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The influence of smoke on Phloeotribus scarabaeoides (Bern.) (Col., Scolytidae)

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Two days after a fire had partially burnt some olive trees, a severe infestation by *Phloeotribus scarabaeoides,* limited to the damaged branches, was observed. In an olfactometer experiment, freshly emerged females were repelled by smoke from olive wood. After having fed for up to two weeks on fresh olive twigs, and while maturing their eggs in the oviposition galery in dying wood, their behaviour was reversed, and they were ever more attracted to smoke from a fire with olive wood. Smoke from cypress wood, by contrast, remained repellent. In males, no attraction to smoke was observed.

Among the scolytids, *Phloeotribus scarabaeoides* occupies an intermediate position between the species which attack and kill vigorously living hosts and those which live only on dying trees. Reproduction is confined to dying branches. In modern olive culture, breeding mainly occurs on the wood which has been pruned from the trees in winter-early spring. The emerging beetles in early summer disperse in the orchards. They attack green twigs where they construct their feeding and eventually their overwintering galeries. According to the attack site, this leads to the drop of inflorescences with olives or weakening and breakage of small branches. It is mainly this activity which makes this species an olive insect pest, although of local importance. Whenever suitable dying wood, i. e. branches with reduced sap flow, is found further generations can be produced, and the long-living adults are also capable of excavating a second oviposition galery on another branch. Attractivity of susceptible wood is attributed to unspecified odours (RUSSO, 1938; ARAMBOURG, 1964; JARRAYA, 1979).

In Crete, Greece, *P. scarabaeoides* occurs in all regions. Its control is achieved by removing the wood shortly after pruning. Where this precaution is neglected, the beetle population can locally and temporarily explode and cause economic damage. The present investigation of the influence of smoke on this bark beetle started from a chance observation: Following a fire caused by a road accident in an olive orchard, a sudden and heavy attack by this beetle was observed.

MATERIALS AND METHODS

On 13-7-81 a car accident near Agii Pantes, 18 km SE of Chania, Crete, started a fire in some 25-year old trees of the Koroneiki olive variety. On 29 trees, all leaves were burnt and the trunks were blackened before the fire could be extinguished. On 5 more peripheral trees, major branches were burnt, while the rest of the canopy remained undamaged.

By 15-7-81 the owner of the orchard observed a heavy attack by *P. scarabaeoides.* On 17-7-81 we counted the fresh bore holes on 1 m of the basal part of

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each of 5 major branches (of 5–15 years of age) per tree. Such counts were made on 5 trees in the centre of the burnt plot, and on 5 undamaged trees adjacent to burnt trees. On 5 trees which were partly damaged, 10 m of branches each were inspected, half on the burnt side, half on the green side of the canopy.

On 23-7-81, 50 pieces of bark and wood, each containing 1–2 beetles which had started to excavate the horizontal part of the oviposition galeries were cut from the tree and brought to the laboratory. In addition, beetles were obtained from heavily infested branches in Aspreas, near Chania.

In the laboratory, the newly emerged beetles were collected daily and kept in cages where they were given freshly cut olive twigs for feeding. These beetles were used in an olfactometer experiment whereby 4 age classes were distinguished: A, beetles on the day of emergence; B and C, beetles which had fed on green twigs for half a week and 1½ to 2 weeks respectively; and D, beetles which were cut out from oviposition galeries. All beetles were removed from their substrates just before the choice experiment.

The olfactometer consisted of an Y-shaped, horizontally placed glass tube with 4.8 mm inner diameter, connected by rubber tubes to 2 vertically placed glass funnels which were continuously ventilated by a hair dryer. Care was taken to keep the light at the same intensity on both ends of the glass tube towards which the beetles were walking. Three types of choice experiments were performed: I. The attractivity of a splinter of newly burnt olive wood in one funnel was compared with the one of fresh wood in the other funnel. II. Humid filter paper which had been held for about 1 min in the smoke of a fire with olive wood was compared with untreated humid filter paper. III. Filter papers saturated with smoke from olive or cypress wood respectively were tested against untreated filter paper. Filter papers were stored at 6 °C, and used for about 1 h each.

Preliminary experiments indicated that the beetles in the olfactometer became unresponsive rather soon. Therefore each beetle was used for only 6 runs. In order to exclude the influence of light and other environmental factors the position of the funnels (including the rubber tubes) was reversed after 3 trials. In addition the Y-shaped glass tube was turned after each trial thereby equalizing the influence of its slight unevenness. Since external morphology does not readily allow one to determine the sex of these coleoptera (Russo, 1937; Schlyter & Cederholm, 1981) each individual was dissected afterwards for sexing.

For testing the behaviour towards smoke of flying as compared to walking beetles, freshly emerged beetles which at night were swarming around a lamp in the laboratory were given the choice between smoky and untreated filter papers. All beetles which landed within 2 min were counted, and the experiment was repeated 10 times. The same type of experiment could not be done with older beetles because of their unwillingness to swarm under these conditions.

For the evaluation, the total number of choices of all beetles of the same sex, age, and test group for the smoky side was compared with the number for the check side in a x^2-test (with correction for continuity, under the null hypothesis of a 50 : 50% split) at $p = 0.05$ (Snedecor & Cochran, 1967). In a second evaluation, the number of beetles which had chosen the smoky side (wood and filter paper combined) 4–6 times were contrasted with those which had walked towards this side only 0–2 times out of the 6 trials. Beetles which had scored 3 : 3 were thereby excluded. Similarly, the number of beetles which preferred olive smoke over the untreated check was compared in a test of homogeneity with those which favoured cypress smoke over the control.

RESULTS

Two days after the fire, the damaged olive trees were infested heavily by *P. scarabaeoides*. After 4 days, all beetles had excavated the vertical galery, and none remained open on the surface of the branches. The major branches of the burnt trees had a mean of 51.4 holes per 5 m versus zero on the neighbouring undamaged trees. Partially burnt trees had 39.8 holes per 5 m on the burnt, and 0.8 holes per 5 m on the green branches (simple SE = 14.0). A search in the surrounding orchards for twigs on which *P. scarabaeoides* had fed before attacking the burnt trees revealed that population levels in this area were low: On hundreds of trees only a few such twigs could be found.

The reaction of beetles of both sexes and of different ages to smoke was then evaluated in the laboratory (Table 1). A total of 253 beetles were tested, out of which 70% demonstrated some degree of preference, while 30% ran 3 times to each side of the olfactometer. This proportion was roughly the same for both sexes and all age groups. The two types of evaluations, according to total numbers of either runs or beetles, gave similar results, those based on beetles being more pronounced. Newly emerged females preferred the fresh olive wood over burnt wood, and the untreated filter paper over filter paper containing smoke. After having fed for half a week on fresh branches, females started to prefer the smoky side of the olfactometer. After two weeks on fresh branches this preference by the females, which were still in their preoviposition period, grew stronger. Finally, females which were cut out from their freshly excavated oviposition galeries and which had the first ripe eggs in their ovaries all preferred the smoky side. Young males were less repelled by smoke than young females, and smoke exerted no significant attraction on older males. In both sexes the reaction was the same whether the choice was between burnt and fresh wood, or between smoke saturated or untreated filter paper. This indicates that attraction or repellence concerned smoke and not vapours from fresh wood.

Young beetles which were swarming around a light at night exhibited the same type of preference for the untreated filter paper as beetles walking in the olfactometer: Out of 187 unsexed beetles which landed on both filter papers within 20 minutes, 26.2% only were on the smoke treated paper ($x^2 = 41.4^*$).

Finally, the influence of smoke from cypress wood on nearly mature beetles was tested in the olfactometer (Table 2). Males were repelled by smoke from both sources. But females exhibited a clear-cut choice: They preferred smoke from olive wood over the untreated filter paper; but they heavily favoured this check above filter paper which was saturated with cypress smoke.

DISCUSSION

After emergence, adult *P. scarabaeoides* feed on fresh olive twigs before searching dying olive wood for reproduction. In the experiment, some reproduction was possible without feeding on fresh growth (unpubl. results). In the orchard, branches become susceptible for a beetle attack only 3–11 days after cutting (Russo, 1938; Jarraya, 1979). It must be assumed that substances which emanate from these branches are responsible for the attraction, as is the case for the «pioneer beetles» in other species (Wood, 1982). These host chemicals become concentrated in the smoke. This would explain the considerable speed and size of attack observed after the burning of the trees, despite a relatively low beetle density in the area. The flabellate structure of the antennae in *P. scarabaeoides,*

Tab. 1: Attraction of adult *Phloeotribus scarabaeoides* females and males of different ages (A-D) to smoke from olive wood, in an olfactometer. a = burnt vs. green olive wood, b = filter paper saturated with smoke vs. untreated check. 6 runs per beetle. Chania, July-Sept. 1981.

Age of beetles and, in brackets, weeks after emergence	Sex	Type of choice	Sum of observed runs by all beetles of each group			Number of beetles with majority of runs towards smoke		
			N	%	χ^2	N[1)]	%	χ^2
A) newly emerged (0)	♀	a	66	31.8	8.02*	20	5.0	14.45*
		b	72	27.8	13.35*			
	♂	a	120	41.7	3.01	28	28.6	4.32*
		b	102	42.2	2.21			
B) on green twigs (0.5)	♀	a	78	65.4	6.78*	20	70.0	2.45
		b	102	53.9	<1			
	♂	a	72	58.3	1.68	23	69.6	2.78
		b	126	58.7	3.50			
C) on green twigs (1.5-2)	♀	a	90	61.1	4.01*	16	87.5	7.56*
		b	78	59.0	2.17			
	♂	a	138	52.2	<1	28	50.0	0
		b	126	48.4	<1			
D) in oviposition galery	♀	a	72	72.2	13.35*	14	100.0	12.07*
		b	30	80.0	9.63*			
	♂	a	144	53.5	<1	28	46.4	<1
		b	102	40.2	3.54			

[1)] number of beetles which chose either smoke or untreated check, a and b combined, beetles with 3:3 score excluded.

Tab. 2: Percentage of older beetles (over 1½ weeks of age) which, when given the choice between untreated and smoke treated filter paper, were attracted to filter paper containing smoke from olive and cypress wood respectively. Based on the number (N) of beetles which exhibited a clear choice (beetles with 3 : 3 score excluded). 6 runs per beetle. Chania, July-Sept. 1981.

Sex	Smoke from				
	olive wood		cypress wood		
	N	%	N	%	χ^2
females	21	90.5	14	21.4	14.32*
males	26	38.5	19	31.6	<1

which is unique among scolytids, thereby suggests a high degree of chemoreception. The experiment with two different sources of smoke points to a possible specificity of a yet unknown attractant coming from host plants. Apart from *Olea* those include other Oleaceae like *Fraxinus, Phillyrea,* and *Syringa* (ARAMBOURG, 1964). For other scolytids, ethanol, monoterpenes and terpene alcohols have been incriminated as host plant attractants (BORDEN, 1974).

The olfactometer data also demonstrate the changes in attraction to host chemicals which may form the physiological basis for the host change. Attraction depends on sex and age: Young females are repelled by smoke in general. As they mature their eggs, they become ever more attracted to those possibly specific chemicals. Males, whose antennae have the same flabellate form, on the other hand, do not react positively to smoke from the host plant. This is in accordance with the observation that pioneer beetles are all females (RUSSO, 1938; unpubl. results). It is suggested that males, and perhaps further females, are attracted to mates and suitable plant hosts by pheromones, as is the case in most scolytids which have been studied more intensely (BORDEN, 1974; WOOD, 1982).

The observation of *P. scarabaeoides* being attracted to smoke from olive wood may be of practical interest in pest management in areas like some parts of Tunesia where this insect sometimes causes great damage (ARAMBOURG, 1964; JARRAYA, 1979). It is proposed to investigate the possibility of trapping out and destroying pioneer beetles on controlled-scorched branches. Similarly, trees struck by lightning are known to be reservoirs for other scolytids in pine forests (HODGES & PICKARD, 1971). But to our knowledge, the present study is the first record of a direct reaction of a bark beetle to smoke.

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Sommaire

Une forte infestation de *Phloeotribus scarabaeoides* a été trouvé sur oliviers deux jours après une incendie, qui avait partiellement endommagé les arbres. L'infestation était restrainte aux branches touchées par le feu. En olfactomètre, les femelles fraîchement écloses sont repoussées par la fumée de bois d'olivier. Après s'être nourries de brindilles vertes d'oliviers pendant une période allant jusqu'à deux semaines, ainsi que pendant la maturation des œufs dans la galérie de ponte dans du bois mourant, les femelles changent leur comportement: elles sont de plus en plus attirées par la fumée. La fumée produite par le bois de cyprès, par contre, a un effet répulsif. Chez les mâles, aucune attraction par la fumée n'a été observée.

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