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Effect of European Hylesinus Beetle Attractants on Monochamus Alternatus Hope (Coleoptera: Cerambycidae) in China Forests

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Abstract

In this study, we firstly performed a comparative analysis of five attractants, four European products and one Chinese product, for their attraction to adult *Monochamus alternatus* Hope and other insects in the forestry area in Fuyang, Zhejiang, China. Research results show that among these 5 different lures to trap *M. alternatus*, Seudenol trapped the largest amount and species of insects. In terms of efficiency, M-99 (the Chinese product) and exo-brevicomin are the best, Seudenol, 2-Methyl-3-buten-2-ol and ipsenol, ipsdienol and cis-verbenol the second, while the control group is the worst. Based on the attractive effect, 2-Methyl-3-buten-2-ol is distinctly different from the other four lures according to the statistical analysis, while there is no significant difference among the other four lures. This is probably due to factors such as the lure composition, natural environment, host plant, geographical difference, and geographical isolation of *Monochamus alternatus* Hope. These five lures not only showed effect on the *Monochamus alternatus* Hope, but also had attraction to borer pests, such as *Spondylis buprestoide* and *Monochamus bimaculatus* Gahan. Among them, Seudenol trapped the largest amount of *S. buprestoides* and *M. bimaculatus* Gahan.

Keywords: Attractant; China; Hylesinus beetle; *Monochamus alternatus* Hope

Introduction

Monochamus alternatus Hope (Coleoptera: Cerambycidae) is a major vector pest insect to spread pine wood nematode, *Bursaphelenchus xylophilus* (Steiner & Buhrer) Nickle in eastern Asia. The control and treatment of *M. alternatus* Hope is difficult because it develops hidden under bark and therefore is not accessible to chemical agents for natural enemies. Allison et al. [1] note that various species of *Monochamus* (Coleoptera: Cerambycidae) respond to conifer volatiles and bark beetle pheromones. As one efficient and eco-friendly way to control species' population, trapping *M. alternatus* with an attractant is useful in the treatment of harmful species with no detriment to environment. This method has been widely utilized in forestry areas [2-4]. In Texas, Billings and Cameron [5] and Billings [6] found a kairomonal response by *Monochamus titillator* (F.) to a blend of Ips spp. pheromones (ipsenol, ipsdienol and cis-verbenol). In recent years, a variety of attractants have been developed from volatiles of host plants, which are crucial for monitoring, prevention and control of *M. alternatus* and to control the spread of *B. xylophilus* and break cycle pathways [7-13]. In southeastern United State, *M. titillator* is attracted to traps baited with ipsenol or ipsenol and ipsdienol [14]. Raffa [15] reported that *M. carolinensis* (Olivier were captured in ipsdienol- baited traps in Wisconsin). In British Columbia, Miller and Borden [16] found that trap catches of *M. clamator* (LeConte) increased as the combined release rates of ipsdienol and (-) – ß - phellandrene increased. Allison et al. [17] found that four *Monochamus* spp. In Northwestern North America respond to the pheromones of sympatric bark beetle, likely a mechanism for optimal foraging by adults for oviposition sites [18]. However, recent field tests in China showed that two bark beetle attractants had a negative attractiveness to *M. alternatus*. Therefore, this study was designed to screen and optimize the more effective substances of *M. alternatus* attractants to enhance their utility. A novel field test was carried out to investigate the attractiveness to *M. alternatus* of six bark beetle attractants combined with a Chinese longicorn beetle attractant. The results provide a theoretical basis for monitoring and controlling *M. alternatus* as well as inhibiting the spread of pine wilt disease.

In this paper, effect of European Hylesinus beetle attractants on *M. alternatus* Hope were firstly studied and compared in eastern China, to find efficient products for treatment of *M. alternatus* and prevention of the spread of *B. xylophilus*.

Materials and methods

Experimental site

The study was conducted in the forest at Fuyang, Zhejiang Province, China (30°03'N, 119°57'E). The dominant species in the forest was *Pinus massoniana*, *P. elliotii* and *P. taeda*. Twenty to thirty percent trees of all species were infected by the pine wood nematode disease, but chemical pesticides were not used in the experimental site for a long time. For *P. massoniana*, it has an area of 301 hm^2, an average age of 23 years, an average height of 6 m and an average density of 800 trees/hm^2.

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Attractants

All of the attractants used in this experiment are listed in the Table 1. *M. alternatus* attractant M-99 was provided by the Forest Pest Control and Quarantine Bureau of Zhejiang Province, China, and bark beetle attractants were provided by the French National Institute for Agricultural Research (INRA) in France.

Lure Compounds	Target or attracted species	Formula	Chemical purity (%)	Enantiomeric ratio(+:-)	Release rate at 24-26℃
Exo-brevicomin	Dendroctonus brevicomis	C9H16O2	98	83:17:00	0.6 mg/d
2-Methyl-3-buten-2-ol	*Ips typographus*	$C_5H_{10}O$	98.0	99.5:0.5	36 mg/d
Seudenol	*Dendroctonus rufipennis*	$C_7H_{14}O$	98.0	91:9	60 mg/d
ipsenol, ipsdienol and cis-verbenol	Ips acuminatus	C10H18O, C10H16O and C10H16O	-	-	70 mg/d
M-99	Monochamus alternatus	C10H16, C2H4O, C3H6O	-	-	10 mL/d

Table 1: Chemical lures and enantiomeric purity of chemicals tested in the field assay

Experimental design

The experiment was carried out from May 1st to July 15th, 2010, which includes pre- and post-peaks of *M. alternatus* adult populations. Pine trees with a distance of 3 m or more between each other and located on the roadside, hillside and ridge where air circulation was good were selected. The cross vanes type trap was used for beetle collection. Traps were fixed with iron wire on the trees and 1.5-2.0 m above the ground as well as at least 50 m apart from each other.

The experiments had 6 treatments (Table 2), each with 5 replications. When a trap was set, the attractants were fixed in the middle of the column inside the trap without a cap or with an opening in the sack for slow release of volatile compounds. M-99 was replaced every 15 days and the rest had no replacement. All insects trapped were collected and recorded every 3-7 days, which was depending on weather conditions. After each collection, each trap was changed the position with the next trap. The insects captured were taken back to the laboratory for counting and identification. Meanwhile, the number of *M. alternatus* Hope adults, eggs and nematodes carried were observed with microscopes and statistically calculated.

Statistical analysis

Statistic analysis of the experimental data was performed using Microsoft Office Excel 2007. One way ANOVA in SPSS13.0 was performed for the attractive effects between different lures. In addition, Duncan's method was used to analyze the differences between various treatments (P<0.05).

Results

Attraction of different lures for *M. alternatus* Hope

A total of 147 *M. alternatus* adults (71 males and 76 females; sex ratio of 0.93) were captured by the five attractants from May 1st to July 15th. The quantity of *M. alternatus* Hope attracted by each lure, the quantity of the nematodes they carried, and the number of eggs were shown in Table 2.

Lure	The total number of trapped insects	Sex ratio (♂/♀)	The average number of insects in each trap (± S.D.)	The number of nematodes	The number of eggs per individual
Exo-brevicomin	35	25-Oct	7.0 ± 1.38b	30500	124
2-Methyl-3-buten-2-ol	21	12-Sep	4.2 ± 1.39a	20250	117
Seudenol	30	15/15	6.0 ± 0.71b	20250	163
Ipsenol, ipsdienol and cis-verbenol	23	12-Nov	4.6 ± 2.0b	16500	171
M-99	35	15/20	7.0 ± 1.5b	39250	229
Water (control)	3	02-Jan	0.6 ± 0.25a	0	16

Table 2: Comparison of effects among five attractants for *M. alternatus* Hope

*The differences between various treatments were analyzed by Duncan method ($P < 0.05$).

Based on their attractive effects, M-99 and exo-brevicomin are best, Seudenol is second, and then 2-Methyl-3-buten-2-ol and Ipsenol, ipsdienol and cis-verbenol. M-99 and exo-brevicomin attracted the largest amount of adult *M. alternatus* Hope is 35, which also showed high quantity of nematodes and eggs. The control group (water) was worst.

ANOVA results show that there is no significant difference between M-99, Exo-brevicomin, Seudenol, and Ipsenol, ipsdienol and cis-verbenol. However, these four lures showed distinctly better attraction than 2-Methyl-3-buten-2-ol which only trapped 4.2 adults on average. The control group again showed the worst effect.

Quantities of captured *M. alternatus* adult-carried nematodes and female-carried eggs

Microscopic examination of *M. alternatus* adults trapped by the five attractants revealed that the percentages of adults carrying pine wood nematodes trapped by M-99, Exo-brevicomin, 2-Methyl-3-buten-2-ol, Seudenol and Ipsenol, ipsdienol and cis-verbenol were 82%, 79%, 71%, 68%, and 56%, respectively. The adult females trapped by the five attractants had deep yellow mature eggs and white immature eggs in

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their ovaries. As shown in Table 2, the number of eggs per females trapped in different treatments had no significant difference.

Attractiveness of different attractant combinations to other wood-boring beetles

The species and number of other wood-boring beetles trapped by M-99 and four attractant combinations are listed in Table 3. As for the species, a large number of insects belong to coleopteran. There are also insects from Homoptera and Orthoptera. In addition, borer pests, such as *Spondylis buprestoides* and *M. bimaculatus* Gahan, are in large quantities, which are close to that of *M. alternatus* Hope. This indicates that these five lures not only show attraction to *M. alternatus* Hope, but also have the attractive effect on borer pests like *S. buprestoides* and *M. bimaculatus* Gahan.

Lure	Other insects	Number of individuals
Exo-brevicomin	*M. bimaculatus Gahan*	11
	Purpuricenus temminckii Guerin	10
	Chrysopa perla	8
	Sphedanolestes impressicollis Stal	9
	Polyphylla chniensis Fairmaire	9
	S. buprestoides	10
	Cryptotympana atrata Fabricius	8
	Anomala corpulenta Motsch	9
	Hippotiscus dorsalis (Stal.)	9
2-Methyl-3-buten-2-ol	*Chrysopa perla*	8
	M. bimaculatus Gahan	11
	Polyphylla chniensis Fairmaire	10
	Goryphus basilaris Helmgren	9
Seudenol	*Hyposipalus gigas Linnaeus*	9
	Megalanguria gravis Arrow	9
	S. buprestoides	13
	Sphedanolestes impressicollis Stal	9
	Polyphylla chniensis Fairmaire	9
	Charaxes berbardus (Fabricius)	8
	M. bimaculatus Gahan	12
	Semanotus bifasciatus Motschulsky	10
	Chlorophorus miwai Gressitt	10
	Cryptalaus larvatus Candeze	9
	Purpuricenus temminckii Guerin	10
Ipsenol, ipsdienol and cis-verbenol	*M. bimaculatus Gahan*	10
	S. buprestoides	11
	Anomala corpulenta Motsch	10
	Dicranocephalus Wallichi	9
	Polyphylla chniensis Fairmaire	10
	Hippotiscus dorsalis (Stal.)	10
	Goryphus basilaris Helmgren	9
M-99	*S. buprestoides*	11
	M. bimaculatus Gahan	10
	Charaxes berbardus (Fabricius)	9
	Anoplophora chinensis Foster	12
	Sphedanolestes impresicollis Stal	10
	Cryptotympana atrata Fabricius	9
	Anomala corpulenta Motsch	10
	Goryphus basilaris Helmgren	9
Water (control)	*Prionus insularis Motschulsky*	3
	Polyphylla chinensis Fairmaire	2

Table 3: The species and number of individuals of wood-boring insects trapped by different attractants

Discussion

Based on the number of trapped *M. alternatus* Hope, Exo-brevicomin showed the best effect. M-99 is relatively more stable and attracts more female insects compared to Exo-brevicomin, which can effectively prevent breeding of *M. alternatus* Hope and spread of *B. xylophilus*. On the other hand, Exo-brevicomin has better an attractive effect on the *M. alternatus* Hope in the period of nutrition supplement.

As for the species and quantity of the trapped insects, Seudenol captured the highest number of species, especially Coleoptera. Among them, *S. buprestoides* and *M. bimaculatus* Gahan have the largest quantities. These results show that Seudenol can be widely applied to various insects. However, the volatilization of M-99 is great and difficult to control. Therefore, M-99 can only be used in a short time and has to be replaced frequently, which limits its practical application. In contrast, Hylesinus beetle attractants are used in a sustained release manner, which can effectively control the volatilization and thus prolong the cycle time and reduce the cost. Therefore, these lures have broad applications.

In this study, we found that there was no significant difference among Exo-brevicomin, Seudenol, Ipsenol, Ipsdienol and Cis-verbenol, and M-99, whereas these four lures showed significant improved effects compared to 2-Methyl-3-buten-2-ol. This could be caused by many factors, such as the lure composition, natural environment, host plant, geographical difference, and geographical isolation of *M. alternatus* Hope. Among them, the lure composition is the most important factor. The preference to host plants from the insects can also cause different attractive effects. For *M. alternatus* Hope, M-99 has the best attraction, because that the plant-sourced volatile substance from M-99 matches well with *M. alternatus* Hope, while the volatile substances in other lures mainly target Hylesinus beetle. Moreover, the attractive effects are influenced by the environment, the installation technique, volatilization control, and weather condition. Therefore, appropriate attractants should be selected to achieve an optimal effect based on the practical condition and requirement.

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