Effects of a Compound Derived from Abietic Acid on Silk Production of the Silkworm, *Bombyx mori* L. (Lepidoptera: Bombycidae)

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When the 5th-instar larva of the silkworm, *Bombyx mori* L., was fed with methyl 6,7-dioxo-5z,10z-podocarpa-8,11,13-trien-15-oate (Compound A-11), the instar period was prolonged and silk productivity increased. The relationship between the method of administration and the specific quality of cocoon were examined.

INTRODUCTION

In a previous paper (Murakoshi et al., 1975), we reported the appearance of precocious pupae in the 4th-instar larvae of the silkworm, *Bombyx mori* L. when they were fed with several compounds derived from abietic acid. Of the compounds tested, methyl 6,7-dioxo-5z,10z-podocarpa-8,11,13-trien-15-oate (tentatively designated as A-11) was found to be the most active.

In continuing this work, we noticed that when the 5th-instar larva of the silkworm was fed on an artificial diet mixed with A-11, the instar period was prolonged and accompanied by an increase in the weight of the cocoon layer. Similar effects have been reported with juvenile hormones and their analogs which were orally or topically administered to the silkworm (Akai et al., 1971; Chang et al., 1972; Murakoshi et al., 1972; Nihmura et al., 1972, 1974), but this report is the first to find that a compound enhances silk productivity without the juvenile hormone activity.

MATERIALS AND METHODS

Test compound. As the test compound, methyl 6,7-dioxo-5z, 10z-podocarpa-8, 11, 13-trien-15-oate (A-11) was synthesized by the method of Ohta and Ohmori (1957) starting with abietic acid (Fig. 1).

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2 Deceased.
Effects of a Compound on Silk Production

Test animal. The 5th-instar larvae of the silkworm, *Bombyx mori* L., commercial race Shunrei × Shōgetsu and Kinshū × Shōwa, reared on the artificial diet, were used.

Method of administration. A specific amount of the compound was dissolved in a small amount of acetone and mixed with the dry components of the artificial diet (Murakoshi et al., 1972). After evaporation of the solvent, the powdery diet was treated with water and continuously administered to the larvae, which were reared at 25°C.

RESULTS AND DISCUSSION

At first, the 5th-instar larva of the silkworm were fed on the artificial diet containing 100 ppm of A-11 for varied periods during the instar period (175 hr). The results are shown in Table 1. When administered for 72 hr following the fourth molting, the compound prolonged the instar period and increased the cocoon weight. This increase in the cocoon weight was attributed to the pupa and not to the cocoon layer. It is of interest that the moths from the heavy female pupae laid a hundred eggs more than those of the control. When the compound was supplied during the period from 72 hr after the fourth molting to maturity, marked prolongation of the instar period was observed. Furthermore, a 35% increase was realized in the cocoon layer weight although the cocoon weight showed hardly any increase. This suggests that through the uptake of the compound during the latter part of the 5th instar, the silkworm larvae enhanced silk production at the expense of body protein synthesis, resulting in reduction in the pupal weight. As expected, the number of eggs laid by the moths from the

Fig. 1. Chemical structure of abietic acid and the derivative A-11

<table>
<thead>
<tr>
<th>Period of administration after molting (hr)</th>
<th>Avg. wt. of larvae after molting (g)</th>
<th>Length of 5th instar (hr)</th>
<th>Avg. wt. of cocoons (g)</th>
<th>Avg. wt. of pupae (g)</th>
<th>Avg. wt. of cocoons layers (mg)</th>
<th>Rate of cocoon layer (%)</th>
<th>Avg. no. of eggs (m±s.d.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 hr</td>
<td>2.86</td>
<td>175</td>
<td>1.55</td>
<td>1.24</td>
<td>305</td>
<td>19.7</td>
<td>518±65</td>
</tr>
<tr>
<td>72 hr</td>
<td>3.54</td>
<td>237</td>
<td>1.58</td>
<td>1.17</td>
<td>410</td>
<td>26.6</td>
<td>401±128</td>
</tr>
<tr>
<td>0—72</td>
<td>2.50</td>
<td>237</td>
<td>1.47</td>
<td>1.12</td>
<td>358</td>
<td>24.3</td>
<td>412±130</td>
</tr>
<tr>
<td>72—M</td>
<td>3.03</td>
<td>237</td>
<td>1.58</td>
<td>1.17</td>
<td>410</td>
<td>26.6</td>
<td>401±128</td>
</tr>
<tr>
<td>0—M</td>
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<td>1.12</td>
<td>358</td>
<td>24.3</td>
<td>412±130</td>
</tr>
</tbody>
</table>

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*a* Compound A-11 was mixed with an artificial diet at a concentration of 100 ppm and administered.

*b* The race of the silkworm was Shunrei × Shōgetsu.

*c* Ten larvae (5 males and 5 females) were used for each run.

*d* Maturity of larvae.
light pupae was a fraction of those laid by the control.

When 5th-instar larvae were fed with A-11 throughout the instar, the period of the instar was markedly prolonged as in the case of administration in the latter period, as mentioned above. Further, the cocoon layer weight increased significantly. Due to the marked decrease in the pupal weight, however, the cocoon weight was reduced to less than that of the control. The number of eggs was also small. From the data shown in Table 1, it can be said that under the influence of A-11 the number of eggs is related to the pupal weight (cocoon weight minus cocoon layer weight); i.e., the number of eggs is inversely proportional to the rate of the cocoon layer.

The relationship between the administration period of A-11 and the specific quality of cocoon was examined. As indicated in Table 2, when the compound (100 ppm) was administered for varied periods following the fourth molting, considerable increases were observed in the weight of the cocoon and cocoon layer; length of treatment was up to 96 hr without prolongation of the instar period.

Table 3 illustrates the results obtained by the administration of A-11 (100 ppm)
for periods after the fourth molting to maturity. When the administration was commenced 48—120 hr after the molting, significant increases were always observed in both the weight of the cocoon and cocoon layer and the rate of cocoon layer; this was accompanied by prolongation of the instar period. However, treatment 144 hr after the molting resulted in a decrease in the weight of the cocoon layer. Furthermore, when the administration was commenced 72 hr after the fourth molting and continued for varied periods, the instar period was prolonged and the cocoon layer weight increased with the length of administration as shown in the table. Thus the 5th instar larvae of silkworm are considered to be the most sensitive to A-11 when orally administered to enhance silk productivity during the 72-144 hr after the fourth molting. It is well known that the juvenile hormones and their analogs are significantly active in increasing silk production in 5th-instar larvae when applied 1—4 days after the fourth molting (MURAKOSHI et al., 1972). Accordingly, the action mechanism of A-11 in this respect seems to be different from that of the juvenoids.

Finally, the relationship between the dosage of A-11 and the cocoon quality was investigated. The results are shown in Table 4. When the compound was administered for 72 hr following the fourth molting at dosages of 50 and 150 ppm, slight increases were observed in both cocoon and cocoon layer weights with 150 ppm but not with 50 ppm. On the other hand, administration during the period from 72 hr after the molting to maturity prolonged the instar period and increased the cocoon layer weight at both 50 and 150 ppm dosages. At the latter dosage, however, the number of reelable cocoons decreased markedly.

Through our experiments, a new control agent has been discovered to increase silk formation in silkworm larvae. As mentioned above, A-11 may produce this biological effect by a mechanism different from that of the juvenile hormones and their analogs. Concerning this matter, it is worth noting the finding in the previous paper (MURAKOSHI et al., 1975) that A-11 induced precocious pupae, probably as an antijuvenoid. This compound seems to selectively control for either body protein involved egg protein and silk protein synthesis in the silkworm larvae with their growth stages. The optimal condition for the administration of the reagent should be established for practical application.

<table>
<thead>
<tr>
<th>Dosage (ppm)</th>
<th>Period of administration after molting (hr)</th>
<th>Length of 5th instar (hr)</th>
<th>No. of reelable cocoons</th>
<th>Avg. wt. of cocoons (g)</th>
<th>Avg. wt. of cocoon layers (mg)</th>
<th>Rate of cocoon layer (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>--</td>
<td>170</td>
<td>39</td>
<td>1.44</td>
<td>287</td>
<td>19.9</td>
</tr>
<tr>
<td>50</td>
<td>0—72</td>
<td>167</td>
<td>38</td>
<td>1.45</td>
<td>285</td>
<td>19.7</td>
</tr>
<tr>
<td>150</td>
<td>0—72</td>
<td>171</td>
<td>38</td>
<td>1.61</td>
<td>301</td>
<td>18.7</td>
</tr>
<tr>
<td>50</td>
<td>72—M</td>
<td>214</td>
<td>37</td>
<td>1.58</td>
<td>383</td>
<td>24.2</td>
</tr>
<tr>
<td>150</td>
<td>72—M</td>
<td>229</td>
<td>18</td>
<td>1.53</td>
<td>400</td>
<td>26.1</td>
</tr>
</tbody>
</table>

* The race was Kinshō×Shōwa.

b Forty larvae (20 males and 20 females) were used for each run.

c Maturity of larvae.
REFERENCES


