Full Length Research Paper

Studies on the immature stages and burrow excavating behavior of *Schizodactylus monstrosus* (Drury) (Grylloptera: Gryllodea: Schizodactylidae) from Sindh, Pakistan

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The biology of nymphal stages and life habits of the *Schizodactylus monstrosus* (Drury) were investigated in this study that was carried out between 2004 and 2007 in the left bank of River Indus Sindh province. The study showed that *S. monstrosus* which is a nocturnal and voracious carnivorous insect, passed through 9 nymphal stages, took 1 year to complete its developmental period, though the female laid a total of 23.10 ± 3.66 eggs at 14.05 ± 1.85 cm depth of the soil. The burrow habit and food preferences of the cannibalistic species of *S. monstrosus* were also investigated.

Key words: *Schizodactylus monstrosus*, biology, life-habits, immature stages, behavior.

INTRODUCTION

The genus *Schizodactylus* represents distinctive features regarding their morphology. It comprises seven species. Of these *S. monstrosus* (Drury) and *Schizodactylus minor* (Ander) occur along the shores of River Indus in Pakistan and River Ganga (India). *S. monstrosus* is a large, robustly built, ferocious looking, burrow maker and nocturnal insect (Khattar, 1972). Usually, it lives singly in burrows and comes out at night, thereby constituting an important part of the food of many arthropods and vertebrates and they also play a signi-ficant role in maintaining the local food chain that prevents certain insect population increasing in the field.

Taxonomy of *S. monstrosus* has been studied by Snodgrass (1937, 1957), Ragge (1957), Imms (1957), Khattar (1958, 1959, 1972), Khattar and Srivastava (1962), Randell (1964) and Uvarov (1952); however, the external genitalia (proximal plate of epiphalus and epiproct) in the postgenital segments when compared between the epiproct and paraprocts of both males and females and the key components of the alimentary can-nal (that is, stomodaeum, crop, proventriculus, mesen-

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RESULTS

*S. monstrosus* laid a total of 23.10 ± 3.66 eggs (Figure 1) at the depth of 14.05 ± 1.85 cm, and the eggs were expended throughout the burrow. These eggs were hatched out in tiny nymphs. Mostly, females preferred to lay eggs where food resources are available so that new hatching nymphs can get the food without any difficulty. The life cycle took more than one year for its completion and passed through nine nymphal instars.

Morphological description of nymphal instars

**First nymph**

Minute tegmina and wing rudiments were present in small triangular lobes on the lateral sides of the meso and meta thorax. These lobes were indistinct in this stage (Figure 2a).

**Second nymph**

Triangular tegmina and wings rudiments became slightly larger and separated from the meso and meta thoracic segments by forming distinct ridges. These lobes are slightly anterior and were pointed downwards (Figure 2b).

**Third nymph**

The size of the tegmina and wing rudiments increased slightly, but they remain as triangular lateral flaps of the meso and meta thorax and were separated by distinct ridges (Figure 2c).

**Fourth nymph**

The tegmina and wing rudiments become large, but remained laterally downwards on the side of the meso and meta thorax. Longitudinal striations also appeared in this stage and their traces were visible on both rudiments (Figure 2d).

**Fifth nymph**

Tegmina and wing rudiments increase further in size when they became conical pads and were directed laterally downwards. Longitudinal striations became more prominent, while the anal areas became distinct and separated on both rudiments (Figure 2e).

**Sixth nymph**

In this stage, tegminal rudiments were slightly directed...
backwards, while the wings turned laterally downwards. As a consequence, the ridge completely separated the anal area that became more diverse at this stage (Figure 2f).

**Seventh nymph**

The tegmina and wing pads turned over to the back of the segment. The wing pads reached the first abdominal segment, while tegmina extended to the posterior margin of the meta thoracic segment. However, the wing rudiments overlapped the basal posterior margin of the tegminal rudiments (Figure 2g).

**Eight nymph**

Tegmina and wing pads were reflected over the back and they further increased in size. In this stage, tegmina reached the first abdominal segment, while the wings extended to the second abdominal segment. In this stage also, tracheation was more prominent in both rudiments (Figure 2h).

**Ninth nymph**

The tegmina and wing pads became larger and they almost covered the dorsal as well as the lateral sides of the first fourth abdominal segments. The wing pads covered the fifth abdominal segment, while the tegmina reached the fourth abdominal segment, and so, both rudiments became darker in color (Figure 3).

**Measurement of S. monstrosus**

The comparison of the body length of the various nymhal instars of *S. monstrosus* is shown in Table 1. This indicated that there was significant difference in the measurement of male and female nymhal instars from the first instar to the adult instar. The total body length slightly increased in the first instar onwards, but it was significantly increased in the adult’s stage (43.96 ± 1.04 mm for male and 50.55 ± 2.19 mm for female).

**Burrowing behavior**

For habitation, the young and adult made isolated slanting tunnels which they rarely leave except at night. They preferred to live in moist sandy places, because they could not survive in dry, hard or water-logged soil. Like the *S. minor*, once they came out of their burrows, they dug fresh ones for further activations (that is, reproduction and preying). The tunnels entered the soil at an angle of 45 to 60° and turned slightly to the left in a majority of cases. The diameter of the tunnel varied from 0.635 to 0.6985 cm. Adults could go as deep as 66.81 ± 7.73 cm. Moreover, no side tunnels branching from the main tunnel was observed. Digging was done by the
Figure 3. Insect (a to c) engaged in digging the burrow with its jaws.

mouth parts and the heap of sand was thrown out with force by the large spurs of hind tibia (Figure 3a to c).

This species was virtually found from large areas of sterile sand, but it was hardly found in edaphically suitable places other than too densely grown places. During the study, it was observed that several nymphs and adults were outside the tunnels trying to escape, but they hid back into the tunnel immediately they were discovered by means of strong light. This indicates that S. monstrosus is strictly night-active which is supported by its coloration, and that it uses its tunnels as a protection and hiding place. However, they were strongly carnivorous and they just compromise during mating with each other for a short period. Their burrows were situated in sparsely grown dry loess zone between the edges of the field and foot of the slope. The intervals between individual burrows varied from 6 to 10 cm on an area, some of which were 50 to 80 ft wide and about 2500 ft long.

Table 2 shows that a total of 421 burrows were examined at the study sites between 2004 and 2007. These burrows were occupied with a single male and female. The total number of the male’s solitary burrows was examined to be 181 with 43%, while the solitary burrows of
Table 1. The average body size (mm) of nymphal stages and adult of S. monstrosus.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Number</th>
<th>Male</th>
<th>LSD</th>
<th>Minimum to maximum</th>
<th>n</th>
<th>Female</th>
<th>LSD</th>
<th>Minimum to maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; nymphal stage</td>
<td>10</td>
<td>7.46±0.050</td>
<td>A**</td>
<td>7.40 - 7.50</td>
<td>10</td>
<td>8.72±0.182</td>
<td>A**</td>
<td>8.5 - 9.10</td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt; nymphal stage</td>
<td>10</td>
<td>11.28±0.09</td>
<td>B</td>
<td>11.23 - 11.46</td>
<td>10</td>
<td>13.44±0.25</td>
<td>B</td>
<td>12.45 - 13.55</td>
</tr>
<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt; nymphal stage</td>
<td>10</td>
<td>14.54±0.05</td>
<td>C</td>
<td>14.50 - 14.60</td>
<td>10</td>
<td>16.38±0.11</td>
<td>C</td>
<td>16.34 - 16.55</td>
</tr>
<tr>
<td>4&lt;sup&gt;th&lt;/sup&gt; nymphal stage</td>
<td>10</td>
<td>18.46±0.10</td>
<td>D</td>
<td>18.30 - 18.60</td>
<td>10</td>
<td>19.44±0.09</td>
<td>D</td>
<td>19.3 - 19.60</td>
</tr>
<tr>
<td>5&lt;sup&gt;th&lt;/sup&gt; nymphal stage</td>
<td>10</td>
<td>20.42±0.05</td>
<td>E</td>
<td>20.10 - 20.20</td>
<td>10</td>
<td>22.25±0.100</td>
<td>E</td>
<td>21.80 - 22.56</td>
</tr>
<tr>
<td>6&lt;sup&gt;th&lt;/sup&gt; nymphal stage</td>
<td>10</td>
<td>26.42±0.24</td>
<td>F</td>
<td>26.0 - 26.70</td>
<td>10</td>
<td>27.85±0.32</td>
<td>F</td>
<td>27.3 - 28.4</td>
</tr>
<tr>
<td>7&lt;sup&gt;th&lt;/sup&gt; nymphal stage</td>
<td>10</td>
<td>27.25±0.84</td>
<td>G</td>
<td>26.4 - 28.70</td>
<td>10</td>
<td>30.54±1.88</td>
<td>G</td>
<td>28.0 - 33.2</td>
</tr>
<tr>
<td>8&lt;sup&gt;th&lt;/sup&gt; nymphal stage</td>
<td>10</td>
<td>30.25±0.04</td>
<td>H</td>
<td>30 - 32 - 30 - 34</td>
<td>10</td>
<td>35.93±0.97</td>
<td>H</td>
<td>35.5 - 37.6</td>
</tr>
<tr>
<td>9&lt;sup&gt;th&lt;/sup&gt; nymphal stage</td>
<td>10</td>
<td>38.46±0.11</td>
<td>I</td>
<td>38.30 - 38.60</td>
<td>10</td>
<td>43.05±2.87</td>
<td>I</td>
<td>39.0 - 46.5</td>
</tr>
<tr>
<td>Adult</td>
<td>10</td>
<td>43.96±1.04</td>
<td>J</td>
<td>42.44 - 45.65</td>
<td>10</td>
<td>50.55±2.19</td>
<td>J</td>
<td>47.80 - 53.70</td>
</tr>
</tbody>
</table>

*Mean ± standard deviation; **the letter indicates a significant difference (P < 0.01) according to LSD test.

Table 2. Showing the percentage of solitary male and female S. monstrosus burrow examined during the year 2004 to 2007.

<table>
<thead>
<tr>
<th>Burrow content</th>
<th>Number of burrows examined</th>
<th>Percentage of burrow (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solitary male</td>
<td>181</td>
<td>43.0</td>
</tr>
<tr>
<td>Solitary female</td>
<td>240</td>
<td>57.0</td>
</tr>
<tr>
<td>Total</td>
<td>421</td>
<td>100.0</td>
</tr>
</tbody>
</table>

DISCUSSION

Various stages of Lepidoptera were studied for the first time by Dyar (1890). He recommended that, the head capsule of these larvae can grow in geometrical succession, thereby increasing in width at each ecdysis; but this is not pertinent for all other species, and the ratio may not be constant for the different structures of the body in the same species. Criddle (1926) reported that a number of antennal segments, development of wings rudiments and modification of pronotum are crucial for the study of the immature stages of Orthoptera, whereas (Riffat, 2007; Riffat and Wagan, 2010) stated that antennal segments, length of antennae, pronotum and total body length of nymphal instars have significant importance to distinguish the various stages of Hieroglyphus spp. Cowan (1929), on the contrary, recommended that development of ovipositor in females and subgenital plate in males is a fundamental character to determine the immature stages of Anabrus simplex, but this character is not much reliable in Schizodactylus.

However, this study suggests that the length of the body, the antennae, the hind femur, the development of the genitalia, the size of the pronotum and the length and position of wings rudiments is particularly very important for determination of the various stages of Schizodactylus. Both the tegmina and wings of S. monstrosus are long, while tapering posteriorly and rolling into a spiral that lies over the cerci. The tegmina sides turn down abruptly and cover the lateral side of the abdomen although this is not present in S. inexpectatus. Choudhuri and Bagh (1974) also found that the female of S. monstrosus lays eggs towards the end of the burrow; moreover, this was not reported in this study. The females laid eggs at the bottom of the burrow, but these eggs never reached the last end of the burrow.

Details of burrowing habits of S. monstrosus are given in this study. Carpentier (1953) stated that the depth of the burrow would depend on the depth of the insect research water, while Khattar (1972) did not find a single instance of a burrow going down to the level of water. During the study, it was observed that the burrows were never directed towards the sea, as Guichard (1961) reported. They appeared on soil surface at night when preying on insects or perhaps, when they had mating desires. Furthermore, the coloration of these insects indicated that they were typical soil or nocturnal insects. All burrows with mounds were invariably occupied by each species containing a solitary individual of S. monstrosus. The species is apparently carnivorous consuming small insects (beetles, grasshopper and cricket) that go into its burrow or preying on them on the
soil surface in the environs of its burrow at night. During increase in the water level of river Indus, not a single individual was found other than those buried in the soil (Aydin and Khomutov, 2008).

Khatkar (1972) also reported that the burrow of both adults and immature stages of S. monstrosus were closed after they were completed; nevertheless, during the study, some opened burrows were also observed, but the exact cause of these open burrows are yet unknown. Khattar (1972) reported a distinct correlation between the depth of the burrow and the condition of the soil. The drier the sand, the deeper the burrow becomes, and vice versa. However, this study is in agreement with this. Ramme (1931) had reported that S. monstrosus used their spurs of hind tarsi for digging, while Carpenter (1953) observed that digging was done by jaws. This study supports the view of Carpenter, because the results obtained are valuable in acquiring a better understanding of the economic importance of this rare genus.

Conclusion

This species does not seem to produce more than one generation a year. It comprises nine nymphal stages, and the insect is a predatory species. As its activity never could have been observed in the day during which the insects could only be detected in their burrow, they were observed in the night while performing mating and searching of prey.

REFERENCES


Dyar HG (1890). The number of moults of Lepidopterous larvae. Psychem, 3: 420-422.


