Distribution of *Chromolaena odorata* (Asteraceae) and Bionomics and Consumption and Utilization of Food by *Pareuchaetes pseudoinsulata* (Lepidoptera: Arctiidae) in India

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Abstract

The distribution of *Chromolaena odorata* is directly related to the areas receiving rainfall of 150 cm and above in India. There are minor differences in the biology of *Pareuchaetes pseudoinsulata* between Bangalore, India and Sabah, Malaysia. The relationships between the instars and the width of the head capsule, and length and width of the fecal pellets are presented. It is suggested that the measurements of the fecal pellets could be used for identification of instars of caterpillars in the field. The consumption index, growth rate, efficiency of conversion of ingested food, approximate digestibility and efficiency of conversion of digested food for different instars are reported. In cage studies fifty larvae between fourth instar to pupation defoliated 78.9 to 82.4% of a plant of one meter high in 15 days after infestation.

Introduction

*Chromolaena odorata* (L.) R.M. King and H. Robinson (Asteraceae) is a perennial, diffuse and scrambling weed native to the West Indies, and Central and tropical South America. It was accidentally introduced from the Caribbean in the ballast of cargo boats into Singapore whence it spread into humid tropical regions of Southeast and South Asia (Biswas 1934). It spread to Africa in 1937 through importation of contaminated *Gmelina arborea* Roxb. seeds to Nigeria from Sri Lanka (Ivens 1974). Since then it has spread to Ghana, Cameroon, Ivory Coast and South Africa. The global distribution and the pattern of spread of this weed is shown in Figure 1.

Ramachandra Rao (1920) was the first to report the rapid spread of this weed in most areas of Assam and Bengal in Eastern India. Obviously, it had spread from Singapore through Malaysia, Thailand and Burma. It was introduced to Southwestern part from Eastern India during the World War II, supposedly through the seeds adhered to the clothing and bedding of returning laborers (Bennett and Rao 1968).

In the introduced humid tropical regions of Africa, Asia and the Pacific, it grows in many soil types but prefers well drained areas. It is most common in plantation crops such as coconut, rubber, oil palm, tea, coffee, cocoa, citrus, teak and cashew, abandoned or neglected fields, wastelands and along forest trails, fence rows, roadsides, and banks (Holm et al. 1977). It interferes with crop growth because of its rapid growth, profuse branching habit and allelopathic properties. It becomes a fire risk during die-back after flowering in areas with a pronounced dry season (Cock and Holloway 1982).

Use of herbicides to control this weed is uneconomical in marginal lands and very much limited in plantation crops because their adverse effect on non-target species. Further, the
biological success of *C. odorata* in areas where it has been introduced and consequent economic effects make it a likely candidate for biological control. As a result in 1968, the West Indian Station of the Commonwealth Institute of Biological Control initiated studies on natural enemies of this weed (Cock 1984). *Pareuchaetes pseudoinsulata* Rego Barros (= Ammalo arravaca Jordan) (Lepidoptera: Arctiidae) was the first insect to be identified as a potential biological control agent of *C. odorata* (Bennett and Rao 1968, Crutwell 1968).

Many field releases of *P. pseudoinsulata* were made in India by the Indian Station of the Commonwealth Institute of Biological Control since 1973 from the cultures obtained from Trinidad without much success (Cock and Holloway 1982).

![Dispersal of Chromolaena odorata](image)

**Figure 1.** Dispersal of *Chromolaena odorata* (L.) R.M. King and H. Robinson from West Indies and Central and tropical South America to other parts of the world.

In 1984, Dr. M.J. Chacko brought in a culture of *P. pseudoinsulata* from Sri Lanka. Subsequent field releases made in Trichur, Kerala resulted in field establishment (Joy, P.J., pers. comm., 1986). Cultures of *P. pseudoinsulata* received from India and Trinidad in late 1984 by Mr. T.F. Seibert were laboratory reared, field released and established on Guam in mid 1985. Since then it has been introduced and established on the islands of Rota, Tinian, Saipan and Aguijan in the Commonwealth of the Northern Mariana Islands. It has been estimated that *P. pseudoinsulata* has defoliated *C. odorata* over 25,000 ha on Guam (Seibert, T.F., pers. comm., 1987) and 5,000 ha on Rota (Muniappan, R., unpubl. data, 1987).

In this paper the distribution of *C. odorata* as a weed in India and its relationship to climatic factors, bionomics of *P. pseudoinsulata* (culture obtained from Sri Lanka) at Bangalore, its consumption and utilization of food at Coimbatore, and its defoliation efficiency at Bangalore, India are presented. Since *P. pseudoinsulata* is a biological control agent of *C. odorata* and a decade of work from 1973 onwards to establish it in the field has proved negative, basic studies were taken up during 1984-85. During this period the senior author was in India under a fellowship to study the problems involved in field establishment of *P. pseudoinsulata*.

**METHODS AND MATERIALS**

**Distribution**

The distribution of *C. odorata* in India was assessed by conducting a personal survey by the senior author during 1984-85 in Southwestern India. The survey in Northeastern India was
based on literature because of travel restrictions imposed by the Government of India. Agroclimatic information was collected from the India Meteorological Department (1978) to determine possible relationships between weather factors such as rainfall, temperature, humidity and altitude and the distribution of this weed.

**Bionomics**

The nucleus culture of *P. pseudoinsulata* obtained from Sri Lanka was maintained in the laboratory on *C. odorata*. The biology of *P. pseudoinsulata* at Bangalore was worked out with the eggs laid by a single female. The larvae on emergence were fed *ad libitum* with the leaves of *C. odorata* in glass tubes of 15 x 2.5 cm size with cotton plugs for early stages. The larvae after 2nd instar were kept in 10 cm ice cream cups with lids cut in the middle and pasted with muslin cloth for aeration. Moths were kept in ice cream cups and were fed with dilute honey solution. Fresh leaves, whose stems were immersed in a tube containing water, were provided for egg laying. Observations on egg, larval, pupal and longevity of adults, and the size of head capsule of various instars and fecal pellets were made. The measurements were made using a compound microscope with a stage and an ocular micrometer.

**Consumption and Utilization of Food**

An egg mass containing 50 eggs was immersed briefly in 1% sodium hypochlorite solution and used for this investigation. The larvae on hatching were transferred to ice cream cups as described above and given tender leaves for feeding. The fecal matter was collected on a disc of filter paper kept at the bottom of the ice cream cup. The live weight of larvae, leaves and fecal matter were recorded once in two days during the first instar and daily thereafter. The food consumption index (C.I.), growth rate (G.R.), efficiency of conversion of ingested food (E.C.I.), approximate digestibility (A.D.) and efficiency of conversion of digested food (E.C.D.), were calculated as detailed by Waldbauer (1968) on live weight basis. The data were corrected for natural weight loss.

**Defoliation Efficiency of P. pseudoinsulata**

The defoliation efficiency of *P. pseudoinsulata* was assessed using potted plants of *C. odorata*. One meter high plants of uniform size were transplanted in 30 cm pots and covered with cages made of metal rings and muslin cloth sleeves of 50 cm diameter. These plants were infested with third instar larvae at the rate of 0, 25, and 50/plant and replicated two times. Most larvae pupated by the 15th day after infestation. An electronic leaf area measuring meter was used for measuring the area of leaves remained at the end of the experiment.

**Results and Discussion**

**Distribution**

The distribution of *C. odorata* and rainfall in India are shown in Figures 2 and 3. Its distribution is limited to areas wherein the rainfall is 150 cm and above and are mostly classified as humid (Fig. 4). These areas are located in the southwestern and northeastern parts of India where heavy rainfall is experienced during the southwest monsoon months of June - November. Ivens (1974) has also stated that *C. odorata* is a problem in areas with rainfall in excess of 150 cm in Nigeria. In southwestern India, distribution of *C. odorata* is limited to altitudes to 1,250 m. Above this altitude another introduced neotropical weed, *Ageratina adenophorum* (Spreng.) has become a common problem. Also at Himachal Pradesh, a subtropical region in Northern India, *A. adenophorum* is a serious problem.
Bionomics

Cruttwell (1968) reported *P. pseudoinsulata* to complete the life cycle in 40-60 days at Trinidad. The moths started oviposition by laying groups of 50-180 eggs within 2-4 d of emergence. She recorded a maximum of 580 eggs/female. In the present study the moths emerged at midnight and mated around 0600 hr. Mating lasted for 1-2 hr and egg laying started within a day after mating. Eggs were laid in batches and glued to the lower surface of the host leaves. Egg laying varied from a scattered few eggs to 118/batch and to a maximum of 390/moth. The longevity of the moth was about 10 d at Bangalore. Eggs were yellowish, dome shaped and 0.76 to 0.83 mm in diameter with an average of 0.82 mm. Eggs turned dark brown at the upper parts on the day of hatching because of the darkening of the head of the caterpillar underneath the chorion. The duration of egg, different larval instars, prepupal and pupal stages are given in Table 1.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Bangalore, India</th>
<th>Sabah, Malaysia</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Range</td>
<td>Average</td>
</tr>
<tr>
<td>Egg</td>
<td>7</td>
<td>7.0</td>
</tr>
<tr>
<td>First instar</td>
<td>4</td>
<td>4.0</td>
</tr>
<tr>
<td>Second instar</td>
<td>3-5</td>
<td>3.8</td>
</tr>
<tr>
<td>Third instar</td>
<td>3</td>
<td>3.0</td>
</tr>
<tr>
<td>Fourth instar</td>
<td>3-5</td>
<td>3.4</td>
</tr>
<tr>
<td>Fifth instar</td>
<td>3-7</td>
<td>4.9</td>
</tr>
<tr>
<td>Sixth instar</td>
<td>5-8</td>
<td>6.6</td>
</tr>
<tr>
<td>Prepupa</td>
<td>1-2</td>
<td>1.7</td>
</tr>
<tr>
<td>Pupa</td>
<td>10-13</td>
<td>11.9</td>
</tr>
<tr>
<td>Larval period</td>
<td>21-32</td>
<td>25.7</td>
</tr>
<tr>
<td>Developmental period</td>
<td>39-54</td>
<td>46.3</td>
</tr>
</tbody>
</table>

1 Data from Syed (1979).

At Sabah all males and some females had five larval instars while other females had six (Syed 1979), whereas, at Bangalore all females and some males had six larval instars and some males had five. The delayed hatching of eggs and extension of some larval instars at Bangalore is due to the prevailing low minimum temperatures with an average minimum of 10°C during the month of December.

*P. pseudoinsulata* larvae feed gregariously until the third instar and then disperse. From 4th instar onwards the larvae feed at night and hide under litter and debris on the ground during the day. The nocturnal habit of these larvae makes it difficult to survey them in the field and to determine their instars. Since fecal pellets are easier to locate in the field, an attempt was made to determine the relationships of the length and width of fecal pellets to various instars and the results are shown in the Figures 5 and 6. There was significant difference in size (both length and width) of the fecal pellets in different instars at *P = 0.01%* level. It is possible that fecal pellets fallen on the leaves could be used for predicting the instar of the caterpillar as the later instars hide during the day. Dyar's law has been calculated for head capsule width and instars (Fig. 7). The x/y ratio was 1.38.
Consumption and Utilization of Food

Since *P. pseudoinsulata* is a biological control agent of the weed, *C. odorata*, laboratory studies were made at Coimbatore to find out the consumption index (CI), growth rate (GR), efficiency of conversion of ingested food (ECI), approximate digestibility (AD) and efficiency of conversion of digested food (ECD) on wet weight basis at room temperature as described by Waldrauer (1968).

The results of this study are reported in Table 2. The C.I. is higher at the later instars than the earlier instars. There is variation in G.R., E.C.I. and E.C.D., between different instars. The decline of A.D. in later instars of lepidopterous insects has been reported earlier by Waldrauer (1968). A marked increase in feeding after third instar is shown by the consumption index. This is directly related to the efficiency of defoliation. The increase in C.I. from the 4th instar onwards also coincides with the change from diurnal to nocturnal behavior of the larvae as well as their dispersal from the habit of feeding together until the 3rd instar.

Defoliation Efficiency of *P. pseudoinsulata*

The larvae consumed terminal and axillary buds first and then the remaining tender leaves. Mature leaves were consumed only in the absence of tender leaves. At the end of the experiment the remaining leaves on the plants were removed and their area and fresh weight were recorded (Table 3).

**Table 2. Utilization of food by Pareuchaetes pseudoinsulata Rego Barros larvae of different instars at Coimbatore, India.**

<table>
<thead>
<tr>
<th>Instar</th>
<th>Consumption index</th>
<th>Growth Rate</th>
<th>Efficiency of conversion of ingested food</th>
<th>Approximate digestibility</th>
<th>Efficiency of conversion of digested food</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>0.21</td>
<td>0.75</td>
<td>0.11</td>
<td>99.82</td>
<td>0.11</td>
</tr>
<tr>
<td>Second</td>
<td>0.49</td>
<td>1.31</td>
<td>0.56</td>
<td>99.62</td>
<td>0.56</td>
</tr>
<tr>
<td>Third</td>
<td>0.63</td>
<td>0.10</td>
<td>0.18</td>
<td>99.66</td>
<td>0.18</td>
</tr>
<tr>
<td>Fourth</td>
<td>1.81</td>
<td>0.64</td>
<td>0.41</td>
<td>99.47</td>
<td>0.41</td>
</tr>
<tr>
<td>Fifth</td>
<td>3.89</td>
<td>0.62</td>
<td>0.66</td>
<td>99.32</td>
<td>0.66</td>
</tr>
<tr>
<td>Sixth</td>
<td>14.68</td>
<td>0.17</td>
<td>0.23</td>
<td>98.63</td>
<td>0.23</td>
</tr>
</tbody>
</table>

The results of this caged experiment show that 50 larvae can cause 78.9 to 82.4% reduction of leaf area in a plant of one meter height. The rate of consumption of the leaves ranged from 17.25 to 19.14 cm²/larva. This shows that at a high population level *P. pseudoinsulata* is capable of severely defoliating the weed. In Sri Lanka, where this insect has well established in the field, *C. odorata* bushes have been killed due to constant defoliation (Kanagaratnam 1976). Further, its preference for feeding on the growing tips reduces flowering when the defoliation takes place during the months of November and December in the Northern Hemisphere (Muniappan, R., pers. obs. 1987). *P. pseudoinsulata* has cleared extensive areas of *C. odorata* infested areas by repeatedly defoliating on Guam and Rota. Ranchers on the island of Rota are quite impressed with the results.

In general, *P. pseudoinsulata* is a valuable biological control agent of the weed, *C. odorata*. The humid tropical countries in Asia, Africa and the Pacific wherein this weed is a problem should take up programs to control this weed using *P. pseudoinsulata* and other available natural enemies.
Figure 2. Distribution of the weed *Chromolaena odorata* (L.) R.M. King and H. Robinson in India

Figure 3. Rainfall distribution in India.
Figure 4. Different humidity regions in India.

Figure 5. Relationship between length of fecal pellets and the instars of *Pareuchaetes pseudoinsulata* Rego Barros.
Figure 6. Relationship between width of fecal pellets and the instars of *Pareuchaetes pseudoinsulata* Rego Barros.

Figure 7. Relationship between head capsule width and instars of *Pareuchaetes pseudoinsulata* Rego Barros.
Table 3. Area and fresh weight of unconsumed leaves in the plants 15 d after infesting
with Pareuchaetes pseudoinsulata Rego Barros at Bangalore, India.

| Treatment | Area (cm²) | Reduction due to feeding (%) | Weight (g) | Reduction due to feeding (%) | Average consumption/larva
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>1047.00²</td>
<td>-</td>
<td>19.15</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>25 Larvae</td>
<td>568.41</td>
<td>45.7</td>
<td>12.31</td>
<td>35.7</td>
<td>19.14</td>
</tr>
<tr>
<td>50 Larvae</td>
<td>184.43</td>
<td>82.4</td>
<td>4.05</td>
<td>78.9</td>
<td>17.25</td>
</tr>
</tbody>
</table>

1 From 4th instar to pupation.
2 Mean of two replications.

Acknowledgments

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U.S.A. and the U.S. Educational Foundation in India for providing the Fulbright Research
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