Eggs and Young of the Lizard, *Eumeces fasciatus*

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A deep and abiding interest in the herpetofauna that extends back for more than two decades has meant the seasonal collection of various and sundry live specimens, and the maintenance of these in the laboratory for varying periods of time. Occasionally gravid females were included and eggs were laid in the laboratory. An especial interest in various aspects of the biology of the five-lined (or red-headed) skink, *Eumeces fasciatus*, made eggs of this particular species the objects of special attention, and from this there accumulated, irregularly and over a period of years, the factual information upon which this paper is based. Records are at hand on a total of eighty-one eggs that were laid in eleven clutches. Completion of development to hatching of the young lizard occurred in 50 eggs or 61.7% of those laid. Other authors have mentioned the eggs of this species but no review of the literature will be attempted here; reference should, however, be made to Fitch's (10) excellent and comprehensive work on the life history and ecology of *E. fasciatus*, to Smith's (19) handbook, and to the work of Noble and Mason (16).

The lizards covered by this report were maintained in screen wire cages with sheet metal floors. In each cage about half of the floor was covered with sod-like moss to which was adherent, underneath, about one to 1½ inches of earth. The remainder of the floor was bare except for a few strips of loose bark and a small water dish. Water was kept in the dish at all times, the moss was sprinkled thoroughly daily, and mealworms (*Tenebrio* larvae) were offered two or three times per week as food. Cages were so placed in the laboratory as to have access to some sunlight each day. Except for occasional basking in the sun, the secretive skinks spent much time concealed under the strips of bark or in burrows in the soft earth under the moss.

Egg Laying

Of the eleven clutches of eggs encompassed by these observations, seven were laid in the recesses in the soft earth beneath the moss in the cages, and four were laid under strips of bark. Whether or not the female specifically burrowed a nest under the moss could not be determined; Corrington (7) and Ruthven (17) have both commented on the apparent burrowing activity of the female in connection with the hollowed-out site in which eggs were laid. Eggs of *E. fasciatus* laid under bark of decaying logs have been recorded by Allard (1), Blanchard (2), Corrington (7), and Ruthven (17). Cagle (6) observed nests in the interior of decaying logs. In the laboratory, Ditmars (9) observed eggs laid under strips of bark, and Noble and Mason (16) had eggs laid between fragments of decaying wood. The common feature in all these reports would seem to be the protected nature of the egg-laying site.

The number of eggs laid per clutch may be seen by referring to Table 1. The range was from a minimal five eggs to a maximal 12 eggs; the mean for the eleven clutches was 7.4 eggs per clutch. Other reports on clutches laid in the laboratory vary from two to six eggs (Ditmars, 9; Burt, 5; Klots, 13; McCauley, 14; Noble and Mason, 16). The numbers of eggs observed in clutches laid in nature have tended to be somewhat greater, varying from five to 15 eggs per clutch (Allard, 1; Brimley, 4; Burt, 5; Cagle, 6; Corrington, 7; Smith, 18; Strecker, 20; Taylor, 21; Ruthven, 17; McClellan, Manseuti, and Groves, 15). Cagle (op. cit.) reported a mean of 9.15 eggs per clutch based on 26 clutches observed, and Fitch (10), after a study of even more ample material, decided that 9, 10, and 11 eggs is the most typical number per clutch. Fitch also found evidence that larger females lay more eggs than do smaller ones. Noble and Mason (16) suggested a possible "captivity effect" operating to reduce the number of eggs laid by female skinks in the laboratory.

As to time of egg-laying, reference to Table 1 will show that one clutch was laid as early as late May, another as late as early July, while the remaining nine clutches were all laid during June. Clutch No. 7 was laid over a three-day period, and Clutch No. 8 was laid over a four-day period. McClellan, Manseuti, and Groves (15) reported a clutch of eight eggs that were laid over the period June 30-July 5. If reports in the literature of earliest observation of clutches in nature be combined with reports of egg-laying in the laboratory, the reports from southern locations such as Arkansas (Burt, 5), Georgia (Allard, 1), Mississippi (Noble and Mason, 16), and South Carolina (Corrington, 7) indicate egg-laying from May through July 8. Similarly, reports from states just north of the 35th parallel of latitude such as Kansas (Burt, 5), Maryland (McClellan et al. 15), and Virginia (Brady, 3) indicate egg-laying from May 23 through July 7. From states which, like Indiana, lie astride the 40th parallel such as Illinois (Cagle, 6) and New Jersey (Klots, 13), and also from Michigan (Ruthven, 17) which lies north of this parallel, egg-laying has been reported between June 22 and July 23. While the latter records are just a little later, there is much overlap, and this rough attempt to classify egg-laying records according to geographic area does not reveal a clear-cut latitudinal pattern.

Incubation Period

Table 1 gives the incubation periods for the 50 eggs which hatched in all clutches. The mean incubation period was 29.62 days. Seven eggs hatched in as short a period as 22 days, while nine eggs required as long as 35 days. In the specific case of egg No. 7 of clutch No. 8, the time from laying to hatching was exactly 30 days and 15 minutes, both processes having been observed and timed. The longest period of incubation exhibited by these clutches is the same as the average time of 35 days reported by Noble and Mason (16) for six clutches. The shortest period of 22 days is not greatly different from a 24-day incubation period reported by Cagle (6). McCauley (14), however, recorded a clutch that exhibited a period of 56 days, and Fitch (10) concluded that the incubation time (in nature) approximated six weeks.

Movement and Manipulation of the Eggs

The first four clutches involved in this report were studied by strictly "observational" methods in that they were left in the cages where they were laid by the female skink and were observed at frequent, usually daily, intervals. The manipulations necessary thereto usually disturbed the adult female considerably, and her movements would roll the eggs about and cause them to become coated with mud or dirt. Even so, these hasty but oft-repeated observations gave evidence of changes that would merit study by more specific and exacting methods. Although Halver (11) had reported that movement injured the embryo of *Lacerta sardoa*, the disturbance of the eggs by female adults did not seem to interfere with hatching of *E. fasciatus*, and the same was found by Noble and Mason (16).

Beginning with clutch No. 5, eggs were removed from the cage in which they were laid and transferred to a finger bowl, the bottom of which was covered with moist moss. The clutch of eggs was then

TABLE 1

Laying and Hatching Dates, Number per Clutch, and the Incubation Period in Eggs of *Eumeces fasciatus*

Clutch	Eggs Laid		Eggs Hatched		Incubation Period
Number	Date	No.	Date	No.	in Days
1	May 28	5	..	0	..
2	June 9	7	July 9	7	30
3	June 9	8	July 10	8	31
4	June 23	7	July 15	7	22
5	June 8	6	July 12	4	35
6	June 11	8	July 14	2	34
			July 15	5	35
7	June 16	7	July 12	1	27
			July 14	1	29
			July 15	3	30
8	June 19	6	July 19	1	31
	June 20	1	July 19	1	30
	June 23	1	..	0	..
9	June 19	10	July 16	8	28
	June 20	2	July 16	1	27
			July 17	1	28
10	June 26	7	..	0	..
11	July 6-9	6	..	0	..

covered with moist towel paper, three sheets thick, and the bowl was covered with a glass plate to prevent undue evaporative loss. Stream or well water was used for keeping both moss and towel paper moist. Eggs that were dirty or discolored were held with blunt forceps in a petri dish containing about 3/8 inch of well water, and stroked gently with a No. 2 Red Sable brush; this procedure usually restored the clean white original color of the eggs. In each clutch individual eggs were marked, using a small pen and India Ink; when more than one clutch was on hand, each clutch was in a separate bowl. These arrangements made possible the keeping of much more exact records, and the records were extended to include accurate measurements and the taking of occasional weights. When all the data are summarized as seen in Table 1, the question as to whether manipulation such as those above were actually harmful may be raised. The above manipulations were accorded clutches 5 through 10 inclusive, thus involving 48 eggs of which 28 or about 58% actually hatched. Clutches 1 through 4 were not given the above treatment, but were subject to much disturbance by the female skink; these clutches encompassed 27 eggs of which 22, or over 81%, hatched.

The eggs of clutches 5 through 10 were subjected occasionally to an additional manipulation which involved their observation through a binocular microscope with the aid of an "egg candler" improvised as follows: a small box-top five-eighths inch deep and of other appropriate dimensions was placed over the face of a Spencer substage lamp which lay horizontally with light shining upward; an oval aperture somewhat smaller than a lizard egg was cut where maximal light would pass through; strips of masking tape fastened these items together and blocked light leaks. Eggs were placed on this device and observed at night with room lights turned off, but no egg was left on the candler for as much as one full minute for fear of heat injury. Little could be seen in eggs candled on the eighth day of incubation, but on the eleventh day embryonic outlines could be seen and movement of the embryo could be detected (Clutch 10). On the 15th (Clutch 10) and 17th (Clutch 8) days of incubation the embryos were indistinct and translucent yet in some cases the head, trunk, and tail regions could be distinguished and movement could be seen (Figure 3). Observed on day 18, Clutch 6 exhibited pigmented eyes and identifiable heads, trunks, tails, and limbs; the pigmented stripe lateral to the dorsal midline could be seen in two cases and barely detected in two others. By day 25 of incubation, pigmented stripes and body regions were easily observed (Figure 4). On day 33, the shell of egg No. 3 of Clutch 6 was punctured opposite the snout of the embryo although the young lizard did not emerge until day 35.

Egg Shape, Size, and Proportion

The shape of the egg of *E. fasciatus* (Figure 1) has been variously described as oval (Smith, 18), short to long oblong (Brimley, 4), and elliptical (Allard, 1). Allard and Brimley recorded egg sizes, and a number of investigators such as Noble and Mason (16), Taylor (21), Cagle (6), McClellan et al. (15), and Smith (19) have presented not only sizes, but also evidence that the eggs changed in size during the course of incubation.

Micrometer calipers were used to measure greatest lengths and diameters of the eggs of Clutches 5 through 10 at periodic intervals. As shown in Table 2, this resulted in an over-all sampling of size from day 2 of incubation through day 33. Dimensional ranges were from least diameter of 6.5 mm and length of 9.7 mm to greatest diameter of 11.6 mm and length of 16.4 mm. Central tendencies based on clutch averages recorded in Table 2 make it amply evident that egg dimension was not static; both length and diameter underwent an increase during the course of incubation time (Figure 2). In Clutches 7, 8, 9, and 10, mean length increased as long as measurements were taken, whereas Clutches 5 and 6 reached a maximum mean length then suffered a decrease prior to hatching. Similarly, mean diameter increased progressively in Clutches 7 and 9, while in Clutches 5, 6, 8, and 10, a post-maximum decrease occurred.

If attention be turned to individual eggs rather than clutch means, egg No. 7 of Clutch 8 measured, less than 10 minutes after laying, 11.5 x 7.2 mm, and thirty days later (45 minutes before hatching) it measured 13.4 x 9.7 mm. During its incubation this egg exhibited a progressive increase of 1.9 mm in length and 1.5 mm in diameter. A total of 197 length-diameter determination on 40 eggs of Clutches 5 through 10 show that no egg failed to undergo dimensional change during incubation. Mean length increase was 2.29 mm or 20.4% of initial length and mean diameter increase was 2.28 mm or 29.7% of initial diameter. In sequential pattern, 26 eggs evinced progressive length increase while in 14 eggs maximal length was followed by some shortening. In diameter, 20 eggs showed progressive increase while 20 eggs decreased some in diameter after reaching a maximum. In spite of the tendency of some eggs to show dimensional decrease prior to hatching, final dimensions as a rule exceeded initial ones: final diameters were greater than initial ones in 36 eggs, less than initial ones in four eggs; final lengths were greater in 35 eggs, less in 5 eggs, than initial lengths.

With respect to egg proportion, or relative behavior of length and diameter on a time sequence basis, Smith (19) implied a strict proportionality of change in the two dimensions during development, but gave credit to McClellan et al. (15) for presenting evidence for differential change. These latter authors maintained that developmental change favored diameter, resulting in a less elongated shape as incubation proceeds. They pointed out, however, that their evidence did not include both initial and final measurements on the same clutch. To investigate these relationships, for each length-diameter determination made on the eggs of Clutches 5 through 10, a quotient $\frac{\text{length}}{\text{diameter}}$ was calculated to yield a ratio (L/D), changes in the value of which would accurately reflect relative dimensional behavior of the egg concerned. Clutch means of these L/D ratios are included in Table 2. For all 197

TABLE 2

Quantitative Data on Eggs at Different Days of Incubation

Clutch No.	Date	Day	Mean Length mm	Mean Diameter mm	Mean L/D Ratio	No. Eggs	Mean Weight mg
	June 10	3	12.7	7.60	1.67	6	....
	June 21	14	14.6	9.95	1.67	6	....
5	June 26	19	14.6	10.70	1.39	5	....
	June 30	23	14.9	10.90	1.37	5	..
	July 3	26	14.7	10.60	1.39	5	836.9
	July 10	33	14.0	9.70	1.45	5	724.0
	June 21	11	14.2	9.95	1.42	8	....
	June 26	16	14.5	10.80	1.33	8	....
6	June 30	20	14.8	10.00	1.34	8	
	July 3	23	14.6	10.80	1.36	8	861.8
	July 10	30	14.4	10.20	1.42	8	809.7
	June 26	11	13.8	10.30	1.34	7	....
7	June 30	15	14.1	10.80	1.31	6	....
	July 6	21	14.8	11.20	1.33	6	1004.9
	June 22	4	11.6	7.90	1.46	6	....
	June 26	8	11.9	8.52	1.39	6	....
8	June 30	12	12.1	8.70	1.40	6	...
	July 3	15	13.0	9.36	1.38	6	521.8
	July 10	22	13.2	9.40	1.40	6	612.8
	July 19	31	13.8	9.30	1.47	5	663.7
	June 20	4	10.4	6.98	1.49	10	....
9	June 26	10	11.9	8.70	1.37	10	....
	June 30	14	12.9	9.63	1.37	10	657.9
	July 6	20	14.6	10.73	1.36	10	880.9
	June 27	2	11.1	8.03	1.38	7	....
	June 30	5	11.5	8.80	1.31	7	458.9
10	July 3	8	12.1	9.40	1.25	6	604.3
	July 10	15	12.8	10.20	1.26	5	672.1
	July 19	24	13.3	9.40	1.43	5	578.6

measurements on the 40 eggs, the mean L/D ratio was 1.38, and the extreme ranged from 1.18 for the relatively shortest eggs to 1.76 for the relatively longest ones. As to final outcome, only five eggs showed identical initial and final L/D ratios, while 17 eggs had initial ratios exceeding the final ones, and 17 eggs showed final ratios exceeding initial ones. The most common sequential pattern, exhibited by 33 eggs, was characterized by an early relatively greater diameter increase (L/D ratio decrease) up to an average of 16.2 days of incubation where minimal L/D ratios occurred. Following this, a relatively greater length increase took place as reflected by increased L/D ratios to hatching. One egg showed an exactly reverse sequential pattern, and six eggs evinced a straight L/D ratio decrease (relatively greater diameter increase) from laying to hatching.

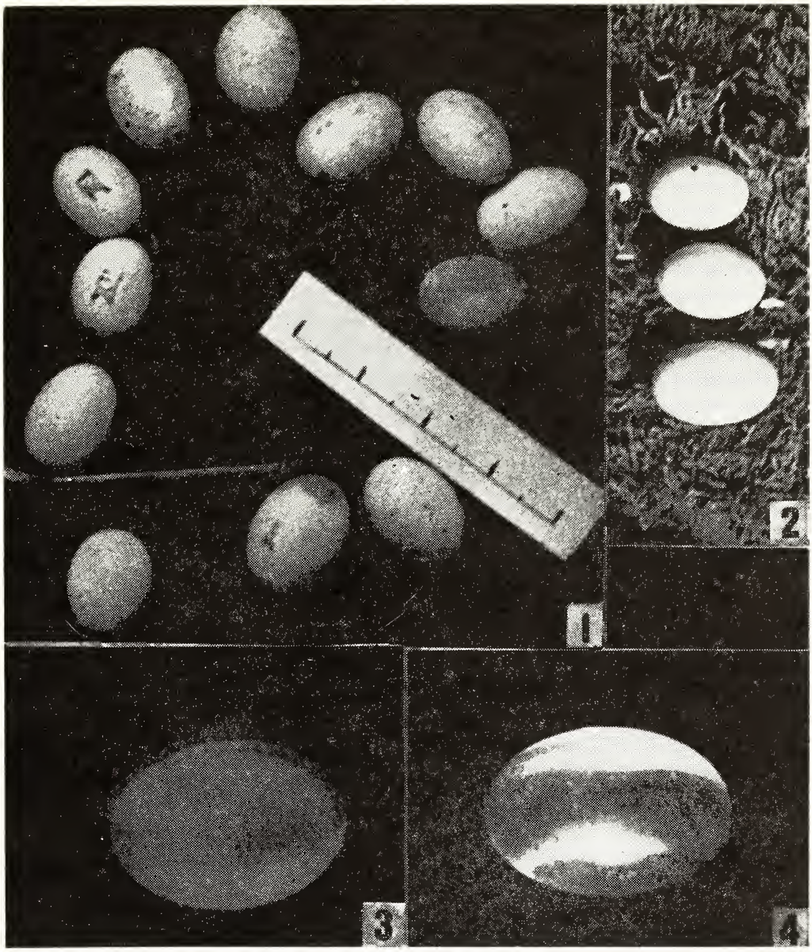

Figure 1. Photograph of Clutch 9 showing markings and size on 19th day of incubation. Larger ruler divisions are 1 cm. (x 1, approximately)

Figure 2. Size and shape of three eggs. These were, from top to bottom, at the 10th, 17th, and 25th days of incubation, respectively. (x 1, approximately)

Figure 3. Photomicrograph of egg No. 2 of Clutch 8, taken on candler on the 17th day of incubation. Embryonic outline visible but not distinct. (x 2, approximately)

Figure 4. Photomicrograph of egg No. 4 of Clutch 6 taken on 25th day of incubation. Note coiled position of embryo, pigmented stripe, shadow of leg to left. (x 2, approximately)

Egg Weight and Moisture Relationships

Information on the weight of reptile eggs is not abundant. Cunningham and Hurwitz (8) reported on 18 eggs of *Sceloporus undulatus* which exhibited mean weight of 0.465 grams at laying and 0.948 grams on day 36 of incubation (hatching occurs at 38-55 days), which represented a weight gain of over 100%. The same authors recorded weight gains of 37% to 47% in eggs of *Malaclemys centrata*, 50% in eggs of *Caretta caretta*, and Karashima (12) reported an increase of 35.7% in egg content (exclusive of shell) in *Thalassochelys corticata*.

While the weight data on Clutches 5-10 inclusive of this report are not as extensive as desired, it is felt that the 97 weight determinations made on seven different days of incubation yield indicative information. The lightest weight taken was 441.6 mg, the heaviest, 1170.4 mg. Clutch average weights are included in Table 2; these values show that Clutches 5, 6, and 10 exhibited mean weight decreases during later incubation time, but the values for Clutches 8, 9, and 10 give definite evidence that mean weight increase did occur. For example, Clutch 8 showed a weight increase of 17% by day 22 and of 26% by day 31. Clutch 10 made a maximal gain of 45% (on day 15) but by day 24 it was only 26% heavier than initially. The actual magnitude of weight change is somewhat masked by the averaging for whole clutches. Egg No. 1 of Clutch 8 made a gain of 85% (562.6 to 1040 mg), egg No. 6 of Clutch 10 gained 64% (484.6 to 795.8 mg), and egg No. 3 of Clutch 9 made a gain of 52% (767.8 to 1170.8 mg). These data on egg weight in *E. fasciatus* would seem to justify the more general statements that: (1) the eggs of this species exhibited a weight range of from slightly less than 0.5 gram to slightly more than 1.0 gram; (2) weight increase during incubation was the general rule; (3) weight gain may be progressive to hatching or may attain a maximum and be followed by a decrease in weight; (4) the weight gain may be as much as 85% but gains of smaller magnitude were more common, and the gains exhibited were of the same order of magnitude as those of other reptiles on which information is extant.

Evidence that has been presented to this point indicates that the eggs of *E. fasciatus* on which this report is based underwent, as incubation progressed, increases in both size and weight. The obvious explanatory inference is that this volume and mass increment was due to water uptake through the egg shell. The remarkable nature of this water uptake capacity was highlighted by an unintentional incident in which the finger bowl containing Clutch 8 was inadvertently permitted to become much too dry. Of the eight eggs in the clutch, five were dessicated, shrunken, and too wrinkled to observe on the candler. On discovery of this situation, both moss and paper egg-cover were made moist to excess. Within 12 hours the wrinkling was greatly reduced, within 20 hours two of the eggs were normally turgid again, and at the end of 25 hours all five eggs were completely normal and all five embryos alive as evidenced by movement when observed upon the candler. Noble and Mason (16) attributed this water uptake capacity to the permeability of the egg shell; except for this suggestion the mechanics of water absorption remain obscure. Similar findings include those of Karashima (12) who reported that egg solids of *Thalassochelys cortcata*, a turtle, decreased from 16.5% at laying to 11.4% at 45 days of incubation, during which period total egg weight increased 35.7%. In *Malaclemys centrata*, Cunningham and Hurwitz (8) found that similar egg solids (exclusive of shell) decreased by 14.5% while total egg weight increased 57% between laying and 54 days of incubation.

Hatching and The Young

The emergence of the young lizards from the shell of the egg was not a rapid process carried through to quick conclusion. Several young required 45 minutes, one 2½ hours, and one as long at 3¼ hours, for emergence. The first evidence that hatching is imminent was a slight pimple on the surface of the egg, which on close examination proved to be a tiny slit in the shell plugged by the tip of the snout of the young lizard. From this start, the snout, head, and body were gradually forced out, enlarging the initial aperture as it emerged. In general, periods of quiescence were interspersed with relatively shorter periods of active struggling and wriggling, the original slit in the shell being made larger by tearing.

In the creation of the original puncture in the shell, the head of the young undoubtedly has an important role. Candling showed that the head of the coiled young (Figure 4) was in such a position that the tip of the snout, which bore an egg tooth, was very close if not in actual contact with the egg membrane. Furthermore, observations at candling demonstrated that the young was capable of movement for some time prior to hatching. It is difficult to see how such movement could avoid wearing down the thickness of the shell and thus leading to the formation of the initial puncture.

The young *E. fasciatus* came out of the shell with an attached stump of umbilicus which varied from very short to 8 mm in length; this soon dried up and broke off. One egg weighed, two hours before hatching, 484.0 mg; just a few minutes after emerging the young lizard weighed 270.0 mg and the shell and contained liquid weighed 161.8 mg. The remaining 82.2 mg could undoubtedly be accounted for by liquid lost during the process of emergence. In another instance the shell and liquid weighed 93.8 mg, and the lizard, 30 minutes after emergence, 342.0 mg.

As a sample of the size and weight of newly-hatched lizards, the data on six animals at the age of three days are presented:

Head (mm)	Snout to vent (mm)	Total length (mm)	Weight (mg)
8.0	24.5	54.5	310.0
8.4	24.2	54.0	329.0
8.8	25.0	55.5	338.4
7.9	24.7	52.9	292.8
8.0	24.6	54.6	303.0
. .	23.0	. . .	307.0
8.22	24.24	54.5	313.5 (MEANS)

These data agree quite closely with a mean snout-vent measure of 24.0 mm reported by Noble and Mason (16), and with a similar mean of 26.2 mm reported by McCauley (14).

Egg Adaptiveness and Evolutionary Implications

Among vertebrates, the members of the class Amphibia are usually regarded as the products of evolutionary processes which did not endow the group with complete independence from its ancestral aquatic environment; amphibians in general make an annual trek to the water to reproduce, and they have definite moisture requirements in adult physiology. The former of these two relationships emphasizes the importance of the vertebrate egg in the evolutionary scheme; adaptation must characterize the egg as well as the adult. Cunningham and Hurwitz (8) reviewed certain features of the development of both amphibians and birds and then called attention to the strategic position of reptiles as an intermediate group, suggesting that the reptilian egg might be studied with profit. They emphasized the paramount importance of maintaining an adequate aqueous medium for the developing embryo. In this latter connection, it is believed that the factual data presented above support the viewpoint that eggs of *E. fasciatus* exhibited two highly adaptive properties in that: (1) they demonstrated unusual capacity to absorb water, as was manifested in marked increments in both mass and size; (2) the shells of these eggs possessed elastic properties permitting the accommodation of size increments, apparently without losing any other properties distinctive to such shells.

Two more adaptive properties may be suggested for these eggs, both relating to the character of the egg shells. The "normal" shell of the *E. fasciatus* egg has a clean white color and firm appearance. It was repeatedly observed, however, that during the 5 or 6 days preceding hatching the shell assumed a dirtier or gray color, became less firm, appeared to have more moisture on the external surface, and developed patches that were markedly translucent, some even slightly transparent. Several of the papers cited above have made reference to these pre-hatching changes in the shell, and Brimley (4) in particular used the term "dirty white," mentioned the apparent thinness of the shell, and called it "almost transparent." That such changes, detected by observational means, may be the reflection of physico-chemical changes in the shell, derives some support from investigations on turtle eggs. Karashima (12) reported, in *Thalassochelys corticata*, a change from 0.061% to 0.131% for CaO and from 0.028% to 0.108% for MgO between egg laying and 45 days of incubation. He explained the increase in egg content of Ca and Mg by assuming that these chemicals were taken from the shell. Regarding the same turtle, Tomita (22) remarked on the large amount of $CaCO_3$ in the egg shell and stated "Im Verlauf der Bebrütung entwicklungsfähiger Embryonen wird die Schale teilweise abgebaut und zum Aufbau des Embryos verwendet." These findings would tend to place the reptilian egg shell in an adaptive role as a reservoir of chemical substances that are gradually withdrawn and incorporated into the embryonic structure (e.g., skeleton). Finally, it may be suggested that the withdrawal process alters the texture and strength of the shell in such a way that it favors the initial puncturing of the shell by the young lizard to initiate the hatching process.

Summary

Over a number of seasons, females of *Eumeces fasciatus* in laboratory cages laid 11 clutches totalling 81 eggs. Laying occurred mostly in June, but extended from late May to early July, and was always

in a protected site. The average was 7 eggs per clutch, and about 30 days was the average incubation period. During incubation, size increase occurred, averaging 20% for length and 29% for diameter; weight also increased, as much as 85% for individual eggs but averaging 45% for clutches. Fifty of the eggs hatched, and the hatching process required 45 minutes for most lizards although one required over 3 hours. Suggested adaptive properties of the eggs having evolutionary significance include: (1) remarkable capacity for water uptake; (2) an elastic shell; (3) the shell as a reservoir of inorganic materials that are withdrawn and utilized in embryo formation; (4) late texture and strength changes in the shell favoring the initial puncture necessary to the process of hatching.

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