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Effects of Norway Spruce (*Picea abies*) Stump Debarking on Insect Colonization in the Polish Sudety Mountains

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This study aimed to determine whether debarking of Norway spruce stumps influences the intensity of their colonization by insects. The observed stumps of Picea abies *(L.) H Karst were located in the eastern Sudety Mountains at elevations between 600 and 1000 meters above sea level (masl) on clear-cut areas where large-diameter timber and small logging slash had been harvested. In total, 720 fresh (up to 12 months old)* P. abies *stumps were investigated, of which half were debarked immediately after tree felling. Insects were collected from 0.5 m^2 bark samples taken from coarse roots around the stump base and then identified with regard to family, genus, and species.* P. abies *stumps were colonized by insects from 18 families from 2 orders: Coleoptera and Diptera. Coleopterans were most frequently represented by the families Cerambycidae (52% of all collected insects) and Curculionidae (41%), including the subfamily Scolytinae (15%). Approximately 1.5% of all insects collected were classified as Diptera. Overall, approximately 40% greater insect colonization was observed in the bark samples collected from debarked* P. abies *stumps. The debarking treatment increased the intensity of stump colonization by both Cerambycidae and Scolytinae but had no effect on colonization by Curculionidae (excluding Scolytinae). These results suggest that debarking Norway spruce stumps does not reduce insect colonization and could be avoided in forest management.*

Keywords: Picea abies*; stump debarking; insect assemblages; Coleoptera; generalized linear model; Poland.*

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Introduction

Tree stumps and their roots provide shelter and habitat for feeding and breeding to a range of insect species. Stumps of felled conifers are specifically chosen for their development by numerous insect species commonly considered to be harmful to forest health. The insects are attracted by volatile emanations from the fresh resin (Nordlander et al 1997; Byers 2004; Schlyter 2004). Debarking of the aboveground basal part of stumps (hereafter referred to as stump debarking) immediately after tree felling was first recommended in Germany at the end of the 19th century (Elton et al 1964) as a method for reducing insect pest populations in Scots pine *Pinus silvestris* (L.) stumps. It was believed that such a treatment would prevent stump colonization by cambiophage beetles and promote wood drying, making stumps unattractive for insects. At that time, it was reported that debarking of the aboveground parts of Scots pine stumps reduced populations of large pine weevils (*Hylobius abietis* [L.]) by preventing them from developing in the roots of these stumps. Debarking resulted in a lower number of weevils and less damage caused by *H. abietis* beetles feeding in reforested areas. This was confirmed by results obtained in Belgium and the Netherlands at the beginning of the 20th century, providing evidence that debarking led to pine stump dryness, followed by increased mortality of large pine weevil larvae in the stumps (Scheidter 1915).

In the first half of the 20th century, Scots pine stump debarking to reduce large pine weevil colonization was commonly applied in a number of European countries, including the Netherlands, France, Estonia, Russia, and Poland (Brammanis 1930; Butovitsch 1931; Ossowski 1941; Hubault 1945). A milestone in the debate on the appropriateness of debarking treatments was the publication of results obtained by Elton et al in 1964. With regard to the large pine weevil, the authors compared insect assemblages on debarked and untreated Scots pine stumps and found no difference in insect colonization (population numbers and species composition). Comparable results were obtained by Skrzecz (2004), who found that *P. silvestris* stump debarking had no effect on the intensity of colonization of stumps and their roots by the large pine weevil.

Debarking of the aboveground parts of stumps was advised especially in mountains covered with fir or spruce forests and threatened by bark beetles. In Canada, such treatment was recommended to reduce the development of populations of the Douglas-fir beetle (*Dendroctonus pseudotsugae* [Hopkins]) in Douglas-fir trees (*Pseudotsuga menziesii* [Mirb]) Franco] injured by fire, defoliation, windthrow, or root disease (Shore et al 2005). Stump debarking was also suggested in the United States in order to completely remove potential breeding material for spruce beetles, which appear to readily colonize the stumps of trees that have broken or fallen, especially in mountains (Albers and Seybold 2002). In Central Europe, debarking of silver fir (*Abies alba* [Mill]) and Norway spruce (*Picea abies* [L.] H Karst) stumps was regularly recommended to reduce stump colonization by cambio- and xylophage insects. Podlaski (1996) advised the debarking of the aboveground parts of silver fir stumps immediately after timber harvesting. He considered that leaving even a small amount of bark provides material for the development of larvae of cambio- and xylophage insects.

Starzyk and Sęk (1983) studied *P. abies* stump entomofauna in the Western Beskidy Mountains of southern Poland and showed quantitatively that the dominant groups in these stumps were cambio- and xylophage insects, namely, secondary pests and large pine weevils. The authors stressed the need for systematic bark removal from spruce stumps situated in clear-cut, fire-burned, and windfall areas. Analogous recommendations were formulated by Kosibowicz (1987), who investigated insect assemblages on *P. abies* stumps in the Eastern Beskidy Mountains and showed the dominance of insect species classified as important secondary and timber pests affecting the health of mountain forest stands. Consequently, the author noted the need for stump debarking in order to enhance stump drying, diminish insect population numbers, and, as a result, decrease insect damage in spruce forests.

In the literature, results from studies on the effects of stump dimension (diameter and height), insolation, and degree of bark and wood decomposition on insect assemblages are available (Långström and Hellqvist 1985; Schroeder et al 1999; Jonsell et al 2005; Lindhe and Lindelöw 2004; Abrahamsson and Lindbladh 2006). However, although spruce stump debarking has been recommended, no research has been conducted so far to evaluate the effects of debarking on insect assemblages colonizing Norway spruce stumps. This lack of information is the impetus for the current research, the goal of which is to verify the hypothesis that colonization by Coleopteran insects is reduced when fresh spruce stumps are debarked. Hence, a 3-year-long study was conducted to compare insect species compositions and population numbers on debarked and untreated fresh stumps of *P. abies*. The study also assessed the usefulness of this method, which is commonly applied in mountain regions. Because it is difficult to get the proper equipment on steep, mountainous terrain, debarking usually involves peeling the bark away by hand and is therefore labor-intensive and expensive.

Material and methods

Area and insect sampling

The study was conducted from 2006–2008 in the part of the Eastern Sudety Mountains called Snieznik Mountains (southwestern Poland; 50°20′35″N; 16°52′43″E) (Figure 1). The climatic conditions in this region show distinct zonation depending upon the elevation above sea level. The average annual temperature oscillates between 6.5°C at an elevation of 500 meters above sea level (masl) to 2.4°C at >1100 masl. The vegetation season lasts between 195 and 200 days at 500 masl to about 150 days at 1200 masl. The average annual precipitation ranges from 700 mm at 500 masl to more than 1200 mm at elevations above 1250 masl. Snow cover remains from 105–110 days at 500–600 masl to approximately 180 days at 1300 masl. Southern and southwestern winds dominate in the region and cause serious damage to forest stands.

Experimental stumps were located in 36 clear-cut areas (1–2 ha each) resulting from the stepwise group cutting technique often used in the mountains (Figure 2A). All observed clear-cuts were situated in productive state forests at elevations of 600–1000 masl, where *P. abies* is a dominant tree species (89%). The clear-cuts were established between September and November of the study years after harvesting 80- to 100-year-old Norway spruce stands. All tree trunks and small logging slash (exposed roots, branches, and treetops) were removed, but stumps were left behind. The observed clear-cuts were surrounded by *P. abies* stands that are more than 60 years old. The experimental stumps were centrally located (>15 m from the forest edge). The treatments were carried out according to the rules of forest practice applied in areas potentially threatened by bark beetles (Kolk and Kapuscinski 2004). The aboveground basal parts of stumps were debarked to the surface of litter stratum (Figure 2B). The treatment was carried out with the use of a chainsaw immediately after tree felling. The bark was left around the stumps with the inner side up to allow faster drying, preventing insects from colonizing it. Within each clear-cut, 20 *P. abies* stumps were observed: 10 debarked and 10 untreated. In total, 720 Norway spruce stumps were investigated (36 plots × 20 stumps). The diameters of the selected stumps ranged from 50 to 60 cm (54.8 ± 4.9 cm; mean ± standard deviation [SD]), and stump heights were between 20 and 40 cm (30 ± 10.3 cm).

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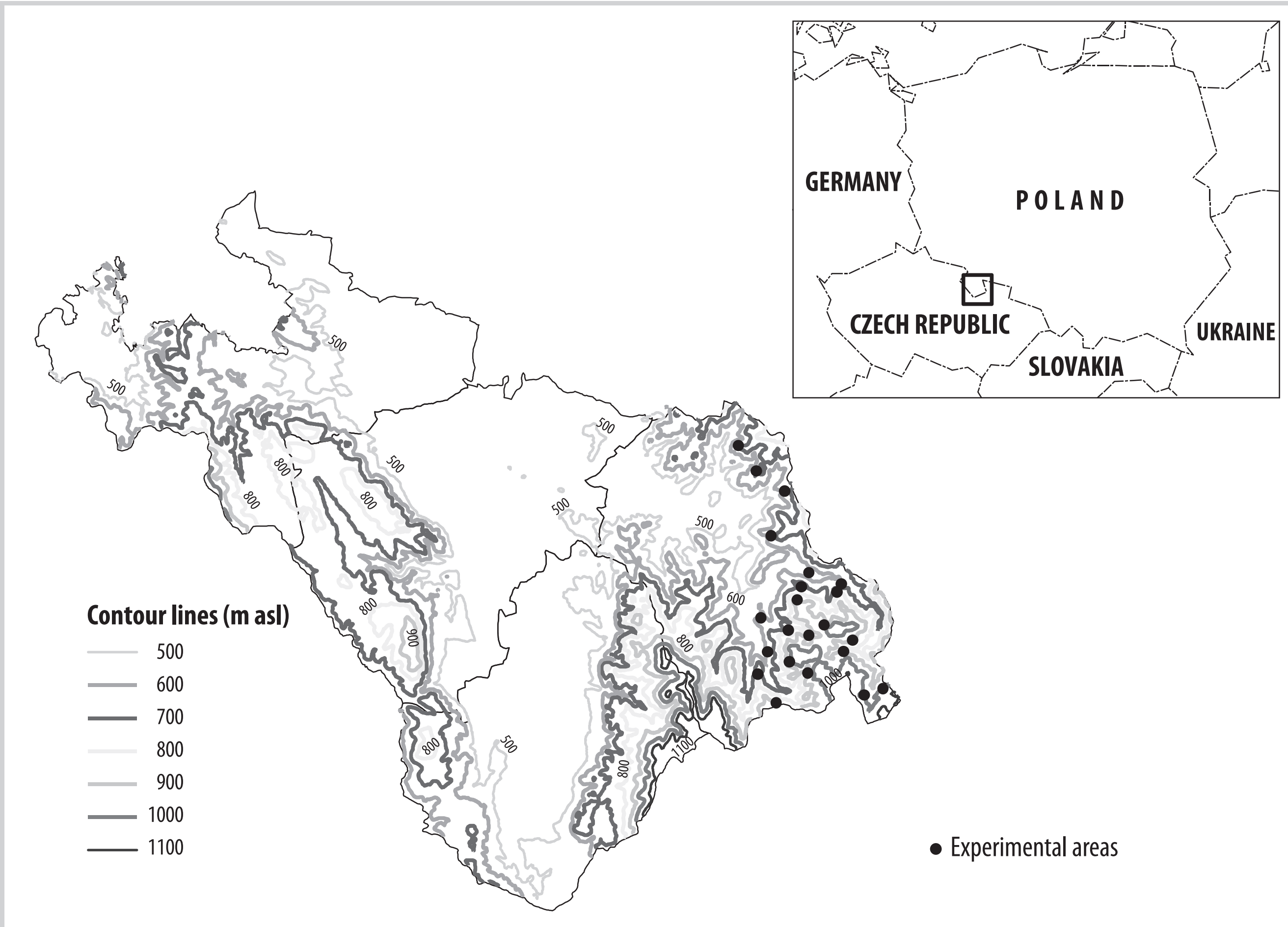
FIGURE 1 Map of Poland showing the locations of the experimental areas (black dots). (Map by Grzegorz Tarwacki)



One year after stump debarking in either September or October, in every plot, 5 bark samples (sections 10 × 10 cm, in total 0.5 m^2 of bark per stump) were taken from coarse roots located to a depth of about 20 cm and at a distance of about 1 m from a basal part of each debarked and untreated stump (Safranyik and Linton 1999). The samples were removed using knives or chisels. Each sample contained insect material found either in or under the collected bark. Specimens that could not be identified in the field were preserved and transported for further identification in the laboratory. All insect larvae, pupae, and adults found in the samples were identified to the family, genus, or species level according to the keys for the determination of Polish insects.

Statistics

The number of insects in the stumps was treated as a count response variable, which was modelled with the use of a Poisson or negative binomial distribution. Accordingly, generalized linear models (GzLM; Nelder and Weddenburn 1972; McCullagh and Nelder 1989) were applied. Analyses were performed on the total number of insects; separate calculations were performed on various identified insect groups (Cerambycidae, Scolytinae, Curculionidae, other insects). For each group, the following fixed model was applied: log $(\lambda_{ij}) = t_i + y_j$, where log$(\lambda_{ij})$ is the canonical link function; λ_{ij} is the mean count for the ijth treatment–year combination; t_i is the ith treatment effect ($i = 1, 2$); and y_j is the jth year effect ($j = 1, 2, 3$). Year was included in the model as a covariate to take into account possible variation between years.

Due to the possibility of overdispersion (McCullagh and Nelder 1989), and therefore the possibility of incorrect application of the Poisson model, the goodness-of-fit statistic (Stokes et al 2000; Littell et al 2002) was applied. A likelihood ratio test based on the Poisson and negative binomial distributions was used to test for overdispersion (Cameron and Trivedi 1998). In the case of overdispersion, analysis of the model for a given insect group was carried out using the negative binomial distribution with log (λ) as the canonical link. Otherwise, the Poisson distribution was applied. The significance of

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FIGURE 2 (A) *P. abies* stumps on experimental areas; (B) debarked *P. abies* stump; the bark was removed from the aboveground part. (Photos by Maria Bulka)

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the model effects was tested with the likelihood ratio chi-squared statistic for type 3 analysis, and contrast analysis was performed for comprehensive comparisons of significant model effects.

The analyses were carried out using SAS 9.2 software. The GENMOD procedure (Stokes et al 2000; Littell et al 2002) was followed.

Results

Total number of insects in *P. abies* stumps

Insects were present in 602 (84%) of the 720 investigated stumps, including 306 debarked and 296 untreated stumps. Most insects found were in the larval stage. Altogether, there were 5241 specimens (both adults and larvae) from 29 species belonging to 18 families (Table 1). On average, there were 8.71 ± 0.38 (mean ± standard error) insect specimens (both adults and larvae) in 0.5 m^2 of stump bark.

The Cerambycidae family was most abundant (52% of all insects found) and was represented by 2736 specimens (4.54 ± 0.22 specimens/0.5 m^2 on average) belonging to 8 species. In the assemblages, 2 species—*Rhagium inquisitor* (L.) and *Tetropium castaneum* (L.)—accounted for 34% of the collected specimens. Excluding the subfamily Scolytinae (bark beetles), the Curculionidae family (weevils) was the second most abundant group with 1352 specimens (2.25 ± 0.17 specimens/0.5 m^2), or 26% of all insects found. These were mainly represented by *H. abietis* (22% of all insects found) and 3 other less numerous species. The Scolytinae subfamily is shown separately because it was the third most abundant taxon, with 9 species of bark beetles. In total, there were 791 beetles (15% of all insects observed), with 1.31 ± 0.19 specimens per stump on average. Most Scolytinae (12%) were identified as *Dryocoetes autographus* (Ratz), *Hylastes* sp., *Trypodendron lineatum* (Oliv), and *Polygraphus poligraphus* (L.).

The remaining 362 insects (7% of all entomofauna collected; 0.60 ± 0.06 specimens/0.5 m^2 on average) belonged to 16 families, the most abundant of which were from the Elateridae (6 species), Cleridae (*Thanasimus formicarius* L), Staphylinidae (6 species), and Asilidae (2 species) families. These insects were analyzed together, forming the group of "other" insects.

Comparison of insect assemblages in debarked and untreated stumps

There were 3311 insects in the debarked stumps and 1930 insects in the untreated stumps. On average, there were 10.82 ± 0.67 specimens in the bark of 1 debarked stump, and 6.52 ± 0.29 specimens in the bark of an untreated stump. Assessments of the number of all insects found in the bark samples indicated a significant increase of the total number of insects in the debarked stumps of 53% (exp [0.425] = 1.529; Table 2; Figure 3).

In the samples taken from debarked stumps, there were a total of 1711 Cerambycidae larvae (5.59 ± 0.38 specimens/0.5 m^2 on average). In contrast, there were a total of 1025 Cerambycidae larvae (3.46 ± 0.21 specimens/0.5 m^2 on average) in the samples collected from untreated stumps. Thus, there were 46% more Cerambycidae larvae in the samples from debarked stumps than in those from untreated stumps, a statistically significant difference (Table 2; Figure 4).

There were also 16% more Curculionidae (excluding Scolytinae; 760 specimens; 2.48 ± 0.27 specimens/0.5 m^2 on average) in the samples taken from debarked stumps than in untreated stumps (592 specimens; 2.00 ± 0.19 specimens/0.5 m^2 on average). However, this difference is not statistically significant (Table 2; Figure 5A).

Statistically significant differences were observed when comparing Scolytinae numbers in the 2 groups of stumps. In the samples collected from debarked stumps, there were a total of 628 specimens (2.05 ± 0.35 specimens/0.5 m^2 on average); untreated stumps contained 3.5 times fewer insects (163 specimens; 0.55 ± 0.13 specimens/0.5 m^2 on average; Table 2; Figure 5B).

The comparisons of the numbers of other insects showed significantly more insects in debarked stumps (40% more insects in debarked stumps in comparison to untreated ones; Table 2; Figure 5C). In the bark samples from debarked stumps, there were a total of 212 specimens (0.70 ± 0.72 specimens/0.5 m^2 on average); in those from untreated stumps, there were 150 specimens (0.50 ± 0.52 specimens/0.5 m^2 on average).

Discussion

P. abies stumps in the Eastern Sudety Mountains provide shelter and sites for feeding and development for entomofauna from 18 families in 2 orders. Coleoptera were most abundant, with the families Cerambycidae and Curculionidae being the most dominant. Other beetle families (eg Cleridae, Elateridae, Staphylinidae) were less abundant, comprising 2% of all the insects found in the examined stumps. The order Diptera comprised approximately 1.5% of the total number of insects found.

Stump debarking influenced the total number of insects colonizing *P. abies* stumps. Higher colonization intensity was observed in the bark samples collected from debarked stumps as compared to samples from untreated ones. This was most likely the result of enhanced resin secretion by debarked stumps (Elton et al 1964). To date, information regarding the effects of debarking on the colonization of spruce stumps by insects has not been available, yet those on pine stumps have been investigated and reported in the literature. For example, Wiackowski

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TABLE 1 Species composition and abundance of insects in *P. abies* stumps. (Table continued next page)

ORDER/Family	Species and genus	Number of colonized stumps (number of individuals)	
		Debarked	Untreated
COLEOPTERA			
Cerambycidae	*Arhopalus rusticus* (L.)	26 (48)	55 (78)
	Corymbia rubra (L.)	39 (45)	46 (52)
	Obrium brunneum (Fabr.)	27 (34)	35 (49)
	Oxymirus cursor (L.)	64 (134)	41 (57)
	Rhagium inquisitor (L.)	95 (271)	58 (78)
	Rhagium bifasciatum (Fabr.)	5 (7)	35 (47)
	Tetropium castaneum (L.)	214 (1172)	194 (629)
	Tetropium fuscum (Fabr.)	0 (0)	22 (35)
Cleridae	*Thanasimus formicarius* (L.)	44 (62)	17 (25)
Curculionidae	*Hylobius abietis* (L.)	257 (662)	239 (510)
	Otiorrchynchus niger (Fabr.)	23 (46)	18 (42)
	Strophosoma melanogrammum (Forst.)	15 (35)	17 (29)
	Liophloeus tessulatus (Müll.)	8 (17)	5 (11)
Scolytinae	*Dryocoetes autographus* (Ratz.)	104 (261)	32 (52)
	Hylastes brunneus (Payk.)	47 (88)	20 (25)
	Hylastes cunicularius (Er.)	11 (27)	5 (7)
	Hylurgops glabratus (Zett.)	8 (20)	4 (4)
	Hylurgops palliatus (Gyll.)	28 (56)	11 (21)
	Ips typographus (L.)	9 (15)	23 (27)
	Orthotomicus laricis (Fabr.)	2 (4)	1 (1)
	Polygraphus poligraphus (L.)	46 (76)	8 (11)
	Trypodendron lineatum (Oliv.)	50 (81)	12 (15)
Elateridae	*Adelocera murina* (L.)	3 (3)	8 (14)
	Ampedus pomorum (Herbst.)	4 (6)	5 (10)
	Denticollis linearis (L.)	3 (4)	4 (7)
	Elateroides dermestoides (L.)	7 (9)	9 (18)
	Hemicrepidius sp.	2 (4)	5 (9)
	Melanotus spp.	1 (2)	2 (2)
Lymexylonidae	*Hylecoetus dermestoides* (L.)	5 (7)	4 (6)
Monotomidae	*Rhizophagus dispar* (Payk.)	12 (15)	7 (11)
	Rhizophagus ferrugineus (Payk.)	6 (9)	3 (5)
Nitidulidae	*Glischrochilus quadripustulatus* (L.)	3 (3)	2 (3)

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TABLE 1 Continued.

ORDER/Family	Species and genus	Number of colonized stumps (number of individuals)	
		Debarked	Untreated
Oedemeridae	*Calopus serraticornis* (L.)	1 (2)	1 (1)
Pyrochroidae	*Schizotus pectinicornis* (L.)	2 (2)	1 (2)
Staphylinidae	*Atheta fungi* (Grav.)	8 (11)	2 (4)
	Mycetoporus piceolus (Rey)	4 (5)	2 (3)
	Nudobius lentus (Grav.)	1 (1)	1 (1)
	Quedius punctatelius (Herr.)	3 (4)	2 (3)
	Philonthus decorus (Grav.)	2 (2)	2 (2)
	Platydracus stercorarius (Oliv.)	1 (1)	0 (0)
DIPTERA			
Asilidae	*Laphria flava* (L.)	23 (29)	6 (8)
	Laphria gibbosa (L.)	13 (17)	5 (11)
Therevidae		1 (2)	2 (2)
Tachinidae		1 (2)	1 (1)
Empididae		1 (1)	0 (0)
Muscidae		2 (3)	1 (1)
Rhagionidae		1 (2)	0 (0)
Syrphidae		1 (1)	1 (1)
Xylophagidae	*Xylophagus ater* (Meigen)	2 (2)	0 (0)

(1957) described entomofauna on *P. sylvestris* stumps and indicated that debarking reduced insect pest populations associated with stump bark or wood, such as the common pine shoot beetle *Tomicus piniperda* (L.), the long-horn beetle *Arhopalus rusticus* (L.), and the black spruce borer *Asemum striatum* (L.). The author stressed the need to systematically debark pine stumps to limit the food supply of these species. At the same time, he stated that stump bark and wood were inhabited by many parasitoids and predators, which caused the pest population to decrease. Wiackowski (1957) recommended debarking as often as possible with no remarks on its possible effects on beneficial entomofauna. Hilszczański (2008) investigated the bark of dead spruce trees as an overwintering site for predators associated with cambio- and xylophage insects and noted that debarking caused both pest and pest predator populations to decrease. Elton et al (1964) reported no effect of debarking on insect numbers in *P. sylvestris* stumps, and Skrzecz (2004) in fact observed 10–20% greater insect populations in debarked stumps as compared to untreated ones.

In this study, debarking contributed to a higher intensity of colonization of *P. abies* stumps by longhorn beetles (5.5 specimens/0.5 m^2 on average) as compared to untreated stumps (3.4 specimens/0.5 m^2 on average). Elton et al (1964) noted lower insect numbers in debarked pine stumps in the case of longhorn beetle species such as *Acanthocinus aedilis* (L) and *Tetropium* sp., but they did not observe any effects of debarking on population numbers of other Cerambycidae species, eg *A. striatum* and *Spondylis buprestoides* (L). However, debarked stumps exhibited lower numbers of *A. striatum* and *A. rusticus* in comparison to untreated ones. Even more contradictory results were reported by Skrzecz (2004), who observed no differences in Cerambycidae population numbers in *P. sylvestris* stumps in either case (debarked versus untreated stumps).

No differences in colonization intensity by Curculionidae were observed when debarked and untreated stumps were compared. These results confirm those obtained by Elton et al (1964), who investigated entomofauna in treated and untreated pine stumps and concluded that the debarking treatment had no effect on

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TABLE 2 Parameter estimates, chi-squared values for the type 3 analysis, and significance of models' effects for the insects tested.

	Parameter estimate (on an exponential scale)	Odds ratio estimates	DF[c)]	χ^2	*p*
All insects					
Stump treatment	0.425[a)]	1.529[b)]	1	42.21	<0.001
Year			2	145.28	<0.001
Cerambycidae					
Stump treatment	0.380	1.462	1	17.95	<0.001
Year			2	56.88	<0.001
Curculionidae (excluding Scolytinae)					
Stump treatment	0.148	1.159	1	1.09	0.297
Year			2	48.20	<0.001
Scolytinae					
Stump treatment	1.264	3.540	1	13.12	<0.001
Year			2	44.70	<0.001
Other insects					
Stump treatment	0.340	1.405	1	6.30	0.012
Year			2	50.48	<0.001

[a)]The values of the parameter estimates indicate the extent to which debarked stumps were more colonized by insects than untreated stumps.
[b)]Odds ratio estimates were obtained by exponentiation of parameter estimates.
[c)]DF, degree of freedom.

H. abietis adult numbers or larval mortality. Skrzecz (2004) also found comparable numbers of weevil adults and larvae in debarked and control *P. silvestris* stumps. The lack of differences in colonization levels can be explained by the results of a study conducted by Nordlander et al (1997). Those authors found that volatiles released by fresh stumps signal to adult large pine weevils that a breeding site is nearby. Females receive an even more specific signal from the essential oils released by the pine roots, which are preferred oviposition sites. The release intensity gives females information regarding the quality of the roots as potential sites for the development of the next generation. The abovementioned research also shows that 80% of large pine weevil eggs are deposited directly into the soil close to the roots of fresh stumps (within 5 cm) and not—as previously thought—in egg hollows located on coarse

FIGURE 3 Total number and mean values (with standard errors) of all insects in 0.5 m^2 bark samples taken from debarked and untreated *P. abies* stumps; different letters show significant differences at $p \leq 0.05$.

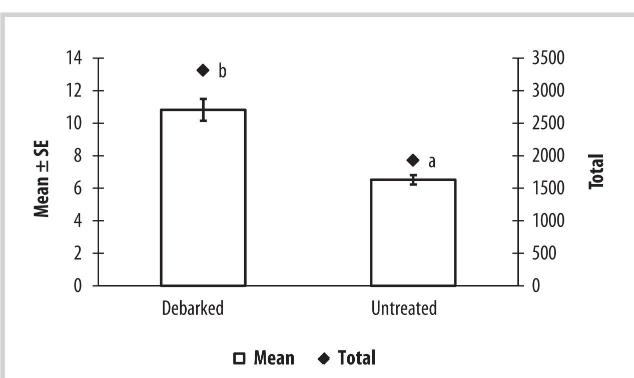

FIGURE 4 Total number and mean values (with standard errors) of Cerambycidae in 0.5 m^2 bark samples taken from debarked and untreated *P. abies* stumps; different letters show significant differences at $p \leq 0.05$.

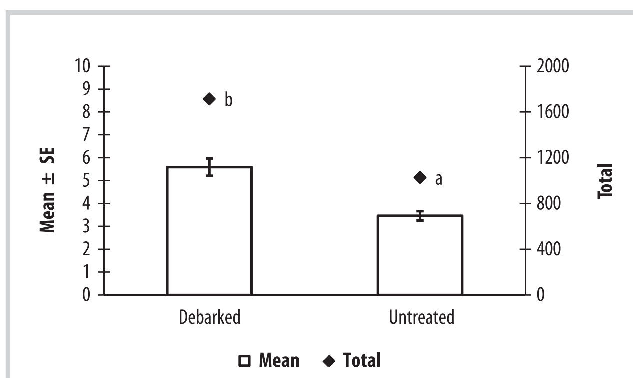

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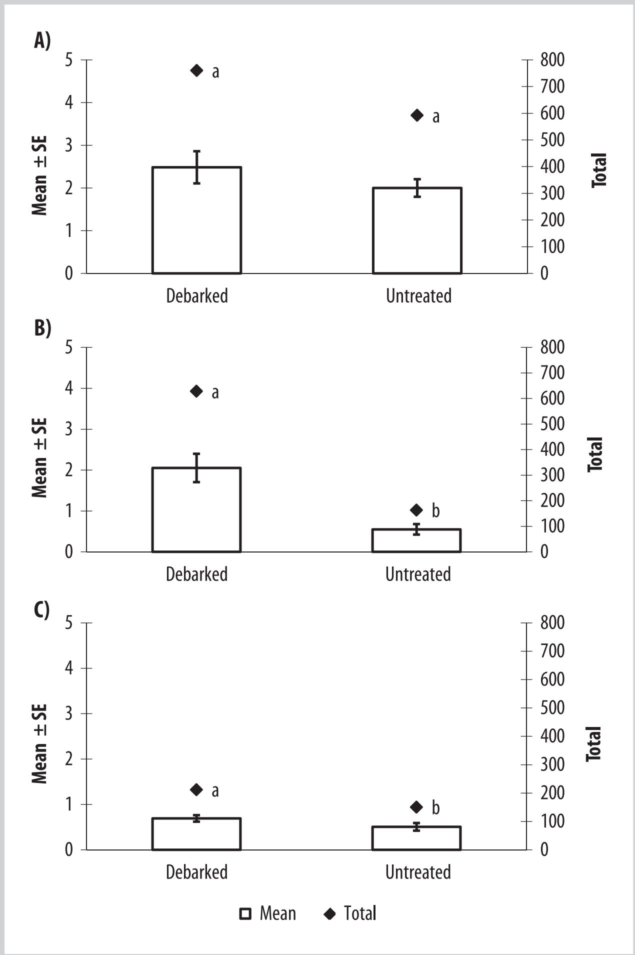
FIGURE 5 Total number and mean values (with standard errors) of (A) Curculionidae (excluding Scolytinae); (B) Scolytinae; (C) other insects in 0.5 m^2 bark samples taken from debarked and untreated *P. abies* stumps; different letters show significant differences at $p \leq 0.05$.



roots. Additionally, hatched *H. abietis* larvae can migrate through soil over distances of approximately 10 cm to find suitable feeding sites (Nordenhem and Nordlander 1994). Nordlander et al (1997) noted that large pine weevil females lay eggs in the soil to protect their progeny against predators who intensely penetrate root bark; the larvae themselves then choose the sites most advantageous for their further development.

The debarking treatment resulted in a more than threefold increase in the colonization of debarked spruce stumps by Scolytinae (2 specimens/0.5 m^2 on average). The most likely reason for this is the enhanced secretion of volatile bark beetle attractants by debarked stumps (Byers 2004). The lack of data in the literature regarding the effect of spruce stump debarking on insects colonizing the stumps impedes a detailed discussion of these results. The only data available concern the effects of pine stump debarking on colonization by some bark beetle species. Elton et al (1964) and Wiackowski (1957) indicated that a debarking treatment resulted in increased mortality of larvae and reduced populations of the black pine bark beetle *Hylastes brunneus* (Erich.) and the pine shoot beetle *T. piniperda*. Skrzecz (2004) noted the occurrence of only 2 bark beetle species in fresh pine stumps, *H. brunneus* and *Hylurgus ligniperda* (Fabr.), the numbers of which were comparable in both treated and untreated stumps.

The analysis of insect abundances in the 16 less abundant families revealed significantly fewer insects in untreated stumps. Similar results were obtained by Elton et al (1964), who observed more insects from the families Elateridae and Asilidae in debarked *P. sylvestris* stumps as compared to untreated stumps.

Conclusion

The results indicate that there is no advantage to applying a debarking treatment to *P. abies* stumps. In this study, debarking contributed to an approximately 40% increase in insect numbers in the bark samples collected from stump roots. The treatment enhanced the numbers of Cerambycidae and Scolytinae, as well as those of less numerous entomofauna from other insect families. Additionally, debarking had no effect on the numbers of Curculionidae (excluding Scolytinae) that colonized the bark collected from the roots of treated stumps.

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