EGG DEPOSITION AND INCUBATION FOR EREMBOATES DURANGONUS WITH NOTES ON THE EGGS OF OTHER SPECIES OF EREMBOATIDAE (ARACHNIDA: SOLPUGIDA)\textsuperscript{1,2}

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Biological studies on the arachnid order Solpugida are rare and usually fragmentary. However, a literature search revealed several original accounts of the eggs, egg deposition, and egg incubation of these little-known arachnids.

Hutton (1843), after describing the burrowing habits of Galeodes sp., stated succinctly, “I now perceived that it was a female, the ova being distinctly visible through the skin of the abdomen. The ova were deposited in the cave, to the number of more than fifty (50), the parent remaining motionless amidst them. In the course of a fortnight, these, which were of the size of a largish mustard seed, and of a whitish hue, were all hatched.”

Turner (1916), Hingston (1925), Lawrence (1947 and 1949), and Junqua (1962) all observed deposition, examined and studied recently laid eggs, or noted egg incubation. All except Turner investigated or observed African and Asian species of the families Galeoideidae and Solpugidae. Their data are compared with those obtained for the North American family Eremobatidae at the end of this report.

Turner’s (1916) observations and studies were based on a single female from New Mexico, identified as Eremobates formicarius (Koch). This species, if recognizable, is Mexican; it is not known at present from the United States. Turner’s specimen was, however, obviously an Eremobates, probably either E. durangonus Roewer or E. palpisetulosus Fichter. His egg observations were fragmentary. Unfortunately he did not observe deposition. Of the two egg masses deposited in 14 days, one was laid in a burrow, the other partially in a burrow and partially scattered over the soil surface. Each egg was about 1.7 mm in diameter but no egg count for either mass was recorded. The second egg mass reportedly turned yellow and shriveled in a few days; the first mass was not discussed further.

The present report represents a two-year study and observation of the egg laying habits and eggs of Erechthax magnus (Hancock), Eremobates auranguous Roewer, Eremobates nodularis Muma, Eremobates palpisetulosus Fichter, and Therobates bilobatus Muma. Only E. durangonus yielded complete or detailed information. However, the other species produced eggs and some egg-laying information.

METHODS

Females were collected as adults or immatures during August 1963 and June, July and August 1964 in southeastern Arizona (while I worked

\textsuperscript{1}Partial report on studies supported by National Science Foundation Grant GBS-496.
\textsuperscript{2}Florida Agricultural Experiment Stations Journal Series No. 2166.
out of the American Museum Southwestern Research Station), in southwestern New Mexico, and western Texas.

All eggs studied were deposited under laboratory conditions. Field collected females were maintained in terraria at 80° F and 70% relative humidity until death. Each specimen was fed daily or whenever it left its burrow during the feeding schedule. Specimens that remained in their burrows for prolonged periods of time were forced out at least once every two weeks for a feeding.

Terraria included 8” x 12” battery jars, one-pint food preserving glass jars, and petri dishes. Sand or a clay-sand mixture from ½” to 2” in depth was provided as a substrate. Small stones, wood chips, or bovine droppings were added to most terraria for cover. The substrate was moistened with water at irregular intervals.

The staple food or prey were soldiers and workers of subterranean termites, Reticulitermes spp. Eremobates magnus refused termites and was fed miscellaneous insects until it was found to accept adult and larval mealworms. Tenebrio spp. At irregular intervals all specimens were offered a wide variety of other arthropods as supplemental food.

Females were disturbed only during feedings, experimental matings, or when the terraria became fouled with excrement, dead prey, or uneaten fragments of food. The study specimens were moved to clean terraria. Exposed eggs were placed in petri dishes for incubation. When the eggs were laid in burrows, the females were moved to new terraria to prevent egg destruction or consumption.

**Egg Deposition**

Although 67 egg masses were deposited by the five species, the complete process of deposition was observed only twice. Regular checks of gravid females were made during most daylight hours and many night hours. Despite this diligence, deposition was observed only in Eremobates durangonus, the most commonly collected species, which laid 56 masses. It would seem that egg deposition is accomplished mainly at night, during late evening or early morning hours. Also, most egg masses were deposited in burrows well beneath the soil surface which prevented observations. All depositions were observed under conditions of a thin substrate and in the absence of cover. To this extent, the depositions may have been aborted by laboratory conditions.

Three reared E. durangonus females, fertilized in the laboratory, deposited fertile eggs. Their previposition period varied from 9 to 14 days with a mean of 11.3 days. Unfertilized reared females either died without producing eggs or laid sterile masses after 10 to 27 days with a mean of 19.2 days.

The time intervals between egg masses laid by the same female varied from 4 to 18 days with a mean of 8.1, and a mode of six days. This close agreement between mean and mode indicates a weekly deposition interval for most females of this species.

Egg deposition of E. durangonus is preceded by a 40 to 60 minute “labor.” During this time, the female lies on her back or side with her legs and palpi partially flexed. Actual “labor” consists of violent abdominal contractions which seem to alternate from one side to the other.
Sometimes these contractions flow rhythmically from the end of the abdomen toward the opercular segment, sometimes they occur at random with no pattern. After a series of contractions, the female's body and legs may tremble for a few seconds or may remain still.

In two observed depositions, the females were not disturbed during "labor" and deposition of the eggs followed immediately. In two other cases, the females were disturbed by moving them. In one case, deposition was not observed but occurred within 25 minutes following interruption of "labor." When the second female was moved, the abdominal constrictions stopped and the female revived. This second female, although quite gravid, died a week later without completing deposition.

Actual deposition lasted 40 to 60 minutes in the two undisturbed depositions. In the first interrupted deposition noted above, 25 eggs were deposited in 25 minutes. Time for deposition is probably directly related to number of matured ova.

During deposition, the eggs may slip from the female while she is absolutely quiescent or may be preceded by "labor-like" contractions and tremors. Furthermore, the eggs may be deposited either rhythmically one at a time or in interrupted frequency, singly at first, then later in series of two, three, or four in rapid succession.

Following deposition, the female lies in torpid condition for a variable length of time. In the two undisturbed ovipositions observed, the recovery period varied from 30 to 90 minutes. It should be noted, however, that several quiescent females lying beside recently deposited eggs recovered immediately upon disturbance. This indicates rapid recovery with movement possibly initiated by hunger or disturbance.

Egg Size and Number

Deposition has been observed only with E. durangonus, but eggs of four other species representing three genera have been deposited under laboratory conditions. These eggs were counted, measured, studied, and incubated. The physical data presented here are among the first for the Eremobatidae.

In general, the eggs of all species were subspherical and glistening opalescent white when laid. Fertile eggs dried quickly to a grayish off-white color (Fig. 1). Sterile eggs generally developed a yellow cast and upon drying or within a day or two collapsed or shriveled. A mucous egg coating glued them together into a loose irregular mass which, when handled, often broke into two or more smaller masses (Fig. 1 and 2).

Cannibalism of eggs was observed for E. durangonus and T. bilobatus and is suspected for other species.

Eremobates durangonus Roewer: Forty-seven females of this common, late-summer species were collected and studied. Twenty-one females produced 47 masses of eggs. The masses varied in number of eggs from 20 to 164 with mean of 64. Thirteen of the 21 egg-producing females laid two masses of eggs, eight laid three, three laid four, and two laid five. The number of eggs per mass for all females compared favorably with that of the females producing more than two masses. Multiple-mass-laying females produced clutches varying in number of eggs from 28 to 164 with mean of 68.
Thirty eggs from two masses were measured. The largest was 1.91 and 1.77 mm in length and width diameter respectively; the smallest was 1.22 and 1.11 mm in diameter. The mean diameters were 1.65 mm length and 1.57 mm width. Four eggs were round. These varied from 1.77 to 1.55 mm in diameter with a mean of 1.65.

Eggs of this species have the chorion ornamented with coarse, widely spaced, truncate microscopic papillae (Fig. 4, 900X magnification).

Eremobates palpisetulosus Fichter: Twenty-two females of this relatively common, early-summer species were collected for study. Only two produced eggs, in both cases a single small mass. One mass contained 12 eggs, the other 21. Both masses were laid on the soil surface but did not hatch though some viable eggs occurred in each. It is believed that a typical egg mass would contain many more eggs because several females greatly swollen with eggs were collected but accidentally killed before they could deposit.

Measurements of 15 apparently fertile eggs from the two small masses resulted in the following data. The length and width diameters of the largest were 1.74 and 1.70 mm, the smallest 1.52 and 1.37 mm. Means of 1.69 mm length and 1.59 mm width diameter are obtained.

These eggs have a microscopic chorion ornamentation of moderately spaced, rounded papillae (Fig. 5, 900X magnification).

Eremobates nodularis Muma: Three females of this uncommon, mid-summer species were collected. Two produced eggs, one a mass of 32, the other 82. The mean of these two masses, 57, is possibly near normal for the species. Neither mass contained fertile eggs.

Measurements of 15 normally shaped eggs from the two masses were made. The largest had length and width diameters of 1.59 and 1.41 mm, the smallest 1.41 and 1.33 mm. Means of 1.48 mm length and 1.41 mm width diameter were obtained.

The chorion of these eggs is ornamented microscopically with weak, faint to invisible nodular papillae (Fig. 6, 900X magnification).

Eremochax magnus (Hancock): This is a relatively common early-summer species, but since collections were made from June to August, only seven females were obtained for laboratory studies. Only one laid eggs, but she produced two masses within 16 days. One mass contained 33 eggs, the other 105. The mean of 69 is possibly near normal for the species. Some of these eggs developed embryos but did not hatch.

Fifteen normally-shaped eggs of the species were measured. The largest had length and width diameters of 1.78 and 1.63 mm, the smallest 1.26 and 1.18 mm. Means of 1.55 mm length and 1.44 mm width diameter were obtained.

Eggs of this species have the chorion ornamented with a distinct series of fine, nodular papillae (Fig. 8, 900X magnification).

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Fig. 1. Egg mass of Eremobates durangous Roewer on sand. Fig. 2. Fragment of same mass on black paper. Fig. 3. Eggs of E. durangous near hatch: note dark lines. Fig. 4. Chorion papillae of E. durangous Roewer. Fig. 5. Chorion papillae of Eremobates palpisetulosus Fichter. Fig. 6. Chorion papillae of Eremobates nodularis Muma. Fig. 7. Chorion papillae of Therobates bilobatus Muma. Fig. 8. Chorion papillae of Eremochax magnus (Hancock). (Fig. 1 through 5 at about 10X magnification.) (Fig. 4 through 8 at 900X magnification.)
The Florida Entomologist  Vol. 49, No. 1

Therobates bilobatus Muma: This is a common early- to mid-summer species. The female’s preferred habitat was not discovered, so only eight females were collected. Three females laid five egg masses but four of the five were laid on the soil surface, indicating abnormal deposition. The masses varied in egg number from 5 to 54 with a mean of 27. Although some of the surface deposited eggs were crushed and eaten, this mean is probably not too unrealistic for this small species. Some of these eggs appeared fertile but none hatched.

One female laid three masses of eggs, the second nine days after the first and the third 14 days after the second.

Fifteen apparently fertile eggs were measured. The largest had length and width diameters of 1.55 and 1.48 mm, the smallest 1.26 and 1.22 mm. Means of 1.41 mm length and 1.37 mm width diameter were obtained.

These eggs have a microscopic ornamentation of coarse, widely spaced, truncate papillae on the chorion (Fig. 7, 900X magnification).

Egg Incubation

Fertile eggs were deposited by E. magnus, E. palpisetulosus, and E. durangonus, but complete incubation and hatching data were obtained only for the latter. Well-developed embryos were observed in several eggs of the first two species but a hatch never occurred.

Incubation and hatching data were obtained for 22 masses of eggs from E. durangonus. Five masses were incubated at 90° F, eight at 80° F, five at 70° F, and four at 60° F (Table 1). The lower temperatures lengthened the incubation period but did not decrease hatch except at 60° F. This temperature apparently is critical because most eggs failed to hatch in 70 to 90 days but 16.1% hatched in one to nine days after the temperature was elevated to 90° F.

<table>
<thead>
<tr>
<th>Incubation Temperature</th>
<th>No. of Eggs</th>
<th>Number Days for Incubation</th>
<th>Percent Hatch</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Maximum</td>
<td>Minimum</td>
</tr>
<tr>
<td>90° F</td>
<td>383</td>
<td>27</td>
<td>18</td>
</tr>
<tr>
<td>80°</td>
<td>581</td>
<td>33</td>
<td>25</td>
</tr>
<tr>
<td>70°</td>
<td>382</td>
<td>66</td>
<td>38</td>
</tr>
<tr>
<td>60°</td>
<td>328</td>
<td>1 egg hatched in 26 days</td>
<td></td>
</tr>
</tbody>
</table>

Table 1.—Incubation and Hatching of Eggs of Therobates durangonus Roewer.

There was an unusual relationship among mass sequence, mass size, and percent hatch when total egg production was considered (Table 2). First masses contained a smaller number of eggs but produced a higher percentage of hatch than second and third masses. Fourth and fifth masses contained the fewest eggs, all of which failed to hatch.

Ten to 14 days prior to hatching, the eggs lose their subspherical shape and off-white color. A pair of poorly defined convergent ridges appear on the upper or outer surface of most eggs and the eggs collapse on one side.
Beneath the convergent ridges, an indistinct to distinct series of fine brown lines appear (Fig. 3). Two adjacent dark spots may occur on a few eggs distal to the crossing of the convergent ridges. These latter eggs have a narrower profile, indicating that they are standing on end. In addition to developing the above markings, eggs near the completion of incubation shrink and exhibit a network of narrow, sharply-defined crescentic ridges.

Two or three days before hatching, the dark spots become identifiable as the embryonic eye-spots and the fine brown lines are distinguishable as long setae on the abdominal and peltidial segments.

**Table 2.** Relationship between egg mass sequence, mass size, and percent hatch of the eggs of *Eremobates durangorum* Roewer.

<table>
<thead>
<tr>
<th>Mass Sequence</th>
<th>No. Masses</th>
<th>No. Eggs</th>
<th>Mean No. Eggs per Mass</th>
<th>No. Hatched</th>
<th>Percent Hatched</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>16</td>
<td>911</td>
<td>57</td>
<td>422</td>
<td>46.3</td>
</tr>
<tr>
<td>Second</td>
<td>12</td>
<td>840</td>
<td>70</td>
<td>129</td>
<td>15.3</td>
</tr>
<tr>
<td>Third</td>
<td>8</td>
<td>625</td>
<td>78</td>
<td>104</td>
<td>16.6</td>
</tr>
<tr>
<td>Fourth</td>
<td>3</td>
<td>156</td>
<td>52</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Fifth</td>
<td>2</td>
<td>84</td>
<td>42</td>
<td>0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

**Summary and Discussion**

*E. durangorum* females have an 11.3-day predepositional period following mating and thereafter lay eggs two to five times at weekly intervals. Deposition is preceded by a “labor” and followed by a “recovery,” with a total time consumption of 1 5/6 to 3 1/2 hours, depending upon the number of eggs deposited and disturbance of the female. The eggs are sub-spherical with average length and width diameters of 1.05 and 1.57 mm and, when fertile, are a grainy off-white color with microscopic truncate papillae on the chorion. Early egg masses average 60 to 70 eggs of which 30% hatch in 21 days at 90°F and 50% hatch in 28 days at 80°F. Embryonic eye-spots and setae are visible through the wrinkled chorion just prior to hatching.

The eggs of other species studied were similar in shape and color to those of *E. durangorum* but differed in size, microscopic chorion sculpturing, and number per mass. *E. palpisetulosus* eggs average 1.69 and 1.59 mm in length and width diameters with rounded papillae on the chorion, but the number per mass was not obtained. *E. nodularis* eggs have average length and width diameters of 1.48 and 1.41 mm, weak papillae on the chorion, and average about 57 per mass. *E. magnus* eggs average 1.55 and 1.44 mm in length and width diameters, have a finely papillate chorion, and average 69 per mass. *T. bitubatus* eggs have average length and width diameters of 1.41 and 1.37 mm, truncate papillae on the chorion, and average 27 per mass.

A comparison of the eggs and egg-laying habits of the North American family Eremobatidae with that of the Asian and African families Galeodidae and Solpugidae indicates some interesting differences and similarities.
TABLE 3.—COMPARATIVE PUBLISHED PHYSICAL DATA ON THE EGGS AND EGG MASSES OF SOLPUGIDS.

<table>
<thead>
<tr>
<th>Published Name</th>
<th>Egg Color</th>
<th>Egg Size</th>
<th>Mass Size</th>
<th>Authority</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Galeodes vorax</em> Hutton</td>
<td>Whitish</td>
<td>Largish mustard seed</td>
<td>50</td>
<td>Hutton, 1843</td>
</tr>
<tr>
<td><em>Galeodes arabis</em> Koch</td>
<td>White, opalescent</td>
<td>1/7&quot;</td>
<td>208</td>
<td>Hingston, 1925</td>
</tr>
<tr>
<td><em>Solpuga cafra</em> Pocock</td>
<td>Dirty light yellow</td>
<td>3.3-2.9 and 3.9-2.9 mm</td>
<td>192</td>
<td>Lawrence, 1949</td>
</tr>
<tr>
<td><em>Solpuga hostilis</em> White</td>
<td>Light yellow</td>
<td>2.7 and 2.4 mm</td>
<td>64-94</td>
<td>Lawrence, 1947 and 1949</td>
</tr>
<tr>
<td><em>Othoae saharae</em> Paneuse</td>
<td></td>
<td></td>
<td>?</td>
<td>Junqua, 1962</td>
</tr>
<tr>
<td><em>Erenobotes formicarius</em> (Koch)</td>
<td>Milk white</td>
<td>1.7 mm</td>
<td>?</td>
<td>Turner, 1916</td>
</tr>
<tr>
<td><em>Erenorphax magnus</em> (Hancock)</td>
<td>Off-white</td>
<td>1.55 and 1.44 mm</td>
<td>33-105</td>
<td>Present study</td>
</tr>
<tr>
<td><em>Erenobates durangonus</em> Roewer</td>
<td>Off-white</td>
<td>1.65 and 1.57 mm</td>
<td>20-164</td>
<td>Present study</td>
</tr>
<tr>
<td><em>Erenobates palpisetulosus</em> Fichter</td>
<td>Off-white</td>
<td>1.69 and 1.59 mm</td>
<td>?</td>
<td>Present study</td>
</tr>
<tr>
<td><em>Erenobates nodularis</em> Muma</td>
<td>Off-white</td>
<td>1.48 and 1.41 mm</td>
<td>32-82</td>
<td>Present study</td>
</tr>
<tr>
<td><em>Theobates vilobatus</em> Muma</td>
<td>Off-white</td>
<td>1.41 and 1.37 mm</td>
<td>5-54</td>
<td>Present study</td>
</tr>
</tbody>
</table>
The predepositional period of 25 to 30 days, reported for Otoeis saharae Panouse by Junqua (1962), is much longer than the 9 to 14 days required for E. durangonus.

The female of Galeodes spp. lies quietly while the eggs slip from her opercular opening (Hutton 1843; Hingston 1925). Dorsal rhythmical contractions of the peltidial and abdominal segments occur during a 3½- to 4½-hour deposition by Solpuga coffra Pocock (Lawrence 1949). These observations agree in essence with those obtained for E. durangonus with the exception that no one has reported a predepositional "labor" as observed for durangonus.

Table 2 presents a comparison of solpugid eggs and egg masses. It appears that egg coloration and egg and mass size are similar among solpugids, with the larger species tending to produce larger eggs and masses. Hingston (1925) reported minute pits on the chorion of Galeodes eggs whereas the chorion of Eremobatid eggs is ornamented with variously developed and spaced microscopic papillae.

The most interesting differences among solpugid eggs are exhibited by the reported incubation periods. Hutton (1843) reported a month (14 days) for Galeodes vorax but Hingston (1925) stated "only one day" for Galeodes aruba and Junqua (1902) recorded several hours for Otoeis saharae eggs. All of these times are much shorter than the 21 to 28 days recorded here for Eremobates durangonus. Also, the variation from only one day to 14 days for two species of the genus Galeodes may be biologically significant.

The visibility of long embryonic setae through the chorion of Solpuga hostilis White eggs (Lawrence 1947) is comparable to that observed here for E. durangonus. Absence of these long setae on Galeodidae embryo is significant.

LITERATURE CITED


