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Lygus Bugs: A Worldwide Problem in Conifer Nurseries

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SUMMARY

Lygus lineolaris (Palisot de Beauvois), Lygus hesperus (Knight) and Lygus rugulipennis (Poppius) can cause multiple-leaders to form on conifer seedlings. Injury due to Lygus bugs has increased during the last two decades to the point where these bugs are now considered the worst insect pest at many conifer nurseries. At several nurseries, Lygus bugs have injured 30% or more of the seedlings. Substantial injury has occurred in the United States, Canada, Europe, and the United Kingdom. Similar injury in other regions of the world (i.e. New Zealand) might also be attributed to Lygus or related species. It is hypothesized that the rise in injury results from a cessation in the use of mineral spirits (also known as white spirits or mineral oils) that were frequently applied to control weeds in seedbeds.

INTRODUCTION

Insects in the Lygus complex¹ occur throughout the world and can be found in North and South America, the United Kingdom, Europe, Africa, India, Russia, China, Japan, Hawaii, Australia, Fiji, and New Zealand (Graham et al. 1984; Wise 1977). It has been known for many years that various insects in this group can injure tree seedlings (Haseman 1918; Graham 1929; Forslund 1936; Francke-Grosmann 1962). Members of the Lygus genus can injure both hardwoods (Haseman 1918; Sapio et al. 1982) and conifers. Several species of Lygus occur in Europe and Asia and more than 30 species can be found in North America (Kelton 1975).

When Lygus injures conifer seedlings, there is usually a distinctive growth distortion at the terminal. Feeding at the terminal leads usually results in a loss of apical dominance. This leads to the formation of multiple-leaders (sometimes referred to as "bushy-tops" in the United Kingdom and United States, "cabbage heading" in Canada, and "brooming" in Czechoslovakia). Within a

¹ For many years, the genus Lygus (family Miridae) contained a number of subgenera (i.e. Orthops, Lygocoris, Agnocoris, Stechus, Neolygus, Apolygus, and Taylorilygus) (Kelton 1975). However, since 1940, many of the subgenera have been raised to generic status. As a result, the number of species in Lygus has been greatly reduced. For the purposes of this paper, the term "Lygus" refers to species in the current genus and the term "Lygus complex" refers to all genera that were at one time classified as Lygus.

week of injury, growth of newly emerging needles is distorted: they are shorter, thicker, and appear to be affected by a chemical or growth hormone. On some seedlings (e.g. 20%), a brown lesion forms on the main stem just below the dead terminal. Overhulser and Kanaskie (1989) have provided color photographs of the insect and associated damage to Pseudotsuga menziesii (Mirb.) Franco. However, reports of injury in conifer nurseries were not common until after the 1970s (Table 1). Either the injury was often misdiagnosed, or the frequency of injury has increased for some reason.

MISDIAGNOSIS

Correct identification of the pest is the first vital step in a nursery pest management program (Sutherland and van Eerden 1980). However, due to the habits of these insects, injury from Lygus bugs is often misdiagnosed. Since these insects are very mobile, they are seldom found on the seedlings when the symptoms appear. During dry spells, they are apparently attracted by the presence of succulent plants that have been fertilized and irrigated (Adkisson 1957). Within a few days, they can move onto nurserybeds, feed, and exit onto adjacent areas that contain alternate hosts. When present in the seedbeds, they seem to be most active during the early morning and can be difficult to find during the afternoon. Since it is difficult to associate the injury with the presence of Lygus bugs, the injury is often blamed on other agents.

Explanations for the cause of the multiple-leadering have ranged from herbicide injury, frosts, viruses, genetics, disease, air pollution, "juvenile instability," nutrient deficiencies, and other insects. In the southern United States, use of the herbicide oxyfluorfen was suspected to cause injury (even though the same herbicide was used at nurseries where no injury was noted). Some thought that multiple-leaders were the result of boron deficiencies (Ray and Vanner 1988; Raitio 1983). In Finland, a virus was thought to be involved (Soikkeli 1985).

In more northern climates, injury from frost damage was suggested as the major reason for multiple-leaders (Raitio 1985; Hofstra et al. 1988). However, Holopainen (1990a) demonstrated that cold temperature alone would not cause an increase in multiple-leaders of Pinus sylvestris L. In the United States, multiple-leaders occur on 1-0 seedlings prior to any frost damage.

Some thought the injury was due to insects that could be readily found in the seedbeds. Springtails (Bourletiella hortensis) were common and were thought to cause multiple-leadered seedlings in the United Kingdom (Bevan 1965; Aldhous 1972) and Canada. However, after conducting several studies, it was concluded that springtails do not cause multiple-leaders in Canada (Marshall and Ilnytsky 1976; Sutherland and van Eerden 1980; Webb and Reese 1984). In the southern United States, several species of thrips (Frankliniella tritici, F. fusca, Sericothrips variabilis, Anoplothrips obscurus) were suspected to cause injury since they were 300 to 500 times more abundant than Lygus lineolaris (Oak 1987a). However, these species of thrips failed to produce multiple-leadering in caging studies (Oak 1987b). Thrips (Thrips tabaci Lindeman) are also suspected of causing multiple-leadering of Pinus radiata D. Don in New Zealand and Chile (Ray and Vanner 1988). When the cause of multiple-leadering is not known, it is understandable that most guesses as to the causal agent will be wrong.

INCREASED FREQUENCY OF INJURY

There has been a simultaneous increase in multiple-leadering in forest nurseries throughout the world [the percentage of seedlings with multiple-leaders can often be quite high (Table 2)]. It is possible that the increase in injury is a result of natural cycles or adaptation by the Lygus bugs. However, the increase is more likely due to a major change in the way weeds are controlled in conifer nurseries.

During the 1950s, managers throughout the world began to control weeds in conifer nurseries by applying mineral spirits (a petroleum oil also known as white spirits and sold under various trade names such as Varsol²; Stoddard solvent; Shell AWK). Although used as a herbicide, mineral spirits also have insecticidal properties (Marshall and Ilnytsky 1976). Applications to conifers was a common practice in Canada, United Kingdom, United States, South Africa, Australia, and New Zealand. However, during the 1970s, the price of oil greatly increased and as a result, the use of mineral spirits declined. In 1975, almost all nurseries in the southern United States were still using mineral spirits, but most had ceased its use by 1984 (South 1987). It was during the 1970s and 1980s when the reports of multiple-leadering increased. At one nursery in New Zealand, the incidence of multiple-leadered seedlings was said to decrease when use of mineral spirits was resumed (Ray and Vanner 1988).

The herbicidal activity of mineral spirits depends on its aromatic content; most brands used by nursery managers had an aromatic content of 10 to 25%. Therefore, the application of mineral spirits may have reduced insect injury by acting as an insect repellent. Although petroleum oils can be used as insecticides, it is likely that any direct contact activity of mineral spirits on insects would be ephemeral (Marshall and Ilnytsky 1976). However, the smell from treated seedlings lasts for several days and could have kept Lygus bugs away from the nurserybeds. If this were the case, then weekly applications would have provided better protection than monthly applications. Of course, if initiated after the injury had occurred on newly germinated seedlings, even weekly applications would not prevent multiple-leadering.

OBSERVATIONS FROM THE SOUTHERN UNITED STATES

Multiple-leadering of pines was not considered a problem in southern nurseries prior to 1982 (Wakeley 1954; South 1986). In 1982, Bill Rayfield at the Coosa Nursery in Alabama reported 4% multiple-leadering (mineral spirits were last used at this nursery in 1978). Similar injury symptoms were recognized at other nurseries in 1983. However, it took several years before the cause of the injury was determined. Numerous guesses as to the causal agent were made. Finally, a report from Canada (Shrimpton 1985) indicated that Lygus lineolaris could cause multiple-leadering of pines. Although this species could easily be found on adjacent fields in southern pine nurseries, initial searches failed to find them on the seedlings. Finally, on June 20, 1985, both instars and adults were observed by Rick Brooks and Dr. Charles Davey on young Pinus taeda L. germinants at the Hopewell Nursery in Virginia. These reports along with caging studies (South 1986) convinced the author that Lygus lineolaris was the causal agent.

² Use of trade or corporation names is for the reader's information and convenience. Such use does not constitute official endorsement by Auburn University of any product or service to the exclusion of others that may be suitable.

In 1987, the Auburn University Southern Forest Nursery Management Cooperative installed monitoring studies at five nurseries to determine if (1) Lygus bugs could be trapped in Pinus taeda seedbeds, and (2) if there was a relationship between injury and the occurrence of Lygus bugs. Nurseries selected were the Stauffer Nursery and Coosa Nursery in Alabama, the Carters Nursery in Georgia, the Piedmont Nursery in South Carolina, and the New Kent Nursery in Virginia (all five nurseries had ceased use of mineral spirits between 1977 and 1982). Twelve white traps (Rebell^R) were placed throughout each nursery (each location was usually greater than 15 m from the end of the nurserybed and at least 15 m from an adjacent cover-crop or fallow field). Each trap was positioned in a seedbed and was hung from a bent piece of rebar so the bottom of the trap would be about 30 cm from the ground. The number of Lygus bugs were usually recorded on Monday, Wednesday and Friday. Once a week, the traps were cleaned with mineral spirits and retreated with Tangle-trap^R. The cumulative number of Lygus bugs caught per trap was determined for each nursery (Figure 1). Seedling injury at all five nurseries began to appear at the end of May and the first week of June.

The cumulative number of bugs trapped by the first week of June was plotted against the amount of seedling injury present in July. The Piedmont Nursery trapped the most insects (34 Lygus/trap) and had the highest injury (Figure 2).

Although trapping may appear to be useful in determining when to begin spraying, it has a major limitation. For example, at the New Kent Nursery, no Lygus were trapped up to and including May 31; during the next two-day period, an average of 2.5 Lygus/trap were caught. A spraying program initiated after scouting on June 2 would only have protected the crop from future injuries. A substantial amount of damage would already have been caused. If only 4% of a crop of 30 million seedlings were culled due to multiple-leaders, a loss of \$36,000 could result. Therefore, most nursery managers that have experienced injury from Lygus bugs usually spray prophylactically with an insecticide (e.g. fenvalerate).

Instead of installing traps, some managers may choose to monitor preferred weed hosts each morning for the presence of Lygus bugs. At nurseries with a high percentage of multiple-leadering, a spraying program should begin if just one Lygus bug is found during crop germination. The host plants to monitor will vary with season and region. In the southern United States, cutleaf evening-primrose (Oenothera laciniata Hill) is suggested while common groundsel (Senecio vulgaris L.) might be used at more northerly nurseries (Holopainen 1989a).

Thus far, Pinus taeda nurseries with substantial Lygus injury have been east of the Mississippi River. Although nurseries west of the river use the same management practices, the percentage of multiple-leadered seedlings is usually less than 0.1 percent. Even though the western nurseries are within the range of Lygus lineolaris, the population levels are apparently not as high as in the east.

OBSERVATIONS FROM OREGON

After nursery managers in the Willamette Valley ceased applying mineral spirits in the 1970s, they began to notice an increase in deformed terminal growth during the 1-0 year. Seedlings with multiple-leaders formed during the 2-0 year. Several studies were initiated during 1983 and 1984

to determine if an insect was causing the problem. Tests were conducted in three conifer nurseries (Weyerhaeuser's Aurora Nursery, the United States Forest Service Nursery at Medford, and the D.L. Phipps Nursery at Elkton). These studies found that Lygus hesperus was causing apical bud abortion in 1-0 and 2-0 Pseudotsuga menziesii seedlings (Schowalter et al. 1986; Overhulser et al. 1986). Detailed reports on the habits of this pest in Oregon nurseries have been made (Schowalter 1987; Schowalter and Stein 1987).

OBSERVATIONS FROM CANADA

Multiple-leadering of conifer seedlings occurs throughout Canada (Hofstra et al. 1988) and was recorded in Ontario nurseries as early as 1957. In some cases, the percentage of seedlings with multiple-leaders has exceeded 50%. Therefore, numerous studies have been conducted on the multiple-leadering problem (Vaartaja et al. 1964; Gross, 1982, 1983, 1985; Webb and Reese, 1984). Apparently, two types of injury can result in multiple-leaders: (1) damage from frost or over-winter desiccation of buds; and (2) abnormal development of the apical bud (Webb and Reese 1984; Hofstra et al. 1988). The terms "Reese syndrome" and "cabbage heading" were coined to describe injury of the second type (Vaartaja et al. 1964; Webb and Reese 1984). Although the initial studies by Gross concluded that springtails were not the problem, they did not eliminate Lygus as the causal agent.

In 1983, notable damage from Lygus lineolaris occurred at several nurseries in British Columbia (Shrimpton 1985). However, this species is found from Alaska to Mexico, and from the Queen Charlotte Islands to Newfoundland (Kelton 1975). Therefore, it is likely that much of the abnormal bud development observed in other Canadian nurseries (Hofstra et al. 1988), is also caused by this species.

OBSERVATIONS FROM SCANDINAVIA

Lygus bugs have injured conifers in Finland (Holopainen 1990b), Sweden (personal communication; Bernt Arvidsson), and Iceland (personal communication; Liseolotte Beyer-Ericson). In Finland, abnormal bud development of conifer seedlings is very important since Section 13 of the Forest Regeneration Material Trade Act (No. 684/1979) states that seedlings with multiple-leaders do not meet the quality standards and therefore cannot be sold (Puttonen 1986). This results in a great economic loss since in 1984 a high percentage of Pinus sylvestris seedlings had to be culled because of multiple-leaders. At one nursery, over 80% of the 2+1 seedlings had damaged buds (Holopainen and Rikala 1990).

Initially, it was suggested that nutrient deficiencies, frost damage and viruses were causing the problem (Raitio 1983, Raitio 1985, Soikkeli 1985). However, it was determined that Lygus rugulipennis was the causal agent (Holopainen 1986). Another species [Lygus punctatus (Zett.)] was also collected from conifer seedlings but it was present in much lower numbers.

Several studies in Finland suggest that much of the multiple-leader damage on pine seedlings could be due to Lygus feeding rather than to frost injury (Rikala and Rpon 1987; Holopainen 1988, 1990a, 1990b). Although multiple-leadering might result from growth hormones present in the saliva (see numerous citations in Graham et al. 1984), it has been suggested that the effect is simply due to the mechanical damage caused by the bug's stylet (Holopainen 1986; 1990a).

Using netting to cover the seedbeds has become a routine practice (Holopainen 1990b). The percentage of multiple-leadering can be reduced from 50 to 90% in uncovered seedbeds to 10 to 30% in covered seedbeds (Poteri et al. 1987).

OBSERVATIONS FROM THE UNITED KINGDOM

Although a common insect, there is no current literature from the United Kingdom regarding injury to conifers from Lygus rugulipennis. However, on a visit in September of 1988, the author observed Lygus rugulipennis on conifer seedlings at three nurseries (Tilhill Nursery at Tilford; EFG Nursery in Whitchurch; and the Forestry Commission's Nursery at Newton). In June of 1989, Lygus was also noted at the Forestry Commission's Research Nursery at Roslin. The symptoms appeared identical to injury caused by the same species in Finland (Holopainen 1986). Although "bushy-top" seedlings in the United Kingdom are assumed to be the result of springtail injury (Bevan 1965; Aldhous 1972), this author is confident that caging studies will prove the injury results from Lygus rugulipennis.

OBSERVATIONS FROM NEW ZEALAND

Multiple-leaders have been observed on Pinus radiata seedlings in the nursery (Burdon and Bannister 1973; Ray and Vanner 1988). In some nurseries, as much as 23% of the seedlings had multiple-leaders. Like other regions of the world, injury was initially thought to be related to other factors such as nutrient deficiencies. Since no single factor was easily found, Burdon and Bannister (1973) attributed the formation of multiple-leaders to "unstable" juvenile growth. However, it is now realized that the occurrence of multiple-leaders can be reduced with frequent applications of insecticides (Ray and Vanner 1988).

Although thrips (Thrips tabaci) can cause needle crinkling of Pinus radiata seedlings, it was assumed they were also the cause of multiple-leaders (Ray and Vanner 1988). Since three members of the Lygus complex [Lygus buchmanii Poppius; Lygus maoricus (Walker); Lygus plebejus Reuter] occur in New Zealand (Wise 1977), it is possible multiple-leaders were caused by one of these species at the same time that thrips were causing needle crinkling. Therefore, caging studies could determine if multiple-leaders of Pinus radiata are caused by thrips or by a member of the Lygus complex.

INSECTICIDES

Numerous insecticides have been tested against Lygus bugs in agronomic crops (Graham et al. 1984). Some of the more promising ones have been used in conifer seedbeds in hopes of reducing the occurrence of multiple-leadering (Table 3). Although a number of insecticides may be used on pine seedlings (Bacon and South 1989), the synthetic pyrethroids (fenvalerate and cypermethrin) have proven effective if applied at the correct time. It has been suggested that these insecticides may have a repellent effect on Lygus (Holopainen 1989b). Multiple insecticide applications are recommended, not only because Lygus bugs have several generations per year, but because it is important to apply the insecticide before the insects have an opportunity to cause damage. The frequency of insecticide application is directly related to the reduction in damage (Overhulser et al. 1987). Although trapping can be used to monitor population levels in

the nursery, its usefulness as an aid in determining when to begin spraying is limited. This is because these insects only need a limited amount of time in order to enter an unprotected nursery and cause a substantial amount of injury. Therefore, to minimize the occurrence of multiple-leaders, prophylactic applications on a weekly (Bryan 1989) or bi-weekly (Overhulser et al. 1987; Ray and Vanner 1988) basis may be required in regions where warm temperatures promote chemical degradation. For best results, applications should be made during the early morning when the insects are the least active.

FIELD PERFORMANCE

There is general disagreement regarding the long-term growth effects of outplanting seedlings with multiple-leaders. Due to governmental regulations, some say that presence of multiple-leaders is unacceptable (Holopainen 1986). There is concern (whether justified or not) that height growth of outplanted seedlings would be reduced. Seedlings with single-leaders might be better suited to outgrow competing weeds (Rikala 1985; Holopainen 1990b).

On the other hand there are data to show that, independent of differences in initial seedling size, multiple-leadering has no effect on subsequent field growth (Burdon and Bannister 1973; Minko 1974; Gross 1985; Kaunisto and Kinnunen 1985). Apparently, the concern is mostly with visual appearance instead of documented reductions in field performance.

CONCLUSIONS

Although Lygus bugs have been known to cause injury to tree seedlings for more than 70 years, they were not considered a major pest in conifer nurseries until after the 1980s, when they rose quickly from a level of obscurity to the status of a major pest. The frequency of reported injury has increased greatly since the decline in use of mineral spirits.

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Table 1. Conifer species affected by Lygus spp.

Species	Reference
<i>Larix occidentalis</i> Nutt.	personal observation; G. Shrimpton
<i>Picea englemannii</i> (Parry) Engelm.	personal observation; G. Shrimpton
<i>Picea glauca</i> (Moench) Voss	Shrimpton 1985
<i>Picea sitchensis</i> (Bong.) Carr.	personal observation; D.B. South
<i>Pinus elliotii</i> Engelm.	personal observation; D.B. South
<i>Pinus clausa</i> (Chapm.) Vasey	personal observation; D.B. South
<i>Pinus contorta</i> Dougl.	Shrimpton 1985
<i>Pinus palustris</i> Mill.	personal observation; D.B. South
<i>Pinus ponderosa</i> Laws.	personal observation; G. Shrimpton
<i>Pinus sylvestris</i> L.	Holopainen 1986
<i>Pinus taeda</i> L.	South 1986; Bryan 1989
<i>Pinus virginiana</i> Mill.	personal observation; D.B. South
<i>Pseudotsuga menziesii</i> (Mirb.) Franco	Shrimpton 1985; Schowalter et al. 1986
<i>Thuja plicata</i> Donn	personal observation; G. Shrimpton

Table 2. Examples of the percentage of conifer seedlings with multiple-leaders.

Nursery	Location	Year	Injury %	Reference
?	United Kingdom	1959-60	35	Bevan 1965
Coosa	Alabama	1982	4	personal observation
Surrey	British Columbia	1982	11	Hofstra et al. 1988
Midhurst	Ontario	1982	30	Hofstra et al. 1988
Prince Albert	Saskatchewan	1982	29	Hofstra et al. 1988
Aurora	Oregon	1983	14	Overhulser et al. 1986
New Kent	Virginia	1984	10	personal observation
Suonenjoki	Finland	1984	65	Holopainen 1986
Phipps	Oregon	1984	33	Overhulser et al. 1986
Piedmont	South Carolina	1984	40	Cantrell 1989
New Kent	Virginia	1984	10	personal observation
Rotorua	New Zealand	1985	23	Ray and Vanner 1988
Phipps	Oregon	1985	62	Overhulser et al. 1986
Carters	Georgia	1986	17	Bryan 1989

Table 3. Insecticides that have reduced the occurrence of multiple-leadering of conifer seedlings.

Insecticide	Species	Reference
acephate	<i>Pseudotsuga menziesii</i>	Overhulser et al. 1986
cypermethrin	<i>Pinus sylvestris</i>	Holopainen 1989b
deltamethrin	<i>Pinus radiata</i>	Ray and Vanner 1988
dimethoate	<i>Pinus taeda</i>	Bryan 1989
endosulfan	<i>Pseudotsuga menziesii</i>	Overhulser et al. 1986
fenitrothion	<i>Pinus radiata</i>	Ray and Vanner 1988
fenvalerate	<i>Pseudotsuga menziesii</i>	Overhulser et al. 1986
oxydemethon-methyl	<i>Pinus sylvestris</i>	Holopainen 1989b

Figure 1. Recorded trapping of *Lygus* at five southern pine nurseries during the spring of 1987 (AL-1 = Stauffer Nursery; AL-2 = Coosa Nursery; GA = Carters Nursery; SC = Piedmont Nursery; VA = New Kent Nursery).

Figure 2. The relationship between number of *Lygus* trapped by June 2 and the percent of seedlings exhibiting injury in July of 1987.