Seasonal Abundance, Arrival and Emergence Patterns of Predaceous Hister Beetles (Coleoptera: Histeridae) Associated with *Ips* Engraver Beetles (Coleoptera: Scolytidae) in Louisiana[1]

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Abstract The most common predaceous hister beetles (Coleoptera: Histeridae) found associated with *Ips* engraver beetles (Coleoptera: Scolytidae) in southern Louisiana were *Platysoma attenuata* LeConte, *P. cylindrica* (Paykull), *P. parallelum* (Say), and *Plegaderus transversus* (Say). The seasonal abundance of histerids caught in flight traps coincided with *Ips* spp. activity in the area. Histerid adults were initially caught in sticky traps on *Ips*-infested loblolly pine logs 1 wk after *Ips* spp. attacks had begun. As a group, histerids emerged from logs in a bimodal pattern with the first peak occurring during *Ips* spp. emergence and a second 4 wks later. The abundance of *P. parallelum* and *P. transversus* indicates that they likely fed on bark beetles and organisms arriving later in the colonization sequence. Visual orientation appeared to play a role in attraction of histerids to logs colonized by bark beetles. *Platysoma attenuata* preferred vertically-positioned logs to horizontal logs, while *P. parallelum* was the opposite. These results suggest that some histerids may be visually attracted to horizontal silhouettes, such as pine trees that have been blown down or felled and often are infested by *Ips* spp. Other hister beetles may prefer vertical silhouettes, such as standing pines, which tend to be colonized by the southern pine beetle, *Dendroctonus frontalis* Zimmermann.

Key Words *Platysoma, Plegaderus,* predation, host finding

Pine bark beetles have a diverse assemblage of associated arthropod natural enemies (Dahlsten and Whitmore 1989). Predators and parasitoids are attracted to beetle-infested trees by odor cues, bark beetle pheromones and host tree volatiles, and perhaps visual cues, tree silhouettes and color (Borden 1982, Wood 1982, Payne 1989, Strom et al. 1999).

Histeridae (Coleoptera) are small, predaceous beetles often associated with ephemeral substrates, such as dung, carrion, or decaying plants; some inhabit bark beetle galleries (Kovarik and Caterino 2000). Bark-dwelling histerids represent a significant portion of the natural enemy complex of pine bark beetles, making up approximately 7% of all southern pine beetle, *Dendroctonus frontalis* (Zimmermann), and 6% of all *Ips* engraver beetle predator abundance (Kulhavy et al. 1989, Berisford 1980). *Platysoma attenuata* LeConte, *Platysoma cylindrica* (Paykull), *Platysoma parallelum* (Say), and *Plegaderus* spp. have been found in pines infested with *Ips* spp.

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and/or *D. frontalis* in several Gulf Coast states (Dixon and Payne 1979, Goyer et al. 1980, Moser et al. 1971, Overgaard 1968, Riley and Goyer 1986, Stein and Coster 1977).

Bark beetle infestations and the resulting damage alter the bark and wood of trees, allowing secondary organisms to feed. Histerids that initially feed on bark beetles may remain *in situ* and subsequently prey upon the secondary gallery fauna. Like other coleopteran predators, they are considered generalists within a specialized habitat (Erbilgin and Raffa 2001).

The objectives of this study were to identify the histerid species associated with *Ips* spp. and to determine their seasonal abundance in southern Louisiana. We also attempted to define histerid arrival and emergence patterns and relate them to those of co-occurring *Ips* engraver beetles. Because little is known about the specific cues that attract histerids to bark beetle-infested trees, data also were collected to ascertain if these predaceous beetles use host tree silhouettes to help in visually locating their prey.

Materials and Methods

Study site. All field research was conducted in loblolly pine, *Pinus taeda* L., stands at the Louisiana State University AgCenter Idlewild Research Station near Clinton, LA, about 40 km north of Baton Rouge.

Seasonal abundance. Seasonal abundance of histerid adults was monitored between May 1999 and May 2000 using Lindgren multiple funnel traps (Lindgren 1983). Traps were baited with turpentine and *Ips* spp. pheromones. Two traps, positioned 30 to 60 m apart, were placed in loblolly pine stands at each of four trap sites that were at least 400 m apart. At each site one trap was baited with turpentine (Klean-Strip®, Memphis, TN) and racemic ipsenol, an attractant pheromone of *Ips grandicollis* (Eichhoff). Another was baited with turpentine and racemic ipsdienol, an attractant pheromone of *Ips avulsus* (Eichhoff) and *Ips calligraphus* (Germar) (ipsenol and ipsdienol in 40 mg polyethylene bubble-cap dispensers, PheroTech, Inc., Delta, BC, Canada). Both ipsenol and ipsdienol were used as baits in order to obtain an inclusive sample of histerid predators of *Ips* spp. Beetles were collected semi-weekly or weekly. To account for possible position effects, the two traps at each site were rotated at the time of each collection. Captured histerids were identified to species and enumerated by date and species in the laboratory. Voucher specimens were placed in the Louisiana State University Arthropod Museum.

Emergence patterns. Emerging *Ips* spp. and histerid adults were collected from 85 logs cut from 14 loblolly pines between June and August of 2000. Two trees were felled approximately weekly and left on the ground, thus facilitating colonization by *Ips* engraver beetles. A schematic of the entire procedure is presented in Figure 1 and is summarized below. Each week following colonization by *Ips* spp., a log approximately 40 to 60 cm in length and 10 to 20 cm in diam was cut from each of the felled trees and sealed inside a 100-L metal rearing drum. Logs were removed weekly from individual trees for 8 wks after initial *Ips* spp. arrival. All emerging *Ips* spp. and histerid beetles were collected for 2 wks in jars containing 70% ethyl alcohol.

Visual preference. During April and May of 1999, *Ips* spp. and histerid arrival data were gathered from an array of 16 freshly cut loblolly pine logs, approximately 2 m long and 20 cm in diam. One-half of the logs were oriented vertically, and the other half were oriented horizontally. The logs were positioned close together in vertical/

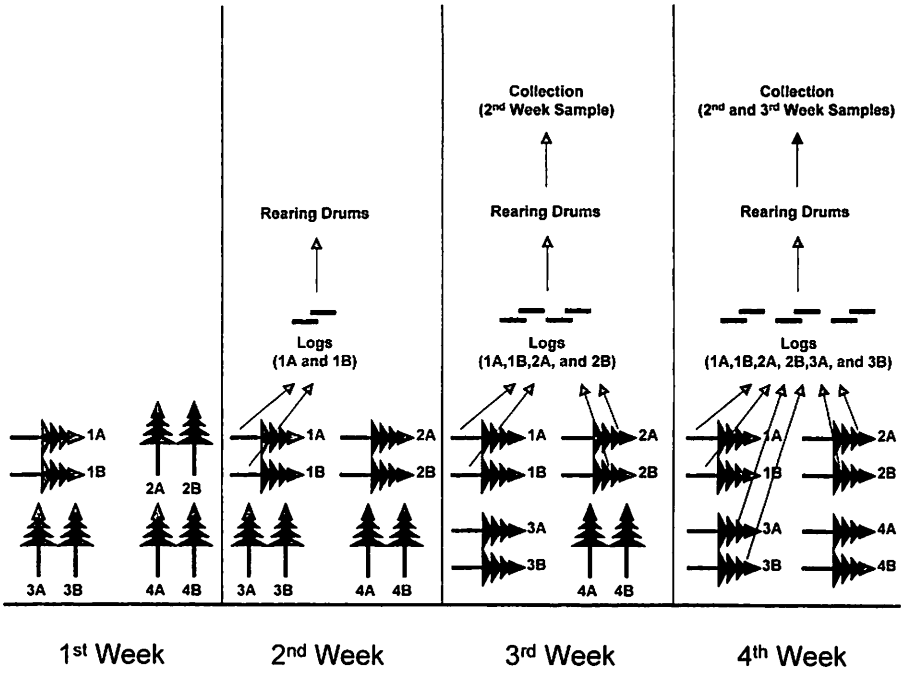

Fig. 1. Schematic diagram of the sampling protocol to determine *Ips* spp. and histerid emergence patterns from felled loblolly pine trees in southern Louisiana.

horizontal pairs that were rotated randomly each week to different sides of a 6 x 6 m square in a small clearing surrounded by a loblolly pine stand. We assumed that the odor plumes originating from each log pair were co-mingled, as we attempted to isolate visual cues as sources for histerid attraction. A 20 x 50 cm sticky Mylar® (DuPont™, Wilmington, DE) plastic sheet was nailed to the middle of each log. Racemic ipsenol and ipsdienol pheromone lures were attached to a wooden post at the center of the clearing to attract *Ips* engraver beetles to the logs, and colonization occurred shortly thereafter. The lures were subsequently removed to prevent interference with the experiment. Sticky sheets were removed and replaced with new ones on a weekly basis for a period of 5 wks, beginning approximately 1.5 wks after the logs were set up.

Statistical analysis. Analysis of variance with *a priori* contrasts at a significance level of $P = 0.05$ was used to compare the mean numbers of histerids captured in ipsenol- and ipsdienol-baited funnel traps, as well as the mean numbers of *Ips* spp. and histerids captured in sticky traps on horizontal and vertical logs (SAS Institute 2001).

Results

Seasonal abundance. Six histerid species were found associated with *Ips* engraver beetles in Louisiana: *P. attenuata, P. cylindrica, P. parallelum, Plegaderus* *barbelini* Marseul, *Plegaderus transversus* (Say), and *Paromalus seminulum* Erichson. *Plegaderus barbelini* and *P. seminulum* were represented by only a few individuals and are included only in overall histerid data analyses.

The total number of specimens of the four most common histerid species was pooled on a monthly basis (Fig. 2). Histerid adults were captured throughout the year in the flight traps, but the largest numbers were caught between March and July. Most were trapped in low numbers during the fall and winter months. *Plegaderus transversus* was most abundant throughout the year. Though abundant in May, *P. attenuata* was not captured in any traps after September 1999. There was no significant difference for any species between the mean number of histerids captured in the ipsenol- and ipsdienol-baited traps (*F* = 0.06; df = 1, 24; *P* = 0.8044 for *P. attenuata; F* = 2.48; df = 1, 24; *P* = 0.1285 for *P. cylindrica; F* = 1.15; df = 1, 24; *P* = 0.2938 for *P. parallelum; F* = 0.02; df = 1, 24; *P* = 0.8874 for *P. transversus*).

Emergence patterns. Total *Ips* spp. and histerid emergence data were standardized to the week of first *Ips* spp. emergence from each tree, which varied from 2 to 3 wks after tree felling. This is defined as "Week 0." Thus, data from all logs were combined to eliminate variation in the number of weeks on the ground after felling and the timing of initial *Ips* spp. emergence. At Week 0, only *Ips* spp. parental adults emerged from the logs, while *Ips* spp. brood emergence began in Week 2. The *Ips* spp. emergence pattern was characterized by a peak 3 wks after initial emergence, followed by a sharp decline (Fig. 3). The histerid emergence pattern was bimodal, with the first peak occurring during peak *Ips* spp. emergence (Week 3) and the

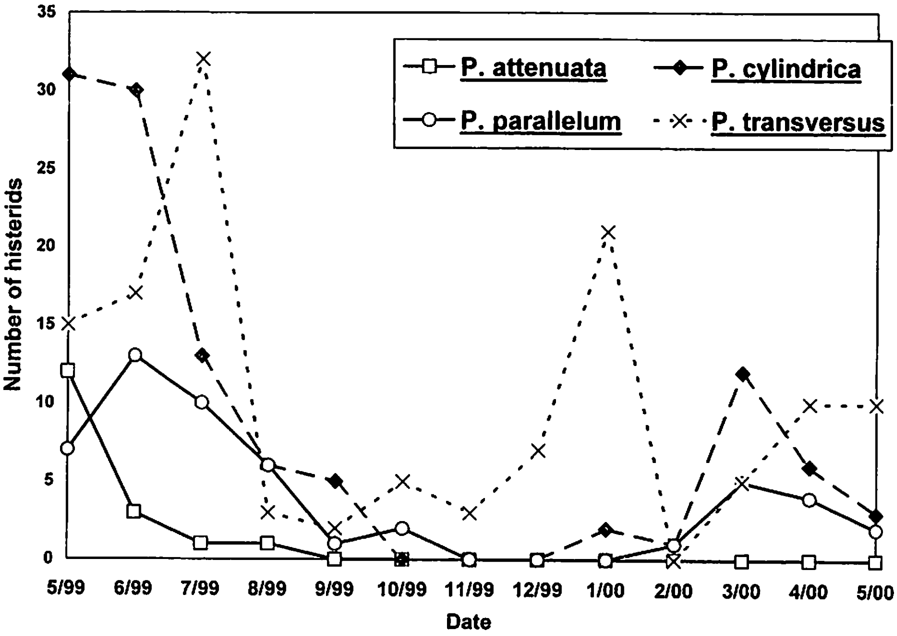

Fig. 2. Seasonal abundance of histerids captured in Lindgren funnel traps baited with turpentine and either racemic ipsenol or racemic ipsdienol, in Louisiana.

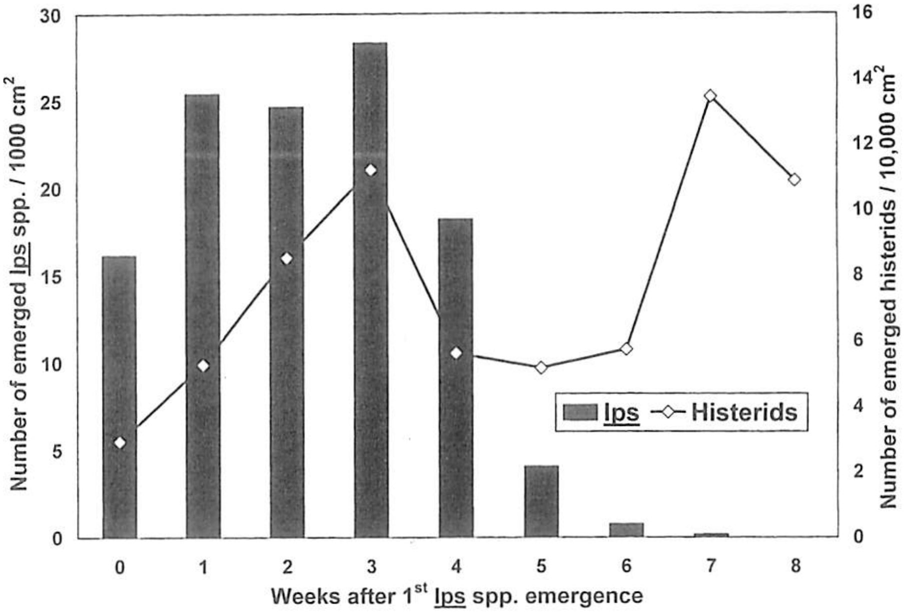

Fig. 3. Emergence of *Ips* spp. and histerid adults from 85 loblolly pine logs sealed in metal rearing drums June-August 2000, in Louisiana. These data were pooled and set to the first week of *Ips* spp. emergence from each tree (= Week 0).

second peak occurring 4 wks later (Week 7) (Fig. 3). This bimodal emergence pattern was observed in all logs left on the ground for at least 2 wks. Nine histerid individuals (of 255 total), representing three species, emerged from logs that had been left on the ground for 1 wk before transfer to the sealed rearing drums –1 *P. attenuata,* 3 *P. parallelum,* and 5 *P. cylindrica.*

When data were partitioned by predator species, *P. parallelum* and *P. transversus* were the most abundant (Fig. 4). These two species accounted for most of the overall histerid emergence. *Platysoma attenuata* and *P. cylindrica* were not collected in sufficient numbers to contribute greatly to the emergence trend.

Visual preference. *Ips* engraver beetles arrived and attacked logs approximately 0.5 wks after tree felling, while the first histerids (3 *P. attenuata* and 8 *P. parallelum*) arrived at the logs 1 wk after initial *Ips* spp. attack. *Platysoma attenuata* ($F = 21.25$; df = 1, 56; $P < 0.0001$) exhibited a significant preference for vertical logs over horizontal logs, while *P. parallelum* ($F = 7.44$; df = 1, 56; $P = 0.0085$) preferred horizontal logs over vertical logs (Fig. 5). *Platysoma cylindrica* ($F = 1.99$; df = 1, 56; $P = 0.1637$), *P. transversus* ($F = 0.06$; df = 1, 56; $P = 0.8149$), *I. avulsus* ($F = 3.97$; df = 1, 42; $P = 0.0527$), *I. calligraphus* ($F = 0.12$; df = 1, 42; $P = 0.7298$), and *I. grandicollis* ($F = 2.56$; df = 1, 42; $P = 0.1172$) showed no significant preference for either log orientation.

Discussion

The pattern of histerid flight activity corresponded to *Ips* spp. flight activity in southern Louisiana, which peaks during the spring and early summer and declines

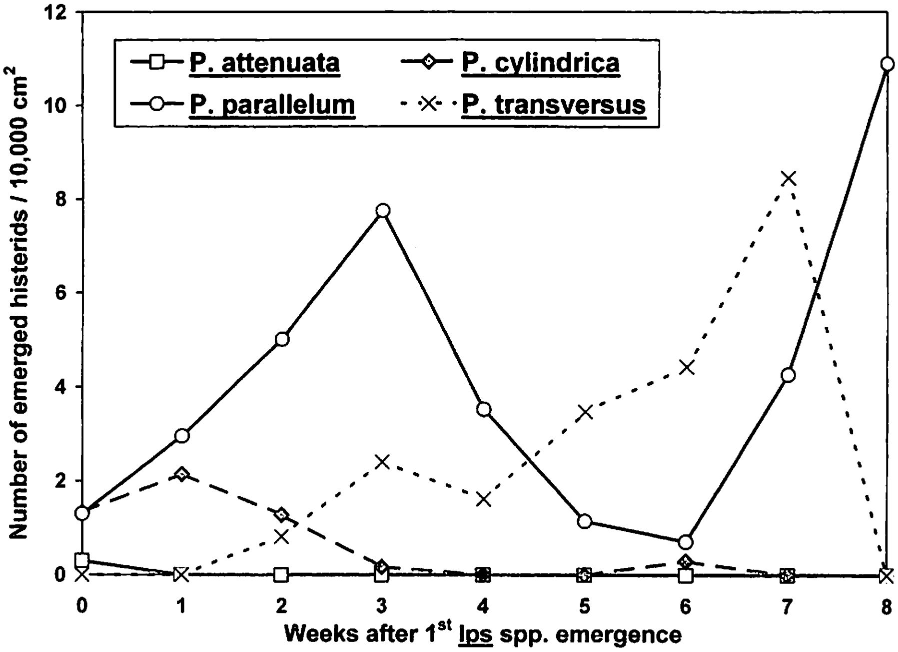

Fig. 4. Abundance of four species of histerid beetles that emerged from 85 loblolly pine logs sealed in metal rearing drums June-August 2000, in Louisiana. These data were pooled and set to first week of *Ips* spp. emergence from each tree (= Week 0).

during late summer, autumn, and winter (Riley and Goyer 1988, Shepherd, pers. obs.). In contrast, histerid emergence from logs colonized by *D. frontalis* in eastern Texas gradually increased from February to September (Stein and Coster 1977). Arrival data indicate that histerids quickly detected and entered logs attacked by *Ips* spp. We found that three histerid species, *P. attenuata, P. cylindrica,* and *P. parallelum,* arrived within 1 wk of their *I. avulsus, I. grandicollis,* and *I. calligraphus* prey. Similarly, Dixon and Payne (1979) observed that these three *Platysoma* species and *Plegaderus* spp. arrived within 1 wk of initial *D. frontalis* colonization. The first histerid emergence peak in our study corresponded to peak *Ips* spp. emergence. The coincident population patterns and rapid location of attacked trees suggest that histerids depend on bark beetle colonies for food.

Three histerid species remained in infested pine logs for 3 to 4 wks after most *Ips* engraver beetles had emerged, presumably feeding on saprophagous and other organisms (e.g., cerambycid and weevil larvae) and completing development in the inner bark area. The bimodal histerid emergence pattern likely represents parental and F_1 generations leaving the infested logs. It is unlikely that parent histerids arrived at logs at two distinct times to produce progeny, due to the fact that histerids reared from logs left on the ground for only 2 wks after felling still emerged in a bimodal pattern. Once development times for each species are determined, emergence pat-

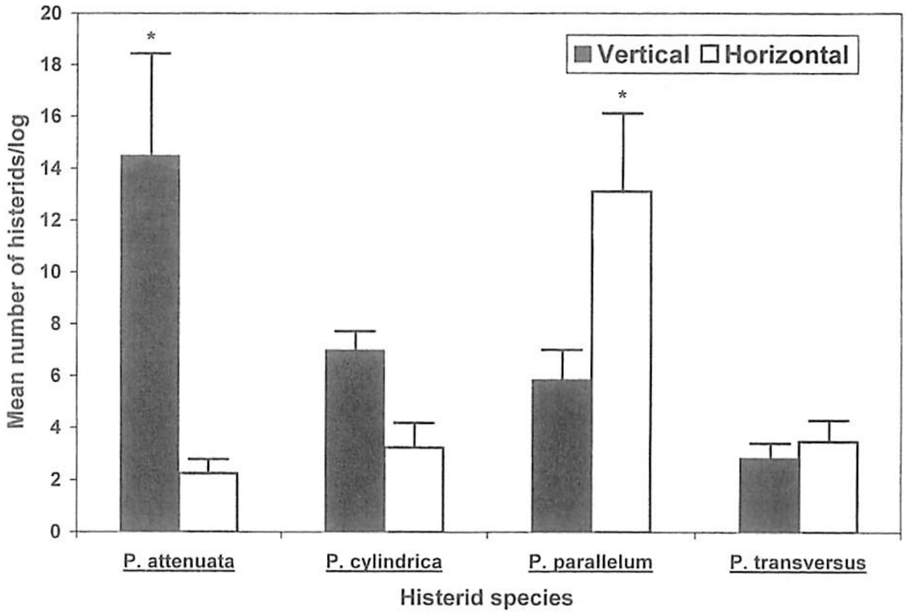

Fig. 5. Preferences of four species of histerids for vertical vs horizontal log surfaces during April and May 1999. An asterisk (*) represents a significantly higher catch using ANOVA with *a priori* contrasts at a significance level of $P = 0.05$. Error bars depict standard errors of the means.

terns may be easier to explain. Some histerids (e.g., *Epierus*) have long developmental periods, requiring over 6 wks to develop from egg to adult in rotting bark. Others undergo a shorter period of development that is characteristic of histerids associated with ephemeral habitats such as dung and carrion (Kovarik 1995).

Although there was no significant difference between infestations in the horizontal vs vertical logs for any of the *Ips* spp., there was a difference in the number of histerids attracted to the different log orientations. We interpreted differences in attraction as being attributable to differences in visual sensitivity to fallen vs upright tree silhouettes. This behavior may facilitate niche partitioning among some histerid species at sites where different bark beetles co-occur. Understanding the details of this niche partitioning is important before manipulation of the system is attempted for augmentative biological control. *Dendroctonus frontalis* and *Ips* engraver beetles share many of the same predators, including histerids. These bark beetles have different host preferences: the more aggressive *D. frontalis* predominantly attacks living, standing trees, and *Ips* spp. often attack weakened or downed trees. In cases where *Ips* spp. are found in standing trees, they are found apart from *D. frontalis* infestations (Drooz 1985, Payne 1980). Interspecific competition among histerids may be reduced via differential landing behavior on trees that attract different bark beetle species. *Platysoma attenuata* arrived in greater numbers at vertical logs and, hence, may be attracted to trees that are typically infested with *D. frontalis.* Conversely, *P. parallelum* was more attracted to horizontally oriented logs which are predominantly colonized by *Ips* spp.

Differential visual orientation may partially explain the extreme drop in *P. attenuata* numbers at our study site beginning in the summer of 1999. The last *D. frontalis* outbreak in southern Louisiana occurred in 1998. Because our data show that this histerid orients toward vertical silhouettes that are more likely to be infested with *D. frontalis,* its populations may remain at low levels pending the next outbreak of *D. frontalis.* Like the clerid *D. frontalis* predator, *Thanasimus dubius* (F.), *P. attenuata* may have responded to the *Ips*-infested trees in 1999 only because its preferred host was unavailable (Reeve 2000).

These experiments are a first step in understanding the factors that attract histerids to bark beetle-infested trees and their population dynamics in the subcortical habitat. Our studies confirm that histerids that feed on *Ips* spp. are closely linked to their prey populations. Histerids rely on specific sensory cues to rapidly locate bark beetle-attacked trees. Visual cues in the presence of odor attractants may allow certain histerids to differentiate among potential prey habitats, promoting niche partitioning. Prey kairomones and/or tree volatile compounds likely attract histerids over longer distances to their feeding sites. Generalist feeding by histerids under the bark may dilute their impact on within-tree bark beetle populations. Further studies of histerid and other bark beetle predator life histories may help explain fluctuations of pine bark beetle populations.

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