INTRODUCTION

The present study describes the life cycles for five different shrimp species and examines the effects of environmental factors on their growth and survival. The research focuses on understanding the life cycle stages of these shrimp species, from egg laying to maturity, and evaluates how different environmental conditions influence their development.

MATERIALS AND METHODS

Benthic samples were collected approximately once per month from February 1977 to February 1978 from a single riffle in North Branch Creek (43° 38' N, 92° 14' W) and in the Caribou River (47° 32' N, 91° 04' W). Collections were made with a modified Surber sampler (0.1 m²) fitted with 471 μm netting (Krueger and Cook 1981). Duplicate invertebrate drift samples (24 hour) were collected by drift nets (15 x 30 x 180 cm) constructed of 471 μm mesh. Discharge through the nets was measured at the end of the 24 hour period. Stream discharge was at base flow on each of the dates sampled. Daily drift rates by month were calculated in the manner described by Waters (1972). Samples were preserved in 10% formalin. Larvae and nymphs were separated into size classes based on head widths or body lengths. Species identifications were based on adults captured at the streamside and on nymphs collected in the bottom samples (Flint 1964; Bednarik and McCafferty 1979; Byers 1978). Larvae and nymphs that were in good condition when measured were set aside by size class for later weighing. Mean individual wet weight was measured to the nearest 0.1 mg for each size class after centrifugation to remove excess water. Further information on the site locations and sampling procedures has been reported elsewhere (Krueger and Cook 1981; Krueger and Waters 1983).

RESULTS AND DISCUSSION

Sialis dreisbacki Flint (Megaloptera: Sialidae)

Monthly size class distributions for larval S. dreisbacki from North Branch Creek indicated a univoltine life cycle with larvae occurring for approximately ten months from July to April or May (Fig. 1). Larvae in the large size classes collected in early spring (March and April) had nearly disappeared by May, probably because of pupation and emergence. Adults were collected on streamside vegetation in May. Small larvae of the new generation dominated the samples in July and grew rapidly through October. During the winter months, larvae were present in a wide range of sizes and little growth occurred.

Stream drift of these larvae occurred principally in the spring and may have been related to movements associated with pupation (Fig. 2a). Standing stocks clearly reflected the life cycle; the decline of standing stocks in the spring was related to pupation and the increase in the summer and autumn months was coincident with recruitment of the new cohort and growth (Fig. 2b).

Previous descriptions of the life cycle of S. dreisbacki were not found in the literature. Univoltinism has been described for S. aquatilis and S. heso from West Virginia (Woodrum and Tartar 1973; Lilly et al. 1978) and S. rotunda from Oregon (Azam and Anderson 1969). S. californica has been reported to be either univoltine or hemivoltine dependent on the availability of food in an Oregon stream (Azam and Anderson 1969). Semivoltinism of two or three years has also been described for this genus and noted in the species that follow: carnuta in Alberta (Fritchard and Leichter 1973), fuliginosa in England (Elliott 1977), lutaria in France and England (Giani and Laville 1973; Elliott 1977; Brooker 1979) and misukashii in Japan (Yamamoto 1972).

Stenonea vicarium (Walker) (Ephemeroptera: Heptageniidae)

Size frequency histograms of nymphs collected in the Caribou River indicated a univoltine life cycle (Fig. 3). Nymphs of S. vicarium were present in the stream for approximately ten months, from the middle of July to early May. Nymphs in large size classes were observed in the spring and probably emerged from late April through May. In June, no nymphs were collected and eggs were probably incubating. The new cohort first appeared in July and grew rapidly until December. Daily drift of nymphs was highest in April and May near the end of the life cycle and did not appear to be related to standing stocks (Fig. 4a, b).
**THE CYCLES OF STREAM INSECTS IN MINNESOTA**

### Length (Millimeters)

<table>
<thead>
<tr>
<th>Month</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan.</td>
<td>15</td>
</tr>
<tr>
<td>Feb.</td>
<td>20</td>
</tr>
<tr>
<td>Mar.</td>
<td>25</td>
</tr>
<tr>
<td>Apr.</td>
<td>30</td>
</tr>
<tr>
<td>May</td>
<td>35</td>
</tr>
<tr>
<td>June</td>
<td>40</td>
</tr>
<tr>
<td>Jul.</td>
<td>45</td>
</tr>
<tr>
<td>Aug.</td>
<td>50</td>
</tr>
<tr>
<td>Sep.</td>
<td>55</td>
</tr>
<tr>
<td>Oct.</td>
<td>60</td>
</tr>
<tr>
<td>Nov.</td>
<td>65</td>
</tr>
<tr>
<td>Dec.</td>
<td>70</td>
</tr>
</tbody>
</table>

*Fig. 1.* Body length frequency distribution of stream insects collected in December 1967.

### Percentage

- **June (6):** 20%
- **July (7):** 25%
- **August (8):** 30%
- **September (9):** 35%
- **October (10):** 40%
- **November (11):** 45%
- **December (12):** 50%

*Fig. 2.* Monthly distribution of stream insects collected in Minnesota.
ACKNOWLEDGMENTS

Paper Number 13,123, Scientific Journal Series Minnesota Agricultural Experiment Station, St. Paul, Minnesota 55108. This research was supported by a National Science Foundation grant (DEB 76-09761) awarded to Dr. Thomas F. Waters and a University of Minnesota Doctoral Dissertation Fellowship.

REFERENCES


