Fecundity, longevity and establishment of *Otiorhynchus sulcatus* (Fabricius) and *Otiorhynchus ovatus* (Linnaeus) (Coleoptera: Curculionidae) from the Pacific North-west of the United States of America on selected host plants

James R. Fisher
United States Department of Agriculture, Agricultural Research Service, Horticultural Crops Research Laboratory, 3420 North West Orchard Avenue, Corvallis, OR 97330, U.S.A.

Abstract
1. The fecundity, longevity and establishment of *Otiorhynchus sulcatus* and *Otiorhynchus ovatus* from the Pacific North-west U.S.A. was studied on five selected host plants: *Picea abies* ‘Nidiformis’, *Picea glauca* ‘Conica’, *Taxus baccata*, *Rhododendron catawbiense* ‘Boursault’ and *Fragaria × ananassa* ‘Totem’.
2. Teneral adults were used to study adult longevity and reproductive success. Leaves of these host plants were used for sustenance for 9 months. Larval establishment was studied by infesting potted host plants with eggs.
3. *Fragaria × ananassa* ‘Totem’ produced the longest survival, shortest preoviposition time, the greatest number of eggs, and the highest fertility for adults of both species. *Picea* spp. were not good adult hosts for *O. sulcatus*. *Taxus* was a good adult host for *O. sulcatus*, but was a nonhost for adults and larvae of *O. ovatus*.
4. Adult hosts did not affect preoviposition time or egg viability with *O. ovatus* adults. With *O. sulcatus*, preoviposition time was greatly increased and egg viability was < 50% on *Picea* spp.
5. The best larval host was *F. × ananassa* ‘Totem’ for *O. sulcatus* and *P. glauca* ‘Conica’ for *O. ovatus*. *Rhododendron* was a poor larval host for both species.
6. When all of the studies on these two pests are considered, *O. sulcatus* appears to have varying host preferences from among its many geographical areas of occurrence whereas *O. ovatus* has a more universal host selection.

Keywords Adult host, black vine weevil, host plants, larval host, strawberry root weevil.

Introduction
Several otiorhynchid weevils (Coleoptera: Curculionidae) are pests of horticultural crops in the Pacific North-west U.S.A. Of these, the black vine weevil *Otiorhynchus sulcatus* (Fabricius) and the strawberry root weevil *Otiorhynchus ovatus* (Linnaeus) are of particular importance to the small fruit and nursery industries. Economic damage by these insects is primarily caused by larvae feeding on and inside roots, often girding the trunks of hosts at soil level or eating large roots close to the main trunk and killing the plant. Adult leaf-feeding (notching) is of little consequence to small fruits but is a cosmetic blemish on nursery stock. Even though both of these insects are nearly ubiquitous throughout the northern tier (> 40° latitude) of North America (Warner & Negley, 1976), sellers of nursery stock from the Pacific North-west are often penalized from completing sales of material exported to other states by buyer refusals on finding the presence of these pests. Both insects have similar univoltine life cycles, have apomictic parthenogenesis, and are flightless (Downes, 1922; Smith, 1932; Suomalainen *et al.*, 1987). Eggs are laid from the early summer to autumn. Overwintering occurs in the larval stage and pupation and transformation to the adult stage occurs from the late spring to early summer.

Correspondence: J. R. Fisher, United States Department of Agriculture, Agricultural Research Service, Horticultural Crops Research Laboratory, 3420 North West Orchard Avenue, Corvallis, OR 97330, U.S.A. Tel.: +1 406 446 9942; fax: +1 541 738 4925; e-mail: fisherj@science.oregonstate.edu
Occasionally, adults of both species have been found to overwinter in the United States (Treherne, 1914; Smith, 1932) and in Ireland (Blackshaw, 1992).

A number of hosts have been listed for both species. Over 40 varieties from a number of families from grasses to conifers have been recorded for _O. ovatus_ (Patch, 1905; Treherne, 1914; Wilcox _et al._, 1934; Gambrell, 1938; Schread, 1950; Emenegger, 1976; Brandt _et al._, 1995; Wheeler, 1999). Over 150 species of an even more expansive list has been recorded for _O. sulcatus_ (Smith, 1932; Warner & Negley, 1976; Masaki _et al._, 1984). However, a number of studies have found that evidence of damage, particularly by adults, does not necessarily denote that the plant is a viable host (Cram, 1965, evidence of damage, particularly by adults, does not necessitate that the plant is a viable host (Cram, 1965, e.g., 1978). For example, in the Pacific Northwest it is known that the effect of host plant foliage on the reproductive success of _O. ovatus_. The present study investigated the effect of host plant foliage on the reproductive success of both weevil species as well as the ability of larvae of each species to establish on one of five host plants, _P. abies_ ‘Nidiformis’, _T. baccata_, _P. glauca_ ‘Conica’, _F. × ananassa_ ‘Totem’ and _R. catawbiense_ ‘Boursault’.

Materials and methods

The study comprised two parts. First, callow adults of each species were individually placed on a range of different host plant foliage and data were collected with respect to preoviposition time, longevity and fecundity. Second, pots containing the same selection of host plants were infested with eggs of each species and subsequently examined for larval establishment.

Insects

Larvae of _O. sulcatus_ and _O. ovatus_ were collected in the late winter (2003) from strawberries and nursery stock in the Willamette Valley of Oregon. The larvae were then reared in a carrot–peat moss system, similar to that described by Masaki & Sugimoto (1991), in plastic food containers (0.5 L; Reynolds Metal Co., Richmond, Virginia). Carrot slices and peat moss were renewed as necessary until pupation. Pupae were transferred to similar containers that contained only moist peat moss. All larvae were reared in complete darkness at 21.0 ± 0.5 °C.

Adult host plant study

As the larvae eclosed, teneral adults were placed individually in 100 mm Petri dishes (Fisher Scientific, Pittsburgh, Pennsylvania) (one per dish) that contained a piece of moistened filter paper (Whatman #1; Whatman plc, U.K.) and a leaf or sprig of a selected host plant in a floral water-pic (Syndicate Sales Inc., Kokomo, Indiana). Adults were maintained in an incubator at 21 ± 0.5 °C under an 18:6 h light/dark photoperiod (Nielsen & Dunlap, 1981; Umble & Fisher, 2002). Every 3–5 days, the dishes were examined for eggs, the plant material renewed and the dishes changed to minimize mold and faecal deposits. Weevils were maintained until death occurred or not more than 9 months.

To estimate egg viability, samples of eggs were randomly removed with a camel hair brush and placed on moistened filter paper (Whatman #1) in a snap lid Petri dish (50 × 9 mm, (J. R. Fisher, unpublished observations). Hanula (1988) demonstrated that the previous feeding experience by larvae or preovipositing adults of _O. sulcatus_ from Connecticut did not influence where subsequent oviposition occurred; the majority of eggs were laid on or in pots with _T. baccata_, _P. abies_, _Rhododendron_ Siebold and Zucc. (Japanese yew). However, Hanula (1988) did not employ a control for each of the tested plant varieties except for _Taxus_. _Otiorynchus sulcatus_ from the Pacific Northwest appear to have a preference for strawberry, whereas little is known about the effect of host on the reproductive success of _O. ovatus_.
Becton Dickinson and Co., Franklin Lakes, New Jersey). On each collection date and host type, up to four dishes each with 25 eggs were prepared and maintained at 21 ± 0.5 °C for a maximum of 4 weeks. Eggs were examined for hatch every 3–4 days. The reported hatch is the mean of all samples per host type.

Four parameters that could be expressed as a mean were recorded: (i) adult survival (days); (ii) preoviposition time (days); (iii) fecundity; and (iv) egg viability (%). Some of the data for all parameters had zero to near zero occurrences and some proportions were very small. Therefore to adjust the data for normality, count data were transformed to the log e (x + 1) and proportion data were transformed to the arcsine (√x).

Thereupon, all data were submitted to general linear model analysis of variance (glm anova) (NCSS, 2004). After analysis, differences among means were examined with the Tukey–Kramer test (NCSS, 2004). Data are presented as original untransformed mean ± SE. Additional data presented include the proportion of individuals that oviposited from the 30 weevils tested on each host plant.

**Larval host plant study**

Host plants were obtained as liner (nursery stock) or transplants (strawberry) and potted in a black plastic nursery container (738 ml, McConkey and Co., Sumner, Washington) with the potting media, OBC North-west Nursery Mix #1 (OBC North-west, Inc., Canby, Oregon). Plants were allowed to establish in the pot for approximately 2 months. Once the plants were established (late July 2003), 20 eggs of *O. sulcatus* or 100 eggs of *O. ovatus* were placed in a shallow hole (approximately 35–50 mm deep) dug in the soil mix next to the plant, and then, refilled with the soil mix. There were 20 replicates (pots) of each weevil species/host plant combination. Once infested, the pots were allowed to grow in a greenhouse for 5 months. At that time, the pots were emptied and the soil and roots examined for larvae. Reported data are the number of larvae found and the proportion of larvae/eggs infested. Again, some counts were zero to near zero and some proportions were very small. Thus, data were transformed and analysed as described above. Additional data presented include the proportion of pots of the 20 per treatment where larvae established.

## Results

**Adult host plant study**

For *O. sulcatus*, there were significant differences among means for all of the measured parameters concerning the five selected host plants: survival (*F* = 8.50; d.f. = 4, 145; *P* < 0.01), preoviposition (*F* = 22.4; d.f. = 4, 84; *P* < 0.01), fecundity (eggs per female) (*F* = 27.65; d.f. = 4, 145; *P* < 0.01) and percent fertility (*F* = 8.93; d.f. = 4, 83; *P* < 0.01) (Table 1). The two conifers in were relatively poor hosts with limited survival time, long preoviposition times, few eggs and reduced fertility. *Taxus baccata* was a relatively good host, but not as good overall as *R. catawbiense* for which survival time was less and preoviposition time increased. *Rhododendron catawbiense* was not significantly different from strawberry as a host for survival, preoviposition and egg production. However, egg viability on *R. catawbiense* was less than on strawberry and similar to that obtained from eggs oviposited when fed *Taxus baccata*.

With *O. ovatus*, there were no significant host differences for preoviposition period (*F* = 1.47; d.f. = 3, 60; *P* = 0.23) or egg viability (*F* = 0.62; d.f. = 3, 50; *P* = 0.60) (Table 1). However, there were significant differences among host plants for adult survival (*F* = 5.49; d.f. = 4, 145; *P* < 0.01) and fecundity (*F* = 10.13; d.f. = 3, 60; *P* < 0.01) (Table 1). The only ‘host’ studied that did not qualify as a suitable host was *T. baccata*, on which no eggs were laid. The number of eggs produced on *R. catawbiense* was significantly less than

### Table 1 Survival and reproductive parameters (mean ± SE) for initially teneral adult *Otiorhynchus sulcatus* and *Otiorhynchus ovatus* when fed one of five host plants for up to 9 months

<table>
<thead>
<tr>
<th>Life parameter</th>
<th>Picea abies</th>
<th>Taxus baccata</th>
<th>Rhododendron catawbiense</th>
<th>Fragaria × ananassa</th>
<th>Picea glauca</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>‘Nidiformis’</td>
<td>‘Boursault’</td>
<td>‘Totem’</td>
<td>‘Conica’</td>
<td></td>
</tr>
<tr>
<td><strong>Otiorhynchus sulcatus</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Survival (days)</td>
<td>97.63 ± 19.02</td>
<td>150.63 ± 17.44</td>
<td>174.47 ± 15.95</td>
<td>215.07 ± 16.40</td>
<td>89.60 ± 12.44</td>
</tr>
<tr>
<td>Preoviposition (days)</td>
<td>109.13 ± 12.66</td>
<td>78.42 ± 11.63</td>
<td>69.12 ± 5.41</td>
<td>34.70 ± 1.31</td>
<td>111.69 ± 12.38</td>
</tr>
<tr>
<td>Fecundity (eggs/9)</td>
<td>41.67 ± 16.26</td>
<td>157.83 ± 39.99</td>
<td>267.00 ± 40.86</td>
<td>880.63 ± 132.51</td>
<td>7.20 ± 3.60</td>
</tr>
<tr>
<td>9/30 ovipositing</td>
<td>0.27</td>
<td>0.63</td>
<td>0.80</td>
<td>0.93</td>
<td>0.27</td>
</tr>
<tr>
<td>Egg viability (%)</td>
<td>47.34 ± 8.4</td>
<td>59.90 ± 5.20</td>
<td>63.83 ± 4.26</td>
<td>79.00 ± 2.52</td>
<td>26.55 ± 6.89</td>
</tr>
<tr>
<td><strong>Otiorhynchus ovatus</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Survival (days)</td>
<td>116.23 ± 16.35</td>
<td>35.60 ± 1.50</td>
<td>80.67 ± 9.00</td>
<td>138.09 ± 18.31</td>
<td>77.20 ± 11.29</td>
</tr>
<tr>
<td>Preoviposition (days)</td>
<td>51.19 ± 10.54</td>
<td>0.00 ± 0.00</td>
<td>46.06 ± 8.01</td>
<td>31.38 ± 1.65</td>
<td>41.43 ± 7.26</td>
</tr>
<tr>
<td>Fecundity (eggs/9)</td>
<td>163.06 ± 23.97</td>
<td>0.00 ± 0.00</td>
<td>72.18 ± 14.08</td>
<td>474.29 ± 89.58</td>
<td>75.86 ± 21.75</td>
</tr>
<tr>
<td>9/30 ovipositing</td>
<td>0.53</td>
<td>0.00</td>
<td>0.57</td>
<td>0.80</td>
<td>0.23</td>
</tr>
<tr>
<td>Egg viability (%)</td>
<td>82.78 ± 1.84</td>
<td>0.00 ± 0.00</td>
<td>86.13 ± 1.57</td>
<td>86.30 ± 1.36</td>
<td>83.40 ± 4.45</td>
</tr>
</tbody>
</table>

Means followed by the same letter within a row are not significantly different from each other, Tukey–Kramer test, *P* < 0.05.

*T. baccata* data not included in the ANOVA because no eggs were oviposited.
the number produced on strawberry (15%) but adult survival was nearly the same as when fed strawberry. *Picea abies* appeared to be nearly as good a host as *F. × ananassa* with similar survival, preoviposition, egg production and egg viability.

Of the five selected hosts for the two weevil species (*O. sulcatus* and *O. ovatus*), strawberry (*F. × ananassa*) produced the longest adult survival, shortest preoviposition time, the greatest number of eggs laid and the highest egg viability (Table 1). Even so, *O. sulcatus* produced more than 1.8-fold the number of eggs on *F. × ananassa* compared with *O. ovatus*. In comparison, *O. ovatus* produced nearly four-fold as many eggs as *O. sulcatus* when *P. abies* was the sole host. *Picea glauca* was the poorest host for *O. sulcatus* but appeared to be a mediocre to good host for *O. ovatus*. Both species appeared to find *R. catawbiense* a relatively good host (Table 1).

**Larval host plant study**

There were significant differences in larval establishment among the five host plants: *O. sulcatus* (*F* = 14.28; d.f. = 4, 95; *P* < 0.01); *O. ovatus* (*F* = 8.22; d.f. = 4, 95; *P* < 0.01) (Fig. 1). Similarly, for both weevil species, there were significant differences in the proportion of larvae recovered among the five host plants: *O. sulcatus* (*F* = 13.97; d.f. = 4, 95; *P* < 0.01); *O. ovatus* (*F* = 7.77; d.f. = 4, 95; *P* < 0.01). *Fragaria × ananassa* was the best host for larval establishment by either species (Figs 1 and 2). At least one larva was recovered in 80% of the pots infested with each species (Table 2). With *O. sulcatus*, *R. catawbiense* was a poor host for larval establishment; larvae were recovered in only 5% of the egg infested pots (Figs 1 and 2; Table 2). With *O. ovatus*, *R. catawbiense* also was a poor larval host with larvae being found in only 35% of the pots (Figs 1 and 2; Table 2). *Taxus baccata* was clearly a nonhost for *O. ovatus* with no larvae recovered from the infested pots. Both *T. baccata* and *P. glauca* were relatively poor hosts for *O. sulcatus* with larvae found in only 40% of the pots infested. The number of larvae of *O. ovatus* found on *P. abies* and *P. glauca* was greater than the number of *O. sulcatus* larvae. Even though both otiorhynchids had the best establishment on *F. × ananassa*, *O. ovatus* had the greatest survival on *P. glauca* with *P. abies* and *F. × ananassa* secondary. For *O. sulcatus*, the best survival was on *F. × ananassa* with *P. abies* being the next best larval host.

**Discussion**

Numerous studies have investigated the host preferences of *O. sulcatus*. Only a few studies have investigated the host plant range of *O. ovatus*, but it is nearly as broad as *O. sulcatus*. Much of the available literature on either species has considered a plant as a host when adult weevils have been observed feeding on the foliage or if larvae feed when confined on some roots. Pedigo (1999) defined a host in the glossary as ‘a plant on which an insect feeds’. This appears to be the context that describes many of the previously described ‘hosts’ of the two *Otiorhynchus* species discussed here. However, Pedigo (1999: 437) also clarifies his definition of host plant as: ‘If nutrients are adequate and no toxicity occurs, the insect completes development within a normal time period and becomes an adult. Also sufficiency is indicated in normal adult longevity and fecundity’. This is a more appropriate definition for this discussion.

Of the many refereed publications that mention host plants for *O. sulcatus*, only three genera of gymnosperms, other than *Taxus*, have been noted as adult host plants, *Chamaecyparis*, *Thuja* and *Tsuga* (Smith, 1932; Maier, 1981; Maier, 1986). The proclivity of larvae for *Taxus* is well documented (Smith, 1932; Schanks, 1980; Maier, 1981; Nielsen & Dunlap, 1981; Hanula, 1988; Van Tol et al., 2004). Van Tol et al. (2004) included species of *Thuja* and *Taxus* from the
gymnosperms among numerous species of angiosperms in their studies of adult longevity and reproductive performance. The authors concluded that *Taxus* was the only gymnosperm in Europe qualifying as a true host plant and that determination of host plants from studies using only feeding tests gives an overestimation of true host plant range.

In Western North America, *O. sulcatus* is not only a pest of rhododendron, *Taxus* spp., strawberry, other members of the Rosaceae and numerous other angiosperms, but also nursery growers continually report economic damage by larvae to many members of the gymnosperm family Pinaceae. Indeed, some studies note that *O. sulcatus* feeds on members of the Pinaceae (Cowles, 1995; Cowles et al., 1997). In Japan, Masaki et al. (1984) found that there was slight damage to *Pinus thunbergii* as a result of adult feeding. However, the ability of these plants to sustain *O. sulcatus* larvae or adults has not been documented. The present study clearly demonstrates that genera of the Pinaceae, particularly *Picea* spp., can be viable hosts for *O. sulcatus*, particularly for larvae.

When the previous studies on host plants and reproductive performance of *O. sulcatus* are considered together with the findings of the present study, there appear to be differences between different areas of origin (i.e. Europe, Eastern U.S.A. and Western U.S.A.). In Europe, *Taxus* spp. appear to be the only viable gymnosperm hosts for adults on which reproductive maturation occurs (Van Tol et al., 2004). The presence of terpenes, which may be feeding deterrents, are the probable reason that they do not feed on other gymnosperms (Van Tol et al., 2004). However, Van Tol et al. (2004) only allowed feeding on their chosen hosts for 52 days from adult emergence. In the present study, when the adults were fed *Picea* spp., the preoviposition period was greater than 100 days. In other studies with less favourable plants such as *Cornus florida*, *Kalmia latifolia* and *R. smirnowii* (Maier, 1981; Nielsen & Dunlap, 1981), the preoviposition period was longer than 50 days. It is possible that Van Tol et al. (2004) did not allow enough time for preovipositional maturation, although they did not list preovipositional times in their study. In both the Eastern U.S.A. and in Europe, *O. sulcatus* appears to feed primarily on a number of angiosperms belonging to the plant orders Rosales, Primulales, Saxifragales and, to a lesser extent, the Ericales. In several studies, strawberry was not found to be the favoured host (Smith, 1932; Maier, 1981; Nielsen & Dunlap, 1981; Hanula, 1988; Van Tol et al., 2004). However, recent studies in Connecticut (Cowles, 2004), Scotland (Watt et al., 1999; Graham et al., 2002) and Norway (Hesjedal, 1984) note that *O. sulcatus* has been a very important pest of strawberries. In Western North America, *O. sulcatus* appears to favour certain Rosales (i.e. strawberry, blackberries and raspberries), Ericales (i.e. certain rhododendrons), blueberries and salal, and members of the gymnosperm families, Taxaceae and Pinaceae. Studies by Cram (1965) and Shanks (1980) have shown that certain species of *Fragaria* are superior for egg production compared with other plants. Furthermore, Shanks (1980) found that, when larvae from Washington or Ohio were allowed to feed on strawberry or yew, strawberry produced more survivors to the adult stage. The present study also found strawberry to be a superior host. Also, *R. catawbiense* was a better adult host for *O. sulcatus* than *Taxus baccata* or *Picea* spp. As a larval host for *O. sulcatus*, *F. × ananassa* was superior, *P. abies* was mediocre and *Taxus* was poor. However, *R. catawbiense* was the poorest larval host for *O. sulcatus*. Even though this species is of central European origin (Van Tol et al., 2004), it may be adapting to the crops in areas where they have colonized. Alternatively, with the worldwide movement of nursery plant material over the past several centuries, this species has probably been introduced to its respective areas of occurrence many different times. This suggests that further studies should consider biological and genetic comparisons of populations of *O. sulcatus* from different areas of the same continent and throughout the world.

Contrary to *O. sulcatus*, *O. ovatus* is known to damage a number of families in the plant order Coniferales (McDaniel, 1930; Whitecomb, 1931; Wilcox et al., 1934; Gambrell, 1938; Warner & Negley, 1976; Brandt et al., 1995). Whitecomb (1931) claimed that *O. ovatus* was a pest of Japanese yew, *T. cuspidata*, in North-eastern U.S.A. In the present study, *Taxus* spp. would not qualify as a viable larval or adult host. Unlike *O. sulcatus*, host plants other than yew did not affect preovipositional maturation time. Treherne (1914) and Wilcox et al. (1934) gave the preovipositional period for *O. ovatus* as 8–33 days. However, these authors used field-collected weevils that were fed strawberry. Brandt et al. (1995) used teneral adults that were fed leaves of *Picea* spp. resulting in a preovipositional period of 30–33 days. This would be within the range found on all host plants in the present study. Furthermore, this would suggest that *O. ovatus* may not be as dependent as *O. sulcatus* on nutrients derived from strawberry or rhododendron, and that some gymnosperms may provide enough nutrition for ovarian maturation. Longevity or survival of *O. ovatus* adults in the present study was longest on strawberry (approximately 138 days) and was significantly shorter on *P. glauca* and *R. catawbiense*. Treherne (1914) reported the minimum longevity on strawberry was 62.5 days from field-collected adults. Brandt et al. (1995) reported longevity approximated 71 days when teneral adults were fed *Picea* spp. and kept at 20 °C. It is apparent

### Table 2

<table>
<thead>
<tr>
<th>Species of weevil</th>
<th><em>Picea abies</em></th>
<th><em>Taxus baccata</em></th>
<th><em>Rhododendron catawbiense</em></th>
<th><em>Fragaria × ananassa</em></th>
<th><em>Picea glauca</em></th>
</tr>
</thead>
<tbody>
<tr>
<td><em>O. sulcatus</em></td>
<td>0.70</td>
<td>0.40</td>
<td>0.05</td>
<td>0.80</td>
<td>0.40</td>
</tr>
<tr>
<td><em>O. ovatus</em></td>
<td>0.50</td>
<td>0.00</td>
<td>0.35</td>
<td>0.80</td>
<td>0.60</td>
</tr>
</tbody>
</table>
that the host plant does affect adult survivorship. Egg viability on all of the host plants, except Taxus on which no eggs were laid, was not significant and approximated 80–90%. Brandt et al. (1995) found a viability of 78% from adults fed Picea spp. Treherne (1914) found an approximate 80% viability when fed strawberry and Emenegger & Berry (1978) found an approximate 80% viability when fed peppermint (Mentha × piperita). It is apparent that adult host plant does not affect egg viability.

The present study is the first to detail larval host suitability of O. ovatus. Taxus baccata was clearly a nonhost. P. glauca produced the most larvae and the greatest proportion of larval recovered. Fragraia × ananassa and P. abies produced fewer larvae than P. glauca but were similar statistically. Rhododendron appeared to be a poor host. This suggests that the larval host range in the present study is similar to that of O. sulcatus, except for Taxus.

When all of the studies on these two pests are considered together, O. sulcatus appears to have varying host preferences from among its many geographical areas of occurrence, whereas O. ovatus has a more universal host selection. In North America, the occurrence of O. sulcatus is divided and isolated between the East and the West of the continent. The difference in host preferences could be due to local adaptation and/or this could be the result of many reintroductions by human shipment of nursery stock within North American regions and from many different areas of the world. Further studies with O. sulcatus should consider biological and genetic comparative studies among geographical areas. Further studies with O. ovatus should consider expanding the knowledge of larval and adult hosts.

Acknowledgements

I gratefully acknowledge the technical expertise of David Edwards, Biological Laboratory Technician, USDA, ARS, HCRL, for rearing the weevils and assisting with these studies. I also thank Denny Bruck, USDA, ARS, and Glenn Fisher, Oregon State University, for earlier reviews of the manuscript and their critical input. The resources for these studies were provided by the USDA, ARS, Horticultural Crops Research Laboratory and funds provided by USDA, CRIS # 5538-22000-032-00D.

References


Maier, C.T. (1986) Relative abundance of adults of Callirhopalus bifasciatus (Roelofs) and three Otiorhynchus spp. (Coleoptera:


Treherne, R.C. (1914) *The Strawberry Root Weevil (Otiorhynchus ovatus Linn.) in British Columbia With Notes on Other Insects Attacking Strawberry Plants in the Lower Fraser Valley*. Dominion of Canada Department of Agriculture, Experimental Farms, Division of Entomology, Entomological Bulletin 3. Department of Agriculture, Canada.


Accepted 2 June 2006

First published online 13 September 2006