is *Salamandra salamandra salamandra* (L.) (EISELT, 1958). Its adults are rarely found and then only during a very limited period at the onset of winter (DEGANI & WARBURG, 1978). They breed in ponds and pools and sometimes in springs or streams, starting with the first rains (end of November), sometimes until mid winter. However, in permanent springs larvae can be found throughout the year (WARBURG *et al.*, 1979). In Europe they breed from March through summer (JOLY, 1968), rarely do they breed in autumn. These larvae spend winter under ice (GASCHE, 1942).

The way larvae are born was first described in detail by SZABO (1959), a more recent account is given by GREVEN (1976). The number of larvae per batch varies with both altitude and latitude. GASCHE (1939) mentions a variation ranging between 10-70 larvae per batch.

In the present study ovoviviparity is described for the first time in the local subspecies. The larvae in each batch were measured and weighed, comparing three populations from different localities and habitats.

II. — MATERIALS AND METHODS

Adult (females) salamanders were collected at the beginning of of winter (1974, 1975, 1977) in three localities : Mt. Carmel, and in Sasa and Hammama spring in the central Galil. Females were allowed to bear their young in aquaria containing soil with some water. The newly born larvae were counted at intervals and measured. A sample was dried carefully with moist filter paper, measured on mm paper, and weighed with a Mettler H 315 balance of $\pm$ 0.1 mg accuracy. A total of 22 larva batches was thus studied. The statistical significance was tested by standard deviation and t-test.

III. — RESULTS

Most larvae were born during the period between November and January. A few batches of newly born tadpoles may sometimes be found already in August or as late as April (Fig. 1).

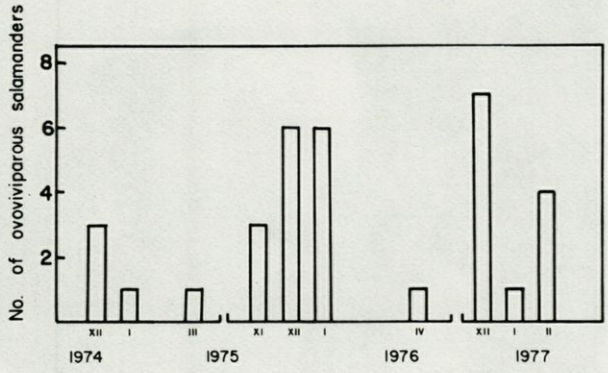

FIG. 1. — Number of ovoviviparous salamanders found throughout the year on Mt. Meron.

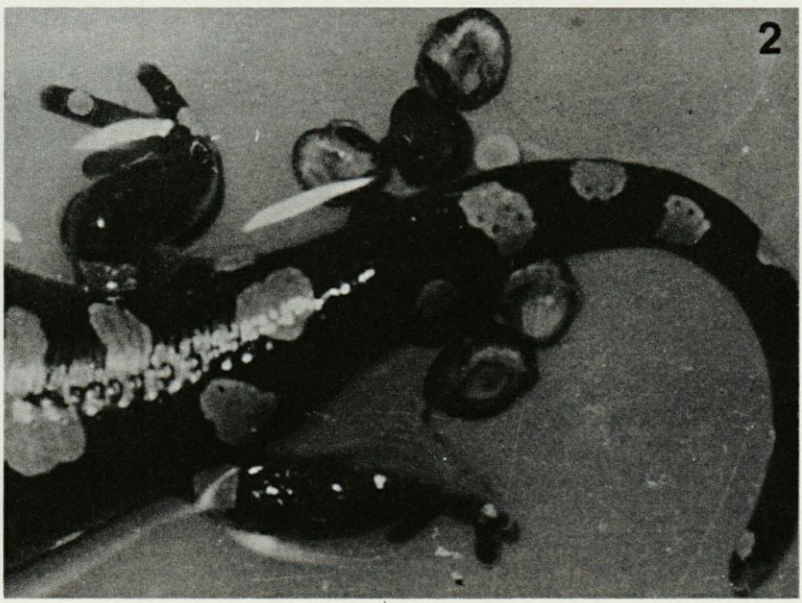

FIG. 2. — Adult female giving birth to larvae still enclosed in their embryonic sac.

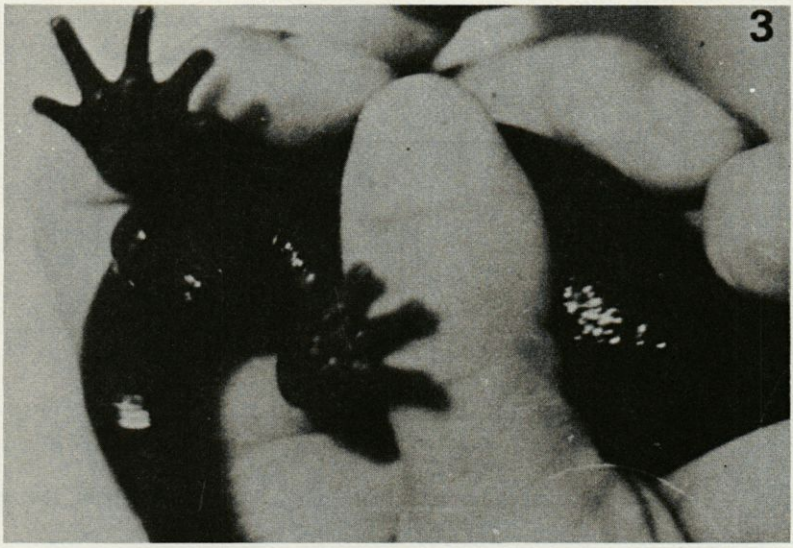

FIG. 3. — A larva born wrapped in its embryonic sac.

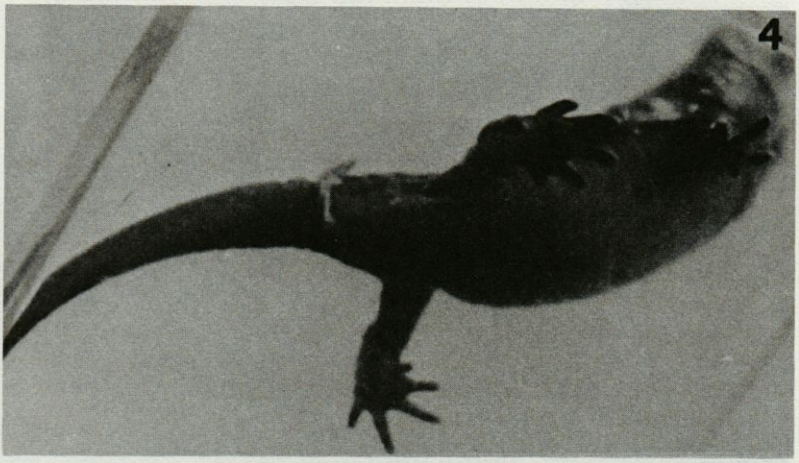

FIG. 4. — A larva born without embryonic sac.

When laying her batch, the female's hind part was submerged in water and, whenever possible, her front part was on dry ground (Fig. 2). Some females were observed swimming while laying their batches. In Israel, *S. salamandra* is mostly ovoviviparous but can be viviparous as well. Most larvae emerged singly or in groups (Fig. 2). Sometimes they were still wrapped in their embryonic sac (Fig. 3). Occasionally larvae were seen to be born alive (viviparous) emerging free of the embryonic sac (Fig. 4).

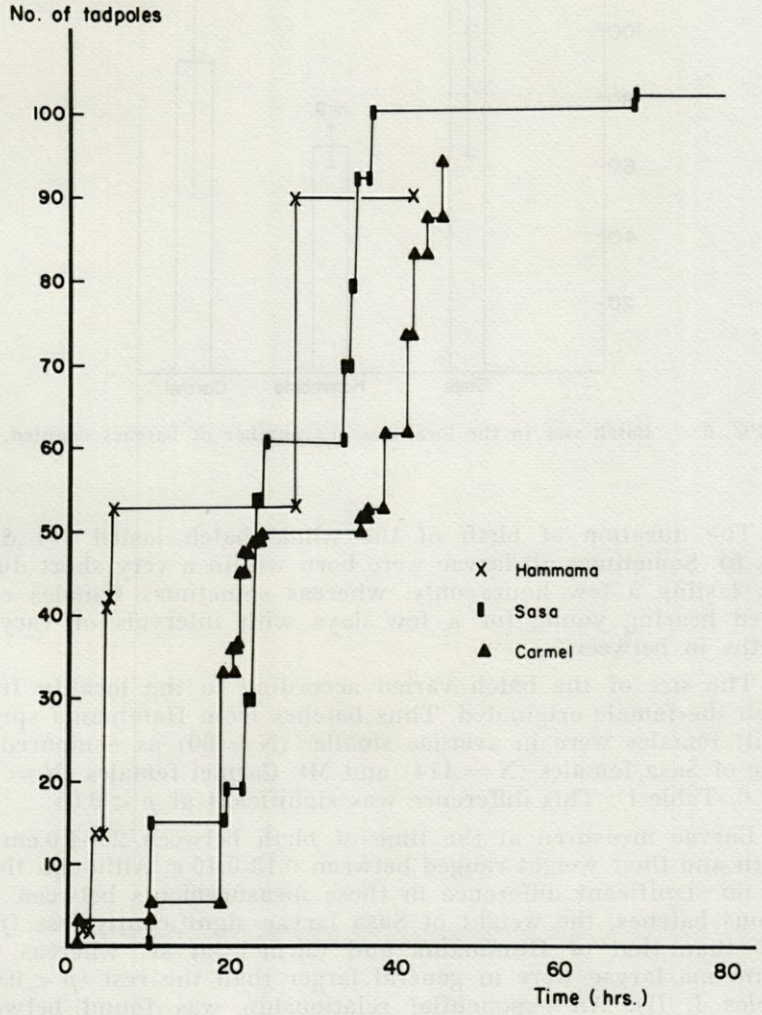

FIG. 5. — Rate of ovoviviparity.

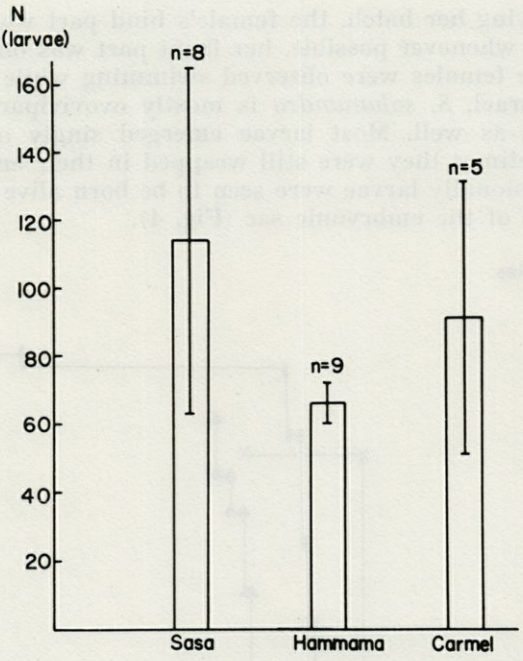

FIG. 6. — Batch size in the localities. *n* : number of batches counted.

The duration of birth of the whole batch lasted 1-4 days (Fig. 5). Sometimes all larvae were born within a very short duration, lasting a few hours only, whereas sometimes females continued bearing young for a few days with intervals of varying lengths in between.

The size of the batch varied according to the locality from which the female originated. Thus batches from Hammama spring (Galil) females were in average smaller ($N = 60$) as compared to those of Sasa females ($N = 114$) and Mt. Carmel females ($N = 91$) (Fig 6, Table I). This difference was significant at $p < 0.05$.

Larvae measured at the time of birth between 2.5-4.0 cm in length and their weight ranged between 0.13-0.40 g. Although there was no significant difference in these measurements between the various batches, the weight of Sasa larvae significantly less ($p < 0.05$) than that of Hummama and Carmel larvae, whereas the Hammama larvae were in general larger than the rest ($p < 0.05$) (Tables I, II). An exponential relationship was found between larval length and weight at the time of birth (Fig. 7).

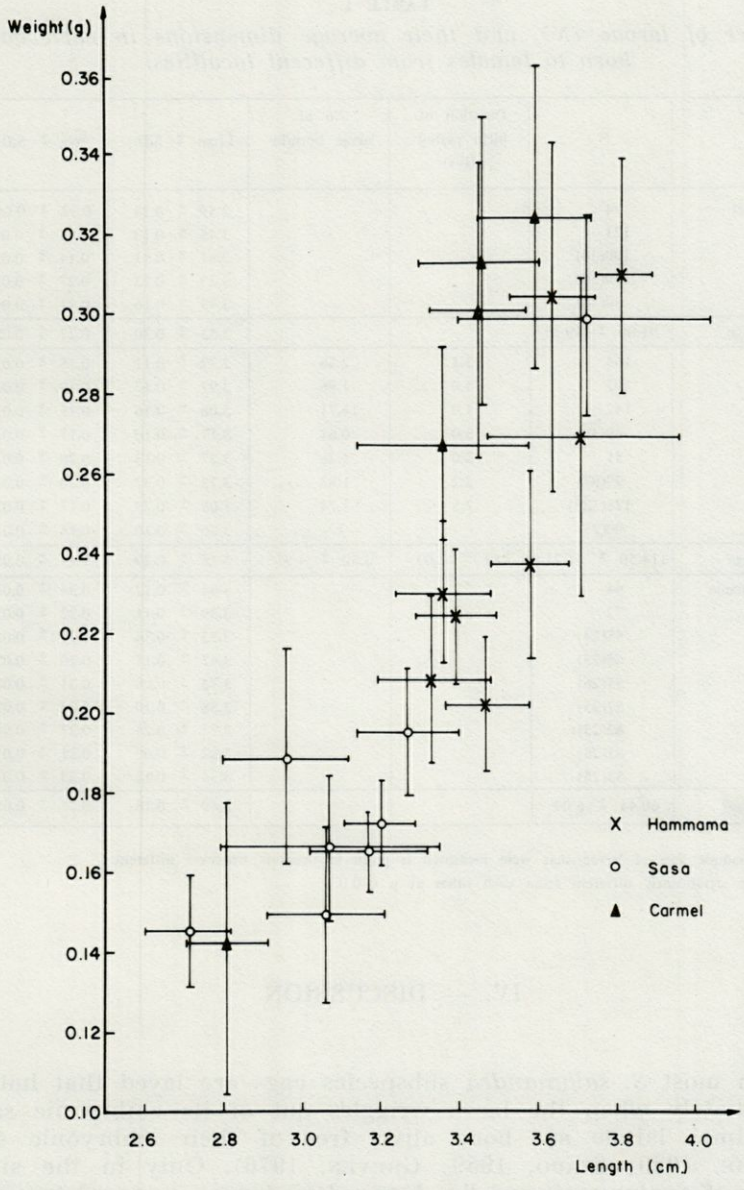

FIG. 7. — Weight as a function of length in newborn larvae. The calculated formula of the curve is : $W = 0.14^{0.84L}$ $r^2 = 0.76$

TABLE I

Number of larvae (N), and their average dimensions in each batch born to females from different localities.

	$\bar{N}$	Duration of birth period (days)	No of larvae born/hr	$\bar{L}$(cm ± S.D.)	$\bar{W}$(g ± S.D.)
Carmel	74			3.59 ± 0.14	0.32 ± 0.04
	121			3.45 ± 0.13	0.31 ± 0.04
	100(30)			2.81 ± 0.11	0.14 ± 0.03
	130(30)			3.33 ± 0.23	0.27 ± 0.03
	30(30)			3.45 ± 0.16	0.31 ± 0.04
Average	91.00 ± 40.35			3.33 ± 0.30	0.27 ± 0.08
Sasa	164	3.5	2.26	2.72 ± 0.11	0.15 ± 0.02
	193	4.0	1.96	2.97 ± 0.17	0.19 ± 0.03
	142	1.0	14.71	3.06 ± 0.16	0.15 ± 0.02
	49(38)	3.0	0.61	3.17 ± 0.10	0.17 ± 0.01
	51	2.0	1.36	3.27 ± 0.13	0.20 ± 0.02
	99(97)	2.2	1.83	3.73 ± 0.32	0.30 ± 0.03
	128(125)	2.5	1.74	3.08 ± 0.29	0.17 ± 0.02
	90(25)	- -	- - - -	3.20 ± 0.10	0.18 ± 0.01
Average	114.50 ± 51.71	2.61 ± 1.00	3.50 ± 4.97	3.15 ± 0.29	0.19 ± 0.05
Hammama	64			3.64 ± 0.12	0.34 ± 0.04
	72			3.39 ± 0.11	0.32 ± 0.02
	55(24)			3.33 ± 0.14	0.21 ± 0.02
	65(25)			3.47 ± 0.11	0.20 ± 0.02
	55(26)			3.73 ± 0.08	0.31 ± 0.03
	57(25)			3.58 ± 0.10	0.24 ± 0.02
	62(25)			3.71 ± 0.25	0.27 ± 0.04
	61(25)			3.22 ± 0.09	0.21 ± 0.01
	53(25)			3.34 ± 0.12	0.23 ± 0.02
Average	60.44 ± 6.09			3.49 ± 0.18	0.25 ± 0.05

The sample size of larvae that were measured is given in brackets wherever different.
$\bar{N}$ are significantly different from each other at $p < 0.05$.

IV. — DISCUSSION

In most *S. salamandra* subspecies eggs are layed that hatch immediately when the larva wriggles out of its embryonic sac. Sometimes larvae are born alive, free of their embryonic sac (GASCHE, 1939; SZABO, 1959; GREVEN, 1976). Only in the subspecies (*S.s. almazoris* and *S.s. bernardezi*) larvae managed to complete an intra-uterine metamorphosis which results in postmetamorphic birth of juveniles (FACHBACH, 1969). This phenomenon is known to take place in the Alps salamander (*Salamandra atra*)

TABLE II

Comparison between the average dimensions of larvae in batches born to females of different populations.

Locality of population	Average of $\overline{W}$ (g ± S.D.)	Locality of population	Average of $\overline{W}$ (g ± S.D.)
Galil	0.22 ± 0.06	Carmel	0.27 ± 0.08
Sasa (*)	0.19 ± 0.05	Carmel	0.27 ± 0.08
Hammama	0.25 ± 0.05	Carmel	0.27 ± 0.08
Sasa (*)	0.19 ± 0.05	Hammama	0.25 ± 0.05
	Average of $\overline{L}$ (cm ± S.D.)		Average of $\overline{L}$ (cm ± S.D.)
Galil	3.35 ± 0.30	Carmel	3.33 ± 0.30
Sasa	3.15 ± 0.29	Carmel	3.33 ± 0.30
Hammama	3.49 ± 0.18	Carmel	3.33 ± 0.30
Sasa (*)	3.15 ± 0.29	Hammama	3.49 ± 0.18

(*) $p < 0.05$. All others n.s.

No. of larvae measured : Sasa 705 ; Hammama 311 ; Carmel 285 ; Galil 1016

No. of oviparing females : Sasa 8 ; Hammama 9 ; Carmel 5 ; Galil 17.

(VILTER & VILTER, 1960). Apparently this phenomenon is connected with a short reproductive season at high altitudes. Both subspecies as well as the latter species are found at altitudes of 2 000 m or more (FACHBACH, 1969). Furthermore, at such altitudes females bear young once every two years (GASSER & JOLY, 1972), the number of juveniles in each batch being smaller than usual (5-8 in *S.s. bernardezi* and 15-18 in *S.s. almazoris*). They are also of a larger size than larvae of other subspecies (110-147 mm in length) (FACHBACH, 1969). The smaller number of larvae and their comparatively larze size can be a result of intra-uterine oophagy (JOLY, 1968) where larvae feed on remnants of eggs and partially developed larvae (FACHBACH, 1969). In a previous study we found evidence of post-birth cannibalism taking place immediately after birth (WARBURG *et al.*, 1979).

So far there is no written record of the rate at which larvae were born. SZABO (1959) described only that larvae were born at large intervals. In the present study this period was found to range between 1-4 days when larvae were born at intervals, several larvae each time. The total number of larvae per batch was counted, but this is probably (at least in some cases) only a conservative estimate as the female might have started laying before having been caught.

The number of larvae per batch is considerably larger in the local subspecies (30-193), as compared with the European subspecies (up to 70), but generally between 10-25 (SZABO, 1959). The difference in number of larvae per batch between the three localities studied here is significant ($p < 0.05$). Females originating at Hammama springs have the smallest number of larvae per batch (60). This finding may be explained by the fact that Hammama spring adults were somewhat smaller in size (DEGANI & WARBURG, 1978).

Similar observations (on plethodontids) by BRUCE (1975) have shown that clutch size increased as a function of body size in *Pseudotriton ruber*, or as a function of length in *Bolitoglossa rostrata* (HOUCK, 1977).

The dimensions of newly born larvae were studied by SZABO (1959) who found that length ranged between 22,5-33.5 mm (Av. 29 mm), and by JOLY (1968) who found their length ranged between 25-33 mm and their weight 0.10-0.17 g. In the present study for the first time a detailed account is given of both dimensions (length varying between 25-40 mm, and weight 0.13-0.40 g). These larvae are somewhat larger than their European counterparts. We do not know of similar detailed accounts of sizable samples where larva dimensions at birth have been compared between different populations. The difference in both length and weight between larvae born to Sasa females, and the other two localities was found to be significant.

RÉSUMÉ

1. Les larves naissent vivantes, seules ou en petits lots généralement enveloppées de leur sac embryonnaire.

2. La durée des naissances est de 1 à 4 jours, le nombre de larves allant de 30 à 200 par émission.

3. Les larves pèsent 0,13 à 0,40 g à la naissance et ont de 2,5 à 4 cm de long; une relation exponentielle a été mise en évidence entre la longueur et le poids des larves nouveau-nées.

4. Le nombre de larves par lots et leurs dimensions sont comparées chez les 3 populations.

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