PARASITOIDS AND HYPERPARASITOIDS OF ZEIRAPHERA DINIANA
[LEP., TORTRICIDAE] AND THEIR ROLE IN POPULATION
CONTROL IN OUTBREAK AREAS

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There are 109 species of primary and secondary parasitoids associated with Zeiraphera diniana Guénéé in the Central European Alps. Ninety species are primary, 6 facultative secondary and 13 obligate secondary parasitoids. At family level, the composition of the complex seems to be the same in every outbreak area of the host, with ichneumonids predominating. In the Upper Engadine Valley (Switzerland), where intensive studies were conducted over a period of 3 consecutive outbreak periods (28 years), 65% of the complex is represented. The nomenclature of Z. diniana parasitoids has been clarified as far as possible. Many species names cited in the literature are synonyms or misidentifications. The complex of parasitoids, together with the associated predators of Z. diniana, is unable to slow down the rate of density increase of the host in outbreak areas. This fact has stimulated investigations on the most important parasitoid species, i.e. Phytodietus grisaeanae KERR. (Ichneumonidae), Sypiesis punctifrons THOMSON, Dicladocerus westwoodii WEST and Elachertus argissa WALKER (Eulophidae) over a period of about 10 years. Recent research has demonstrated that immigration of Z. diniana moths into the outbreak areas during the phase of host density increase is very important. The rate of increase of the natural enemies — which are univoltine — can never equal or exceed that of their host; consequently, control by these natural enemies alone is not possible.

Zeiraphera diniana Guénéé is univoltine throughout its entire distribution area. Flight and oviposition occur when temperature is above 8° C in June and July at altitudes below 1000 m and from July to October at higher altitudes. Eggs diapause and hatch in May of the following year. Synchronization of the hatching period with the flushing of the larch is essential for the successful establishment of the 1st instar larvae, which feed between the larch needles. This feeding habit is observed during the 1st 3 larval developmental stages. The old 3rd and the 4th instar larvae spin the needles together to form a characteristic tubular case. The 5th instar larvae move freely on the branches; when their density is high, they live in webbings along the branch axes. Mature larvae descend to the ground by means of a silken thread, enter the forest litter, construct a cocoon of humus and mineral particles, and pupate. The larvae are oligophagous; feeding is restricted to conifer genera such as Larix, Pinus and Picea.

In the Alps, the areas where visible damage of Z. diniana occurs are located above 1600 m. Here the population density of the insect increases 20'000 to 30'000 fold within 4 to 6 years. There is visible damage when population density exceeds 100 larvae per kg larch twigs with needles. A large proportion of the needles is then destroyed and the
colour of the trees turns brown in July. Starvation during the period of visible damage leads to heavy larval and pupal mortality and reduces weight and fecundity of the survivors. The defoliation effect lasts about 4 to 5 years, after which the population density of Z. diniana increases again. One cycle of Z. diniana lasts 8 to 10 years.

During 3 cycles of Z. diniana, i.e., 28 years (1950-1977) the population samples taken in study areas located throughout the Central European Alps between France and Austria (fig. 1) were reared to estimate, inter alia, the degree of parasitism; parasitoids were identified. In addition, the development of the parasitoid complex of Z. diniana was followed during at least one host cycle in selected areas of the Upper Engadine Valley.

Research on the most abundant parasitoids, i.e., 3 eulophids and Phytodietus griseanae Kerr. (Ichn.), was carried out from 1965 to 1977. The results from these studies are compared with those reported from other areas, i.e., Tirol and Carinthia (Austrian) (Jahn, 1948, 1958), Ore mountains (Erzgebirge) and low Tatra mountains (Kolubajev, 1934; Čapek, 1968), Siberia (U.S.S.R.) (Raigorodskaya, 1963, 1970; Pleshanov, 1972) and England (Day, 1977). An attempt to evaluate the role played by the natural enemies of Z. diniana is also made in the light of recent studies on the behavior of the host. Predators and a virus disease of Z. diniana are included in table 1 for completeness. No additional investigations on these mortality factors have been carried out since the work of Martignoni (1957), Graf (1974) and Delucchi et al. (1975).

### Table 1

**Summary of the natural enemy and disease complex associated with Zeiraphera diniana in the Central European Alps**

<table>
<thead>
<tr>
<th>Systematic category</th>
<th>Distribution</th>
<th>Most common species</th>
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<tbody>
<tr>
<td></td>
<td>Alps - all areas</td>
<td>UEV (*)</td>
</tr>
<tr>
<td>Tachinidae</td>
<td>15 (15)(a) species</td>
<td>10 (10)(a) species</td>
</tr>
<tr>
<td>Ichneumonidae</td>
<td>43 (47)</td>
<td>28 (31)</td>
</tr>
<tr>
<td>PA(b) Braconidae</td>
<td>27 (27)</td>
<td>—</td>
</tr>
<tr>
<td>Chalcidoidea</td>
<td>5 (7)</td>
<td>4 (6)</td>
</tr>
<tr>
<td>Total</td>
<td>90 (96) species</td>
<td>58 (63) species</td>
</tr>
<tr>
<td>Ichneumonidae</td>
<td>7 (11)(c) species</td>
<td>5 (8)(c) species</td>
</tr>
<tr>
<td>Chalcidoidea</td>
<td>5 (7)</td>
<td>4 (6)</td>
</tr>
<tr>
<td>Proctotrupoidae</td>
<td>1 (1)</td>
<td>1 (1)</td>
</tr>
<tr>
<td>Total</td>
<td>13 (19) species</td>
<td>10 (15) species</td>
</tr>
<tr>
<td>Acarina, Miridae, PR (f) Neuroptera, Dermatopera, etc.</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>DI (g) Granulosis virus</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

(a) UEV = Upper Engadine Valley (see fig. 1)
(b) number without parentheses : obligate primary parasitoids
(c) number in parentheses : obligate and facultative primary parasitoids
(d) PA = Parasitoids
(e) HY = Hyperparasitoids (secondary parasitoids)
(f) PR = Predators
(g) DI = Disease.