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Jack E. Coster

Catherine Stein

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Distribution of Some Predators and Parasites of the Southern Pine Beetle[1] in Two Species of Pine[2]

CATHERINE R. STEIN[3] AND JACK E. COSTER

School of Forestry, Stephen F. Austin State University, Nacogdoches, TX 75962

ABSTRACT

Southern pine beetle, *Dendroctonus frontalis* Zimmerman, and its natural insect enemies were reared from infested loblolly pines, *Pinus taeda* L., and shortleaf pines, *P. echinata* Mill. Southern pine beetle broods were most dense during spring (Mar.–May) and least dense in late summer. Populations were higher in late winter than in midsummer. There were no differences in beetle densities between the pine species. Twelve predators and 9 parasites comprised ca. 99% of the natural enemy complex. Total density of the 12 predators did not vary with either season or tree species. Total parasite density, however, was highest in midsummer, lowest in late winter, and was significantly higher in shortleaf pine. Species diversity of predators and parasites was highest during spring and summer seasons and varied significantly between tree species.

Attack and colonization of pine by southern pine beetle, *Dendroctonus frontalis* Zimmerman, results in the coestablishment of a wide variety of entomophagous, xylophagous, and saprophytic insects. From 60–96 species of associated insects have been listed by Moser et al. (1971), Overgaard (1968), and Thatcher (1971)[4], but many of these insects may have no direct impact on southern pine beetle populations. Insect species identified as natural enemies of the beetle range from 5 predators and 6 parasites in southeast Texas to 16 predators and 18 parasites in North Carolina (Bushing 1965, Camors and Payne 1973, Moore 1972, Overgaard 1968, Thatcher 1971[4]).

In North Carolina, Moore (1972) observed 4% of the southern pine beetle broods parasitized when a single parasite species was present and up to 30% destroyed when 3 or more species of parasites were present. Beetle brood mortality due to insect predators averaged 15%.

Several studies have examined variation in seasonal abundance and/or within-tree height distributions of the parasites and predators of southern pine beetle (Fiske 1908, Mignot 1966,[5] Moore 1972, Moser et al. 1971, and Overgaard 1968). Little has been published, however, on the influence of tree species on these parasites and predators. Consequently, we undertook studies in eastern Texas to clarify the influence of seasonal variation, within-tree distribution, and pine species on the abundance and diversity of southern pine beetle parasites and predators.

Methods and Materials

Infested trees were selected from a southern pine beetle infestation in Nacogdoches Co., Texas. Beginning in Feb., 1974, and continuing at ca. 40-day intervals, we felled 2 loblolly pines (*Pinus taeda* L.) and 2 shortleaf pines (*P. echinata* Miller) containing predominantly late larval and pupal stages of southern pine beetle. Twenty-three trees, 12 shortleaf and 11 loblolly pines, were obtained. A total of 55 bolts, each 76 cm long, were cut from the 23 trees: 23 bolts at 3 m, 22 bolts at 6 m, and 10 bolts at 9 m. Bolts were not cut if the beetle infestation did not extend to the sample height.

The 12 shortleaf pines ranged from 15–29 cm DBH and from 10.7–26.5 m in height; height of beetle infestation within trees ranged from 7.3–15.2 m. The 11 loblolly pines were from 20–25 cm DBH and 10.7–19.8 m tall, and the top of beetle infestation ranged from 4.6–15.2 m.

The bolts were brought to the insectary and bark sample disks were removed using an 11-cm diam hole saw. We removed samples from each end of each bolt and the samples were radiographed using a Faxitron 805 x-ray unit and Kodak AA2 film. The radiographs were examined on a light table and the numbers of southern pine beetle larvae, pupae, and adults were counted and the avg number of beetles/dm^2/bolt was determined.

After removal of the bark disks, we trimmed 15 cm from the sampled area on each bolt end, leaving the sample bolts 46 cm long. These were placed in individual rearing cages similar to those described by Germain and Wygant (1967). Insects were collected daily from each cage until emergence of southern pine beetles, predators, and parasites was complete. Emergence of all insects was expressed as numbers/dm^2 of bolt surface area. Specimens of unknown insects were sent to the Systematic Entomology Laboratory at Beltsville, Md., for specific determination.

The Veldman (1967) AVAR 23 program for analysis of variance, utilizing unequal-sized groups and subgroups, was used to determine the effects of season, sample height, and tree species on insect abundances. Because no infested bolts were obtained

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[3] Present address: U.S. Forest Service, State and Private Forestry. 2500 Shreveport Hwy., Pineville, LA 71360.

[4] Thatcher, R. C. 1971. Seasonal behavior of the southern pine beetle in central Louisiana. Ph.D. dissertation. Auburn University.

[5] Mignot, E. C. 1966. The biology and effectiveness of two species of predators (*Temnochila virescens* Mann. and *Thanasimus dubius* Fab.) for the control of bark beetles. Master's thesis. Duke University.

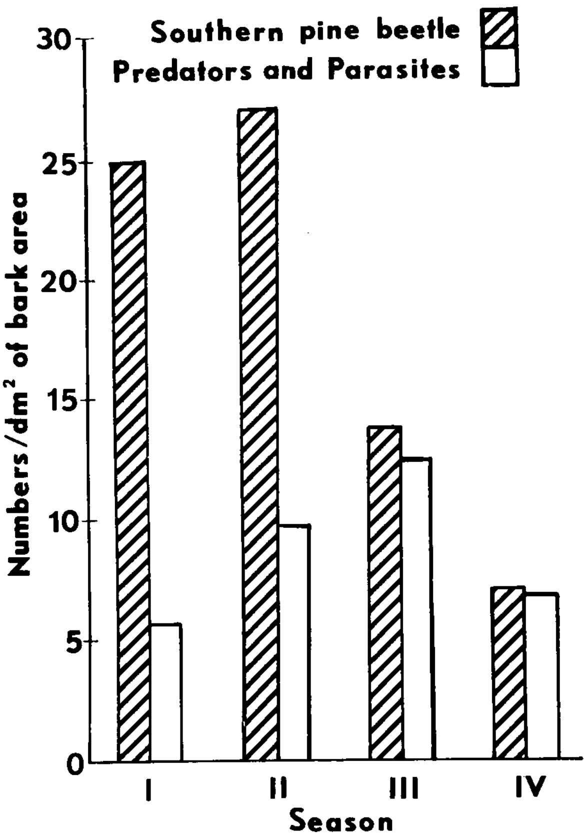

FIG. 1.—Seasonal emergence of southern pine beetle and its predators and parasites, shortleaf and loblolly pine bolts combined. Season: I = Feb., II = Mar. and May, III = June–Aug., and IV = Sept.

at the 9 m sample height in Feb., 2-way, rather than 3-way, analyses of variance were applied to the data. The Shannon-Wiener information function (Southwood 1968) was used to measure the diversity of the parasites and predators in each of the sample bolts. One-way analysis of variance was applied to the diversity indices to test the effects of season and sample height, while the Student's t-test was used to test the effect of tree species.

Results and Discussion

Southern Pine Beetle

Based on the radiograph counts, mean southern pine beetle brood densities ranged from 9.7–89.7 beetles/dm² in the 23 study trees. A total of 28,218 beetles emerged from the 55 sample bolts. The sex ratio of 1♂:0.95♀ did not differ significantly from unity.

Effect of Season.—Trees were grouped in 4 "seasonal" categories. Season I consisted of 3 trees in Feb.; season II, of 8 trees cut in late Mar. and May; season III, of 8 trees cut from June through Aug.; and season IV, of 4 trees cut in Sept.

The within-tree brood density of southern pine beetle varied significantly with season ($P < .01$). Means of brood density were:

Season	Brood density/dm²
I	41.4
II	57.7
III	26.4
IV	18.8

Southern pine beetle emergence density also varied significantly with season ($P < .01$). Highest mean density (27.0 beetles/dm²) occurred in season II while lowest mean density (7.0 beetles/dm²) occurred in season IV (Fig. 1).

Effect of Height.—Neither southern pine beetle brood densities nor emergence densities showed a significant difference among their means for the 3 sample heights when height alone was considered ($P < .05$). Similar results were reported by Stephen and Taha (1976), although Mayyasi et al. (1976) found variations in southern pine beetle density with sample height. The samples taken by Mayyasi et al. included the upper and lower extremes of the infested bole height, whereas our samples were limited to the infested bole between 3–9 m. The interaction of height and tree species, however, had a significant effect on the abundance of emerged beetles. Mean southern pine beetle emergence density decreased with increasing height in shortleaf pine while it increased with increasing height in loblolly (Fig. 2). This height-species interaction was significant ($P < .05$).

Effect of Tree Species.—Mean southern pine

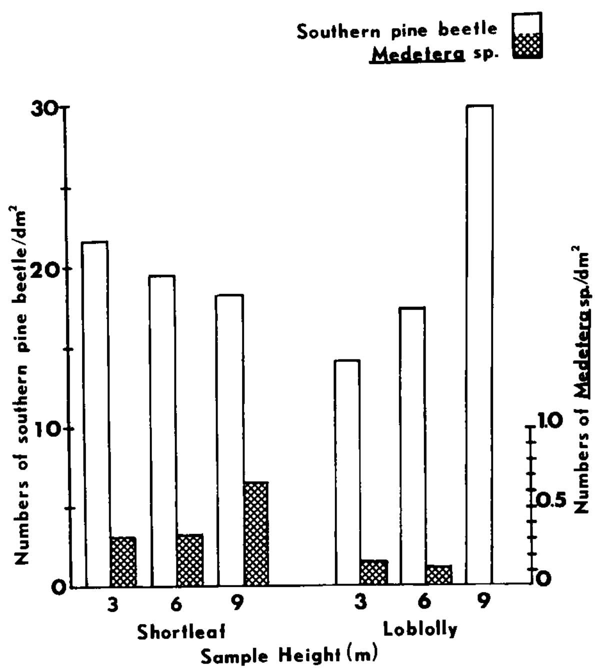

FIG. 2.—Mean emergence densities of *Medetera* sp. and southern pine beetle by height and tree species.

beetle brood density and emergence density were not significantly different between shortleaf and loblolly pine ($P < .05$).

Predators and Parasites

Eleven predatory species of Coleoptera, 2 Diptera, and 2 Hemiptera predators, and 11 species of Hymenoptera parasitic on southern pine beetle were identified. A total of 11,165 predators and 3137 parasites were collected. For statistical analysis, the most abundant species of known or suspected predators and parasites were selected. They represented 99% of the predator-parasite population and included the following 12 predators and 9 parasites:

HEMIPTERA
- Anthocoridae: *Lyctocoris stalii* (Reuter), *Scoloposcelis* sp.

COLEOPTERA
- Histeridae: *Platysoma attenuata* LeConte, *P. cylindrica* (Paykull), *P. parallelum* Say, *Plegaderus* sp.
- Trogostidae: *Temnochila virescens* (F.)
- Cleridae: *Thanasimus dubius* (F.)
- Colydiidae: *Aulonium tuberculatum* LeConte, *Lasconotus referendarious* Zimmerman
- Tenebrionidae: *Corticeus glaber* LeConte

DIPTERA
- Dolichopodidae: *Medetera* sp.

HYMENOPTERA
- Braconidae: *Coeloides pissodis* (Ashmead), *Dendrosoter sulcatus* Muesebeck, *Meteorus hypophloei* Cushman, *Spathius pallidus* Ashmead
- Torymidae: *Roptrocerus eccoptogastri* (Ratzeburg)
- Pteromalidae: *Cecidostiba* sp., Nr. *Dinotiscus* sp., *Heydenia unica* Cook and Davis, *Rhopalicus pulchripennis* (Crawford)

Although they were the most abundant species, the 21 predators and parasites were not necessarily present in all samples.

The abundance of the predators in decreasing order were *C. glaber, A. tuberculatum, Scoloposcelis* sp., *L. referendarious, T. dubius, Medetera* sp., *Platysoma* spp. (*P. attenuata, P. cylindrica* and *P. parallelum*), *Plegaderus* sp., *L. stalii* and *T. virescens.* The parasite species in decreasing order of abundance were *R. eccopotogastri, D. sulcatus, H. unica, C. pissodis, R. pulchripennis, S. pallidus, Cecidostiba* sp., nr. *Dinotiscus* and *M. hypophloei.* Because the specimens could not be determined to the species level at the time of collection, the 1st 3 species of Histeridae were grouped, referred to as *Playtsoma* spp. and treated as one taxon in the statistical analyses.

The predator and parasite species were treated individually in the statistical tests, except where results are identified as "Total predators and parasites" (21 species), "Total predators" (12 species), or "Total parasites" (9 species).

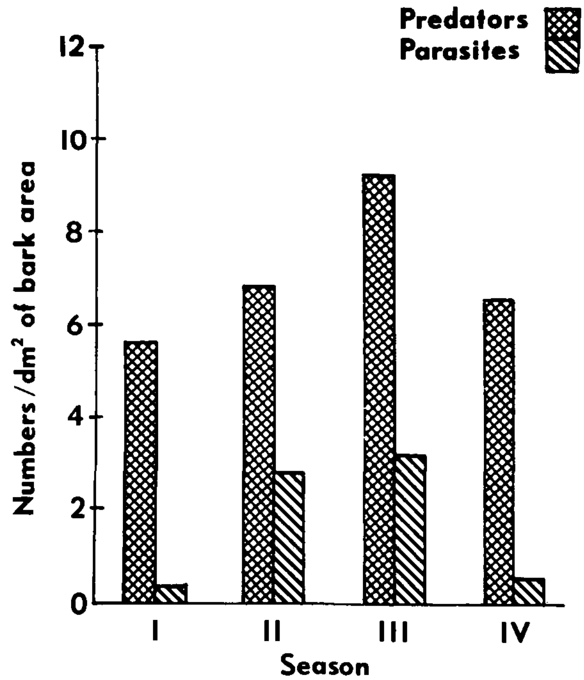

FIG. 3.—Seasonal emergence of southern pine beetle predators and parasites, shortleaf and loblolly pine bolts combined. Season: I = Feb., II = Mar. and May, III = June–Aug., and IV = Sept.

Abundance of Predators and Parasites

Effect of Season.—Abundance of total predators and parasites varied significantly with season ($P<.01$) lagging behind that of southern pine beetle and peaking one season later (Fig. 1).

Total predator emergence density did not vary significantly with season; however, changes in total parasite density with season were highly significant ($P<.01$) (Fig. 3). Parasite density ranged from a high of 3.1 insects/dm^2 in season III to a low of 0.2 insects/dm^2 in season I. Insect associates were most abundant in the spring at trees attacked by *Dendroctonus brevicomis* LeConte (Stephen and Dahlsten 1976), although *D. brevicomis* has only 2 discrete generations/yr in contrast to 5–7 overlapping generations for southern pine beetle.

Five predators differed significantly in abundance among seasons (Fig. 4); the remaining 7 predators did not. Three predators (*Plegaderus* sp., *Scoloposcelis* sp., and *Platysoma* spp.) increased in number as the southern pine beetle populations decreased. Abundance of *T. dubius* and *C. glaber,* however, increased and decreased in the seasons following increase or decrease in southern pine beetle. This may be expected of *T. dubius,* because it feeds primarily on bark beetles. Mignot (1966)[5] reported that under lab conditions, clerids starved to death if no bark beetles were provided. Why abundance of *C. glaber* followed that of southern pine beetle is uncertain, because it is thought to be a facultative predator (Moser et al. 1971).

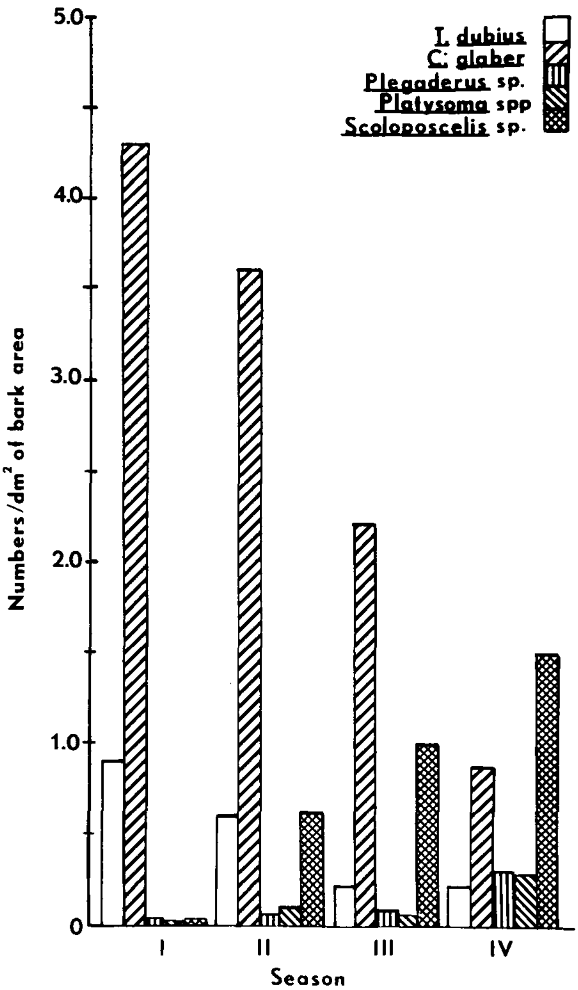

FIG. 4.—Seasonal emergence of 5 southern pine beetle predators from shortleaf and loblolly pine bolts. Seasons: I = Feb., II = Mar. and May, III = June–Aug., and IV = Sept.

Four Hymenoptera parasites varied significantly in their mean emergence densities with changes in season ($P<.01$) (Fig. 5). *R. eccoptogastri* and *R. pulchripennis* were least abundant in season I and most abundant in season II, while *D. sulcatus* and *H. unica* were least abundant in season I and most abundant in season III (Fig. 5). Research in Georgia showed that, in *Ips* infestations, *R. eccoptogastri* was most abundant in June and Aug. when trees were sampled in Mar., June, Aug., and Oct. (Berisford and Franklin 1972).

Effect of Height. — None of the predators and parasites of the southern pine beetle differed significantly in emergence abundance among the 3 sample heights. Moore (1972) and Thatcher (1971[4]) found that parasite abundance increased with increasing height in southern pine beetle infested trees. Thatcher suggested that parasite abundance increased in height in the tree because the thinner bark of the upper bole allowed more successful parasitism of the bark beetles. Research with other *Dendroctonus* species has shown that higher levels of parasite activity are common in the thinner-barked, upper sections of beetle-infested trees (Dahlsten and Stephen 1974, Stephen and Dahlsten 1976, Ryan and Rudinsky 1962). The different results may be due to the smaller size of our sample trees. The trees sampled by Thatcher averaged 27 m in height and 38 cm DBH—much larger than those in the present study. Bark thickness may be suitable over a greater length of the smaller trees.

Height and tree species interaction had a significant effect on the abundance of the predator *Medetera* sp. ($P<.05$) (Fig. 2). In shortleaf pine, its emergence was similar at 3 m and 6 m levels but increased at 9 m; in loblolly pine, its emergence decreased with increasing height and there was no

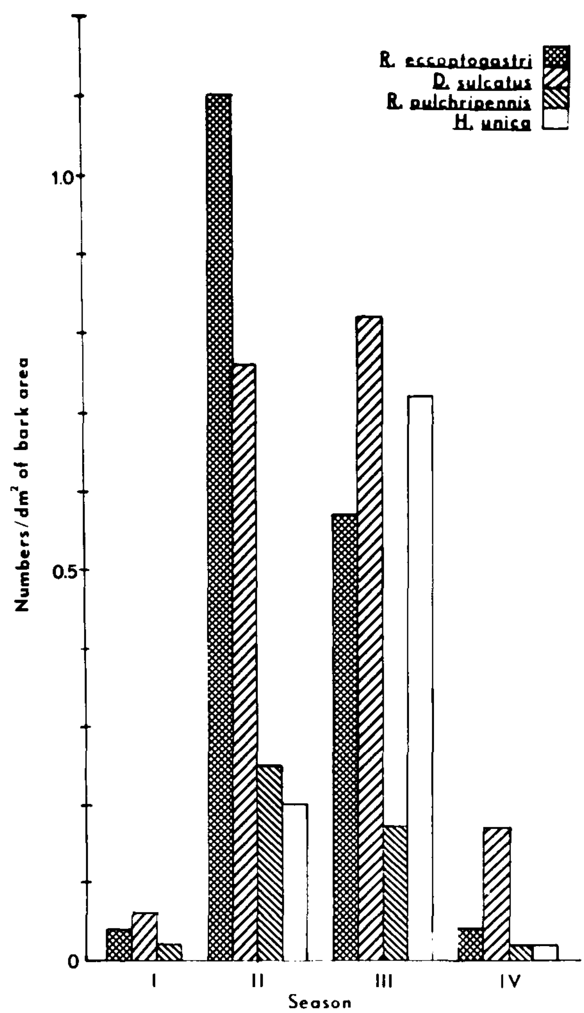

FIG. 5.—Seasonal emergence of 4 hymenopterous parasites of the southern pine beetle from shortleaf and loblolly pine bolts. Seasons: I = Feb., II = Mar. and May, III = June–Aug., and IV = Sept.

emergence at the 9 m level. In both pine species, emergence of southern pine beetle was least at tree heights where emergence of *Medetera* sp. was high, and high where the latter was lowest.

Effect of Tree Species. — Tree species did not significantly affect total predator density, but significantly more total parasites emerged from shortleaf pine (2.1 insects/dm^2) than from loblolly pine (1.0 insects/dm^2) ($P<.05$). Since southern pine beetle density did not vary significantly with tree species, the hymenopterous parasites were apparently reacting to tree host as well as to the southern pine beetle populations. A similar reaction to tree host has been exhibited by parasites of *Ips* engravers in southern pines (Berisford and Franklin 1972) and in western pines (Ball and Dahlsten 1973). With the southern *Ips,* however, the degree of parasitism was higher in loblolly pine.

Four predators exhibited significant differences in abundance between the 2 tree species (Fig. 6). *Plegaderus* sp. occurred more abundantly in loblolly pine (0.17 vs. 0.06 beetles/dm^2) ($P<.05$). *Platysoma* spp., *Medetera* sp. and *Scoloposcelis* sp. were more abundant in shortleaf pine (0.18 vs. 0.06 beetles/dm^2, 0.34 vs. 0.09 insects/dm^2, and 1.18 vs. 0.41 insects/dm^2, respectively) ($P<.01$).

The abundance of *L. referendarious, Scoloposcelis* sp., *Platysoma* spp., and *Plegarderus* sp. differed significantly with the interaction of tree species and season (*L. referendarious,* $P<.05$; others $P<.01$). In shortleaf pine, lowest emergence density for the 4 predators occurred in season I and highest density occurred in season IV. But in loblolly pine, the seasons of lowest and highest emergence differed for each predator (Fig. 6).

Among the parasites, only *H. unica* showed a significant difference in mean occurrence between tree species, with 0.34 insects/dm^2 in shortleaf compared to 0.11 insects/dm^2 in loblolly ($P<.05$). *H. unica* also showed a significant difference in mean occurrence when the effects of tree species and season were combined ($P<.05$). In shortleaf pine the mean densities for *H. unica* for seasons I through IV were 0.0, 0.20, 1.17, and 0.11 insects/dm^2. In loblolly pine the mean densities for seasons I through IV were 0.0, 0.18, 0.27, and 0.0 insects/dm^2.

It is difficult to explain the apparent effect of tree species on the individual predators and parasites, because some were more abundant in shortleaf while one was more abundant in loblolly pine. Different factors may have affected each insect species, causing their abundances to vary between tree species. Difference in a tree characteristic, such as the chemical composition of bark, could have directly affected the insects. Perhaps only one insect species was directly affected, while its abundance affected that of the other 3 predators and parasites.

Diversity of Predators and Parasites

Diversity indices for the 55 bolts ranged from 0.579–3.352 and diversity did not vary significantly with either height of sample or tree species.

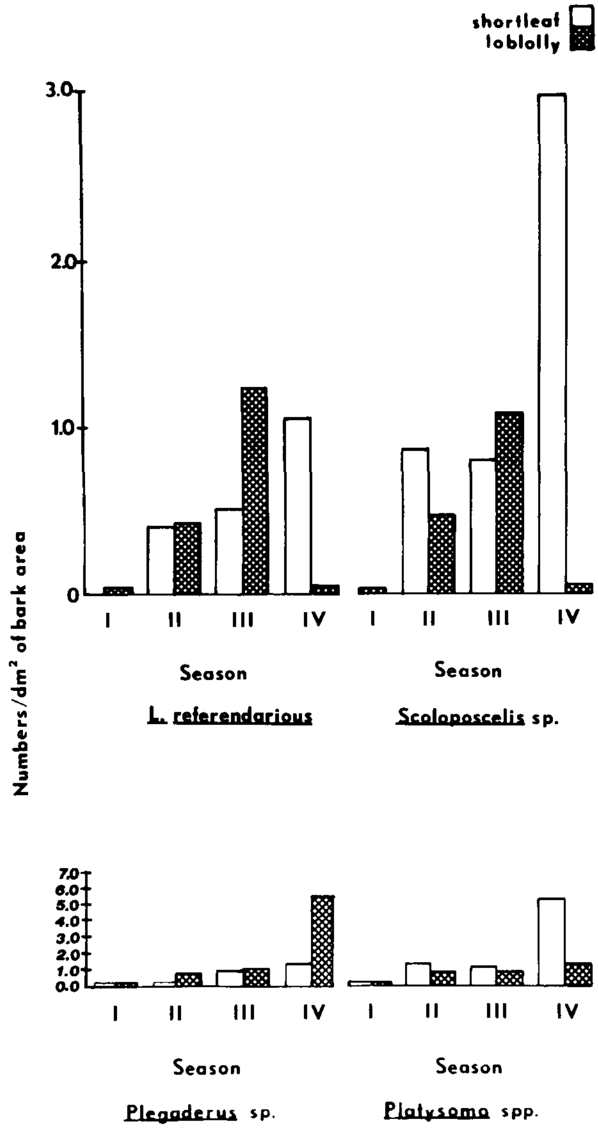

FIG. 6.—Seasonal emergence of 4 southern pine beetle predators from shortleaf and loblolly pine. Season: I = Feb., II = Mar. and May, III = June–Aug., and IV = Sept.

Diversity of predators and parasites varied significantly with season ($P<.01$) as follows:

Season	Species diversity±SE
I	1.362±.334
II	2.730±.192
III	2.733±.260
IV	2.438±.221

It is possible that the higher density of southern pine beetle during spring and summer provided more available prey for more predator and parasite species. In winter, diversity may have been reduced by direct cold temperature mortality or by loss of several insect species overwintering somewhere other than the bark of beetle-infested trees. Increase in diversity of species associated with single generations of *D. brevicomis* was noted by Stephen and Dahlsten (1976).

Season apparently had the strongest influence on the density of parasite and predator populations, perhaps due to seasonal variation in beetle abundance. Or, southern pine beetle populations could have been reacting to a seasonal fluctuation in parasites and predators.

Apparently, tree species influenced parasites more than it did predators. Height within infested trees seemed to have an effect only when it interacted with tree species, and even then, only one predator, *Medetera* sp., was affected.

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