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A review of insects affecting production of willows

A. West

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FOREWORD

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This report is based on ENFOR project P-172 which was carried out under contract by A. West, Torbay, Newfoundland (DSS File No. 01K24-5-0006).

ABSTRACT

This annotated bibliography lists 66 references with abstracts to world literature dealing with insect pests that may attack willows (*Salix* spp.). Author and species indexes are provided.

RÉSUMÉ

La présente bibliographie annotée comporte 66 références, avec résumés, tirées de la documentation internationale traitant des insectes susceptibles de s'attaquer aux saules (*Salix* spp.). Cette liste est accompagnée de tables alphabétiques des auteurs et des espèces concernés.

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A REVIEW OF INSECTS AFFECTING PRODUCTION OF WILLOWS

by

A. West

Part I

INTRODUCTION

The oil crisis of the last decade made Canadians aware of the necessity for developing alternate sources of energy. On the island of Newfoundland, which must import all fuel oil, the need to produce energy "at home" is acute. The Newfoundland Forest Research Centre under the auspices of the ENFOR program of the Canadian Forestry Service is developing the use of willows as a short rotation crop to help meet local demands for fuel.

One important factor in the economic feasibility of growing any crop is the amount and type of damage caused by insects. Willows have a complement of defoliators, wood-borers, sapsuckers and gallformers feeding on them. These pests can cause two types of damage - qualitative and quantitative. Qualitative damage reduces the grade of a crop and includes wood-boring, stem-galling and various deformities of branches in willows. Quantitative damage reduces the amount of crop that can be harvested and thus is critical for willows being grown for energy. The evaluation of an insect infestation on an energy crop must first determine whether the damage is qualitative or quantitative and second whether the amount of damage justifies control measures. The following briefly outlines the types of insect damage expected to influence energy yields from willows.

a) <u>Defoliation</u>

The most apparent damage to trees is defoliation. Leaf-eating is done by the larvae of sawflies, moths, butterflies and larval and adult beetles. The initial effect of defoliation is to reduce the photosynthetic capacity of the plant, but the ultimate effect on growth may be negligible. The key factor in defoliation appears to be the timing of the attack. Wilson (1976) reports that defoliation in the spring reduces the growth of summer wood in the trunk, and that defoliation late in the season causes little loss in growth but may leave twigs unlignified and in greater danger of frost damage. <u>Lepyrus palustris</u>, a weevil feeding on willows at the time of budburst, caused serious reductions in the growth of young plants (Maisner 1965), and the caterpillars of <u>Smerinthus</u>

ocellata and *Dicranura vinula* feeding on willows in the late summer and early fall caused no significant reductions in growth presumably because the willows had already completed most of their development (Richter 1959). Bassman *et al.* (1982) in their study of simulated insect damage on hybrid poplars, also members of the family Salicaceae, found that the timing of the defoliation treatment did not seem to be important.

Defoliation early in the season allows the trees to refoliate by producing a second crop of leaves. Rose (1958) stated that the refoliated leaves of *Populus tremuloides* Michx. (Salicaceae) attacked by the forest tent caterpillar were the same size as normal leaves. However, Reeks and Smith (1956) reported that the second crop of leaves on poplars defoliated by *Stilpnotia salicis* were smaller and lighter.

Most studies on the defoliation of *P. tremuloides* report that the effect on mortality of trees is negligible (Rose 1958, Hildahl and Reeks 1960), but Churchill *et al.* (1964) found that the mortality of *P. tremuloides* increased as the intensity of defoliation increased. The incidence of attacks by fungi and other insects also increased with the amount of defoliation (Churchill *et al.* 1964).

b) *Wood and Shoot Boring*

There is no doubt that wood and shoot boring insects cause damage, but most studies of such pests on willows have emphasized the qualitative damage to the rods, which made them useless for basketry. Attacked shoots were killed or at least had their growth arrested and the lateral buds were stimulated to start developing (Miles and Miles 1934; Richter 1959; Smith and Stott 1964; Solomon and Randall 1978). In evaluating the economic loss Richter's study (1959) found that the lengths of rods that had been attacked by *Cryptorrhynchus lapathi* were on average only 30% of the controls, but he only considered rods long enough to be used in basketry. Whether the total volume of the attacked plants is significantly reduced was not determined. In fact, the early destruction of some of the shoots may even have a pruning effect resulting in greater overall vegetative production. Richter (1959) stated that a willow can compensate for the destruction of shoots by *C. lapathi* early in the season by the vigorous growth of replacement shoots.

Tunnelling in a shoot can seriously weaken ~~it~~ so that the first strong wind or precipitation will break it (Ritchie 1920; McDaniel 1933; Harris and Coppel 1967). The tunnels in willows made by such pests as *Cryptorrhynchus lapathi*, *Dizygomza barnesi*, *Rhabdophaga* spp. and *Euura atra* provide a means of entry for secondary pests such as fungi and bacteria (Barnes 1933; McDaniel 1933; Richter 1959; Smith and Stott 1964; Wong, Melvin and Drouin 1976). Another problem caused by wood-boring larvae is the damage produced by birds digging the larvae out of the wood (Barnes 1935; Wong, Melvin and Drouin 1976).

The damage of shoot-feeding may be modified by the time of the year in which it occurs. Both Smith and Stott (1964) and Richter (1959) concluded that damage to shoots late in summer did not significantly affect the yield although the quality of the rods for basketry was reduced. On the other hand, damage to the shoots in the spring affected their physiology throughout the growing season by delaying their development. This caused the leaves of attacked shoots to drop later and the shoots to be exposed to a greater risk of frost damage (Richter 1959).

Bassman et al. (1982) simulated the insect damage of boring and girdling on hybrid poplars and concluded that the damage treatments had to be very severe to show a statistically significant reduction of growth in the following year.

c) Galling

The effect that galling has on plants has not been well studied. The insect induces immature tissues, which would normally form part of the dermal, ground or vascular system, to form an atypical structure that provides the insect with food and shelter (Lalonde and Shorthouse 1984). The gall may act as a metabolic sink utilizing nutrients for its own development at the expense of the rest of the plant (Jankiewicz, Flich and Antoszewski 1970, Stinner and Abrahamson 1979, Harris 1980). In studying the effect of leaf galls of sawflies on their host willow leaves, Niklas (1955) did not find a simple correlation between galling and leaf size. Galled leaves could be larger, the same size or smaller than ungalled leaves. Zivojinovic (1961) does report that the galling of poplar stems by Saperda populnea had a negative effect on growth. The portions of stem distal to the galls were thinner and had smaller and fewer leaves. Galling may increase the vegetative production of plants over a longer period. One study found that, although the galling of adventitious shoots of blueberry halted the growth of that shoot, it stimulated the development of more shoots around the base of the gall in the following year (West 1983). The gall midges, Rhabdophaga heterobia and R. terminalis, may have a similar effect on willow because they stimulate the development of lateral shoots at the same time as they stop the elongation of the galled shoot (Barnes 1930, 1932). On the other hand, Weis (1984) found that the gall of R. strobiloides on willow shoots exerted apical dominance over the lateral buds and prevented them from developing. However, Weis does not report on the development of the buds of the galled shoots in the year following the attack, and it is possible that there may be a net gain in vegetative production in the long term.

d) Sapsucking

The sapsucking pests include the Homoptera, aphids and scale insects and the Acari, the mites. Although the latter are not insects, but are in the class Arachnida, their method of feeding and the type of damage they cause is similar to that of the sapsucking insects. Richter (1959) reports a reduction in the length of willow rods caused by the feeding of *Schizotetranychus schizopus* and *Aphidula farinosa*. *A. farinosa* also causes branching below the point of attack and so any evaluations of lost yield should consider the total volume of shoots. Sapsucking pests cause the willows to drop their leaves prematurely reducing the amount of resources that can be stored for next year's growth (Richter 1959, Wasielewski 1982). Attack by sapsuckers can also lead to other problems. Wasielewski (1982) states that attack by the aphid *Lachnus viminalis* on willows often leads to fungal infection, and Richter (1959) related the attack of the mite, *S. schizopus*, on willows to greater incidences of other arthropods, such as aphids, cicadas and weevils, in the following years.

Monocultures of plants are very attractive to insects, and insect infestations in plantations of agroforestry crops are inevitable. It is hoped that this project will be a useful aid to researchers working on the identification of and damage caused by willow pests, evaluation of economic losses and implementation of controls.

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Part II

ABSTRACTS

Ahman, I. 1984. Oviposition and larval performance of *Rhabdophaga terminalis* on *Salix* spp. with special consideration to bud size. Entomol. exp. appl. 35:129-36.

Rhabdophaga terminalis (H. Loew.) was the most serious pest of *Salix alba* L. and *Salix fragilis* L., two species of willow grown in Swedish plantations producing biomass for fuel. The life cycle could be completed in one month allowing two to three generations per year in Sweden.

Four aspects of insect-host plant relationships were considered:

1. To what extent did females discriminate between species and clones?
2. Did bud size affect egg distribution?
3. Did the female's choice of host plant affect larval performance?
4. Was there any intra-gall competition?

Host-specificity was ascertained by preference tests in laboratory and field studies. Eggs were laid on all four clones of *S. alba* and *S. fragilis*. *S. alba* shoots had more eggs than those of *S. fragilis*, but there was no significant difference between clones of the same species. *S. fragilis* buds were sticky which may have hindered the female during oviposition. Three eggs were laid on one shoot of *S. viminalis*, and no eggs at all were laid on *S. triandra* , *S. daphnoides*, and *S. smithiana*. In the field the proportion of *S. fragilis* buds lost was as high or higher than that of *S. alba*. This may have been a result of the spatial distribution and density of host plants because there was a positive correlation between the abundance of host plants in the field and the proportion of infested buds as well as the number of eggs and larvae per gall.

Larval performance was tested by transferring eggs to buds of the various species. Eggs transferred to *S. alba* formed galls in 79% of the treated buds and to *S. fragilis* in 40%. No galls developed as a result of transfers to the other species. After 13 to 14 days a higher proportion of larvae in cocoons and pupae was found in the galls on *S. alba* possibly indicating a faster developmental time, but there was no significant difference in weight between the two groups of larvae.

Within the species *S. alba* larger buds were preferred for oviposition. There was a negative linear relationship between the number of larvae per gall and larval weight suggesting that there was competition between larvae within a single gall.

Auersch, O. 1955. Zur Kenntnis des Goldafters (Euproctis chrysorrhoea L.). (A study of the gold tailed moth (Euproctis chrysorrhoea L.)). Beitr. Ent. 5:97-126.

Euproctis chrysorrhoea was not usually ranked with the major forest pests, although recent outbreaks in England, the Soviet Union and Germany have demonstrated it was capable of significant damage. In orchards destruction of conspicuous "winter nests" tended to keep populations low.

E. chrysorrhoea was an extremely polyphagous species known to feed on plants of 24 different families. Salix alba L. and S. caprea L. sometimes were fed on by the larvae and contained the "winter nests."

The female moths did not fly much and were usually dispersed by wind. The males flew only far enough to reach the females. Oviposition took place in July. A female laid 112 to 480 eggs in batches on the undersides of leaves. Hatching occurred after 10 to 18 days and the young larvae skeletonized the leaves, leaving only the lower epidermis and the veins intact. Older larvae made irregular indentations in the leaf margin. A single larva required 50 to 60 mm^2 of leaf before it was ready to overwinter. Depletion of the food supply on one host caused the larvae to migrate to another. Heavy infestations caused premature leaf drop on their host plants reducing the accumulation of assimilates and increasing the risk of frost damage. The larvae usually gathered at their starting point, the oviposition site, to make their "winter nest." The nests were made up of 4 to 40 separate chambers and the number of larvae per nest varied from 45 to 3232. Nest-building was usually completed by mid-September. The mortality of the larvae inside the nests was 6 to 10%. The surviving larvae emerged in April. If well fed, a larva was ready to pupate by late May or early June. Pupation took place in loosely spun "summer nests", which housed one to several pupae.

Many species of birds have been found to attack the nests and a list of the European species was provided. A long list of the Ichneumonidae, Braconidae and Chalcidoidea recorded as parasitizing or hyperparasitizing E. chrysorrhoea was given. Only two of these ichneumonids and two chalcidoids were actually reared from E. chrysorrhoea during these studies. Eight unrecorded species of Tachinidae, one Drosophilidae and one Phoridae were reared from E. chrysorrhoea.

Barnes, H.F. 1930. On the resistance of basket willows to button gall formation. Ann. appl. Biol. 17:638-640.

Barnes, H.F. 1931. Further results of an investigation into the resistance of basket willows to button gall formation. Ann. appl. Biol. 18:75-81.

Of the three species of gall midge damaging basket willows in Britain, Rhabdophaga heterobia H. Lw. was the most serious pest. R. heterobia formed button-like galls on the terminal growing points, galls on the lateral buds or galls on the catkins. The button galls were the most serious because they halted growth of the shoot and stimulated the development of the laterals. The two studies examined the degree of resistance to button gall formation shown by different varieties and species of willow.

It was found that 12 commercial varieties of Salix triandra were highly susceptible. Three varieties of S. purpurea, one variety of S. viminalis, three varieties of the hybrid S. viminalis X purpurea and S. alba var. vitellina were completely immune to button gall formation. It was suggested that the hybridization of S. triandra with S. purpurea, S. viminalis or S. alba should be attempted.

Barnes, H.F. 1932. On the gall midges injurious to the cultivation of willows. I. The bat willow gall midge (Rhabdophaga terminalis H. Lw.). Ann. appl. Biol. 19:243-52.

Several species of cecidomyiid larvae caused serious damage to willow plantations. The bat willow gall midge, Rhabdophaga terminalis, induced a gall in terminal buds of Salix alba var. vitellina, the golden willow and S. caerulea (= S. alba var. caerulea), the bat willow. Galling halted the terminal growth of a shoot and induced the growth of side shoots. These side shoots made infested golden willows useless for basketry and bat willows useless for the manufacture of cricket bats.

The morphological characteristics of the adult midge were briefly described. The size of the adult and the number of antennal segments appeared to vary with larval nutrition. R. terminalis was found throughout western and central Europe, Denmark, Italy and England. In England it was not found in every commercial willow bed, but when present it was usually present in high numbers.

The midge overwintered as a larva in the surface soil layers and pupated there the following spring. The adults were on the wing in early May and mated as soon as possible. The female then laid her eggs in the terminal buds where galls developed. The larvae were sometimes found as inquilines in the rosette galls of *Rhabdophaga rosaria* on *Salix* spp. Further generations of the midge were on the wing at approximately monthly intervals until September. There were three to five generations per year depending on weather conditions.

R. terminalis had been reported to attack *S. alba*, *S. fragilis*, *S. amygdalina* (= *S. triandra* L.), *S. hastata*, *S. pentandra*, *S. purpurea*, *S. viridis* and *S. repens*. These records should be considered unproven in the absence of biological trials. In the field *R. terminalis* was found only on *S. caerulea* and *S. alba* var. *vitellina*. In preference trials the midges preferred *S. caerulea* to *S. alba* var. *vitellina* and did not attack *S. triandra*, *S. viminalis* and *S. purpurea* at all.

Several chalcidoid parasites, the bug, *Anthocoris nemorum* L., and tits fed on *R. terminalis*. Population levels may have been controlled by weather because outbreaks were exceptional although normally populations were high. As control measures, handpicking galls, cultivating between the rows in early spring and the destruction of hedgerow *Salix* shrubs to prevent reinfestation were suggested.

Barnes, H.F. 1933. A cambium miner of basket willows (Agromyzidae) and its inquiline gall midge (Cecidomyidae). Ann. appl. Biol. 20:498-519.

The cambium miner, *Dizygomyza barnesi* sp. n. Hendel, was common in willow beds in Lancashire and Hertfordshire. Specimens were also received from Yorkshire and Suffolk. It has been found on *Salix viminalis*, *S. triandra*, *S. purpurea*, *S. viminalis* X *purpurea* and *S. triandra* X *viminalis* and seemed to prefer soft-wooded varieties to hard ones.

The morphology of the egg, the larva and the pupa was described. Hendel's description of the adults was included. There was only one generation of flies per year with the adults emerging from May 21 to the end of June. Adults in captivity lived for one week. Mating was only observed once, lasted several hours and was followed shortly by oviposition. The female selected a point 10 or 12 inches above the ground on a shoot in its first year of growth and bored into the stem with her ovipositor. A single egg was deposited into each puncture. The egg stage lasted one or two weeks. The newly hatched larvae burrowed downwards throughout June and July remaining in the cambium. In late July the larvae changed direction and began working upwards. When ready to pupate the larvae formed slits in the outer skin of the rods, emerged and made their way to the ground. Larvae left the rods from late July to mid-September, but most started pupating in August. Pupation took place in the soil around the stubs and the puparia remained in the soil throughout the winter and spring.

Damage to willows was caused by the larval tunnelling and by secondary bacterial and insect attacks in the tunnels. The tunnelling made rods grown for basketry useless. Rods grown for two or more years as stake rods were weakened when new growth covered the tunnels. Willows grown for wood were useless because of the "fleck marks" throughout the cross-section. There was little change in the external appearance of attacked rods and the damage was usually not detected unless secondary infection set in or the rods were peeled back to reveal the tunnels.

D. barnesi was parasitized by two braconids, Symphia ringens Halid. and Symphia hians Nees and, although parasitism was high, it did not appear to effect any control. Apanteles fulvipes, another braconid, was a possible parasite of D. barnesi.

The larvae of the gall midge, Profeltiella dizygomyzae sp. n., were found in the tunnels of the cambium miner only on S. viminalis. There they lived gregariously as inquilines. The larvae reached maturity in August and September whereupon they spun separate cocoons inside the tunnels. They pupated the following spring and the adults emerged in July. There was one generation per year. A scelionid wasp, Ectadius craterus Walk., parasitized this midge.

Barnes, H.F. 1935. On the gall midges injurious to the cultivation of willows. II. The so-called "shot hole" gall midges (Rhabdophaga spp.). Ann. appl. Biol. 22:86-105.

A number of gall midge larvae inhabiting British willows caused a distinctive type of damage called "shot holes." The "shot holes" were the exit holes in willow stems prepared by the larvae for the emergence of the adult midges.

"Shot hole" damage has been ascribed to midges under a variety of names. Four species of Cecidomyiidae were found to form "shot holes" on cultivated willows. Rhabdophaga saliciperda Dufour was first described in 1841 and the other three species, R. triandraperda sp. n., R. purpureaperda sp. n. and R. justini sp. n., were new species. Morphological descriptions of the larvae, pupae and adults of all four species and keys for distinguishing between them were provided.

R. saliciperda was found on Salix caerula (=Salix alba var. caerula) and S. fragilis. There was one brood per year with the adults emerging from late April until early July. Eggs were laid in cracks in the bark of the stubs and branches. The larvae lived in individual chambers, but the chambers were usually clustered. Individuals from S. caerula and S. fragilis mated successfully and produced progeny that survived on either species of willow. Midges reared from S. fragilis reproduced on S. caerula and vice versa.

R. triandraperda sp. n. infested the stubs and bases of the rods of S. triandra. The adults of the single annual generation emerged from mid-April until early June. Emergence took place in the mornings and was followed immediately by mating. Mated females began ovipositing into cracks in the bark and continued laying eggs for the next eight to ten hours. At this time most of the 150 or so eggs had been laid. Females usually died within 48 hours of emergence. Eggs hatched after 10 to 13 days and the larval behaviour was the same as that of R. saliciperda. Attempts to rear this species on S. purpurea, S. viminalis X purpurea and poplar were unsuccessful.

R. purpureaperda sp. n. lived in the bases of rods of S. purpurea. Emergence of the adults took place from mid-April until early July. There was one generation per year. The behaviour of the adults and the larvae was similar to that of R. triandraperda except that the eggs hatched in 6 to 12 days. Attempts to rear this species of gall midge on several other species of Salix were unsuccessful.

R. justini sp. n. had two broods per year on S. purpurea. The adults of the first overwintering generation emerged from late April until the beginning of June. The second flight of adults took place in July and sometimes a partial third generation was present in the last half of August. Females oviposited on any available new growth and eggs and larvae were never observed on old growth. Eggs were usually laid singly so that the individual chambers of the larvae were more isolated from each other than those of the other three species.

In addition to the "shot holes" formed by the larvae, birds caused additional damage in their search for the larvae by tearing up the bark. Control of these species was difficult, but cutting the new growth of S. purpurea in May destroyed the first generation of R. justini along with frost and caterpillar damage and allowed the replacement rods to grow straight. Wild willows near plantations, which can act as reservoirs for these pests, should be destroyed. A list of the hymenopteran species parasitizing these gall midges was provided.

Barnes, H.F. 1949. "Gall midges injurious to basket willows". In Gall Midges of Economic Importance. Vol. VI. Gall Midges of Miscellaneous Crops. London. Crosby, Lockwood and Son Ltd. 229 pp.

The gall midges (Diptera: Cecidomyiidae) found on Salix amygdalina L. (= S. triandra L.), S. hippophaefolia Thuillier (= S. viminalis X S. triandra L.), S. purpurea L., S. triandra L., S. viminalis L. and S. vitellina L. were described. Only those species that were not available in other references are described here.

Rhabdophaga marginemtorquens (Bremi)

R. marginemtorquens infestation on Salix viminalis could be recognized by the tightly rolled and swollen leaf margins. It was considered a minor pest for the basketry industry because it did not directly affect the rods. This gall midge was common throughout Europe.

There were several overlapping generations per year. The first generation of adults appeared from early May to late June. The first adults of the second generation were on the wing during late June. In 1937 there were at least four flights of midges. There were partial emergences of the generations towards the autumn so that the overwintering larvae were from several different generations. The females oviposited into the leaves of terminal buds and the gall developed in 14 to 21 days. Each gall contained many larvae.

Several other species of Salix had been reported as hosts for R. marginemtorquens but these required verification. Parasites were reared from the midges but not identified. The only known control, which was probably too expensive to be done regularly, was to handpick the infested leaves when the galls became noticeable.

Rhabdophaga sp.

The larvae of this unidentified gall midge infested the terminal buds of Salix viminalis and S. hippophaefolia (= S. viminalis X S. triandra). Up to three larvae were found in a single bud and they caused the death of the terminal shoot. It was believed to be found throughout Europe, but misidentifications have caused problems. There were at least two generations per year with the first adults emerging in May.

Rhabdophaga viminalis (Westwood)

This species was first described from larvae found on Salix viminalis and S. rubra. The larvae lived gregariously, but each was found in its own cell putting this midge into the "shot hole" group. It was not clear whether this species was distinct from the "shot hole" midges on other species of Salix.

Unidentified Gall Midge on Salix viminalis

The larvae lived gregariously under the bark of S. viminalis but nothing further was known about this species.

Brown, C.E. 1962. The life history and dispersal of the Bruce spanworm, Operophtera bruceata (Hulst.), (Lepidoptera: Geometridae). Can. Ent. 94:1103-7.

The Bruce spanworm was most common in the mid-latitudes of North America. In Canada it ranged from Newfoundland to British Columbia. The preferred hosts in western Canada were trembling aspen, Populus tremuloides Michx., and willows, Salix spp., while in eastern North America sugar maple, Acer saccharum Marsh and beech, Fagus grandifolia Enrh. were preferred. Many other trees and shrubs have been recorded as hosts. This study was conducted near Calgary, Alberta from 1958 to 1960.

Descriptions of the morphology of all stages of the life cycle - egg, four larval instars, pupa and male and female adults - were given. In the fall the adult females laid their eggs in bark crevices or any other protected spot on the host tree. The eggs hatched in late May when the aspen buds were opening. For five to seven weeks the larvae fed first on buds and then leaves. Pupation took place in cocoons in the soil or debris below the host. In late fall adults emerged. The wingless female climbed the tree, and then mating occurred. Adults were active even at low temperatures. The Bruce spanworm was parasitized by a number of hymenopterans, but none effected significant control.

This insect could not disperse by flight as do most forest lepidopterans. First instar larvae dispersed by spinning long threads and then dropping. When the threads broke, the larvae drift in the wind with the thread acting as a sort of balloon. In theory the larvae could travel long distances if they were carried up by a thermal updraft.

Brown, W.J. 1951. The North American species of Phratora Chev. (Coleoptera: Chrysomelidae). Can. Ent. 83:121-30.

This genus was properly Phratora, but had recently been designated as Phyllodecta by some authors. The genus was holarctic and the North American species were poorly known.

All Phratora spp. seemed to have similar life histories with feeding restricted to poplars and willows. The adults hibernated and appeared on their host plants in May or June depending on the weather and the latitude. The eggs were laid on the undersides of leaves in two rows of 12 to 18. Oviposition was completed by mid-June in southern Ontario and mid-July in central Manitoba. The larvae fed gregariously on the undersides of leaves leaving the upper epidermis intact. Pupation took place in the soil and in late summer the new generation of adults was present on the host plants. There appeared to be some parthenogenesis.

A general description of the beetles and their genitalia was provided. The body was metallic above without spots. A key to the species and subspecies was given. The species, subspecies, their host plants and their distributions are listed below:

Species	Host plant	Distribution
P. aklaviki (Carr)	Salix	northern British Columbia, Northwest Territories, possibly Alaska
P. purpurea purpurea n. sp., s. str.	Populus spp. Salix spp.	transcontinental
P. purpurea novae-terrae n. subsp.	Salix discolor Muhl. Populus tremuloides Michx.	southeastern Newfoundland
P. americana americana (Schaeffer)	Salix	in and near mountains of eastern U.S.A.
P. americana canadensis n. subsp.	Salix	eastern North America
P. hudsonia n. sp.	Unknown	Great Slave Lake, Northwest Territories
P. frosti frosti n. sp. s. str.	Salix	Nova Scotia
P. frosti remissa n. subsp.	Salix	Manitoba, Alberta, Wyoming

Callan, E.McC. 1939. Cryptorrhynchus lapathi L. in relation to the watermark disease of the cricket-bat willow. Ann. appl. Biol. 26:135-7.

Cryptorrhynchus lapathi was attacking Salix viminalis and appeared to be moving on to the cricket-bat willow, S. alba var. caerula in England. The cricket-bat willow was subject to the watermark disease caused by Bacterium salicis, which ruined the wood. The adult weevils fed by making punctures into the wood and thus were possible transmitters of the disease. This study examined the possibility that C. lapathi was responsible for spreading the bacteria.

Weevils were exposed to B. salicis or allowed to feed on diseased shoots and then were transferred to healthy plants. No symptoms of the disease were observed in these plants. In addition the weevils were never found associated with the disease in the field.

Caltagirone, L.E. 1964. Notes on the biology, parasites and inquilines of Pontania pacifica (Hymenoptera: Tenthredinidae), a leaf gall incitant on Salix lasiolepis. Ann. ent. Soc. Am. 57:279-91.

This study of Pontania pacifica Marlatt, a gall-forming sawfly, was conducted in southern California. The galls were only found on Salix lasiolepis, but in captivity females oviposited into S. breweri without inducing any galls.

The egg, larva, prepupa, cocoon and pupa were all described. The mature gall was spherical or oval and protruded from both sides of the leaf. The top was red, pink or brown and the bottom green.

Females were able to oviposit immediately after emergence. Eggs were laid into developing buds with a secretion from the colleterial gland. The gall began developing at once, keeping pace with the growth of the leaf. The larvae fed on the tissues of the gall, which eventually became filled with frass and cast skins. After five male instars and six female instars the larva moulted into a prepupa. The prepupa left the gall through a hole, which it had made, and dropped to the ground. A cocoon was spun in the soil or plant debris for pupation. Overwintering took place in the prepupal stage. No information about the number of generations per year was given although more than one per year was implied.

The gall and the sawfly larvae were the centre of a large community of inquilines and parasites. The biologies of three inquilines, Eurytoma sp. (Hymenoptera: Eurytomidae), Batrachedra salicipomonella Clemens (Lepidoptera: Cosmopterygidae) and Anthonomus sycophanta Walsh (Coleoptera: Curculionidae), were described. All three were phytophagous but caused the death of the gall-former or any other inhabitant of the gall. The biologies of two ichneumonid parasites, Lathrostizus euurae (Ashm.) and Scambus vesicarius euurae (Ashm.), were also described. Three other hymenopterans found in this gall were Habrocytus borrowi Girault, Pimploterus sp. and Chelonus (Microchelonus) sp.

Carleton, M. 1939. The biology of Pontania proxima Lep., the bean gall sawfly of willows. J. Linn. Soc. Lond. Zool. 40:575-624.

Pontania proxima and its gall have long been known to occur on many species of willow. It has been recorded throughout the British Isles, in almost every European country and in western Asia. The gall was not economically important on basket willows, but it was possible that heavy attack could reduce the plant's vitality. The species was studied on Salix fragilis L. and S. triandra L. in Somerset and Gloucestershire.

There were two complete generations on both hosts and a partial third generation on S. triandra. The adult females of the first generation emerged in May and June. Males were very rare and only one was found during the course of this study. A female laid 20 to 35 eggs and injected a glandular fluid with the egg into the leaves of willows. Females usually sawed many suitable leaves and injected glandular fluid without laying an egg, which resulted in normal-seeming galls. Hatching occurred after 12 to 19 days when the gall had attained its maximum size. There were five larval instars over a period of about fifteen days. The larvae left their galls when feeding was completed and searched for a site for pupation either on the ground around the host or in cracks in the bark. They spun cocoons and pupated over a period of seven to fifteen days. In the second generation most of the insects overwintered as prepupae inside the cocoon. The mature gall was an oval about 7 mm long protruding equally from both surfaces of the leaf. Galls were bright red on S. triandra and rose pink on S. fragilis.

The synonymy of the insect was quite extensive: Nematus proximus Le Peletier, N. gallicola Stephens, N. crassispina Thomson, N. vallisnieri Hartig, N. festivus Zaddach and N. parvulus Holmgren.

There has been a lot of confusion about the host plants of P. proxima, because of the problems of the synonymy and of properly identifying the willows. It has been reported on S. caprea L., S. fragilis L., S. vitellina L., S. alba L., S. amygdalina L. (= S. triandra L.), S. cinerea L., S. pentandra L. and S. silesiaca Willd. Behavioural differences between specimens from S. triandra and those from S. fragilis have been found suggesting that there are two biological races.

Thirteen species of Ichneumonidae, two species of Braconidae and four species of Chalcidoidea parasitizing P. proxima were listed. The biologies of the ichneumonids, Angitia vestigialis Ratz., Pimpla vesicaria Ratz. and Scopimenus pygobarbus Rom.; of the braconids, Microbracon discoideus Wesm. and M. picticornis Wesm. and of the chalcidoids, Eulophus tischbeinii Ratz. and Habrocytus capreae Thoms. were described. Balanobius salicivorus, a curculionid beetle and two tortricid moths, Tortrix podana Scop. and Peronea logiana Schiff., were inquilines but killed the gall former.

Chaudry, G.U. and M.A. Cheema. 1965. Studies on the insect pests of Populus and Salix species. I. Biology of the double tail caterpillar, Cerura wisei Swinhoe. Pakist. J. For. 15:72-81.

The increased demand for forest products has resulted in the increased cultivation of fast-growing trees such as Populus and Salix spp. The populations of some insects previously found in small numbers have consequently increased. Cerura wisei Swinhoe, the double tail caterpillar (Lepidoptera: Notodontidae), was one of these.

C. wisei attacked all species of poplar but preferred Salix spp. The caterpillars were present soon after bud-burst and fed on the young leaves. The young caterpillars fed on the leaf margins making rounded indentations while the older larvae skeletonized the leaves. Damage was not usually severe, but in outbreaks trees could be 50 to 100% defoliated, and even the young shoots would be eaten.

The adult moths appeared in the field from late February until March. Mating started within a few hours of emergence. The females laid most of their eggs about one day after copulation and died within two days of completing oviposition. A female laid an average of 191 eggs on leaves and branches. In the laboratory the eggs hatched in nine to twelve days and had a viability of 74.6%. After a larval period of about two months the fully grown caterpillar gnawed a trough-like cavity into the bark of its host tree and spun a hard cocoon. Pupation lasted from the end of May until February-March of the following year. There was only one generation per year.

No natural enemies of C. wisei were discovered. Control of the populations could easily be achieved by removing the cocoons from the trees and destroying them. Large areas of trees could be protected by spraying with pesticides such as Endrin, BHC or Dipterix.

Cuming, F.G. 1961. The distribution, life history and economic importance of the winter moth, Operophtera brumata (L.) (Lepidoptera: Geometridae) in Nova Scotia. Can. Ent. 93:135-42.

The winter moth was introduced to Nova Scotia from Europe in the 1930's and at the time of writing was not known to occur elsewhere in North America. It was gradually expanding its distribution.

The most common hosts were Acer rubrum L., red maple; Tilia americana L., basswood; and Ostrya virginiana (Mill.) K. Koch., ironwood. Other hosts were Salix spp., Populus spp. and Betula spp.

The morphology of each of the stages of the life cycle was described. There was one generation per year with the egg overwintering. Hatching occurred from late April to late May. The newly hatched larvae fed on buds, older larvae skeletonized the leaves and fourth instars fed inside a rolled leaf. The fifth instar dropped to the ground and formed a cell for pupation in late June to early July. Adult emergence occurred from late October to mid-December. The period of emergence was affected by snowfalls and frosts. The adults were active in sub-freezing temperatures but not during daylight. Eggs were laid in bark crevices and under lichen on host trees. Caged females laid an average of 154 eggs.

Studies conducted in red oak stands showed that repeated defoliation caused the stands gradually to deteriorate and the trees eventually to die.

Doom, D. 1966. The biology, damage and control of the poplar and willow borer, Cryptorrhynchus lapathi. Neth. J. Pl. Path. 72:233-40.

Cryptorrhynchus lapathi L. had been studied in many countries, and greatly differing results were obtained. This fact made another study of this curculionid beetle in the Netherlands seem worthwhile. C. lapathi was found only on willow, poplar and alder in the Netherlands with poplar being the most susceptible and alder the least.

In the Netherlands just as in other colder areas there was a two year life cycle. The adults overwintered inside the host trees and emerged from mid-May onwards. They fed by boring holes into twigs of their host. After a 10 to 14 day period of feeding the adults became sexually mature. The female excavated an oviposition hole with her proboscis and laid a single egg inside. In willows the stumps were favoured for oviposition while in poplars leaf scars, callus growths and the area around branch' forks were preferred. Periods of oviposition were interspersed with periods of feeding and both continued until October. In November the beetles retreated to the leaf litter where they eventually died.. The eggs hatched in 18 to 21 days. The first instar larvae had a short active period, during which they made a short gallery, followed by an obligatory diapause and overwintering. The larvae resumed their activity in March. At first they made galleries in the cambial zone, but they eventually penetrated the wood. The fourth instar tunnelled up the pith where the fifth instar made a pupal chamber. Pupation took place in late July and was completed by early August, but the new adults overwintered in their pupal chambers. The two year life cycle meant that excluding some very limited and localized exceptions there were only larvae in odd years and beetles in even years.

The feeding holes of the adults made the twigs more susceptible to breakage and sometimes killed them. The larval tunnel often girdled trees, made them susceptible to breakage and reduced the production of new shoots in willow stumps. C. lapathi caused indirect damage by providing entrances for other pests of poplars and willows. These included the goat moth, Cossus cossus L., the clear underwing, Sciapteron tabaniformis (Rott.), bacterial cankers (Pseudomonas) and the mould, Dothichiza populnea Sacc. et Briard (= Chondroplea populea (Sacc.) Klebahn).

Theoretically both adults and larvae could be controlled with insecticides. However, the extended period of emergence of the adults made more than one large scale treatment with toxic chemicals necessary. On the other hand a single close range application of a systemic insecticide would suffice to destroy the larvae and would be safer. The systemic and non-systemic insecticides used successfully against C. lapathi were listed.

Duffy, E.A.J. 1949. A contribution towards the biology of Aromia moschata L., the "musk" beetle. Proc. S. Lond. ent. nat. Hist. Soc. 1947-48:82-110.

Information on this species of cerambycid beetle in the scattered literature was contradictory and incomplete, so it was thought that a study of the taxonomy, ecology and life history would be worthwhile. The study was conducted mainly on a large well-established colony near Guildford in Surrey.

The morphology, the colour varieties and genitalia of the adult beetles were described. A general description of cerambycid larvae was followed by one of larvae of the genus Aromia. The final instar of A. moschata, the first instar and the later instars were all treated separately. The exact number of instars was not known but there were at least five. The pupa and egg were also described.

The adults emerged from June to August, and activity peaked in July. The beetle had scent glands, and in July a large colony would be very heavily scented. Males fought for possession of females. Copulation, which lasted several hours, took place on stems and large branches of host trees. The females chose the main stem or the base of the largest branches for oviposition. They often used holes made by other insects as well as cracks and other openings. One to several eggs were deposited at each site. The dissected ovaries of females contained an average of 48 eggs. The adult beetles have been recorded as feeding on flowers of rag-wort, chrysanthemums and various Umbelliferae as well as ripe gooseberries and the sugar stations of lepidopterists.

After the eggs hatched, the larvae bored through the bark and fed subcortically until the third instar. The older larvae then tunnelled horizontally to the sapwood and then up vertically for a foot or more. By their third winter they were almost fully grown. In the following spring they prepared for pupation by boring to just below the bark and then forming a four to five inch-long vertical tunnel at that point. The tunnel was enlarged to form a chamber and wood shavings were used to pad the walls and plug the entrance. After pupation was completed the new adults stayed in their chambers for one to two days until their integuments were fully hardened and then gnawed their way out.

The beetles were found on young and old willows of the following species: Salix atrocinerea Brot. (= S. cinerea subsp. oleifolia (Sm.) E.A. & G. Camus), S. caprea L., S. fragilis L. and S. viridis L. They were often found on trees inhabited by larvae of the goat moth, Cossus cossus L., probably because A. moschata prefers wounded but still healthy trees. A. moschata was found throughout England but was more common in the south and was found at scattered locations in Ireland and Wales.

The musk beetle was not regarded as a serious timber pest because its hosts had little commercial value, but could be considered a plantation pest attacking ornamental species.

Fenton, F.A. 1917. Observations on Lecanium corni Bouché and Physokermes piceae Schr. Can. Ent. 49:309-20.

The common and widely distributed soft scale, Lecanium corni was studied at Madison, Wisconsin. It was probably introduced from Europe and was first described as Lecanium tiliae in 1851. This species showed much morphological variablility even on the same host and had been described under many names. It was polyphagous and was found on various members of the Salicaceae as well as many other plant families. Because of the wide range of host plants and its general distribution it was not usually economically important although outbreaks in orchards have been recorded.

The populations overwintered as second instar nymphs attached to the bark below scales and a waxy coating. Growth was resumed in the spring when the sap flow started. Both sexes moulted after about one week, and then development of the male differed from that of the female. The male went into a non-feeding phase and emerged as a winged adult after five to nine days. Males survived for only a few hours. At the same time the female grew rapidly. After fertilization the scale was brown or chestnut coloured, pitted and convex. In May and early June development of the ovisac took place. When mature, the female stopped feeding and began laying her eggs into the cavity formed by the shrinking ovisac. At the end of oviposition the female was a mere shell forming a protective barrier over the eggs. A female laid up to 2000 eggs before the end of oviposition in mid-June. Eggs hatched in early July and the young moved on to the principal veins of the leaves where they fed until autumn.

A number of chalcidoid parasites were reared from L. corni and identified. Coccophagus lecanii Le Baron var. was the major parasite in Wisconsin where it almost completely eradicated its host in some areas. The maggots of the small fly, Leucopsis nigricornis Egger, preyed on the eggs, and the larvae of the coccinellid beetles, Hyperaspis binotata Say and Chilocorus bivulnerus Mulsant, ate the eggs and nymphs of L. corni. Female L. corni were subject to many fungous diseases but especially Cordyceps clavulatum Ellis.

Francke-Grosmann, H. 1953. Über die Brutfürsorge einiger an Kulturweiden lebender triebstechender Rüssler (Curculionidae) und ihre phytopathologischer Bedeutung. (On the tending of their broods by some shoot-boring weevils (Curculionidae) on willow and its phytopathological significance). Beitr. Ent. 3:468-478.

The annual cutting of rods in basket-willow plantations resulted in the appearance in spring of young, vigorously growing shoots, which attained their full length in the autumn. A number of opportunists was found taking advantage of this pattern of growth and these opportunists included the shoot-boring weevils.

Plantations in northern Germany harboured the following weevils: Balanobius salicivorus Payk., Balanobius crux Fabr., Rhynchaenus (Tachyerges) stigma Germ., Rhynchaenus (Tachyerges) salicis Lin., Merhynchites (Pselaphorhynchites) tomentosus Gyll., Merhynchites (Pselaphorhynchites) longiceps Thoms., Merhynchites (Pselaphorhynchites) nanus Payk. and Merhynchites germanicus Hbst. The most heavily attacked species was Salix viminalis f. regalia, but various wild and cultivated willows were hosts.

The two species of Balanobius were not economically important on willow, and they had the poorest brood-tending habits. The adult beetles appeared in early spring and fed on the shoots. The narrow holes left by their feeding were soon filled with callus and caused little damage. As soon as the galls induced by the sawflies of the genus Pontania were present, the beetles began feeding on them. Their eggs were laid inside the galls and the larvae lived as inquilines.

The other six weevils all laid their eggs inside willow shoots and the larvae fed inside the shoots. A growing shoot normally would be a poor oviposition site for weevil eggs. The young tissues were well supplied with moisture, and the egg could drown. Callus tissue developing in the oviposition wound could crush the egg. The brood-tending of the female weevils prevented the destruction of their eggs by these means.

The simplest form of brood-tending was practised by the two species of Rhynchaenus. The adults first fed on the leaves, and then the female excavated a chamber for the egg in the cortex of a shoot. The chamber was sealed with a thin lid of frass. The disruption of the vascular system at the point of excavation first caused growth to stop and eventually the shoot tip to die. The larva bored upwards in the shoot and then reversed direction returning to its starting point by which time it was ready to pupate. R. stigma oviposited 5-6 cm below the shoot tip and R. salicis 2-3 cm below. Rhynchaenus spp. were more common on native willows as the development of callus in the vigorously growing shoots of cultivated willows would crush the eggs.

Pselaphorhynchites tomentosus, P. longiceps and P. nanus all initially fed on willow shoots, gnawing long furrows into the buds. They bored a simple hole into the terminal bud, laid an egg inside and covered the hole with a loose wadding of hairs from the leaves. In effecting the wilting of the shoot tip, the three species of Pselaphorhynchites differed. P. tomentosus almost completely severed the shoot by gnawing through it up to 12 cm below the tip. The shoot tip usually broke off, leaving the larva to develop inside the rotting tip on the ground. P. nanus and P. longiceps made a series of punctures around the shoot disrupting a significant portion of the vascular system. Because of the incomplete separation, the shoot tip wilted slowly and usually remained attached.

Merhynchites germanicus had the most highly developed brood-tending habits. It was a polyphagous species only recently discovered feeding on willow. The feeding of the adults on the shoots caused sustainable damage except in heavy infestations when the shoots were killed. The females made a ring of six to twelve punctures around the shoot a few centimetres below the tip almost completely severing the vascular system and causing immediate wilting. At a point above the punctures two chambers were excavated in the stem. The inner chamber containing the egg was larger and separated from the outer chamber by a thin wall. The two chambers were connected only by a narrow slit. Finally the stem was severed above the egg chamber. The larva lived in the decaying portion of stem above the punctures until autumn.

These shoot-boring weevils were considered serious pests because of their destruction of the shoot tips, and their role in causing bushiness in willows has probably been underestimated.

Gäbler, H. 1953. Beitrag zur Kenntnis von tierischen Forstsamenschädlingen. (A contribution to the knowledge of animals damaging seeds of forest trees). Beitr. Ent. 3:479-87.

The forest industry required seeds for the propagation of commercial species, but the seeds collected were often damaged. This study conducted at Eberswalde examined the pests damaging seeds from a number of forest trees including willows.

Both male and female catkins were found damaged. Immature catkins were often found with large clusters of tangled seed hairs and the seeds inside eaten away. This damage was caused by dipteran, coleopteran or lepidopteran larvae.

Some catkins shorter than normal with a brown, dry tip were also found. Examination showed that the inner portion had been mined by curculionid or tortricid larvae. The seeds of these catkins matured earlier, but whether they had normal viability was not determined.

Another curculionid was found mining male catkins and eating the stamens of Salix purpurea. Diptera on female catkins were identified as Egle parva Rob.-Desv. and Egle collaris Ringdahl. Female catkins were also attacked by early instars of the moth Xanthia gilvago Esp. The older instars moved on to other host plants.

Gautreau, E.J. 1963. The poplar and willow borer. Bi-mon. Prog. Rep. For. Ent. Path. Br. Dep. For. Can. 19(3):3.

The poplar and willow borer, Sternochetus (Cryptorhynchus) lapathi (L.), was first recorded in Alberta in 1961 and may have spread from Southeastern British Columbia. It had a wide distribution in southern Alberta and was found at elevations of up to 5000 feet.

Willow, an important shelterbelt and watershed species in Alberta, suffered 40% mortality in areas heavily infested by borers. Willows with stump diameters of ½ to 6 inches were attacked and killed. Only two species of willow were found to be hosts: the sandbar willow, Salix interior Rowlee var. pedicellata ((Anderss.) Ball) and the blueberry willow, Salix myrtillifolia.

In late April adults were collected from the debris below host trees, and pupae were collected from infested trees showing that at least two stages overwintered. Adults mated from July to August and the first larvae were observed on July 3. Newly emerged adults were observed mating on July 18.

Gunn, D. 1919. The fig and willow borer (Phryneta spinator). Un. S. Afr. Dep. Agr. Bull. No. 6. 22 pp.

This cerambycid beetle was a serious pest of fig and willow trees in South Africa, and this study of its life history and habits was undertaken with the aim of developing control measures.

The most serious damage was caused by the tunnelling of the larvae although the adults damaged the bark with their gnawing. The larval tunnels reduced sap flow consequently stunting the growth of the trees. Girdled trees were killed and heavy attack left trees exposed to wind-breakage. The exit holes of the insect in the trunks allowed the entrance of parasitic fungi into the trees.

All the stages of the two-year life cycle were described. Emergence of the adults started in early November and oviposition began soon afterwards. Oviposition continued until mid-March when the adults began to die off. Eggs were deposited into slits, which the female made in the bark with her jaws. The slits were made on a main stem from ½ to 15 inches above the soil. Usually only a single egg was deposited into a slit, but up to four were sometimes found. Females laid 18 to 34 eggs. Hatching of the eggs occurred 10 to 18 days after being laid, and the new larvae first fed on the tissue around the egg slit. Later they began excavating large galleries beneath the bark usually heading towards the roots. Frass and wood fragments were pushed out of holes in the bark. Early in June the larvae started forming their pupal chambers, which took three to four months to complete. Pupation then took another three months, and the new adults finally chewed their way out in November.

No parasites were reared from the fig and willow borer, but a parasitic fungus, Isaria sp. infected adults especially in wet summers. Some control recommendations were made for fig trees: cutting out the larvae, protecting the trunks against oviposition with netting, using insecticides as repellents and destroying worthless infested trees.

Harris, J.W.E. and H.C. Coppel. 1964. The poplar-and-willow borer, Sternochetus (= Cryptorhynchus) lapathi (Coleoptera: Curculionidae), in British Columbia. Can. Ent. 99:411-8.

In British Columbia attacks by Sternochetus lapathi on native trees were negligible and even heavily infested trees were rarely killed. Nevertheless, the biology of this insect was studied in cages and in the field.

Distribution and Hosts:

S. lapathi was first reported in B.C. in the 1920's where it has since become established south of 52°N latitude. Caged adults tested for their feeding preferences preferred Salix scouleriana, Populus trichocarpa, Populus X canadensis "Regenerata" and "Robusta Bachelier" and P. nigra "Italica". They occasionally fed on P. alba but never on Alnus rubra, P. tremuloides or Betula papyrifera commutata. Feeding in a mixed plantation favoured Salix sp. and P. trichocarpa.

Breeding preferences were tested by confining pairs of adults on nine species of trees. The following summer S. babylonica had the most larvae. Salix sp., P. X canadensis, P. nigra and P. trichocarpa all had some larvae while P. alba, A. rubra and B. papyrifera had none.

Life History:

Dissections of infested stems showed two peaks in the number of eggs. The first peak occurred in summer-early fall when both the overwintered and newly emerged adults were ovipositing. The second peak in the spring was made up of overwintered eggs and eggs laid by the overwintered adults. Measurements of head capsules indicated that there were probably six instars. The first instar usually overwintered. Pupae were present from mid-July to mid-December being most abundant in August. The majority of adults emerged in the fall, overwintered and were active the following summer. Fifty-six percent of the caged population lived a second winter making their complete life cycle three years.

Habits:

Caged weevils were active throughout the day and night when their cages were sprayed with water. Flight was observed only once and was presumed to be a result of overcrowding.

The adults used their mandibles to cut small holes in the bark for feeding and oviposition. Feeding usually took place on green, smooth-barked shoots of the current year while oviposition was mainly into stems older than one year within three feet of the ground.

After the eggs hatched, the larvae enlarged their egg chambers before winter dormancy. In spring they mined the circumference of the stems. The fourth instar larvae tunnelled inward and then up through the pith. After pupating the adults emerged via the larval mines.

Infested clumps of willows usually had several borer-killed stems surrounded by younger living stems. Heavy mining caused the stems to break. The injury caused by the feeding and oviposition of the adults was of little importance. The mines of the larvae provided oviposition sites for other wood-boring Coleoptera and Lepidoptera but apparently not entry to disease organisms.

Associated Organisms:

Two nematodes and four dipteran larvae were found in the mines and three mites were found on the borers. The eulophid, Dolichomitus messor sparsus Townes was the only insect parasite observed. Ants and birds preyed on the larvae in the mines.

Control:

Control was difficult because of the secretive habit of the adults and the protected habitat of the larvae. Cutting and burning of infested stems was thought to be impractical where native willow, from which reinfestation could occur, was abundant. It was found that borers rarely attacked other species when native willow was present.

The results of tests using DDT, dieldrin, BHC and lindane are described.

Hood, C.E. 1940. Life history and control of the imported willow leaf beetle. U.S.D.A. Circular No. 572.

Plagiodera versicolora Laich. is a small, metallic blue beetle. Introduced from Europe, it was first reported in New York in 1911. At the time of writing it was abundant in the northeastern U.S.A.

In New England feeding was confined to willow but it had also been reported on poplar. P. versicolora prefered Salix nigra Marshall and S. alba var. vitellina (L.) Koch but also attacked S. babylonica L. and S. lucida Muehlenburg.

Adults and larvae skeletonized the leaves, feeding gregariously. Heavy feeding caused the foliage to turn brown and in severe infestations trees were completely brown by mid-June.

P. versicolora overwintered in the adult stage under bark or in debris at the base of the tree. The adults emerged the following spring from late April to early May. In Massachusetts three full generations and a partial fourth were present.

Natural controls on populations of P. versicolora were extremely cold winters, which killed adults above the snow line, and a parasite, Schizonotus sieboldi (Ratz.). This beetle could also be controlled by spraying with lead arsenate.

Hutchison, H.P. and H.G.H. Kearns. 1930. The control of Phyllodecta vitellinae L. (Chrysomelidae) a major pest of willows. Long Ashton Agr. & Hort. Res. Sta. Ann. Rep., pp. 112-26.

This serious pest of basket willows was found everywhere in Great Britain where basket willows were grown. At times the damage caused by P. vitellinae resulted in the total loss of the crop.

The adults hibernated in sheltered spots such as under loose bark, in cracks in willow stumps or under debris. Emergence in the spring was synchronized with bud burst and took place from April until the end of May. The adults fed on the willows for a time and then mated. Oviposition lasted from late May until the third week in June. Batches of 10 to 30 eggs were laid on the undersurface of the lower leaves of the rods. A single female usually laid 200 to 300 eggs. The eggs hatched after 7 to 14 days. The larval period lasted 15 to 23 days during which the larvae fed gregariously skeletonizing the leaves. There were three larval instars, each of which had protrusible dorsal glands, but the amount of glandular fluid increased with larval age. Pupation lasted about two weeks and took place just below the surface of the soil. Emergence of the second generation of adults started in the first week of August and continued until the third week. During this period the greatest amount of damage occurred, and the rods could be completely stripped of their foliage. A third generation emerged in October, fed until leaf-drop and then sought out sites for hibernation. The beetles were not observed flying, and their progress in a willow bed from the outskirts towards the centre suggested that their main means of locomotion was walking.

The adults fed on the leaves eating the upper epidermis and the mesophyll, but in years with a late spring ate the unopened buds. This bud-eating as well as a preference for feeding terminally caused basal branching. The larvae began feeding on the lower leaves and moved upward. Each larva consumed 2¼ to 4 cm^2 of foliage during its larval life.

Salix purpurea, S. alba, S. nigricans and S. repens were severely attacked. Salix hybrids such as S. purpurea X viminalis and S. fragilis were subjected to moderate attack. S. viminalis was attacked only slightly by the adults and not at all by the larvae. S. coerula (= S. alba var. caerula), S. triandra and S. americana were not attacked at all. Adults and larvae were found on poplars.

No natural enemies of P. vitellinae have ever been observed. Extensive trials in the laboratory and in the field showed that pyrethrum dust or emulsion would not economically control the adults. Pyrethrum dust was effective in controlling first and second instar larvae but not third instars which were protected by their dorsal glands. The prolonged period of oviposition made more than one application advisable. Lead arsenate, when applied with an effective spreader, was a successful repellent to egg-laying and killed the larvae.

Judd, W.W. 1954. Euura salicis-nodus (Dalla Torre) (Hymenoptera: Tenthredinidae) and its hymenopterous parasites reared from spindle galls of willow. Can. Ent. 86:542-6.

The branches and twigs of Salix interior Rowlee near London, Ontario were infested with spindle-shaped galls. Most of the galls were separate swellings, although occasionally two were so close together as to form a single bilobed swelling. Up to eight galls were found on a single branch. The gall former was identified as the sawfly, Euura salicis-nodus. The name, Euura nodus Walsh, used by Felt in his key to insect galls was invalid.

The female sawflies laid one or two and occasionally three eggs in the twigs of Salix interior. A spindle-shaped gall of one or two chambers developed, and the larvae fed on the wood inside them. The chambers gradually became filled with wood dust and frass. The larvae extended their chambers at one end piercing the wall to form an opening or leaving only a thin membrane. A cocoon was spun wherein the larva overwintered. The following spring pupation took place, and the adults emerged. Some very slender galls had their wood undisturbed and contained no larvae. They were thought to result from failure of the egg to hatch.

A number of hymenopterans were also reared from the spindle galls: Ichneutes sp. (Braconidae), Hoplocryptus sp. (Ichneumonidae), Habrocytus thyridopterigis Howard (Pteromalidae) and Eurytoma sp. (Eurytomidae).

Krämer, K. 1958. Gallmücken als Kätzchen-Schädlinge an Weiden. (Gall midges damaging willow catkins). Anz. Schädlingsk. 31:188.

A West German plantation of Salix smithiana Wild. (= Salix caprea X S. viminalis) suffered a heavy loss of catkin buds in November. Eighty to 90% of all the buds developed prematurely and dried out. Only the occasional bud remained closed as expected at that time of the year and developed normally the following March.

Examination of the damaged buds revealed that an average of six but up to twelve gall midge larvae inhabited these buds. The feeding of the larvae had left the inside of the bud necrotic. Specimens were taken to the laboratory and reared to the adult stage. These were identified as Rhabdophaga heterobia H. Loew., which induces shoot and stem galls on willows. The last generation of the summer oviposited into the catkin buds.

Kusch, D.S. 1967. Notes on the biology of Epinotia criddleana Kft. Can. Dep. for. Bi-mon. Res. Notes 23(1):3.

The tortricid moth, Epinotia criddleana, was common in Ontario, Manitoba, Saskatchewan and Alberta. Its principal host was Populus tremuloides Michx., but it fed occasionally on Salix spp. The species was first described as Proteopteryx criddleana.

In Alberta, where this study was done, there was one generation per year with the adults present in August and September. The eggs were laid from mid-August to mid-September. Six to seven eggs were laid in overlapping rows at the bases of buds on twigs. The eggs overwintered and hatched in the spring before the buds flushed. The young larvae bored into the buds and fed there, stunting or destroying the developing leaves. The third instar larvae fastened two leaves together with silk and fed on the surfaces of the leaves inside this shelter. Some larvae constructd more than one shelter during their developmental period. The mature fourth instar larva became an inactive prepupa for several hours before dropping to the ground to pupate. In the laboratory pupation required about 14 days.

Descriptions of the larvae of E. criddleana were provided to aid in distinguishing them from late instars of Pseudexentera oreganana, which also fed on aspen.

Larsson, S. and A. Wiren. 1982. Leaf-eating insects in an energy forest stand of Salix viminalis L. in central Sweden. Ann. Ent. Fenn. 48:199-25.

The new interest in short rotation forestry for fibre and wood fuel production had prompted Sweden to set up 20 experimental stands of energy forest, mainly Salix spp. No data on the effects of herbivorous insects being available yet, the authors investigated an energy forest stand of Salix viminalis L. established in central Sweden in 1979.

The site was a plantation of 10 ha with subareas of different species of Salix. Sampling was done on five 10 X 5 m plots (1979) and one 25 X 25 m plot (1980) at two week intervals during the growing season.

Relatively few species were found but seasonal succession occurred with only the chrysomelid beetle, Galerucella lineola, present all summer. Populations were higher in 1980 than in 1979. One group of species had a population peak in early June and a second group peaked in late July. When the abundance of leaf-eaters was expressed as number per unit leaf-weight, the distribution changed with levels of all species higher in early summer. Thus the young tissue had a greater risk of being consumed and overall growth could be threatened. Consumption was estimated to be about two and six percent, respectively of all the available biomass of the leaf in 1979 and 1980.

The authors tentatively (in the absence of further study) concluded that the low number of species and their low abundance were mainly a result of the characteristics of the plantation -- stand size, simple spatial structure of young stools and juvenile leaf chemistry.

Lejeune, R.R. and G.T. Silver. 1961. Parasites and hyperparasites of the satin moth, Stilpnotia salicis Linnaeus, (Lymantriidae) in British Columbia. Can. Ent. 93:456-67.

The satin moth, a widely distributed defoliator of poplars and willows in Europe and Asia was introduced to British Columbia and the eastern Maritime Provinces of Canada in the early twentieth century. Several outbreaks in North America prompted the importation of parasites from central Europe. Two braconids, Apanteles solitarius (Ratz.) and Meteorus versicolor (Wesm.); the chalcidoid, Eupteromalus nidulans (Thoms.) and the tachinid, Compsilura concinnata Meig., were introduced in British Columbia and Washington state from 1929 to 1932. Populations of S. salicis appeared to decrease, but more study was thought necessary.

Most adult moths in British Columbia emerged during July. Females soon began laying eggs and continued for about five days. Flat batches of 100 to 200 eggs were laid from early July until late August. The eggs were found on leaves, twigs and trunks of host plants as well as on non-host plants and other objects. The first and second instar larvae skeletonized leaves for two to three weeks before spinning hibernacula in cracks and crevices of trunks. The third instar larva overwintered inside the hibernaculum and emerged at the end of April. Larvae then fed on the leaves until ready to pupate in mid-June. There were seven larval instars.

No egg parasites were recovered on the coast, but a few unidentified specimens were recovered from the Kamloops area. Three native tachinids, Tachinomyia similis Will., Exorista mella Walk. and Achaetoneura frenchii Will. attacked the larvae or pupae of the satin moth and two sarcophagids, Sarcophaga aldrichi Park. and Agria affinis Fall. attacked the pupae. Apanteles solitarius, Meteorus versicolor and Compsilura concinnata became established in most areas of British Columbia. The two braconids appeared to be effective parasites, but may have had their effectiveness restricted by a heavy hyperparasitic load. However, records from 1941 to 1959 showed little change in the level of parasitism. The scarcity of recent outbreaks in coastal British Columbia suggested that populations of the satin moth were being controlled by their parasites.

Maisner, N. 1965. Zur Morphologie und Biologie einiger schädlichen Rüssler an Weide: Lepyrus palustris Scop. (Col. Curculionidae). (A contribution to the morphology and biology of some weevils injurious to willows: Lepyrus palustris Scop. (Col. Curculionidae)). Z. ang. Ent. 56:239-54.

The annual appearance of large numbers of Lepyrus palustris in the experimental garden at Tulln in Austria provided an opportunity for study. The study was conducted both in the laboratory and the field from 1958 to 1964.

L. palustris was found mainly in southern, central and eastern Europe as well as parts of the U.S.A. In Austria it was found mainly in willow plantations. Salix rigida Mühl., S. viminalis L., S. pentandra L. and S. alba L. have been recorded as hosts by other authors. This study found S. smithiana Willd. (= S. caprea X S. viminalis), S. viminalis L. and S. hippophaefolia Thuill. (= S. triandra X S. viminalis) to be the most heavily attacked species. S. purpurea L. and its varieties, S. amplexicaulis Bory & Ch., S. helix L. (= S. purpurea X S. viminalis) and S. Baltica Lkschw. were also attacked but to a lesser degree, as L. palustris preferred willows with fleshier leaves. The adults also fed on the leaves but never the shoots of poplars, and attacks on poplars were never heavy.

The morphology of the egg, larva and pupa was given, but for the morphology of the adult the reader was referred to two earlier descriptions.

The life cycle required one year to complete. The new adults emerged from late July to September with a peak in August. These adults did not copulate or oviposit but fed on the leaves of willows until October-November. They overwintered in the ground either in the leaf litter or a few centimetres below the surface of the soil. Activity was resumed in the spring as soon as the willow buds opened about mid-March to early April. The adults fed on the buds and by mid-April began mating. Mating took place on the host plant when the temperature was above 10°C. Oviposition followed shortly afterward and continued for an extended period, from April to June and sometimes even into July. Bouts of egg-laying were interspersed with periods of regeneration. Oviposition took place at dusk and not always in the immediate vicinity of a host. The femal dug a hole about 1 cm deep with her snout, laid one egg into the hole and covered it with frass and soil. Feeding continued in the summer on the mature leaves and the young shoots. After reproducing the older beetles began to die.

The egg stage lasted from 8 to 18 days in the field; its length varied with the weather. The newly hatched larvae fed on the trunk and larger roots of smooth-barked cuttings. Feeding continued from June to August, and then the larvae were found in chambers about 13 to 20 cm deep in the soil. Pupation took place in these chambers, and in July the new generation of adults began emerging from them. There was some overlap in the old and new generations of adults during the summer.

Temperature trials were conducted in the laboratory and the results presented. Information on rearing these beetles was also given.

The feeding of the adults on the buds was most damaging to younger plants that had their growth reduced as a result. L. palustris could cause damage in basket willows by feeding on the young shoots. The damaged shoots often died and broke off resulting in the development of two to four lateral shoots. The larval feeding on roots was serious in newly rooted cuttings often causing their death, but negligible in older plants.

Of all the eggs laid very few completed the life cycle. All stages were preyed on by mice, predatory insects and fungal infections. Long periods of drought killed the eggs, and too much rainfall killed the larvae.

Martin, J.L. 1956. The bionomics of the aspen blotchminer, Lithocolletis salicifoliella Cham. (Lepidoptera: Gracillariidae). Can. Ent. 88:156-68.

The aspen blotchminer was abundant on trembling aspen, Populus tremuloides Michx., in central Canada. It mined the underside of leaves and was responsible for premature browning of the foliage when populations were very high. Its distribution was thought to be general throughout temperate North America wherever the host plants were found. Recorded host plants were Salix alba L., S. babylonica L., S. interior Rowlee, Populus tremuloides Michx., P. grandidentata Michx. and P. balsamifera L. In Ontario P. tremuloides was favoured.

The leafminer was impossible to rear in the laboratory, and all observations were made on field-collected material. There was one generation per year. Oviposition took place on the underside of leaves from mid-May to mid-June. There were five larval instars from mid-June to early August. The early instars fed only on the spongy parenchyma, and the last instar devoured the palisade layer as well. The mine was initially circular but later became oblong with a fold or bulge in the lower surface. The morphology of each instar and its corresponding mine was described. Pupation occurred within a cocoon inside the mine. Adults emerged in late summer via an exit made by the pupa. The adults overwintered and hibernation was thought to take place under the bark scales of coniferous trees. The adults became active in spring shortly after the aspen leaves had unfolded. They were active mornings, evenings and nights when the temperature was above 40°F.

Natural controls were larval competition and parasitism. When two or more larval mines coalesced, one larva would attack and kill the others. Parasites, all Hymenoptera, were first observed in June. They caused light mortality in the second instar, and the level of mortality increased steadily with larval age. One thousand four hundred and seventy-nine (1479) eggs were marked, and their development was monitored. Only 0.5% reached the adult stage. Larval competition accounted for 53% of the mortality and parasitism for 36%.

The insect showed a preference for young trees under four inches d.b.h., growing in partial shade, open or fringe situations on flat terrain. It was not expected to cause serious injury to other than reproduction or polewood stands.

Matheson, R. 1917. The poplar and willow borer (*Cryptorhynchus lapathi* Linnaeus). Cornell Agr. Exp. Sta. Bull. 388. 30 pp.

This species of curculionid or snout beetle had been known in Europe as a pest of alders and willows for centuries. When abundant it caused extensive damage especially to young trees.

A description of the morphology of all the stages of the life cycle was given. The adults appeared in late July, were abundant in August and were present until October. They were found to be generally inactive and were not observed to fly. Immediately after emerging the adults fed voraciously on the tender young shoots, puncturing the bark with their beaks and eating the cambium. One year-old shoots were sometimes riddled to such an extent that they died. After about ten days of feeding, the adults mated and the females began laying their eggs. The females formed deep holes with their beaks in corky parts of wood at least two years old. One to four eggs were deposited in the hole and then covered with fine pieces of wood. After 18 to 25 days the eggs hatched, and the new larvae fed on the plant tissues adjacent to the egg chambers eventually reaching the cambium. Feeding continued until cold weather and then recommenced in the spring. The direction of feeding was usually around the limb and girdling often occurred. In mid-June the fully grown larvae burrowed upwards into the hard wood and formed a pupation chamber there. The pupal stage required 10 to 18 days to complete. It was not determined what proportion of the population overwintered as adults.

In Germany the beetles were reported to have a two year life cycle in which the adults overwintered, and mating and oviposition took place in the spring. In Scotland a one year life cycle but again with the adults overwintering was reported.

The only controls used to date have been the destruction of infested trees and the use of arsenicals in the summer to kill adults. The results of control trials using Scalecide, Carbolineum, kerosene emulsion and creosote were reported.

McCall, C.D., F.A. Titus and A.H. Rose. 1972. A willow shoot-boring sawfly, *Euura atra* (Jurine). Bi-mon. Res. Notes, Can. For. Serv. 28 (2,3):8.

The larvae of the sawfly, *Euura atra*, fed within new shoots of willows causing partial or complete shoot mortality. In Ontario the weeping willow, *Salix babylonica* L., was attacked and in the Maritimes *S. fragilis* L. and *S. alba* var. *vitellina* L. Elsewhere *S. repens* L., *S. viminalis* L. and *S. purpurea* L. have been reported as hosts.

The species was univoltine. In New Brunswick adults emerged and mated in late May-early June. The females laid their eggs in new shoots. The young larvae fed in the pith of the shoots forming galleries 8 to 20 mm long. A shoot could contain up to three separate galleries. There were at least five larval instars. When mature the larva cut a hole in the bark and plugged it with frass and webbing. It then spun a cocoon, inside which it overwintered as a prepupa. Pupation took place early in the following spring.

In the Maritimes *Tetrastichus* sp., a trichogrammatid and two species of *Eurytoma* were reared from infested shoots. In Ontario *Tetrastichus* sp. and the *Eurytoma studiosa* complex were found.

McDaniel, E.I. 1938. Some woodborers attacking the trunks and limbs of deciduous trees and shrubs. Michigan Agr. Exp. Sta. Spec. Bull. No. 238.

Saperda calcarata, the Poplar Borer (Cerambycidae).

The poplar borer inhabited various species of poplar and willow and was generally distributed throughout North America wherever its hosts grew. It preferred sick, weak or previously infested trees, and activity was confined to certain individuals known as "brood trees". Infested trees could be identified by excelsior-like shreds of wood and frass which were pushed out of the tunnels by the larvae and collected at the base of the trees and sometimes by sap flowing from the openings of the tunnels.

The larvae were usually found in the trunk and larger limbs in the middle third of the tree. They initially fed in the outer bark, then in the cambium and finally in the wood itself where they made large winding tunnels. The tunnelled trees were weakened and might break in a high wind. The boring usually did not kill the tree directly, but a borer attack was usually followed by other insects and fungi, which might cause its death.

Two to three years were required to complete the life cycle, and broods overlapped in local infestations. The poplar borer overwintered as a larva and pupated late in the spring. The adults were present from July to September. Shortly after emerging the adults sought out injured areas in the bark where the eggs were laid. The eggs hatched and within a few days the larvae made their way into the outer bark where they began feeding.

The destruction of the "brood trees" before the adults emerged usually checked an infestation. When a "brood tree" was cut and split for firewood it was possible to stack it to dry rapidly so that the larvae could not complete their development. Infested trees also could be treated by applying paradichlorobenzene and cottonseed oil to the injured area during the dormant period.

Plectrodera scalator, the Cottonwood Borer (Cerambycidae)

This large black and white long-horned beetle was particularly destructive to cottonwoods, poplars and willows. It was usually not sufficiently abundant in Michigan to cause economic loss.

The larvae usually attacked the tree at the base or below ground level frequently girdling it. Trees of all ages were attacked. Its life cycle was similar to that of the poplar borer with the females laying their eggs in August and September.

The bases of trees could be protected with screen barriers, and enfested trees could be treated with paradichlorobenzene and cottonseed oil during the dormant period.

Cryptorhynchus lapathi, the Mottled Willow Borer (Curculionidae)

The mottled willow borer attacked willows, poplars, alder, dwarf birch and red birch older than one year. Attacked trees were characterized by irregular galls or swellings on their branches and trunks. Young trees were killed outright or were deformed. Older trees were weakened and could break during storms. The damage was always more severe when many trees were closely spaced. Nurseries, plantations and windbreaks were at great risk.

The female beetle used her mouthparts to make an opening in the bark for the eggs. When the larvae hatched from the eggs, they fed on the inner bark and the cambium. Later a pupal tunnel was made in the wood proper. The larvae sometimes girdled branches. The bark over the tunnels might crack and expose the wood below.

The beetles had one annual generation. The partially developed larvae overwintered under the bark. In the spring they resumed feeding, and by late June most of the brood were pupating. Pupation was completed in three to four weeks, and adults were abundant in late July. The adults fed for seven to ten days on the cambium of tender young shoots and then returned to the older wood to lay eggs. Egg-laying continued until well into October. Adults have not been observed to overwinter in Michigan.

The beetle could be controlled by cutting and burning infested limbs and trees before the adults emerged. Planting poplars and willows near old plantations or near trees growing along riverbanks was not recommended. Paradichlorobenzene and cottonseed oil could be painted over the openings in the trees to kill both the larvae and the adults.

Miles, M. and H.W. Miles. 1934. Studies of the willow-shoot moth, Depressaria conterminella, Zell. Bull. ent. Res. 25:47-53.

The willow-shoot moth was found to be causing economically significant damage in commercial willow beds. This study of the moth's biology was conducted at Mawdesley, Lancashire to aid in the development of control measures.

The presence of D. conterminella larvae in willow shoots was marked by leaves spun together around the terminal bud. The larvae caused the damage in spring and early summer by feeding in the tips of the willow rods and eating out the terminal bud. The destruction of the terminal bud prevented the rods from reaching their full length and caused the development of lateral shoots resulting in the condition known as "bushy top". The moths preferred Salix viminalis although occasionally S. purpurea was attacked.

A description of the adult moths was provided. The adults were on the wing in June and July. In captivity they lived eight to twelve days and spent the daytime on the soil surface or willow shoots. No mating or oviposition was observed.

The egg was also described. Eggs were found in bark crevices on the base of willow stocks. They were laid from June to July and hatched the following April when the willow buds were opening. The newly hatched larvae were very active and wandered in search of food. In the laboratory, when a larvae exhausted the food supply in one shoot, it moved on to another. A single larva destroyed three to four shoots during the course of its development. A description of the four larval instars was given. The pupa was also described. Pupation took place in silken cocoons below the soil over a three to four week period.

Other insects were found damaging the tips of willow rods, although D. conterminella was the only one present in numbers large enough to be economically important. Depressaria ocellana F. destroyed the tips of S. purpurea. It reached maturity two to three months later than D. conterminella. Anacampsis populella Cl., Compsolechia temerella Zell. and Gelechia sororculella Hübn. were found in tips of dwarf sallows while Cheimatobia brumata L. and Orthosia lota Cl. were on S. viminalis. Pandemis corylana F., P. heparana Schiff., P. cinnamomeana Tr., Peronea hastiana L., Argyroploce micana Frol., Cnephasia pascuana and C. chrysanthemana Dup. were tortricid moths found on willow shoots.

Three control measures were tested. Sprays of paraffin emulsion and 7% tar distillate applied during the winter to destroy the eggs were not successful. Willow stocks were burned in the winter also to destroy the eggs. The growth of treated stocks was delayed by about one week but the stocks were almost completely free of D. conterminella. Delaying the harvesting of the rods until spring also reduced infestation significantly, because the young larvae were either removed with the crop or starved before the basal shoots developed.

Mittler, T.E. 1957. Studies on the feeding and nutrition of Tuberolachnus salignus (Gmelin) (Homoptera, Aphididae). II. The nitrogen and sugar composition of the ingested phloem sap and excreted honeydew. J. exp. Biol. 35:74-84.

This study examined the chemical relationship between the insect's food and excreta by comparing the nitrogen and sugar composition of the sap ingested with that of the honeydew excreted. The aphids used in this study were reared on Salix acutifolia Willd.

The nitrogenous matter ingested by Tuberolachnus salignus was in the form of amino acids and amides. The same amino acids and amides were excreted in smaller amounts. The number and concentration of the amino acids and amides in the sap and the honeydew fluctuated with the seasonal development of the host plant. Sucrose was the only sugar normally ingested, but the honeydew contained fructose, glucose and meletizose.

A single T. salignus that ingested 10 to 40 ml per day of phloem sap having a sugar concentration of 10% imposed a sucrose drain of 1 to 4 mg per day on its host plant. Given the approximate rate of photosynthesis per unit area of leaf over an average day of ten hours, a single T. salignus ingested the photosynthetic product of 5 to 20 cm^2 of leaf per day.

Morris, R.C. 1984. The poplar and willow borer, Cryptorhynchus lapathi (L.) (Coleoptera: Curculionidae), an introduced pest in Canada and the United States. 17th Session of the International Poplar Commission, Ottawa, 1984.

The poplar and willow borer was native to Europe and Asia and was introduced to North America in 1882. It has now spread across southern Canada and the northern United States.

The beetle favoured poplars, willows and alders as host-trees but also attacked Betula spp. in North America. In Ontario it was found on Populus balsamifera, P. tremuloides and Salix spp.

No dollar value has been put on the damage caused by this insect, but the wood of the trees was destroyed and nurseries lost large amounts of cutting material. Attacks started at the base of young trees and moved higher as the trees aged. The larval feeding could girdle trees and riddled the wood with tunnels often causing breakage. Older trees were weakened and might become infested with pathogenic bacteria.

The adult beetles emerged in August and fed on sap and inner bark by chewing small holes into host trees at lenticels and scars. Ten days after emergence mating took place. The female then chewed a small hole or slit into the bark, inserted one or two eggs under the edge of the bark and covered the hole with pieces of wood. The eggs hatched in August, and the larvae fed in the cambium and inner bark until cold weather. Feeding was resumed in May. In June the larvae bored into the wood forming a vertical tunnel about 50 mm long. A pupal cell was prepared at the upper end of the tunnel which was packed with shredded wood.

After pupation the new adults emerged in August. There was one complete generation per year but the author also reported that the beetles could live up to three years.

This insect had no native enemies in North America. In Europe and Asia it was fed on by parasitic wasps, predatory insects and woodpeckers. Chemical controls have been extensively tested in Spain and Italy. Spraying in April-May controlled the larvae in the bark and in July-August killed the emerging adults. The author treated wild poplars with lindane and chlordane and killed the adults in their tunnels before emergence. These treated trees remained uninfested the following year. Applications of lindane and chlordane in May killed the overwintering larvae in their tunnels.

The results of clonal susceptibility surveys conducted on 169 poplar clones in Ontario were reported.

Niklas, O.F. 1955. Untersuchungen zur Ökologie der Weidengallen-Blattwespen *Nematus* (*Pontania*) *proximus* Lepeletier und *N. vesicator* Bremi. (A study of the ecology of the willow gall sawflies, *Nematus* (*Pontania*) *proximus* and *N. vesicator* Bremi.) Beitr. Ent. 5:129-52.

This study conducted near Hamburg in northern Germany began by looking at the biology and ecology of *Nematus proximus* and *N. vesicator*, but soon encompassed the interactions between the gall formers and their hosts. *N. proximus* galled the leaves of *Salix fragilis* L. heavily and those of *S. amygdalina* L. (= *S. triandra* L.) lightly. Galls of *N. vesicator* were found only on *S. purpurea* L.

N. proximus overwintered in cocoons in the soil and leaf litter. Emergence and mating took place in early May. Eggs were laid into the unfolding leaves. The gall grew in conjunction with the leaf, and all five instars of larvae fed on the tissue of the gall. The third to fifth instars removed the frass from the gall via a hole, which they had chewed through the wall of the gall. The mature larvae left the gall and pupated in the ground. The adults emerged in July-August and laid the eggs of the second generation. The second generation began pupating from late September until all the leaves had fallen and overwintered as pupae. There was considerable overlap of the two generations. The mature gall was bean-shaped and protruded from both sides of the leaf. A single leaf could have up to 22 galls. A number of hymenopteran parasites and the inquiline, *Balanobius salicivorus* Payk. (Coleoptera: Curculionidae), were found inside the galls. The degree of parasitization was found to be low, but the number of *N. proximus* larvae indirectly killed by *B. salicivorus* could not be determined. Oviposition by *B. salicivorus* was responsible for the deformity of many *N. proximus* galls.

when oviposition by B. salicivorus took place early in the development of the gall, the deformity was even greater.

Emergence and oviposition of N. vesicator took place slightly later than that of N. proximus. The development of the gall kept pace with the growth of the leaf and the six instars fed on the gall tissue without removing their frass from the gall. Pupation took place in the ground in large cocoons. There were two poorly separated generations. The mature gall was large, thin-walled and balloon-shaped. Occasionally it was a flat structure. No more than five galls per leaf were found but one to three was usual. N. vesicator galls were never parasitized, but mature larvae were preyed on by titmice, Parus sp. A single B. salicivorus was usually found inside the flat galls, but never associated with either eggs or larvae of N. vesicator. The beetles were not thought to be responsible for the undeveloped state of the gall.

The largest galls were found on S. amygdalina and the most dense accumulations of galls were on S. fragilis. In general the more dense the galls were, the smaller they were. The time required for the N. proximus larvae to complete their development differed by up to eight weeks between populations from different trees and that of N. vesicator larvae by up to four weeks. These differences were not a result of the time of oviposition nor of microclimatological differences between the trees, but must have been caused by physiological differences between the trees. A comparison of the growth of galled and ungalled leaves also showed great differences in the reactions of individual trees of the same species to galling. These differences were thought likewise to originate from physiological differences between the trees.

Nord, J.C., D.G. Grimble and F.B. Knight. 1972. Biology of Saperda inornata (Coleoptera: Cerambycidae) in trembling aspen, Populus tremuloides. Ann. ent. Soc. Am. 65:127-135.

Saperda inornata Say has been known under various names - Saperda concolor LeConte, S. concolor unicolor Felt & Joutel, and S. moesta LeConte. The authors believed that S. inornata should prevail because of priority. The larvae of this beetle inhabited the stems and twigs of several species of Populus and Salix, and the female beetles induced a gall on the stems during oviposition. S. inornata was found in eastern North America from Minnesota, southern Ontario and southern Quebec to southern Illinois and southern Pennsylvania and in the west from northern Manitoba and Saskatchewan to southern Colorado.

The results of earlier studies on S. inornata were reported extensively before the results of this study conducted in Michigan and

Wisconsin were reported. The adult beetles emerged from late May until early July and fed on the margins of leaves or the bark of tender shoots and twigs. Oviposition took place from mid-June until late August. The female gnawed a horseshoe-shaped furrow in the outer bark and deposited one egg between the bark and the wood. Two to three egg niches on one to five year old stems were usual. Within a few days the cambial tissue around the egg turned brown and died. The eggs hatched after 14 to 15 days, and the larvae first fed in the xylem. Later they bored a horizontal peripheral tunnel just under the bark. Callus tissue developed around the injuries forming the gall. Toward the end of the first summer the larvae tunnelled into the centre of the gall and then up or down the long axis of the stem for an average distance of 23 mm. Larvae pupated in the central tunnel from mid-May to late June. Larvae from eggs laid early in the season matured after one summer and emerged the following spring. The rest of the larvae required two summers to complete their development.

The economic effects of infestation by S. inornata were usually negligible. In large trees only a few twigs were attacked, and these rarely died unless infected with Hypoxylon pruinatum. Test plantings in Wisconsin were subjected to heavy infestations causing stunting and occasional top mortality. Control was achieved with sprays of lindane or malathion in the second or third week of June or by the application of a hormone solution, which stimulated the callus to form rapidly and overgrow the eggs and larvae.

Oliver, A.D. 1964. A behavioral study of two races of the fall webworm, Hyphantria cunea, (Lepidoptera: Arctiidae) in Louisiana. Ann. ent. Soc. Am. 57:192-4.

The two distinct forms of the fall webworm have sometimes been described as two separate species, Hyphantria cunea (Drury) and H. textor (Harris). The race with orange heads and orange tubercles was called the "orange race" and that with black heads and tubercles the "black race". Adults and larvae of both races in Louisiana showed much phenotypic variation.

The "black race" had a greater range of host plants. Willow, Salix nigra, was in third place on the list of preferred hosts with 11% of the total nests. The "orange race" had a total of ten host plants, but 83% of the nests were found on pecan. It was not found on willow at all. Host preference changed during the season over the several annual generations of both races. The number of nests found on willow decreased each generation. This may have been caused by weather, changes in foliage or wider distribution of moths after the first generation.

The first "black race" adults appeared in mid-March and there were four annual generations. The adults of the "orange race" did not appear until mid-April and there were only three generations. The developmental time for the larvae in the laboratory on sweetgum was the same, 50 ± 4 days. The two races differed in patterns of oviposition, construction of the nest and larval behaviour.

Adults of the two races mated readily in cages and produced viable F_1 and F_2 progeny. There was no evidence of crossing between the two races in the field, but, because the progeny resemble their mother phenotypically, crossing might not be detected.

Phillips, J.H.H. 1962. Description of the immature stages of *Pulvinaria vitis* (L.) and *P. innumerabilis* (Rathvon) (Homoptera: Coccoidea), with notes on the habits of these species in Ontario, Canada. Can. Ent. 94:497-502.

The purpose of this study was to identify and describe pests in the peach-growing areas of southern Ontario. The scale insects used in the study were reared on willow cuttings in the laboratory.

Pulvinaria vitis (L.)

The morphology of the egg, the three instars of the nymph, the adult and the ovisac was described. The species was wholly parthenogenetic and there was one generation per year in Ontario. The partly grown adult females overwintered on the bark of branches and twigs. Oviposition started in the second or third week of May. The eggs hatched after 25 to 30 days and the new nymphs moved to the leaves and bark of young twigs where they settled. The first moult took place 12 to 18 days, the second 28 to 36 days and the third 56 to 93 days after hatching.

A number of hosts have been recorded for this insect. In the insectary several species of *Salix* and *Populus* were readily colonized.

Pulvinaria innumerabilis (Rathvon)

The morphology of the egg, the first instar nymph, the male and female second instars, the adults and the ovisac was described. In contrast to *P. vitis*, this species molted only twice. There was one generation per year. The females overwintered on the bark of young twigs and branches. They grew rapidly in the spring and started laying eggs in early June. The eggs hatched seven to ten days later than those of *P. vitis*, and the nymphs settled mainly on the leaves. Males emerged in early September, and mating took place immediately. The eggs of unfertilized females developed only into males.

In Ontario severe infestations could occur on Acer saccharum and Acer negundo. P. innumerabilis had many other hosts including Salix spp.

The two species could be distinguished in the field by differences in life-history, colour of eggs, nymphs and host preference.

Prentice, R.M. 1955. The life history and some aspects of the ecology of the large aspen tortrix, Choristoneura conflictana (Wlkr.) (N. Comb.) (Lepidoptera: Tortricidae) Can. Ent. 87:461-73.

This study was undertaken as a result of periodic outbreaks in the prairies which severely defoliated trembling aspen. The large aspen tortrix had been in a number of other tortricid genera, Tortrix, Heterognomon, Cacoecia and Archips, before Freeman transferred it to Choristoneura. In Canada it was found from Newfoundland to British Columbia. Its range extended as far north and south as did the range of its preferred host, Populus tremuloides. The larvae fed on a number of other trees including Salix spp. when they occurred in outbreak areas.

A description of the morphology of each of the stages of the life cycle was given. Also presented were the head capsule measurements of the five instars and descriptions of the male and female genitalia.

The eggs were laid from mid-June to early July in flat clusters of 60 to 450 on the upper surfaces of leaves. There was a larval migratory phase immediately after hatching in July when the larvae were very active and often hung on spun threads. The first instar larvae webbed the flat surfaces of leaves together and four or five fed gregariously within on the epidermis. In late August the larvae congregated at the base of trees where they spun small hibernacula in bark crevices or under moss. The second instars overwintered in the hibernacula and emerged in May several days before the buds broke. There was a second migratory phase at this time. In the event of unfavourable weather secondary hibernacula were spun at the base of branches. The larvae mined the buds shortly after they began to swell. Mined buds failed to develop. The third to fifth instars fed inside rolled leaves, consuming all parts of the leaves and causing the severest defoliation. Pupation took place within the same rolled leaves in June. The adult moths emerged 12 to 14 days later.

Experimental sampling of the larvae was conducted in the spring to determine its usefulness for predictions of defoliation. Significant differences between trees and crown levels and interactions between trees and crown levels were found and must be considered in any sampling programs. No directional differences in the distribution of larvae were found.

The large aspen tortrix caterpillars were attacked by seven parasites and the pupae by two. Many of these were also parasites of such common forest insects as the spruce budworm, the jack-pine budworm, the ugly nest tortrix and the oblique banded leaf-roller.

A number of dead and diseased larvae were found but no viral disease was isolated from the specimens. A fungus, Beauveria bassiana (Bals.) killed larvae in their hibernacula.

The small caterpillars were preyed on by two species of ant and by downy woodpeckers and red-eyed vireos.

Price, P.W. and T.P. Craig. 1984. Life history, phenology and survivorship of a stem-galling sawfly, Euura lasiolepis (Hymenoptera: Tenthredinidae), on the arroyo willow, Salix lasiolepis, in northern Arizona. Ann. ent. Soc. Am. 77:712-9.

Euura lasiolepis Smith was the only stem-galler of Salix lasiolepis Bentham and had not been recorded on any other willow. In California it was found from Monterey County north to Mendocino County and from the coast west to the Sierra Nevada. A black phase was found on the coast and an orange phase in the Central Valley. The latter phase was studied near Flagstaff in northern Arizona. At the study site S. lasiolepis grew as a 2-3 m high, coppiced shrub along a small spring-fed stream.

The adults emerged from late May to the end of June. The lifespan of the adults was a brief three to eight days. The female attracted the male by a pheromone, mated with him and almost at once began laying eggs. The ovipositor was inserted through the petiole into the stem leaving the egg just below the axial bud primordium. Sometimes two and even three eggs per gall were found. The galls grew rapidly in June and were three-quarters of their maximum size when the eggs hatched. The larvae fed on the parenchyma tissue of the gall and were fourth instars when the galls were fully grown at the end of August. The fifth instar did not feed but rasped at the gall tissue to prevent the continuously expanding parenchyma from crushing it. In October-November an exit burrow to a point just below the bark was made and a cocoon was spun. The mature larva overwintered inside the cocoon and pupated next spring.

Thirty-nine per cent of the cohort's mortality occurred in the egg stage. Failure of the gall to develop accounted for 17% of these and and failure of the egg to hatch for 22%. Nineteen per cent of the mortality was in the larval stage. Unknown factors killed two percent of these, the parasitoid, Pteromalus sp. (Habrocytus), killed two percent; the inquiline, Batrachedra striolata Zeller, killed four percent; predation by mountain chickadees, Parus gambelis (Ridgeway), killed four percent and the parasitoid, Lathostizus euurae (Ashmead) killed ten percent. Ants preyed on emerging adults, and grasshoppers fed on galls killing the inhabitants, but not in the cohort being studied. The 42% survivorship of E. lasiolepis was relatively high for an insect species. The low diversity of enemy species compared to other gall-forming sawflies may have been a product of isolation.

Randall, W.K. 1971. Willow clones differ in susceptibility to cottonwood leaf beetle. Proc. 11th Conf. Southern Forest Tree Improvement, pp. 108-11.

The larvae of the cottonwood leaf beetle, Chrysomela scripta F., defoliated poplars and willows, but willow clones showed variable resistance to defoliation by this insect. Three clones of Salix interior Rowlee, two clones of S. babylonica L. X S. alba L., one clone of Salix X argentinensis and 37 clones of S. nigra Marsh. were tested for their resistance.

The overall average defoliation was 63%. S. interior and S. babylonica X S. alba, both under 10%, had the least damage and S. X argentinensis with 52% defoliation had considerably more damage. Defoliation of the clones of S. nigra ranged from 21 to 95%. The heritability for resistance to defoliation was $h^2 = 0.95$. Certain clones may have been more resistant because they had physiological or morphological characteristics that made them unsuitable for larval development or unappealing to the ovipositing female.

Trees that were lightly attacked in the fall of 1970 were lightly attacked again in the spring of 1971. The crowns of heavily attacked clones began dying back in the fall and winter, and in the spring these clones were dead or dying.

Reeks, W.A. and C.C. Smith. 1956. The satin moth, Stilpnotia salicis (L.), in the Maritime provinces and observations on its control by parasites and spraying. Can. Ent. 88:565-79.

The satin moth, a pest of shade trees, had been present in the Maritimes for about 25 years and was now found in the more populated areas where poplars were favoured as shade trees. It was originally a native of Europe and western Asia.

The caterpillars were restricted to poplars and willows but were usually found on poplars, willows being relatively scarce after the willow blight of the 1930s. The caterpillars defoliated their host trees. The trees refoliated after being stripped, but the leaves of the second crop were smaller and lighter. Repeated stripping over several years caused little mortality of the trees but considerable mortality of branches.

The development of Stilpnotia salicis was affected by climate, and development in Newfoundland was somewhat later. Oviposition took place from mid-July to mid-August. Masses of 200 or more eggs were laid on tree trunks, posts, buildings and other objects. The incubation period was about 14 days, and hatching peaked in the first week of August. The larvae fed on the leaves skeletonizing them until September, when they made hibernacula on the bark. The third instar overwintered inside the hibernaculum until May, when it emerged and recommenced feeding. Now the entire leaf except for the main veins was consumed. Some of the larvae had seven instars and others had eight. Pupation started at the beginning of July. From July 10 until August 10 the new generation of adults emerged.

The overwintering larvae suffered very high mortality especially when the minimum temperature dropped below -30°F. Larvae also died when they were dispersed by wind to unsuitable hosts. Parasitism by two native Diptera and Ichneumonidae were negligible. Three of four introduced parasites were recovered and the tachinid, Compsilura concinnata Mg. and the braconid, Apanteles solitarius (Ratz.), showed high rates of parasitism in some areas. Chemical control with lead arsenate or DDT could be effected in the spring on the older larvae or in the summer as the newly hatched larvae crawled up to the foliage. In the latter case less effort was needed, but timing was more important.

Richter, D. 1959. Über Insektenschäden in Korbweidenhegern und ihre Beurteilung. (On the damage caused by insects in basket willow plantations and its evaluation). Arch. Forstw. 8:1057-77.

One of the goals of the state forestry industry in the German Democratic Republic was to increase the production of the raw material for the basketry industry. Yields could be increased by decreasing the damage caused by insects. Up to this time there had been few objective assessments of damage in the field. The problem of field evaluations was complicated by the simultaneous or successive feeding of several pests and the difficulty of obtaining homogeneous samples of host plants. This paper intended to show the qualitative and quantitative reductions of yield caused by a few selected pests.

Cryptorhynchus lapathi L.

This weevil had a two year life cycle and caused damage in both the adult and larval stages. The adult fed on the young shoots causing weakening, staining, branching and deformities. Feeding early in the season delayed growth of the shoot for the entire season and, because of the longer maturation period, increased the risk of frost-damage in the fall. Attack by C. lapathi reduced the lengths of usable rods by 30% compared to unattacked control rods. Feeding later in the season caused less quantitative but more qualitative damage.

The tunnelling of the larvae in the shoots caused immediate physiological damage to the shoots and long-term damage by providing an entrance for moulds, bacteria, etc. A correlation between the surface area of the root stock and the volume of rods produced was positive allowing comparison of attacked rods with control rods. Stocks that had been damaged once without a second attack produced more rods but shorter ones than did the control stocks. Stocks that had been attacked for the first time produced half of the volume of rods of the controls. Stocks that had undergone repeated attack produced only one-third of the volume of the controls. By eating out the new buds the newly hatched larvae caused a greater reduction in volume than the more obvious damage of the older larvae.

Earias chlorana L.

This lepidopteran had two generations per year and in favourable years even three. The generations overlapped so that all stages were always present in the field. The caterpillars used silk to fasten together the terminal leaves of a willow shoot. They ate the tips of the leaves and then the apical meristem. Two-fifths of the larvae required more than one shelter to complete their development. The feeding caused branching and reduced the shoot length, but the diameter of the shoots was increased. Although Salix viminalis was the usual host plant, the species fared equally well on S. amygdalina (= S. triandra L.) after being transferred there. However, an attack by E. chlorana reduced the lengths of rods three times more on S. viminalis than on S. amygdalina. S. viminalis also suffered greater branching from an attack. Because an attack increased the diameter of a rod, comparing the lengths of attacked and control rods of the same diameter actually obscured the reduced length of the attacked shoots. Attacked shoots had greater diameters because the compensatory branching required more vascular tissues to supply them. Because compensation was only possible at cost to the potential of the whole stock, E. chlorana had an effect on the total harvest above and beyond that of the rods actually attacked.

A comparison of the damage caused by the first generation with that of the second showed that the first was more dangerous. Younger rods branched more easily so that an attack in June reduced yield by 30% while an attack in August only 10%. It would be more cost-effective to undertake control measures against the first generation.

Rhabdophaga terminalis H. Lw.

The damage caused by gall midges was often attributed to other pests because of their smallness and cryptic lifestyle. This and their difficult taxonomy has caused them to be overlooked in most German studies.

There were three to five generations per year on Salix acutifolia depending on the weather. The larva induced a gall on the terminal bud of a shoot and in the process ate the apical meristem of that shoot. The rod reacted by branching and stopping its elongation.

To assess midge damage a simple comparison of the usable lengths of attacked and control shoots was not adequate. The midges preferred rods with a diameter greater than 4 mm for oviposition. Three-quarters of the rods greater than 4 mm were attacked and only one-third of those less than 4 mm. The rods less than 4 mm had their length reduced by an average of 10 cm. The rods greater than 4 mm had theirs reduced by an average of 40 cm even when usable lengths of any branches were included. When the two classes were mixed and compared to the controls, there was no significant difference in the lengths of the two groups.

Schizotetranychus schizopus Zacher

This mite was one of the most serious pests on Salix amygdalina. The first sign of mite damage was yellowing of the leaves. Eventually the entire leaf became yellow, dried out and usually abscised early. The bark on attacked shoots dried out, forming cracks and ripples reducing their quality. Mites caused a 40% reduction in length of shoots in the year of attack. Furthermore, the early loss of the leaves lowered the accumulation of assimilates necessary for the next season's growth. Plants that suffered attack by mites in one year were more likely to be attacked by other pests, such as aphids, cicadas and weevils, in the following years.

Smerinthus ocellata L. and Dicranura vinula L.

These two lepidopterans were present in almost every willow plantation. Their periods of feeding and the type of damage, which they caused, were similar, and so they were assessed together.

The larvae were astoundingly voracious. A large caterpillar could completely defoliate a rod in two days. However, there was no significant difference between the attacked rods and the control rods, because the heaviest feeding took place just before pupation in late summer-early fall when the rods had almost completed their growth. Furthermore, the rods remained alive despite defoliation and carried on a limited photosynthesis via small axillary shoots, the petioles and the bark.

Aphidula farinosa Gmel.

Salix viminalis and other species often had large colonies of these aphids on their shoot tips. Attacks in May reduced the growth of the affected rod, but other rods compensated by increasing their growth. An epidemic of aphids was usually accompanied by high populations of predacious coccinellids, anthocorids and syrphid larvae and the effect of these predators had to be taken into account. Rods with aphids and predators had a very small reduction in their length. Rods with aphids and no predators showed a serious reduction in growth and increased development of the axillary shoots. The quality of attacked rods was poorer because they were less flexible and broke easily.

Ritchie, W. 1920. The structure, bionomics and economic importance of Saperda carcharias Linn., "the large poplar longhorn." Ann. appl. Biol. 7:299-343.

The author conducted this study of S. carcharias in Aboyne, Aberdeenshire in Scotland where the species was locally abundant on natural stands of poplar.

A minutely detailed description of the male and female adult, the egg, the larva, the pupa and the male and female reproductive organs was given.

The adult beetles fed on the leaves of host trees, biting a hole in the centre of a leaf and then enlarging it so that the entire centre of the leaf may be eaten away. Both sexes were observed flying but the males flew more readily and easily. Males outnumbered females. Pairing occurred on twigs and small branches of hosts during the daytime.

Females oviposited into the stems of healthy trees near their base. The female gnawed a notch about 2.25 mm deep into which an egg was inserted. Over a two to three week period females laid 28 to 51 eggs on several stems.

After hatching, the larva formed a characteristic gallery consisting of horizontal portions through the phloem and cambium and vertical portions through the sapwood. When a single stem contained many larvae, the galleries were irregular and the larger larvae canniblized the smaller ones.

In Scotland the life cycle took about four years to complete. Adults emerged from mid to late July and females oviposited throughout August. Eggs hatched the following June and the larval period lasted for about 23 months. Pupation took place during June and July.

In Aberdeenshire Populus tremula Linn. was used as a host tree, but various species of poplar and willow were acceptable. Trees three to 20 years old were preferred. The adults caused damage by defoliation, and the egg incisions, which sometimes destroyed the cambium, caused distorted growth. The egg incisions also provided an entrance for fungi and disease bacteria. The larvae were more significant economically by destroying portions of the stem. Damage to the phloem and cambium interrupted sap flow stunting growth and sometimes killing the tree. The tunnels rendered the wood worthless.

Controls were suggested. Infested trees should be cut down and burned before June. Adults should be caught and destroyed. Small stands of trees could be protected from ovipositing females by coating the base of the trunk with chemicals or netting.

Schvester, D. and H. Bianchi. 1957. Cryptorrhynchus lapathi L. (Coleoptera: Curculionidae) ravageurs des osiers cultivés. (Cryptorrhynchus lapathi L. (Coleoptera: Curculionidae), pest of cultivated willows.) Ann. Epiphyt. 8:137-51.

An outbreak of Cryptorrhynchus lapathi in willow plantations near Lyon, France prompted this study, which had as its main aim the development of methods of control.

On poplars the major damage was caused by the larval tunnelling and feeding, but on willows it was found that the damage caused by the adults was more significant economically. When they emerged, the adults fed on shoots, puncturing them with their snouts. In young shoots the punctures were usually on the tip, killing the shoot tip and leading to the development of laterals. In older woodier shoots the tip was not killed, but there was local destruction of phloem, cambium and sometimes even the heartwood resulting in necrosis and scarring. The damaged areas formed weak points, which tended to break under pressure. On Salix americana a density of five to six adults per m^2 was serious because every adult was responsible for many punctures and in some plots every rod had been attacked.

Contrary to the findings of other studies the adult beetles in France did not overwinter. At the beginning of the winter eggs or young larvae were present. The larvae overwintered inside gall-like swellings of the rods. Larval development continued throughout the winter albeit slowly. A gall contained three to four larvae and there were up to 20 larvae per rod. They did not form straight galleries, but took a more or less winding route. The frass was deposited outside the galleries and accumulated around the base of the rods. Pupation started in mid-May in specially excavated individual chambers, and lasted two to three weeks. Emergence of the adults began in May or June depending on the weather and lasted until July The adults began feeding at once and females began ovipositing after about three weeks. Oviposition was always into wood at least two years old. Thus, oviposition and larval development took place mostly in the stumps and was largely unaffected by the annual harvest of the rods.

Salix americana was the most popular host species and had almost every rod attacked. S. purpurea X S. viminalis had 10 to 30 rods per 100 infested, and attack on S. triandra was even less severe. S. alba and S. daphnoides were not attacked despite the proximity of infested S. americana. An attempt to rear C. lapathi on S. alba failed suggesting that the weevil could not reproduce on this species.

Trials with adults in the laboratory showed that C. lapathi was resistant to DDT and to a lesser extent to HCH and dieldrin. Treatment of adults in plots of S. americana with three successive applications of HCH or dieldrin gave very limited control, but the severity of the feeding damage was reduced. The difficulty in penetrating the dense vegetation with the chemicals was thought to be responsible for the limited success of the chemical trials.

Sengalewitsch, G. 1966. Schädliche Cossidae an Obst- und Forstgehölzen und ihre Bekämpfung in Bulgarien. (Injurious Cossidae on fruit and forest trees in Bulgaria and their control.) Beitr. Ent. 16:693-706.

Zeuzera pyrina Linnaeus and Cossus cossus cossus Linnaeus both appeared in epidemic numbers in Bulgaria and caused serious damage to fruit and forest trees. Z. pyrina attacked many species and was also sometimes found on willows. Willows were among the preferred species of C. cossus cossus. Both species preferred solitary trees, espaliered specimens or trees lining roads, i.e. those exposed to lots of sunlight.

Zeuzera pyrina

The adult moths were on the wing from the beginning of June until the beginning of September. The females were poor fliers, only making short flights during the oviposition period while the males were strong fliers. Eggs were deposited singly on young shoots in the upper crown area. A female laid an average of 1500 to 2000 eggs.

The eggs hatched after 10 to 13 days and the new larvae crawled out on the twigs and bored into the wood. Attacked twigs were killed. The larvae overwintered in the trees but had no obligatory diapause. In late February or early March the larvae sought new feeding sites wandering along the stem and usually boring into the stem near the base.

A wide tunnel 20 to 50 cm long was made during the course of feeding. Most of the larvae spent a second winter inside their tunnels and extended them the following spring. Pupation then took place inside the tunnel. The entire life cycle required 24 months to complete.

Cossus cossus cossus

The adult moths were active from early June to late August. The eggs were laid in groups of 10 to 18 at the entrance to *Z. pyrina* tunnels or in bark cracks on stems close to the ground. A female laid 450 to 1000 eggs. The eggs in a batch usually hatched simultaneously and the larvae remained under a thin web while boring into the trunk. The larvae of a batch stayed together forming a large feeding tunnel. By late autumn most larvae were in their third or fourth instar while others were only in their second. The speed of the larval development depended partly on the sugar content of the host and, because of their comparatively high sugar content, willows were preferred. The larvae had an obligatory diapause, and groups overwintered inside cocoons. Feeding started again in late March. Larvae often abandoned one feeding tunnel and started a new one, sometimes even changing over to a new tree. After a heavy attack by these insects many young trees were broken down by wind or rain. Most larvae spent a second winter in the tunnels while some went into the soil. In the following summer all larvae went to pupate in the soil. There were eight instars, and the life cycle required 22 to 24 months.

It was difficult to control the larvae inside their tunnels with chemicals, but several tables giving the results of numerous chemicals tested against each species were presented. Several parasites, predators and diseases affecting each species were listed.

Smith, B.D. and K.G. Stott. 1963. Some preliminary experiments on the control of adults of the willow weevil, *Cryptorrhynchus lapathi* L. Long Ashton Agr. & Hort. Res. Sta. Ann. Rep., pp. 122-7.

Most of the economically important pests in British basket willow plantations were being controlled, but *Cryptorrhynchus lapathi* was still causing problems. This weevil had a two year life cycle. Eggs were laid in the summer, and the adults from those eggs emerged in May two years later.

The newly emerged adults fed on the young shoots and made punctures penetrating the pith. The terminal part of the shoot withered or broke off resulting in branching. Feeding later in the season on the larger shoots did not cause breaking, but deformities, such as burls or swellings, developed at the sites of feeding. The amount of damage varied considerably between locations and from year to year, ranging from 5-75% of the rods being damaged.

Mature wood was preferred for oviposition, and most of the eggs were laid into the stools. The larvae fed first in the bast and then penetrated the wood. By providing an entrance for fungi the larvae promoted the decay of the stools. In their tunnelling the larvae often girdled the rods and sometimes burrowed right up them.

Studies in continental Europe had shown that the weevils were resistant to DDT and required three times the usual dose of BHC. Parathion, phosdrin, metasystox and endrin provided satisfactory control but were difficult to apply and expensive.

Only control of the adults was attempted. Experiments in the laboratory showed that BHC was most effective, dieldrin and endosulfan were good and DDT was the least effective. However, in field trials spraying with BHC did not provide any control. Dieldrin was effective in the field for a period of about twelve days and several sprays of dieldrin at two week intervals were suggested.

Smith, B.D. and K.G. Stott. 1964. The life history and behaviour of the willow weevil, Cryptorrhynchus lapathi L. Ann. appl. Biol. 54:141-51.

Cryptorrhynchus lapathi was studied on Salix triandra, the basket willow, in Somerset in Great Britain. Both the adults and the larvae caused serious damage to basket willows. During their feeding in spring and early summer the adults punctured young shoots causing the tips to wither and break in the wind. The broken shoots branched and were useless for basketry. Feeding later in the season did not cause breakage but induced the formation of burls again rendering the shoots useless. The larvae fed by tunnelling through the wood weakening the rods and providing access to fungi.

The life history was studied by observing adults in cages and in the field. The caged adults had a one year life cycle similar to that reported in France, Italy and North America. Part of the caged population had a two year life cycle similar to that of the weevils studied in the field and reported for weevils in northern and eastern Europe.

Feeding was heaviest and caused the most damage in May and June soon after the emergence of the adults. An outbreak in 1959 resulted in damage to 62% of the rods. Adults were capable of flight although dispersal by flight was never observed. Little movement between trees by the adults was noted. Oviposition took place from mid-July to mid-September into scars, lenticels and wherever else corky tissue was available. Females oviposited only into shoots at least one year old. The field population at any time consisted of a mixture of stages because of the extended period of oviposition and the small number of adults with a one year life cycle. No parasitism or predation of any stage was observed. The size of the local populations could be affected by the time and the method of cutting the rods.

Smith, E.L. 1968. Biosystematics and morphology of Symphyta. I. Stem-galling *Euura* of the California region, and a new female genitalic nomenclature. Ann. ent. Soc. Am. 61:1389-1407.

A study of the biosystematics and morphology of three genera of tenthredinid sawflies - *Phyllocolpa*, *Pontania* and *Euura*, which induce galls on Salicaceae, has disclosed several new species and some new taxonomic criteria.

The nomenclature for the genitalic structures of the Symphyta was revised because of the inadequacy of earlier studies based on whole mounts examined at relatively low magnifications. Keys to the gall-forming genera, to the species of *Euura* and to the stem galls of *Euura* were provided, as well as taxonomic descriptions of the new species.

Phyllocolpa, *Pontania* and *Euura* all induced simple procecidial galls. The females introduced colleterial fluid along with the egg into immature host tissue. The fluid initiated the gall well before larval eclosion. *Phyllocolpa* formed open galls on leaf margins and were not host-species specific within *Salix* and *Populus*. *Pontania* formed closed leaf galls on *Salix* and appeared to be host-species specific. *Euura* formed closed galls in buds, petioles or stems of *Salix* and was not only host-species specific but showed preferences for certain clones.

There were two major subdivisions within the stem-galling *Euura* that differed in the morphology of their genitalia and their biology. The exiguae group was confined to the exiguiod complex of willows and the lasiolepis group was found on the lasiolepoid group of willows. The exiguae group consisted of *E. exiguae*, n. sp. on *Salix exiguae* Nuttall; *E. geyerianae*, n. sp. on *S. geyeriana* Andersson and *E. breweriae*, n. sp. on *S. breweri* Bebb. The lasiolepis group was made up of *E. lasiolepis*, n. sp. on *S. lasiolepis* Bentham; *E. lemmoniae*, n. sp. on *S. lemmonii* Bebb and *E. scoulerianae*, n. sp. on *S. scouleriana* Barratt. The lasiolepis group were three sibling species.

Smith, F.F., R.E. Webb, J.A. Dickerson and H.W. Everett. 1975. Willow-beaked gall midge: control by insecticides and pruning. J. econ. Ent. 68:392-4.

The willow-beaked gall midge, *Mayetiola rigidae* was a widely distributed pest of *Salix* spp. in North America. The highly susceptible

French pussy willow or goat willow, Salix caprea L., was a common ornamental and was widely grown by florists for its shoots with catkins.

In Maryland adults emerged from their galls at the same time as pollen appeared on the catkins in late March-early April. An infestation destroyed the salability of 80-95% of the shoots.

A series of eleven systemic insecticides was tested by application to the bark, foliage sprays of insecticides including six of the systemics were applied to bushes while the galls were in the leafy rosette stage and plants were pruned to a height of 18 inches.

Three of the systemic insecticides, Ortho 9006 (high dosage), disulfoton and oxydemetonmethyl were most effective because they not only killed the larvae but acted so rapidly as to prevent the galls from developing.

The foliage sprays were less effective because the galls continued to develop normally even though by September demeton and disulfoton had killed 94 and 89% respectively of the larvae in the galls.

Pruning proved very effective by reducing the percentage of galls by 97% when compared with untreated shoots and by producing more salable shoots.

Solomon, J.D. and W.K. Randall. 1978. Biology and damage of the willow shoot sawfly in cottonwood and willow. Ann. ent. Soc. Am. 71:654-7.

Both the larvae and adults of the willow shoot sawfly, Janus abbreviatus (Say), caused damage to poplars and willows. The adult females girdled shoot terminals with a series of punctures made by their ovipositors, and the larvae tunnelled within the shoots. J. abbreviatus was found in southeastern Canada and the eastern half of the U.S.A. This study was conducted in a nursery in Mississippi containing Salix nigra L., S. babylonica L. X S. alba L. and Populus deltoides Bartr.

The adults, egg, larva and pupa were described. There were three generations per year in Mississippi although other studies had found one generation per year. The willow shoot sawfly overwintered as a larva in a brownish cocoon inside the willow stem. Pupation took place inside the cocoon during late March and early April and lasted 12 to 21 days. The first generation of adults emerged from mid-April to mid-May. The females oviposited into tender shoots and were very selective about the diameter of the stem and the distance from the tip of the shoot.

A diameter of 1.7 to 3.1 mm located 32 to 80 mm from the shoot tip was preferred in willows. The female first made a series of 5 to 15 punctures around the stem and then placed one and occasionally two eggs into the pith below the punctures. After the eggs hatched, the larvae first tunnelled toward the tips and then turned around and tunnelled in the direction of the base for 15 to 36 cm. The mature larva chewed an exit almost through the bark and then prepared a cocoon for pupation. The second generation adults attacked shoots from mid-June to mid-July. The larval development and pupation of the second generation required less time than the first. The third generation adults were active from early August through September. In September and October the larvae from this generation prepared the cocoons, in which they would overwinter.

The first generation of adults caused heavy damage during late April and early May. Shoots began to wilt shortly after being girdled, turned black within a week and eventually broke at the girdled point. The larvae killed many shoots down to the rootstock by girdling the stem with spiral tunnelling. The second and third generation of adults attacked more shoots, but, because the plants were by then larger and had more shoots, the proportion of shoots killed was smaller. The tips of infested shoots died back, and many branches were produced below the damage. The attacks of the three generations produced extensive die-back, branching and formation of crooked or forked stems reducing the quantity and quality of the vegetative cuttings.

Although many parasites have been reported to attack J. abbreviatus, only Bracon jani Muesbeck and Eupelmus sp. were reared from the willow shoot sawfly in this study. The mortality of the larvae in the smallest and least vigorous shoots during the fall and winter was 56%. Cutting out and destroying infested shoots could reduce populations in small nurseries.

Szalay-Marzso, L. 1962. Zur Morphologie, Biologie und Bekämpfung des Erlenwürgers Cryptorrhynchus lapathi L. (Col. Curcul.) in Ungarn. (A contribution to the morphology, biology and control of the poplar-and-willow borer, Cryptorrhynchus lapathi L. (Col. Curcul.), in Hungary. Z. ang. Ent. 49:161-94.

Increased commercial planting of Salix americana in Hungary resulted in a proportionate increase in the populations of basket willow pests. Of these, Cryptorrhynchus lapathi caused the most damage. This study was conducted in the laboratory and in willow plantations from 1958-59.

In Europe C. lapathi has been found from 65°N latitude to southern-most Italy. It has also been reported in Asia, Japan, Canada and California. This study found that in plantations Salix americana, S.

fragilis, S. cinerea and poplars were the preferred host plants. Native species of willow attacked were S. triandra, S. fragilis, S. cinerea, S. multinervis and S. viminalis. S. aurea and S. amygdalina (= S. triandra) received significantly less damage.

The morphology of each stage of the life cycle was described as well as methods of collecting specimens for study and of rearing the larvae in the laboratory.

The life cycle required 11 to 13 months to complete. The overwintering adults left their shelter in the leaf litter in April. They began feeding on the shoot tips of willows during the shoots' most intensive period of growth. The feeding often caused the shoots to break leading to the development of lateral shoots and bushiness. Copulation took place in May, and females laid an average of six to nine eggs. In July the new generation of adults finishing pupation appeared. The shoots were becoming hard and woody at this time, and feeding was restricted to callus developing over areas which had already been gnawed. Attacked shoots became swollen, deformed and discoloured below the bark. The new adults copulated as soon as two weeks after emergence, and females laid about nine to ten eggs. Thirty percent of this new generation of adults overwintered while the remainder died off in the fall.

The eggs were laid into holes excavated by the females in the bark of larger rods abut 1-5 cm above the ground. Eggs usually hatched after 12 to 18 days, and all hatching was finished by November. The larvae, which emerged during the summer and fall began feeding under the bark but soon went into diapause over the winter. Feeding was resumed in March, and tunnels penetrated farther into the wood as the larvae matured. There were five instars. Pupation started at the end of June and took place in chambers at the end of the feeding tunnels.

The sap flow from the feeding wounds and tunnels of C. lapathi attracted many species of Hymenoptera, Diptera, Coleoptera and Lepidoptera. These attracted many predators, but a bird, Parus major L., was the only vertebrate preying on C. lapathi. A hymenopteran, Perosis sp., was the only parasite found. Its low numbers prevented it from effecting any control on populations of its host. The caterpillars of Cossus cossus and Sesia spp., which also tunnelled in willows, ate any C. lapathi larvae that they encountered.

When larval populations were high, their tunnelling killed trees, but the feeding damage of the adults even at low densities made the profitability of plantations questionable. The beetle was also a vector for disease, specifically Bacterium salicis and B. tumifaciens in willows.

Various chemicals were unsuccessful in controlling the larvae. Scorching in early spring reduced larval populations significantly. A new harvester, which cut off the rods at ground level destroyed the overwintering larvae just as effectively and with less trouble and expense. Good results in controlling the adults were obtained with Metasystex, Ekatox 20, Ekatin and Wofatox. Control of the overwintering adults by chemical means in the spring was thought to be better than controlling the new adults in the summer because the overwintered adults were more susceptible, fewer beneficial insects were present in the spring and the smaller trees required less chemicals.

Szalay-Marzso, L. 1963. Schädigungen von Coenorrhinus aeneovirens Marsh. (Col. Attelabidae) an Korbweiden. (Damage by Coenorrhinus aeneovirens (Col. Attelabidae) on basket willows.) Anz. Schädlingsk. 36:51-3.

In the spring of 1961 the wilting of young shoots was noticed in Hungarian basket willow plantations. Sixty per cent of the rods, which at that time were 20 to 25 cm long, were affected. The wilting was caused by the feeding punctures of a small, dark blue weevil, Coenorrhinus aeneovirens.

This weevil was found in Europe, Persia and North Africa and had been recorded on Quercus, Corylus, Betula, Sorbus and Fragaria. Its appearance on willows was a new record.

The adults appeared in the first or second week of April and were present until well into June. They were quite active in warm weather although usually found on the shaded side of the plant. They were capable of flying. The wilting of the shoot tips was caused by a ring of feeding punctures which girdled the shoot. An oviposition hole was made into the wilted portion of the shoot and a single egg was deposited into it. The oviposition hole was hidden by the tiny epidermal hairs and the wrinkling of the epidermis which was a consequence of the wilting.

In the laboratory the eggs hatched after 14 to 16 days and the larvae mined the wilted tip. The laboratory colony died in their third instar after about 50 days of development. After mid-June no more larvae were found in the willow shoots and it was presumed that they were pupating in the soil. More than one generation per year was not observed.

To date only Salix viminalis had been attacked and neighbouring plots of S. americana were untouched. Treatment with Wofatox (methyl-parathion) was successful.

Szalay-Marzso, L. 1963. Zur Kenntnis des an Korbweide schädlichen *Lepyrus palustris* Scop. (Col. Curculionidae). (A study of the basket willow pest, *Lepyrus palustris* Scop. (Col. Curculionidae)). Anz. Schädlingsk. 36:189-93.

Lepyrus palustris was a serious pest of willow throughout Hungary, although epidemics only occurred in the warmer, southern areas. It was found in Europe, Siberia, the Caucasus and the U.S.A. *L. palustris* preferred *Salix americana* but was also found on *S. viminalis*, which started development earlier in the spring. Beetles in the laboratory fed indiscriminately on several species of willow but were fed mainly with *S. babylonica* for convenience.

The morphology of all the stages of the life cycle was described. The adults overwintered and appeared again in April. They mated and fed on the young shoots chewing holes in the leaves and the bark. The females laid eggs from May to June on the ground near willows. There were four instars and a prepupal stage. The larvae bored into the soil and fed on the bark at the depth of 2 to 3 cm. They gnawed long troughs through the bark and into the wood of the larger roots. Pupation took place in the soil. The new generation of adults appeared in July and fed on the leaves before disappearing for seven months of diapause and overwintering.

The adult feeding in the spring was very destructive because the shoots were very susceptible at that time of the year. The feeding caused deformed growth and branching. If the spring was warm and dry, damage was even greater because the beetles were more active and the growth of the shoots was retarded. The defoliation caused by the adults later in the summer was not so important. The larval feeding resulted in disruptions of the vascular system and was dangerous primarily to very young and newly rooted stock.

The beetles were highly resistant to DDT and HCH, but Wofatox gave satisfactory control. Treatment of the new shoots in the spring, when the adults gathered there, was recommended.

Szontagh, P. 1982. Bockkäfer der Papplen und Weiden. (Long-horned beetles of poplar and willow). Fol. Ent. Hung. 43:175-8.

The author lists 28 species of cerambycid beetles reported on poplars and willows of Hungary since 1956. The list includes serious pests and economically insignificant species as well as one species new to Hungary.

Forest Pests

Saperda populnea L., the small poplar long-horned beetle, was an important pest. All cultivated species of poplar and Salix caprea were hosts. Boring by the larvae caused galls to form in stems and twigs resulting in breakage or the tree drying out. Outbreaks occurred in stands which were in poor physiological condition.

Saperda carcharias L., the large poplar long-horned beetle, attacked all economically important species of poplar in Hungary. The larvae formed extensive galleries in the wood causing the most serious physical and physiological damage to the host tree.

Lamia textor L. was said to attack all economically important species of poplar and willow but was found more often on willow in Hungary. Low numbers made its damage negligible.

Aromia moschata L., the musk long-horned beetle, attacked all species of willow especially those in flood plains. The larvae tunnelled in both twigs and stems of healthy older trees.

Oberea oculata L. was found on various species of willow primarily on flood plains. The larvae tunnelled in twigs and stems but were not considered economically significant in Hungary.

Economically Unimportant or Rare Species

Megopis scabricornis Scopp. was very common in older poplars and willows of the Danube and Theiss flood plains. It attacked old diseased or injured trees.

Prionus coriarus L. Its host plants included willow.

Stenochorus meridianus L. The larvae developed in stems and twigs of diseased and injured willows.

Strangalia aurulenta Fabr. and S. quadrifasciata L. The adults were often found in older poplars and willows of the Danube-Theiss region.

Cerambyx cerdo L. Its hosts included poplar and willow.

Gracilia minuta Fabr. The larvae developed primarily in thin shoots of basket willow.

Obrium cantharium L. was rare but distributed throughout Hungary on poplars.

Natrius brevipennis Muls. developed in small twigs of willow.

Molorchus salicicola Stiller. The larvae were found in willow twigs. To date it has been confined to Hungary.

Rhopalopus clavipes Fabr. was found in willows in the high water area of the Danube.

Xylotrechus rusticus L. Its hosts included poplar and willow.

Xylotrechus pantherinus L. The larvae developed in larger twigs of goat willow, Salix caprea L. This species was new to Hungary.

Plagionotus arcuatus L., this pest of oaks has been observed on willows as well.

Acanthoderes clavipes Schrank. This insect was reported to be a pest of poplar but in Hungary it has only been found on Salix caprea.

Mesosa curculionides L. This species was collected on Populus robusta and Salix alba.

Mesosa nebulosa Fabr. was widely distributed on white willow, Salix alba L. in Hungary.

Anasthetis testaceus Fabr. was collected on Salix caprea L. in the Màtra mountains.

Saperda scalaris L. Its host plants included poplar and willow.

Saperda octopunctata Scopp. Its main host plant is trembling aspen.

Saperda perforata Pall. was rare in Hungary but found on trembling aspen.

Menesia bipunctata Zoubk. was very rare in Hungary but found on trembling aspen and willow.

Stenostola ferrea Schrank. Its host plants included Salix aurita, S. caprea and poplars.

Tooke, F.G.C. 1936. The willow-tree caterpillar, Gonimbrasia tyrrhea Cram. Un. S. Afr. Dep. Agr. & For. Bull. No. 142, 4 pp.

These caterpillars were native to South Africa and were originally found on several species of Acacia. They were polyphagous and seriously defoliated willows, especially Salix babylonica, among other trees.

The moths emerged from late September to mid-October. They lived only a few days during which they mated and laid eggs. The eggs were deposited in batches of 100 to 150 around young shoots and twigs. Most eggs hatched in 12 to 14 days and the larvae in a cluster first underwent a quiescent period of a few hours. They then began feeding, devouring the leaves and bark of the twigs. There were six instars which required 11 to 12 weeks for development. In mid-January the larvae burrowed two to three inches into the soil to pupate. The pupal period lasted 8 to 13 months. A small second brood of moths appeared in late January and February, but the biology of this brood was not studied.

The natural controls of this moth were wasps parasitizing the eggs, tachinid flies parasitizing the larvae and a braconid wasp Apanteles maculitarsis. Pupae that could not burrow deeply enough in hard soil succumbed to the great diurnal fluctuations in temperature or to desiccation. Suggested means of control were mechanically destroying the egg masses, hand-picking the larvae and allowing pigs access to destroy the pupae.,

Vasseur, R. and D. Schvester. 1957. Biologie et écologie du pou de San José (Quadraspidiotus perniciosus Comst.) en France. (Biology and ecology of the San José scale (Quadraspidiotus perniciosus Comst.) in France). Ann. Epiphyt. 8:5-67.

The San José scale was introduced to Europe before 1931 and at the time of this study was found in most eastern European countries. In France it was found in separate scattered locations probably reflecting separate introductions.

Exact identification of the San José scale was possible only by microscopic study of the pygidium of the adult female. The females were viviparous producing a large number of nymphs. These neonate nymphs were initially mobile, but they attached themselves several hours after emergence and began secreting their scale. Differentiation of the two sexes began at the end of the second moult. The female scales remained round and increased in size. The male scales became elongated and underneath, the transformation to a winged adult took place. The females were fertilized after their last moult, then matured and over a period of several weeks produced nymphs. The first instar nymph composed the overwintering stage and was the only form capable of hibernating successfully. There were two full generations with a partial third per year in most of France, but in southern France, where the growing season was longer, there was at least one more generation.

Excessively high temperatures caused mortality in the summer, but the insects could withstand cold or wet conditions. The latter frequently caused the first generation to go into diapause and thereby reduced fecundity. Thus warm dry summers were more likely to have outbreaks.

The natural enemies of the San José scale included two indigenous chalcidoids that had adapted to this new host. Adaptation was not perfect, and mortality of the parasites in the winter was high. A number of coccinellid beetles and their larvae preyed on the scales. Adult Chilocorus bipustulatus, the most numerous species, were capable of eating 20 scales per day.

The host plants were ranked according to degree of susceptibility and Salix spp. were in the category of second most susceptible. The duration of the developmental period was slightly longer and the fecundity of the females was lower compared to plants in the category of most susceptible. However, the scales established themselves and overwintered successfully on S. babylonica.

Weis, A.E. 1984. Apical dominance asserted over lateral buds by the gall of Rhabdophaga strobiloides (Diptera: Cecidomyiidae). Can. Ent. 116:1277-9.

Rhabdophaga strobiloides induced a gall on the terminal bud of newly growing twigs of Salix cordata, the heart-leaf willow. The formation of this gall halted the elongation of the twig and caused the development of tiny scale-like leaves from the terminal bud. The subversion of the apical meristem during gall formation did not cause the lateral buds to burst, and the gall appeared to assert apical dominance. Galls were examined at the end of the growing season to see whether or not the death of the gall former had affected the growth of the gall. Galls containing healthy larvae were found to be larger than those containing dead or parasitized larvae. Many other cases were known where the continued stimulation by the gall former was necessary to maintain the growth of the gall.

An experiment was performed to determine whether or not the gall former directly inhibited the development of the lateral buds or whether the terminal bud retained this characteristic after its conversion into gall tissue. It was found that the frequency of bursting of lateral buds on twigs with the terminal bud removed was identical to that of galled twigs with the gall removed. However, only 4% of the lateral buds on galled twigs, where the gall former had been killed by the injection of insecticide, burst. Thus lateral buds are suppressed in the presence of the gall even if the gall former is dead. Because new growth from the laterals would compete with the gall for resources it is advantageous to the gall former to have apical dominance maintained.

Weiss, H.E. and E.L. Dickerson. 1917. Plagiodera versicolora Laich. - an imported poplar and willow pest. Can. Ent. 49:104-9.

This small, metallic blue, chrysomelid beetle had been introduced from Europe and was becoming abundant on poplars and willows in New Jersey where this study was conducted.

The adult beetles emerged from hibernation and began feeding on leaves from late April to early May. Oviposition started in early May and continued throughout the month. By early June the adults of the first generation had disappeared, and the eggs were hatching. The adults of the second generation appeared from June 10 to early July and they oviposited throughout July into early August. The adults of the third generation were present from late July until late August. After feeding and copulating these adults went into hibernation under loose bark or in cracks in the bark of their hosts.

A description of the egg was given. An average number of 19 eggs was laid in a mass on the underside of a leaf. Each of the five larval instars was also described. The larvae fed gregariously on the underside of the leaves. The larvae ate only the epidermis in contrast to the adults who ate all leaf tissues. The larvae also ate any unhatched eggs. Pupation took place on the leaves over a period of two to three days.

The parasite, Coelopisthia rotundiventris Girault and the hyperparasite, Pleurotropis tarsalis Ashmead were reared from the pupae. They were not abundant enough to reduce the populations of the beetle. A predacious hemipteran was found attacking adults and larvae.

P. versicolora was sometimes found associated with the other chrysomelid, Lina scripta Fab., and the differences between the two species were listed.

Wilson, L.F. 1968. Life history and habits of the willow beaked gall midge, Mayetiola rigidae. Can. Ent. 100:202-6.

The characteristic gall of Mayetiola rigidae has been reported on Salix discolor Mühl., S. humilis Marsh., S. rostrata Richards, (= S.

bebbiana Sarg.), S. cordata Mühl., S. lucida Mühl., S. petiolaris Sm. and S. viminalis L. This study was conducted on young S. discolor shrubs in East Lansing, Michigan from 1963 to 1966.

The gall was monothalamous and was apical when a terminal bud was attacked or subapical when a lateral bud was attacked. The first sign of galling was a swelling of the bud, as the leaves flushed. The mature gall was subglobular to fusiform, terminating in a slender beak with an open tip which led to the larval chamber. The gall was green early in the season but turned partially or completely red in the fall. At the same time it became hard and woody.

M. rigidae was univoltine in Michigan. The adults emerged on sunny mornings soon after the first few warm days in April. Mating was not observed, but eggs were found two days after the first females had emerged. Dissections determined that the average number of eggs per female was 355. Eggs were deposited singly on or near buds. There were three larval instars. The first instar which was present from late April to mid-May, spent several days boring through the soft tissue of the bud to reach the small cavity above the central meristematic area. The second instar was present from mid-May to early July. The third instar and the gall reached maturity in September. The larva overwintered inside the gall chamber after lining the upper portion with silk and closing off the passageway with one or more silken septa. Pupation started in the following March. Just before eclosion the pupa wriggled through the passage to protrude from the tip of the beak. The pupal skin split, and the adult emerged. Judd (1957, Can. Ent. 89:8-11) has reported on the hymenopteran parasites and inquilines of this midge.

During the four years of study the date of first pupation varied by one week and that of adult emergence by almost two weeks.

Wilson, L.F. 1968. Life history and habits of the pine cone willow gall midge, Rhabdophaga strobiloides (Diptera: Cecidomyiidae) in Michigan. Can. Ent. 100:430-3.

Rhabdophaga strobiloides (Osten Sacken) formed characteristic galls on Salix spp., which resembled the female strobilus of pine. This study was conducted on Salix eriocephala Michx. shrubs in Michigan. The gall has also been found on S. humilis Marsh.

The gall was single-chambered and was formed by hypertrophy of the shoot tip. The young gall was like a small cabbage - rounded, green and covered with numerous leaves. When mature in August the gall was top-shaped and had numerous (60 or more) dry, grey, regularily arranged scales. The insect was in a central chamber surrounded by a ring of stiff, elongated scales. Normal galls on S. eriocephala averaged 22 x 19 mm, but parasitized galls were smaller and rounded.

There was one generation per year in Michigan. The adults emerged on warm sunny mornings in late April and early May. The pupa wriggled up the central chamber and protruded from the apex allowing the adult to emerge. Eggs were laid singly on the leaves. The larvae, which appeared in early May, crawled to the shoot tips. They bored into the apical meristem of the shoots in one or two days. Eight to ten days later the base of the shoot began to swell. There were three instars, and the larvae were mature by early September. In late September the larvae prepare for overwintering by lining the lower half of the gall chamber with silk. Pupation took place in early April inside the gall.

The inquiline midge, Dasyneura albovittata Walsh, was the other most common inhabitant of the gall. Various other unidentified insects in different stages of development were collected.

Wong, H.R. 1954. Common sawflies feeding on white birch in the forested areas of Manitoba and Saskatchewan. Can. Ent. 86:154-8.

Twelve species of sawfly were common on white birch, Betula papyrifera Marsh., in Manitoba and Saskatchewan. The current nomenclature and biological information were presented because the descriptions are scattered in many publications and many of the generic and specific names have changed.

Only six of the twelve species are exclusively found on white birch. Of the remaining six species, Trichiosoma triangulum Kirby, Arge clavicornis (Fabr.), Cimbex americana americana Leach and Priophorus pallipes (Lepeletier) were found also on willows.

T. triangulum larvae were present in the field in early June, A. clavicornis in late June and P. pallipes and C. americana americana in early July. All were present until September-October. All the larvae were external feeders. P. pallipes larvae fed on the surface of leaves eating holes through them, while the other three species clung to the edges of leaves when feeding. Most species were solitary feeders. A. clavicornis larvae were known to feed gregariously elsewhere but were always found individually in this study. Feeding caused negligible damage. All species had one generation per year except P. pallipes which had a second or partial second generation. A. clavicornis and P. pallipes overwintered in cocoons in the leaf litter while C. americana americana and T. triangulum overwintered in cocoons in either the topsoil or the leaf litter.

A key to the common sawfly larvae on white birch was presented.

Wong, H.R., J.C.E. Melvin and J.A. Drouin. 1976. Damage by a willow shoot-boring sawfly in Alberta. Tree Planters' Notes 27:18-20.

In 1974 many of the whips at a provincial tree nursery in Alberta had to be culled when they were found to be infested with larvae of the sawfly, Euura atra (Jurine).

E. atra was found in both Europe and North America and in Canada ranged from the Maritime Provinces to Alberta. In Alberta Salix acutifolia Willd., S. alba var. tristis L. and S. pentandra L. were hosts of E. atra. In Ontario it was found on S. babylonica L. and in the Maritimes on S. fragilis L. and S. alba var. vitellina L. In Europe it has been reported on S. repens L., S. viminalis L., S. purpurea L., Populus tremula L., S. alba var. caerula Smith, S. lapponum L. and S. cinerea L.

The larvae overwintered inside a brownish cocoon and pupated early in the spring. The adults emerged in late May and early June, and by mid-June the females were laying their eggs. The eggs were deposited singly next to the pith in tender shoots. The young larvae, who were pale green with black heads, tunnelled in the pith. When young they produced reddish frass, but the older larvae produced whitish frass. A gallery 10-21 mm long was excavated. When two larvae met in one gallery, one killed the other. In the fall the larvae made an exit hole plugged with frass, wood chips and webbing at one end of the gallery and a cocoon at the other. There was only one generation per year.

The larvae attacked new stems and laterals of willow favouring those between 3-18 mm in diameter. Many infested stems died the following spring, and some were attacked by the fungus, Cytospora capreae Fckl. Woodpeckers damaged the willow shoots further when they used their beaks to dig the larvae out of their tunnels. In the tree nursery S. acutifolia was the most susceptible species and S. alba var. tristis was less susceptible. No larvae were found on S. amygdaloides Anderss. or S. pentandra although S. pentandra in shelterbelts sometimes had larvae.

Mechanical control was not feasible because the infested shoots were not recognizable as such until after bud burst when the adults had already emerged. Field tests showed that a soil drench of dimethoate in early July gave 93% control.

Woods, W.C. 1917. The biology of the alder beetle, Altica bimarginata Say. Maine Agr. Exp. Sta. Bull. 265:249-84.

The alder flea beetle belongs to the tribe Alticinae of the family Chrysomelidae. It was usually rather scarce but large outbreaks occurred more or less periodically. An outbreak in Maine in 1914 left almost every alder bare and brown by mid-August.

The beetles hibernated as adults until spring when the leaves of the host were well expanded. The females oviposited from mid-June to late July, and the eggs hatched within a few days of being laid. The larval period lasted about 25 days during which the larvae first ate the lower surface of the leaves and then skeletonized them. The beetles then spent six days in a cell in the ground as prepupae and ten days as pupae. The newly emerged adults fed on alder chewing small holes in the leaves until September-October when they began hibernation. There was only one generation per year.

Detailed descriptions of the morphology, the molting habits and coloration of each stage of the life cycle were given.

In Maine A. bimarginata was found almost exclusively on alder but some were also found on Salix rostrata Richards (= S. bebbiana Sarg.). A biological race occurring on balsam poplar was found, and these adults and larvae ate alder and various species of willow as readily as poplar. By contrast the alder-race refused poplar although it readily ate willow.

The natural enemies of the alder beetle were a fungus, Sporotrichum globuliferum Speng., which attacked all stages except the egg, a wilt disease, probably bacterial, which attacked the pupae and a tachinid fly, Hyalomyodes triangularis Loew, which parasitized the adult beetles.

No control measures were attempted but methods used on other flea beetles such as spraying with lead arsenate would probably be effective.

Finally the synonymy of the genus Altica Geoffroy was discussed in great detail.

Zanov, Z. and I. Naidenov. Croissance et resistance à la cécidomye du saule (Rhabdophaga saliciperda Duf.) de quelques clones de saules du bassin fluvial du Danube. (Growth and resistance to willow gall midge (Rhabdophaga saliciperda Duf.) of some willow clones of the Danube river valley.) FAO Int. Poplar Comm., Casale Monferrato, Italy, 1982. 5 pp.

Willows were the most useful trees in the Danube flood plain for the prevention of erosion and the production of wood because of their rapid growth and tolerance of flooding. The most serious threat to willows in Bulgaria was the willow gall midge, Rhabdophaga saliciperda. This insect was responsible for deformed shoots and dead branches. This study evaluated the resistance to R. saliciperda and the growth in ecologically differing sites of several clones of Salix alba.

The growth of the clones was measured and the degree of resistance determined using a formula that incorporated the amount of damage. Two clones, S. alba L. cl. Bg-1/64 and S. alba L. cl. Bg-2/64 showed the most growth and were the most resistant, making them the best candidates for planting. Clones, such as S. alba L. Erdüt No. 201 and S. alba cl. Valenza I-1/59, which had smooth bark, were very susceptible to R. saliciperda and should not be planted.

Zivojinovic, S. 1961. Zur Biologie und Bekämpfung des kleinen Pappelbockes (Saperda populnea) in Jugoslawien. (The biology and control of the small poplar longhorned-beetle (Saperda populnea) in Yugoslavia. Z. ang. Ent. 48:410-22.

Saperda populnea had gained economic importance in the last ten years because of the increased cultivation of poplars and the inadequate measures being used to control it. This study was begun in 1951 and conducted mainly in the plain of Wojwodina (Serbian People's Republic) where poplars had been grown since 1945.

Various authors studying S. populnea in different regions have reported a two year life cycle. In Yugoslavia it was found to have a one year life cycle. Adults emerged about May 1st and remained active for approximately 20 days. Adults of both sexes immediately began feeding on leaves chewing small holes in them, but the females also fed on the bark of young shoots. Soon afterwards mating took place. The average number of eggs per female caught soon after emergence was 18. The females chewed a horseshoe-shaped furrow in the bark of a young shoot and deposited an egg and cecidogenetic substances under the bark. The females often gnawed furrows without laying an egg. The gall-inducing substances deposited with the egg first caused the death of plant tissues immediately surrounding the egg. This was followed by the formation of wound callus upon which the larvae fed. The eggs hatched in early summer 10-16 days after being laid. The larvae constructed a central gallery and a peripheral gallery within the gall. By mid-September the larvae were fully grown and were preparing to overwinter in the central gallery by sealing it off from the peripheral gallery with wood chips. In March-April the larvae resumed their activity and prepared for pupation by tunnelling a passageway for emergence. This passage led from the central gallery to just under the bark which was left intact. The length of the pupal stage varied with the weather and lasted 30 days with a cold spring. After eclosion the adults remained inside the gall for three to four days while their integuments hardened, their pigmentation developed and their reproductive systems matured. After this period the adults chewed through the bark over the emergence hole and began their feeding.

The damage caused to the leaves by the feeding of the adults was negligible. Only 8.5% of the leaves were damaged with a 0.3% loss of leaf mass. The damage to the bark caused by the females feeding on young shoots, the oviposition furrows and the emergence holes of the adults all provided entry to dangerous micro-organisms. An epidemic of the fungus, Dothichiza populnea, in 1956 spread by entering the emergence holes of the adults. The larvae caused considerable damage by galling and tunnelling the twigs. Growth distal to a gall was reduced, and both the twig and leaves were smaller than normal. The peripheral galleries of the larvae partially girdled the twigs making them very susceptible to wind-breakage. Galled twigs that survived usually bore marks of damage caused by Fusarium sp. The wind-breakage of terminals resulted in bushier growth and increased development of sucker shoots. S. populnea attacked all species of poplar and trees of all ages, but those three to ten years old were favoured. S. populnea also attacked two species of willow, Salix viminalis and Salix caprea.

Natural controls were spotted woodpeckers (Dryobates sp.), spiders, tachinid flies and ichneumonid wasps. Sciapteron tabaniformis Rott. (Lepidoptera) laid its eggs in S. populnea oviposition furrows and the caterpillars killed the longhorned-beetle larvae inside the galls. None of these served to reduce significantly the population levels of S. populnea. One important control was the resistance of the plant. A large accumulation of wound callus smothered eggs or cracked the bark over them allowing them to desiccate. Forty percent of the eggs failed to hatch.

Mechanical control methods such as cutting out and burning infested twigs did not control populations in heavily infested areas. Good control was possible with chemicals but the timing of application was important. The best results were obtained with lead arsenate, Gamexan and 0.3% Toxaphen applied during the period in the spring when the adults were active.

INDEX TO INSECTS ON WILLOW[1]

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[1] Species are indexed according to author. Although all species listed are mentioned in the original references some were of minor importance and not included in the annotated abstract.

AUTHOR INDEX