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TRAP PREFERENCES OF *RETINIA METALLICA* AND SEASONAL FLIGHT BEHAVIOR OF *RETINIA* SPP., *RHYACIONIA* SPP. (TORTRICIDAE), AND *CHIONODES* SPP. (GELECHIIDAE) IN THE DAKOTAS

MARY ELLEN DIX

Rocky Mountain Forest and Range Experiment Station,
Forestry Sciences Laboratory, East Campus, University of Nebraska,
Lincoln, Nebraska 68583

AND

MARTIN JACOBSON

Biologically Active Natural Products Laboratory,
Agricultural Environmental Quality Institute, Agricultural Research Service,
Beltsville, Maryland 20705

ABSTRACT. At high population levels, white and green traps baited with (Z)-7-dodecenyl acetate caught more *Retinia metallica* than blue traps. Diamond-shaped traps were more effective than cup traps, but did not differ significantly in effectiveness from triangular-shaped traps. *Rhyacionia fumosana* and *R. neomexicana* responded throughout May to synthetically-baited traps. *Rhyacionia bushnelli* and *Retinia metallica* flew in late May or early June.

Tip mining lepidopterous larvae can cause extensive damage to ponderosa pine (*Pinus ponderosa* Laws.) in the northern Great Plains (Stein & Kennedy 1972). Information on their distribution is limited; effective techniques for detecting and evaluating infestations are not available (Dix et al. 1984). Accurate determination of the flight period of Lepidoptera that are concealed for most of their life cycle is crucial to the effective timing of insecticide applications. Sex attractants are ideal for detecting and delineating the adult flight period of such Lepidoptera (Stevens et al. 1980). Jacobson and Jennings (1978) and Stevens et al. (1980) identified attractants of *Rhyacionia fumosana* Powell and *Rhyacionia neomexicana* (Dyer). Several possible lures of *Retinia metallica* (Busck) and *Rhyacionia bushnelli* (Busck), two of the more common species in the north central U.S., were identified by Dix et al. (1984). A trapping technique for *Retinia metallica* using these lures needs to be refined. This article describes trap design and trap color preferences of *R. metallica,* and delineates the flight period of *Retinia* spp., *Rhyacionia* spp. (Tortricidae: Olethreutinae), and *Chionodes* spp. (Gelechiidae) that infest ponderosa pine in North Dakota and South Dakota.

TABLE 1. Description of sites used to determine flight periods of pine-feeding Lepidoptera in North Dakota and South Dakota, 1973–76.

Year	Locality	Type of stand	Tree height (m)	Estimated number of trees	Trapping period
1975	Near Burning Coal Vein, Little Missouri Grasslands, Custer National Forest, Slope Co., North Dakota	Native	0.5–20	500	10 May–20 July
	North Cave Hills, Custer National Forest, Harding Co., South Dakota	Native	0.5–20	500	10 May–20 July
	Slim Buttes, Custer National Forest, Harding Co., South Dakota	Native	0.5–20	500	10 May–20 July
	Big Sioux Conifer Nursery, Coddington, Co., South Dakota	Planted	2–6	3,000	8 May–15 June
1976	Near Burning Coal Vein, Little Missouri Grasslands, Custer National Forest, Slope Co., South Dakota	Native	0.5–20	500	10 May–3 Aug
	Big Sioux Conifer Nursery, Coddington Co., South Dakota	Planted	2–6	3,000	27 May–22 June

METHODS AND MATERIALS

Trap design and trap color preferences of *R. metallica*. Trials were conducted in May and June at the Big Sioux Conifer Nursery, Coddington Co., South Dakota. Initially, a moderate population (5 pitch blisters/tree) was present in the 9-year-old ponderosa pine provenance planting, and a high population (36 pitch blisters/tree) was present in the 20-year-old ponderosa pine in the nursery's border planting.

A cardboard cup trap (0.24 liter), a triangular milk carton trap (9 cm high and 15 cm long), and a diamond-shaped milk carton trap (9 × 9 × 15 cm) were each lined with Stikem Special® and were baited with 10 mg of (Z)-7-dodecenyl acetate. All traps were open at both ends and were white. There were six blocks of three traps (one of each design). Traps in each block were hung in the border planting 20 m apart at a height of 1.5 m.

The effect of trap color on trap catch was determined with diamond-shaped traps painted white (2A1), pale blue (24A5), green (28D8), or fluorescent orange (7A8). Notations following colors refer to Kornerup and Wanscher's (1967) standard colors. All traps were baited with rubber septum dispensers containing 10 mg (Z)-7-dodecenyl acetate plus 10 mg trioctanoin and were deployed 20 m apart at a height of 1.5 m in perimeter ponderosa pines. There were six blocks of four traps (one of each color) in trial 1 and four blocks of four traps in trial 2.

TABLE 2. Comparison of trap catch of male *R. metallica* with different sticky trap designs baited with 10 mg of (Z)-7-dodecenyl acetate plus 10 mg trioctanoin.

Design	Surface area (cm^2)	Number of traps	No. males/trap		No. males/cm^2	
			Mean[1]	SE	Mean[1]	SE
Diamond	427.5	3	187a	21.4	0.5a	0.05
Triangular	405.0	3	142ab	28.4	0.3a	0.06
Cup	220.5	3	59b	4.3	0.3a	0.02

[1] Means followed by the same letter are not significantly different ($P < 0.05$) according to Tukey's procedure for multiple comparisons.

Each week for three weeks, trap catches were counted and the traps were randomly reassigned to a new site within the block. Analysis of variance and Bartlett's test for homogeneous variance were performed on the total catch per trap. When necessary, the data were transformed by $\ln(x + 1)$ to stabilize the variance for analysis of variance. Tukey's honestly significant difference procedure at the 5% level was used to separate means (Sokal & Rohlf 1969).

Seasonal flight record. During spring and early summer of 1975 and 1976, known attractants of *Rhyacionia* spp. and *Chionodes* spp., and several related synthetic compounds were used to attract *Rhyacionia* spp., *Retinia* spp., and *Chionodes* spp. that damaged ponderosa pine in native and planted stands (Table 1). Compounds used as lures included (*E*)-7-decenyl acetate, (Z)-7-decenyl acetate, (*E*)-7-dodecenyl acetate, (Z)-7-dodecenyl acetate, (Z)-7-dodecen-1-ol, (*E*)-8-dodecenyl acetate, (Z)-8-dodecenyl acetate, (Z)-9-dodecenyl acetate, (*E*)-9-dodecenyl acetate, (*E*)-9-dodecen-1-ol, (Z)-10-dodecenyl acetate and (*E*)-10-dodencenyl acetate. In 1975, each compound was replicated twice at a site, and traps and dispensers were changed three times during a trapping period. In 1976, each compound was replicated five times at a site, and traps were changed six times at two-week intervals during a trapping period.

Traps were cardboard cups (0.24 liter) with a 2.5 cm diameter opening at both ends. The inside was coated with Stikem Special®. In 1975, a cotton wick dispenser (12 × 10 mm) was impregnated with 20 mg of a test compound and placed in the bottom of each trap. In 1976, a rubber septum dispenser (5 × 9 mm) baited with 10 mg of test compound was used. In 1975 and 1976, compound activity was prolonged by adding 10 mg of the extender trioctanoin. Control dispensers also were baited with 10 mg of trioctanoin and were replicated twice per site in 1975 and five times per site in 1976. Traps baited with synthetic attractants or with control dispensers were hung on ponderosa pine branches at a height of 1.5 m and a spacing of at least 20 m.

TABLE 3. Effect of trap color on catches of male *Retinia metallica* in diamond-shaped sticky traps baited with 10 mg of (Z)-7-dodecenyl acetate plus 10 mg trioctanoin.

Trap color	Trial 1			Trial 2		
	Number of traps	No. males/trap		Number of traps	No. males/trap	
		Mean[1]	SE		Mean[1]	SE
White	4	150.3a	35.91	4	3.5a	1.19
Green	4	123.5a	34.50	4	2.5a	0.95
Orange	4	95.3a	44.18	4	1.8a	0.63
Blue	4	16.0b	2.16	4	0.8a	0.48

[1] Means followed by the same letter are not significantly different ($P < 0.05$) according to Tukey's procedure for multiple comparisons.

Captured moths were identified and counted when traps were changed. Moths were removed from traps with forceps or by carefully cutting the trap around the moth. Specimens were tentatively identified and numbers of moths per species were recorded. Representative samples of each presumed species were sent to specialists for identification.

RESULTS AND DISCUSSION

Trap design and trap color preferences of *R. metallica*. Traps in several blocks were blown down during a spring storm; catches in traps from these blocks were not included in analyses. The second color preference trial was conducted the following spring, after the number of active *R. metallica* had abruptly decreased (less than 1 pitch blister/tree). An unusually wet August and winter probably contributed to the high larval mortality and reduction in number of adults.

Effectiveness of the traps varied with design and color (Tables 2, 3). Diamond-shaped traps had the largest surface area and caught more moths than either triangular or cup traps. However, only mean catches per trap of the diamond-shaped traps and cup traps differed significantly. At high population levels, as exhibited in trial 1, white, green, and orange traps caught significantly more males than blue traps (Table 3). However, at low population levels (trial 2), trap color did not affect trap catch.

Seasonal flight behavior. The beginning and end of male flight for five species of Olethreutinae which infest the branch tips of ponderosa pine varied yearly with the onset of spring. For example, the spring of 1976 was warmer than in 1975, and moth flights of *Retinia metallica, R. gemistrigulana* and *Rhyacionia fumosana* were earlier (Fig. 1).

In southwestern North Dakota and northwestern South Dakota, male *R. fumosana* and *R. neomexicana,* the first species trapped in the

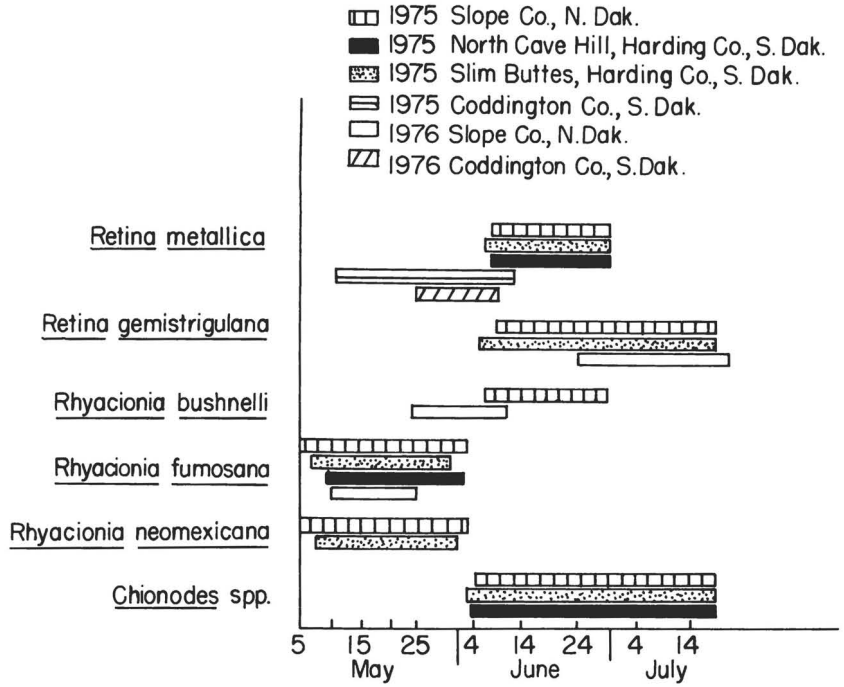

FIG. 1. Seasonal flight of Tortricidae: Olethreutinae and Gelechiidae that damage ponderosa pine in North Dakota and South Dakota.

spring, were usually caught in early May. *Rhyacionia bushnelli*, *Retinia metallica*, and *R. gemistrigulana* (Kearfott) were caught two to three weeks later, frequently in late May or early June. Large numbers of *Chionodes* spp. (Gelechiidae), which mine cones of ponderosa pine, were caught during June and July. Flight of *Retinia metallica* in northeastern South Dakota (Coddington Co.) was about two weeks earlier than in northwestern South Dakota.

In conclusion, white, green, or orange diamond- and triangular-shaped traps are effective in catching male *R. metallica*. However, diamond-shaped traps are preferred for future attractant trials and for detecting males because they provide a larger surface area. Time of moth flight varies annually. Additional research is needed to determine the effect of cumulative atmospheric and ground temperature on moth flight and to develop a method for accurately predicting moth flight.

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