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DISPERSAL OF PINE ENGRAVER BEETLES

IN SECOND GROWTH PONDEROSA PINE FORESTS

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Abstract

Flight capability and dispersal of marked and unmarked pine engraver beetles Ips pini (Say) (Coleoptera: Scolytidae) were measured in two second growth ponderosa pine stands Pinus ponderosa Lawson in western Montana and northern Idaho. Overall, 26% of 4,900 marked beetles released failed to fly, 8% of these died on the release platform, and only 5% of those that flew were recaptured. Most marked beetles were recaptured the day of release, however 4% of one day's release were recaptured from 3 to 5 days after release. Most beetles (67 and 81%) at the two test sites were caught on traps within 7 m of the ground. The ratio of females to males for beetles reared in the laboratory from field infested slash was 1.2 while that for both recaptured marked beetles and wild beetles responding to the attractive traps was 1.7.

INTRODUCTION

The pine engraver beetle Ips pini (Say) (Coleoptera: Scolytidae) is one of the most widely distributed bark beetles infesting coniferous forests in North America (Sartwell et al. 1971). In western United States it is most destructive in ponderosa pine stands Pinus ponderosa Lawson following thinning when it emerges from the thinning slash and kills nearby apparently healthy saplings and poles as well as the tops of mature trees.

Field study of the flight and dispersal of bark beetles is difficult because of the small size of the beetles, and behavioral variation between populations (Atkins 1968). Consequently, much of our understanding of dispersal has been inferred from observing other related behavior such as host selection and the pattern and spread of infestations. Comparison of the infestation pattern of the pine engraver to that of other scolytids, such as the mountain pine beetle in lodgepole and ponderosa pine stands reveals several important differences involving flight and dispersal. The pine engraver generally kills almost every tree within the group it attacks during the same season it emerges from the slash. Additionally, the newly infested group is usually within sight of a previous infestation as evidenced by accumulation of suitable slash that is the preferred breeding material of the overwintered adults. Standing trees are infested in groups from 50 to 500 and frequently every tree within the group larger than 5 cm is killed. Intolerable levels of tree killi.g seldom last more than 2 years (Sartwell et al. 1971).

In contrast, the infestation pattern of the mountain pine beetle is characterized by the largest trees in a stand being infested first. In subsequent years, progressively smaller trees are killed until those left are too small to support successful larval development. This pattern results in the outbreak phase of a mountain pine beetle infestation exceeding that of the pine engraver by 6 to 8 years (Cahill 1978, Amman and Baker 1972).

The concentrated arrangement of infested trees in pine engraver infestations, as well as the close proximity of the infestations to the apparent breeding site of the attacking beetles, suggests this beetle may be particularly susceptible to manipulation with synthetic pheromones. To date the aggregative and inhibitive elements of the beetles pheromone have been identified and geographic variation in attractant pheromones of populations from California, Idaho, and New York have been reported (Anderson 1948, Lanier et al. 1972, Mustaparta et al. 1977, Dickens 1979).

However, before suppression measures employing behavioral chemicals can be designed and efficiently tested, the flight capacity and flight pattern of the beetle during dispersal and host selection must be known. Studies of the flight and dispersal of eastern pine engraver populations showed that upwind response decreased at wind speeds above 1.8 kph and that beetles may fly lower at higher temperatures (Seybert and Gara 1970). Similar tests with *Ips paraconfusus* in ponderosa pine stands revealed that wind velocity, intensity of attractants and type of ground cover affected flight behavior (Gara 1963). The two tests described herein utilized attractive male infested logs to determine the vertical distribution of

responding wild beetles and to gain a measure of the flight capacity and recapture rate of dispersing marked adults in second growth ponderosa pine stands.

METHODS

The response to attractive ponderosa pine billets infested with male engraver beetles as well as their vertical distribution was measured in two 60 to 80 year old ponderosa pine stands on the Lolo National Forest near Tarkio, Montana during 1967 and the Coeur d'Alene Indian Reservation near Worley, Idaho during 1971.

At the Tarkio study site 15 cm sq. plexiglas panels were attached to suspended nylon lines at 1.5 m intervals and coated with Stickem Special[1] to census flying engraver populations. The vertical lines bearing these panels were suspended over a pulley attached to a horizontal suspension line supported by the crowns of adjacent trees (Fig. 1). Height of the topmost traps was limited by the maximum height of the support trees. Panels were lowered to the ground daily before flight began and the number of beetles caught on the panels were removed and counted. Four lines, one in each cardinal direction, were positioned approximately 45 m from a walk-in type screened cage filled with 90 lineal m of attractive ponderosa pine billets infested with male pine engraver beetles. Trapping was conducted from July 24 to August 12, during the flight of F-1 adults.

Tests at the Worley site were conducted from July 8 to 14 and were designed to measure the flight capability of newly F-1 emerged adults and their response to attractive 30 cm long bole sections infested with 25 male beetles. The sections were covered with 16 x 18 mesh screen to prevent the entry of wild females and were placed on plywood disks surrounded by hardware cloth cylindrical traps coated with Stickem Special. Four traps were placed on platforms supported by waterpipe 1.8 m above ground and four were positioned at midcrown by attaching the plywood platform to a rope that passed over a pulley attached to a horizontal support line fastened in

[1]The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture of any product or service to the exclusion of others which may be suitable.

the crowns of adjacent trees. One of each of the four traps was positioned approximately 60 m from a central release platform in each of the cardinal directions. The release platform consisted of a 5 cm wide circular band cut from a 40 cm diameter plywood disk. The 35 cm dia. hole in the center of the band was covered with 16 x 18 mesh wire screen. This band was supported by a platform 1.6 m above ground attached to a wooden post. An 18 cm dia. plastic funnel attached to a length of waterpipe was positioned over the center of the disk. The neck of the funnel was fitted with a 30 cm dia. plywood disk (Fig. 2). The screen was dusted with a different colored powdered fluorescent marker for each day of beetle release. Equal numbers of male and female engraver beetles reared in the laboratory from field infested slash were placed in the funnel mouth that was then covered with a lid (Fig. 3). Injured or malformed beetles were eliminated from the test. The photopositive beetles walked toward the light entering the open neck of the funnel and then dropped to the screen coated with the fluorescent dust. The 30 cm dia. disk around the neck of the funnel forced the beetles to walk through the dust to reach the edge of the wire disk where they could take flight (Fig. 4). Beetles were released into the funnel within 36 hours of emergence in lots of 50 until 1,000 beetles had been released daily. Releases were begun in the morning after air temperatures reached the 20°C range. The number of beetles that died, failed to fly or had flown from the disk was recorded at 1 hour intervals.

The hardware cloth traps surrounding the attractive male billets at the ground and midcrown levels were removed daily before flight and taken to a darkened enclosure where they were scanned with a black light to detect the marked beetles. Both marked and released beetles were removed and counted and sexed in the laboratory.

RESULTS AND DISCUSSION

Flight Capacity of Marked Beetles

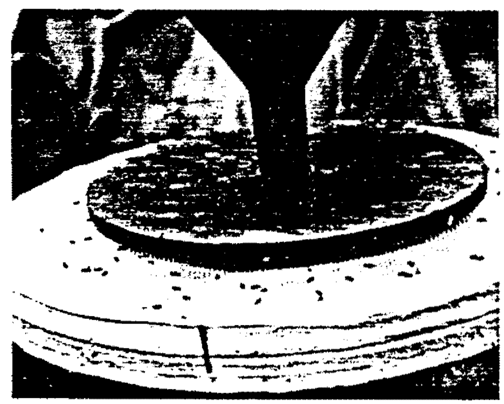
Overall 26% of the 4,900 marked beetles that were released failed to fly, and of these nonflyers, 8% died on the release platform. Those beetles that lived but failed to fly, walked around the platform and periodically raised their elytra as if they were about to fly but did not. Generally, they continued this action until they eventually tumbled off the

Fig. 1. Trap arrangement used at the Tarkio site showing the 15 cm sq. sticky plexiglas traps fastened at 1.5 m intervals to the nylon support ropes.

Fig. 2. Release platform at the Worley site used to mark and re 4,900 beetles used in the recapture study.

Fig. 3. A plywood disk on the funnel neck forced beetles to walk through the powdered fluorescent marker on the release platform.

Fig. 4. A darkened funnel dispenser was used to direct positively photo traphic beetles toward the light at the funnel neck and onto the release platform dusted with a powdered fluorescent marker.



platform and dropped to the soil. These beetles were not injured because they were examined for signs of injury at the time they were sexed and again at release and discarded if appendages were missing or broken, or obviously deformed. The findings suggest a closer investigation of flight capability of the pine engraver is warranted, especially as it may be influenced by physiological condition and possible presence of internal parasites in emergent beetles. Gara (1963) has suggested differences in flight capacity of I. paraconfusus are due to physiological differences rather than inherited ability.

Beetles that flew generally oriented toward the sun and flew upward in a spiral pattern, generally keeping within 45° of a line between the release platform and the position of the sun. Winds in excess of 3.6 to 4.8 kph tended to lessen the number of beetles taking flight and those that took flight between gusts quickly oriented with the wind. These data are similar to those obtained by Seybert and Gara (1970) in New York. Flight activity also was less when the sun was obscured by clouds even though temperatures were in excess of 18°C.

Table I. Number of marked I. pini recaptured by height and direction from point of release.

Direction from release point	Trap height Ground No.	%	Mid-Crown No.	%	Totals No.	%
W	59	32	17	40	76	34
E	58	31	2	5	60	27
N	43	23	7	17	50	22
S	24	13	16	38	40	17
Total	184	81	42	19	226	

Interval between Release and Recapture

In general most of the recaptured beetles reached the attractive trap the same day they were released. However, in one instance, 10 of 787 marked beetles were not recovered until 3 days after release, 13 were not recovered until 4 days after release and 8 were not recaptured until 5 days after release. Weather during a portion of the period was marked by frequent thunderstorms with cool nights that may have inhibited initial flight, but it may also suggest that not all flight capable beetles leave the area immediately after emergence. Studies of the dispersal of I. avulsus also showed that most new adults did not linger in the old infestation area (Mason 1969).

Recapture by Height and Direction

Only 226 (5%) of the 4,900 marked beetles released at the Worley site were recaptured. The hardware cloth traps at this site caught 226 beetles and 81% of these were caught on traps 1.8 m above ground (Table I). Fewer beetles (19%) were caught on traps suspended at midcrown.

Table II. Number of I. pini responding to attractive male infested logs by height and direction, Tarkio, Montana, 1967.

Trap Height m.	ft.	Direction from attractive source N	E	S	W	Total	%
17	55	1	0	0	0	1	1
15	50	3	0	0	0	3	3
13	45	4	4	0	2	10	9
12	40	2	1	0	1	4	4
11	35	1	4	0	0	5	4
9	30	6	7	1	1	15	13
7	25	4	1	3	0	8	7
6	20	7	6	4	3	20	17
5	15	3	11	4	3	21	18
3	10	12	7	2	1	22	19
2	5	1	1	4	0	6	5
Total		44	42	18	11	115	
Percent		38	36	16	10		

The plexiglas traps at the Tarkio site caught 115 beetles of which 67% were caught between 2 and 7 m above ground (Table II). An average of 3.8 beetles were caught on traps between 2 and 7 m above ground and 2.4 beetles per trap between 9 and 17 m.

Overall, 67% of the catch at Tarkio and 81% at Worley were recaptured on traps closest to the ground. Since most beetles were observed to follow a spiral flight path from the platform toward the upper crown it was surprising more beetles were not caught in the midcrown traps. While the study was not designed to determine the reason for this preference, the lowest branches on the crown in both test areas tended to extend to within 6 to 7 m of the ground and hence the flight zone with the least physical barriers was within 6 m of the ground. In contrast Gara (1963) found that at periods of low wind I. paraconfusus was rather evenly distributed between sampling heights and tended to concentrate closer to the ground and within the crown at relatively high wind speeds (1 to 1.5 m/sec).

Most of the beetles responding to the attractive caged logs at the center of the four lines of traps at the Tarkio site were caught on the north (38%) and east lines (36%) of traps (Table II). This meant they were flying toward the south and west and hence into the prevailing wind. In comparison, the greatest number of beetles (34%) dispersing from the central release platform were caught on the trap lines west of the release point, again in the direction of prevailing winds (Table I). In contrast, the second highest total catch (27%) was on traps on the east side of the release platform and fewest 17% were caught on the south traps suggesting these beetles did not always orient in the direction of the prevailing W to SSW wind. These results contrast in part with those obtained by Gara (1963) with I. paraconfusus that showed most beetles took off with the wind, especially at velocities greater than 1.8 kph.

Sex Ratios

The ratio of females to males of 500 pine engraver beetles collected in lots of 100 from field infested slash reared in the laboratory was 1.2:1.0 (range 1.0-1.4). There was no difference in the female to male ratio of 226 recaptured marked beetles and 6,400 wild beetles that averaged 1.7. The ratio for marked beetles ranged from 1.3 to 2.4 while the ratio for wild beetles ranged from 1.0-2.2. Sex ratios for reared and field trapped wild I. paraconfusus were identical to those recorded during this study (Gara 1963). Gara suggested this imbalance in the sex ratio was due to the females apparently greater ability to respond to attractive sources beyond 50 m.

CONCLUSIONS

An appreciable percentage (26%) of 4,900 beetles selected for the release and recapture study failed to fly. These marked beetles were collected from slash only within the study area so it is unknown whether a similar percentage of nonflyers exists in all populations. Evaluation of other populations throughout the beetles' range would be useful for predicting subsequent attack densities and damage. Further, the fact that so few of the marked beetles (4%) were recaptured suggests that the group kills caused by the F-1 generation in standing trees during July is more likely a result of the pheromone bouquet produced at that time rather than an inherent facet of the beetles dispersal and orientation mechanisms. Additionally, the role of visual stimuli should also be evaluated since Gara et al. (1965) and Mason (1969) suggest this may be a factor in the host selection of I. paraconfusus and I. avulsus respectively.

Overall, differences in the height of flight and orientation of dispersing beetles determined during this study and those of Gara (1963) and Gara and Seybert (1970) are likely a result of stand structure at the different test localities and variation within beetle populations studied. The variability in the results reemphasize the value of the analysis of Atkins (1968), who warned that only by balancing research efforts devoted to isolating and testing pheromones for suppression of bark beetles with indepth research in the ecology, behavior and genetics of the species involved can we hope to use these chemical messengers effectively and assure their future value for survey and suppression.

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REFERENCES

Amman, G. D. and B. H. Baker. 1972. Mountain pine beetle influence on lodgepole pine stand structure. J. For. 70: 204-209.

Anderson, R. F. 1948. Host selection by the pine engraver. J. Econ. Ent. 41: 596-602.

Atkins, M. D. 1968. Scolytid pheromones--ready or not. Can. Ent. 100: 115-117.

Cahill, D. B. 1978. Cutting strategies as control measures of the mountain pine beetle in lodgepole pine in Colorado, pp. 188-191. In A. A. Berryman, G. D. Amman and R. W. Stark (Eds.), Theory and Practice of Mountain Pine Beetle Management in Lodgepole Pine Forests, Symp. Proc. Coll. For., Wildl. Range Sci., Univ. Idaho, Moscow.

Dickens, I. C. 1979. Electro physiological investigations of olfaction in bark beetles. Bull. Soc. Ent. Suisse 52: 203-216.

Gara, R. I. 1963. Studies on the flight behavior of *Ips confusus* (Lec.) (Coleoptera: Scolytidae) in response to attractive material. Contrib. Boyce Thompson Inst. 22: 51-66.

Gara, R. I., J. P. Vité and H. H. Cramer. 1965. Manipulation of *Dendroctonus frontalis* by use of a population aggregating pheromone. Contrib. Boyce Thompson Inst. 23: 47-66.

Lanier, G. N., M. C. Birch, R. F. Schmitz and M. M. Furniss. 1972. Pheromones of *Ips pini* (Coleoptera: Scolytidae): Variation in response among three populations. Can. Ent. 104: 1917-1923.

Mason, R. R. 1969. Behavior of *Ips* populations after summer thinning in a loblolly pine plantation. For. Sci. 15: 390-398.

Mustaparta, H., M. E. Angst and G. N. Lanier. 1977. Responses of single receptor cells in the pine engraver beetle, *Ips pini* (Say) (Coleoptera: Scolytidae) to its aggregation pheromone, ipsdienol, and the aggregation inhibitor, ipsenol. J. Comp. Physiol. 212: 343-347.

Sartwell, C., R. F. Schmitz and W. J. Buckhorn. 1971. Pine engraver, *Ips pini* in the Western States. U.S. Dep. Agric. For. Serv. For. Pest Leafl. 122. 5 pp.

Seybert, J. P. and R. I. Gara. 1970. Notes in flight and host-selection behavior of the pine engraver *Ips pini* (Coleoptera: Scolytidae). Ann. Ent. Soc. Amer. 63: 947-950.