Dispersal of the zoophytophagous predator *Brontocoris tabidus* and *Podisus nigrispinus* (Heteroptera: Pentatomidae) in an eucalyptus plantation

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Abstract

Forest plantations, especially eucalyptus, increase wood supply, avoid deforestation of native plants, and preserve local biodiversity. Defoliating caterpillars often reduce the productivity of these plantations. Rearing and releasing pentatomid predators is a strategy to manage these pests biologically. In this study, the predators *Brontocoris tabidus* (Signoret) and *Podisus nigrispinus* (Dallas) (both Heteroptera: Pentatomidae) were evaluated in a clonal eucalyptus (*Eucalyptus urophylla* Blake × *Eucalyptus grandis* W. Hill ex Maiden) (both Myrtaceae) plantation. *Brontocoris tabidus* dispersed further than *P. nigrispinus* over the 7-d trial. Males of both species dispersed more than females, and most *P. nigrispinus* were found within 10 m from the release point, whereas the majority of *B. tabidus* were observed between 15 and 30 m from their initial position of release.

Key Words: distance traveled; longer coverage; lower density; releasing technique

Resumo

Plantios florestal, especialmente de eucalipto, garante o fornecimento madeira, evitando o desmatamento de florestas nativas e preserva a biodiversidade local. As lagartas desfolhadoras frequentemente reduzem a produtividade dessas plantações. A criação e liberação de pentatomídeos predadores é uma estratégia para manejar essas pragas, biologicamente. Nesse estudo, os predadores *Brontocoris tabidus* (Signoret) e *Podisus nigrispinus* (Dallas) e (Heteroptera: Pentatomidae) foram avaliados em plantio clonal de eucalipto (*Eucalyptus urophylla* Blake × *Eucalyptus grandis* W. Hill ex Maiden) (Myrtaceae). *Brontocoris tabidus* dispersou mais que *P. nigrispinus* ao longo de sete dias de avaliação. Machos de ambas as espécies se dispersaram mais que as fêmeas, e a maioria dos indivíduos de *P. nigrispinus* foram localizados a 10 metros do ponto de liberação enquanto a maioria de *B. tabidus* foram observados entre 15 a 30 metros da posição inicial em que foram liberados.

Palavras Chaves: distância percorrida; maior cobertura; baixa densidade; técnica de liberação

Eucalyptus (Myrtaceae) is a fast growing plant that is primarily grown for charcoal and cellulose (Gomide et al. 2005; Botrel et al. 2007), with Brazil having one of the largest geographic areas planted for this production (Abraf 2013). The establishment of *Eucalyptus* plantations is important to reduce deforestation of native forests; however, insect pests may damage production of this monoculture. The homogeneity of these ecosystems is often characterized by high food supply combined with low diversity and abundance of natural enemies; this favors increased development of injurious pest populations (Fisher et al. 2008; Nadel et al. 2010; Silva et al. 2010).

Integrated Pest Management (IPM) is a decision-making system whereby control tactics, whether employed singly or in combination (i.e., considering cost per benefit relationships and the impact on producers, society, and environment) in order to maintain pest populations below an economic damage level (Kogan 1998). Sometimes, biological control is an important component of this system because it reduces production costs and improves the quality of agricultural products (due to lower pesticide use), as it improves public health by reducing environmental contamination through unnecessary pesticide residues (Pires et al. 2016).

Stinkbugs of the subfamily Asopinae have been used as biological control agents of agricultural and forest pests because they are generalist predators. The characteristics of these enemies, i.e., widespread occurrence, aggressiveness, and voracity, have made them widely studied in Brazil for use in Integrated Pest Management programs. These pentatomid predators contribute to the regulation

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of lepidopteran pest populations by consuming defoliating caterpillars. This action reduces pesticide usage in agricultural systems and cultivated forests that may directly improve general environmental conservation efforts in these areas (Vacari et al. 2004, 2007; Torres et al. 2006; De Bortoli et al. 2011).

Asopinae have been intensively studied for the last 80 yr in Brazil. Investigations have included biology (i.e., biological and reproductive parameters), physiology, biochemistry, biological control, ecology, systematics and morphology, toxicology, mass rearing methods, and plant resistance in cooperation with producers in the forest sector (Pires et al. 2015). Members of this subfamily, *Podisus maculiventris* (Say) and *Perillus bioculatus* (Fabricius) in North America and Europe, *Eocanthecona furcellata* (Wolff) in Southeast Asia and India, *P. nigrispinus* (Dallas), *Podisus distinctus* (Stål), *Brontocoris tabidus* (Signoret), and *Supputius cincticeps* (Stål) (all Heteroptera: Pentatomidae) in South America are the main Asopinae species that have been used in biological control programs (Pires et al. 2016).

The dynamics of predator movement, such as general biological attributes and dispersal patterns in the field, influences the effectiveness of natural enemies in biological control programs (Stinner 1983; Bell 1990; Turchin & Thoeny 1993). For example, body size, developmental time, prey consumption frequency, presence or absence of prey, release time, climate variables, and structural plant characteristics (such as trichome abundance) may affect polyphagous predator movement (Bell 1990; Lachance & Cloutier 1997; Reisig et al. 2013). In order to develop effective release strategies using pentatomid predators in forest and agricultural crops, studies of their dispersal and migration should be conducted. We report here on the dispersal dynamics of the predators *B. tabidus* and *P. nigrispinus* when released for use as potential biological control agents in Brazilian eucalyptus plantations.

Material and Methods

Brontocoris tabidus and *P. nigrispinus* were obtained from the rearing facility at the Universidade Federal de Viçosa in Viçosa, Minas Gerais State, Brazil. Dispersal studies were conducted in a 3-mo-old clonal eucalyptus (*Eucalyptus urophylla* Blake × *Eucalyptus grandis* W. Hill ex Maiden [Myrtaceae]) plantation. The study area consisted of 13 ha with approximately 3-m tall plants.

Predators were marked on the pronotum with synthetic enamel paint (Colorama, L'Oréal Brasil Comercial de Cosméticos Ltd., Rio de Janeiro, Brazil) using different colors for each release. Insects were marked 1 d before release, then released 24 h later; sampling was conducted for 7 d.

EXPERIMENTAL DESIGN

Six plots were established in the study area (Fig. 1). One release point (referred to as point zero) was determined per plot. Eight directional markers were placed equidistantly at each release point to determine maximum and minimum limits of the circular area sampled. String wires connecting these markers assisted walking and delimited sampling areas.

Ten releases with 300 individuals each of *B. tabidus* and *P. nigrispinus* (50:50 M:F) were released per plot. Mark-release areas were assigned by drawing lots with each release in order to switch habitats and avoid pseudo-replication. Sampling consisted of visual inspection of plants while walking in a spiral beginning at 9:00 AM to avoid the dew effect on this activity, and finishing at 12:00 PM. Samples stations were located at point 0 to 10 m (A-1), 10 to 20 m (A-2), 20 to 30 m (A-3), 30 to 40 m (A-4), 40 to 50 m (A-5), and 50 to 60 m (A-6).

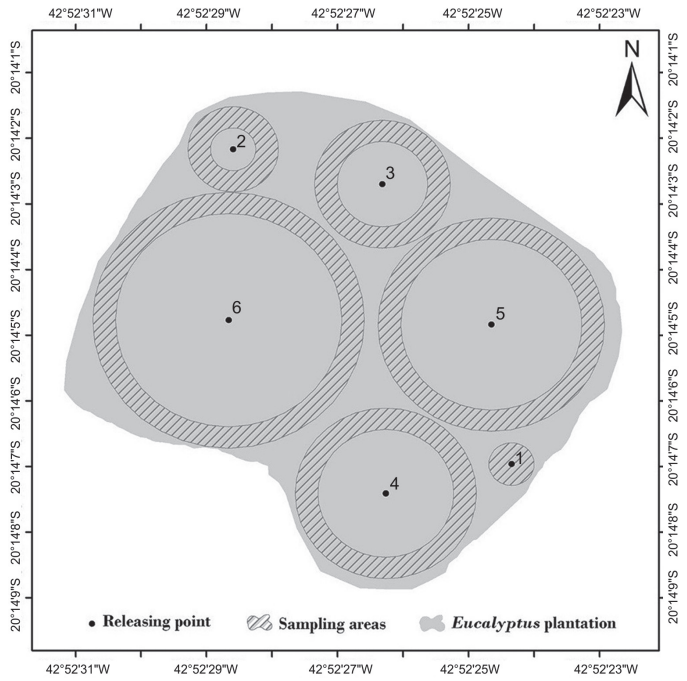

Fig. 1. Experimental design showing the 6 sample areas in the Viçosa Municipality, Minas Gerais State, Brazil. Map was produced with QGIS version 2.18.3 (Open Source Geospatial Foundation Project, http://www.qgis.org/ [last accessed 16 Dec 2019]).

PROCEDURES AND DATA ANALYSIS

Daily dispersal distance of *B. tabidus* and *P. nigrispinus* was determined using a 3D Parabolic model in Sigma Plot 10.0 (Systat Software Inc., San Jose, California, USA). These data were then subjected to an *F* test and means were compared using the Scott-Knott test at $P < 0.05$ (SAEG 9.1 Statistical Software, Universidade Federal de Viçosa, Viçosa,

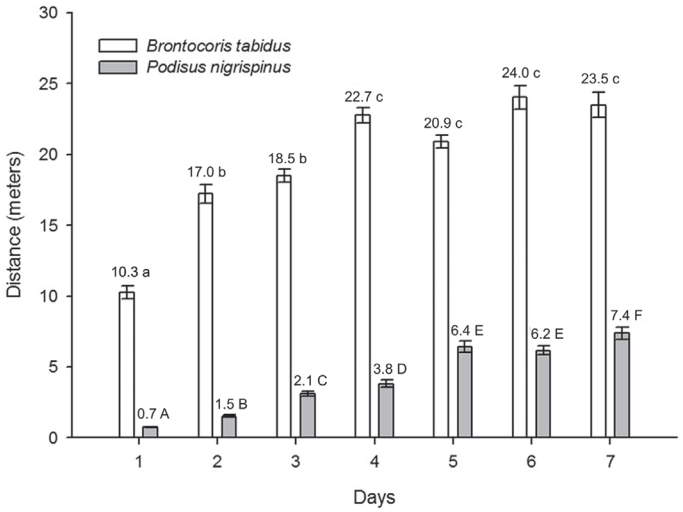

Fig. 2. Daily dispersal distance of the predators *Brontocoris tabidus* and *Podisus nigrispinus* (Heteroptera: Pentatomidae) in a clonal eucalyptus *Eucalyptus grandis* × *Eucalyptus urophylla* plantation in Viçosa, Minas Gerais State, Brazil. Means followed by the same letter, uppercase or lowercase, do not differ according to the Scott-Knott test with $P < 0.05$.

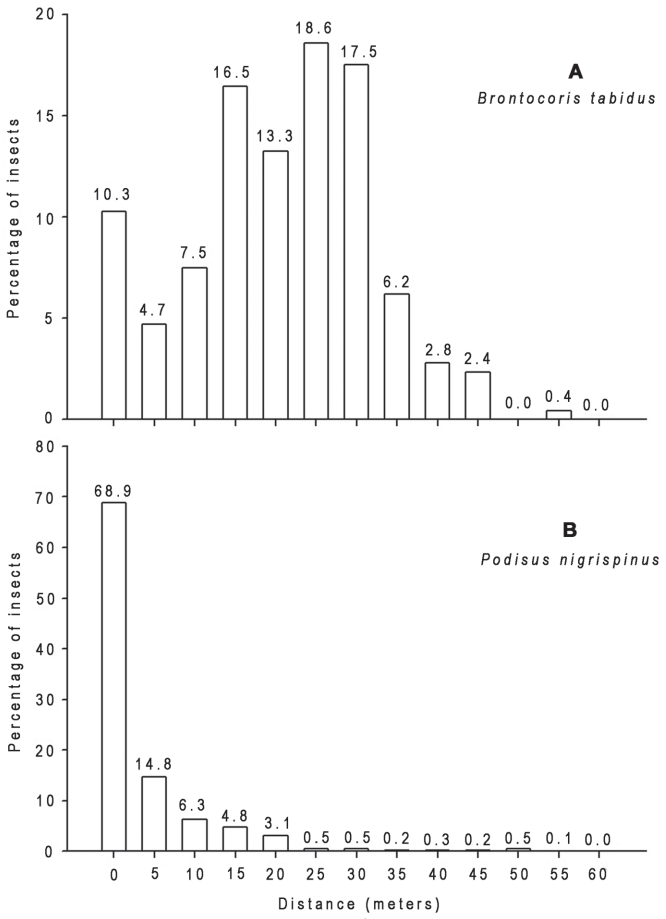

Fig. 3. Distance traveled by the predators *Brontocoris tabidus* (A) and *Podisus nigrispinus* (B) (Heteroptera: Pentatomidae) up to 60 m from release point in a clonal eucalyptus plantation (*Eucalyptus grandis* × *Eucalyptus urophylla*) during a 7 d evaluation.

Minas Gerais, Brazil). In addition, percentage of *B. tabidus* and *P. nigrispinus* present every 5 m to 60 m from release point was calculated to determine effective release methodology for both predators in eucalyptus plantations.

Results

Time period and distance effects on predator dispersal abundance were significant for *B. tabidus* ($F = 10.55$; $P < 0.05$) and *P. nigrispinus* ($F = 24.30$; $P < 0.05$). *Brontocoris tabidus* dispersal averaged 19.6 m more than *P. nigrispinus* ($F = 1754.8$; $P < 0.05$), and 4.0 m at the end of the 7-d evaluation. Dispersal of both predators (*B. tabidus* $F = 18.86$; $P < 0.05$ and *P. nigrispinus* $F = 49.95$; $P < 0.05$) increased after initial release. *Brontocoris tabidus* exceeded 10 m in the first d after release where it was observed between 20 and 24 m after the fourth d, whereas *P. nigrispinus* reached 7.4 m on the seventh d (Fig. 2). Overall *B. tabidus* abundance peaked at 25.0 m from release point (18.6%) (Fig. 3A). Abundance of *P. nigrispinus* was highest at the release point (68.9%), then decreased as distance increased (Fig. 3B).

Brontocoris tabidus and *P. nigrispinus* males dispersed farther than females. Male *B. tabidus* ($F = 151.0$; $P < 0.05$) reached 25.8 m and females 13.5 m at 7 d (Fig. 4A). Male *P. nigrispinus* ($F = 237.2$; $P < 0.05$) reached 7.0 m and females 1.1 m (Fig. 4B). Dispersal behavior of male and female *B. tabidus* differed with greater numbers of males dispersing between 15 to 30 m. Most females were found 25 m from the release point with no individuals collected at 30 m. Observations of *P. nigrispinus* males showed that > 10% reached 20 m with some present at 55 m. On the other hand, > 10% of the females were collected at 5 m but none beyond 20 m from the release point (Fig. 5).

Discussion

The short dispersal distance that we observed for *B. tabidus* and *P. nigrispinus* may be due to high foliage density of the eucalyptus plants in the cultivated plots. We believe this would reduce visibility of predators and may prevent flights over long distances. Oliveira et al. (2007) stated that landscape characteristics may stimulate or inhibit movements at short or long distances, but with a gradual increase in daily distance traveled by insect predators.

The greater dispersal of *B. tabidus* than *P. nigrispinus* in our study may be explained by their larger antennae and greater number of chemoreceptor sensillae of the first species (Pires EM, unpublished data). This may lead to greater success of *B. tabidus* as a predator because it is generally one of the first species to reach defoliator caterpillar prey outbreaks. This species usually is followed by other pentatomid predators such as *P. nigispinus*, *P. distinctus* (Stål), and *Tynacantha marginata* (Dallas) (Heteroptera: Pentatomidae) (Zanuncio JC, personal communication).

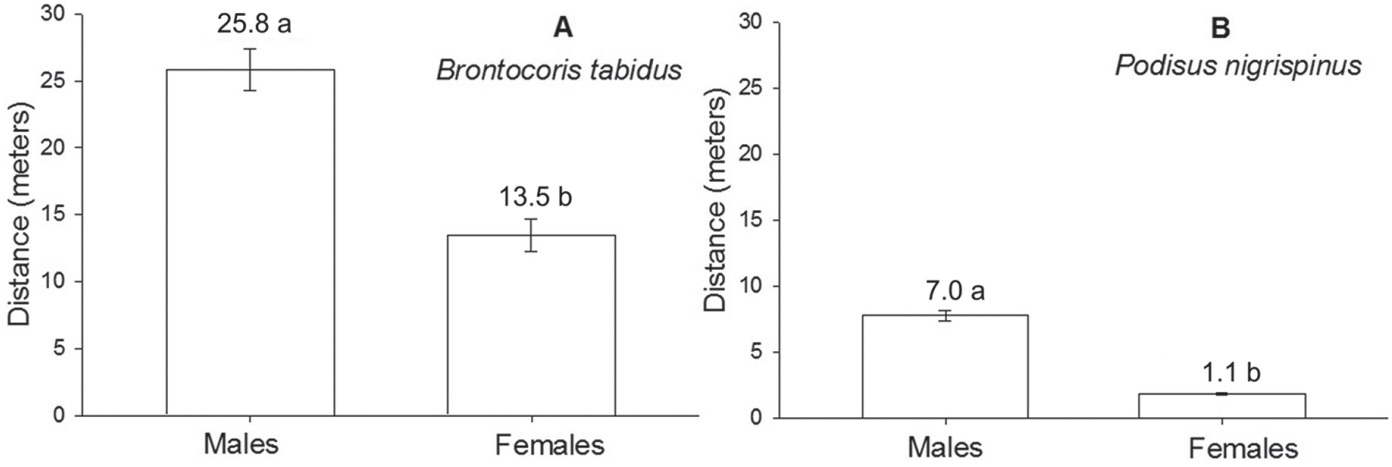

Fig. 4. Distance traveled by the predators *Brontocoris tabidus* (A) and *Podisus nigrispinus* (B) (Heteroptera: Pentatomidae) males and females in a clonal eucalyptus plantation (*Eucalyptus grandis* × *Eucalyptus urophylla*) 7 d after release. Means followed by the same letter do not differ according to the *F* test with $P < 0.05$.

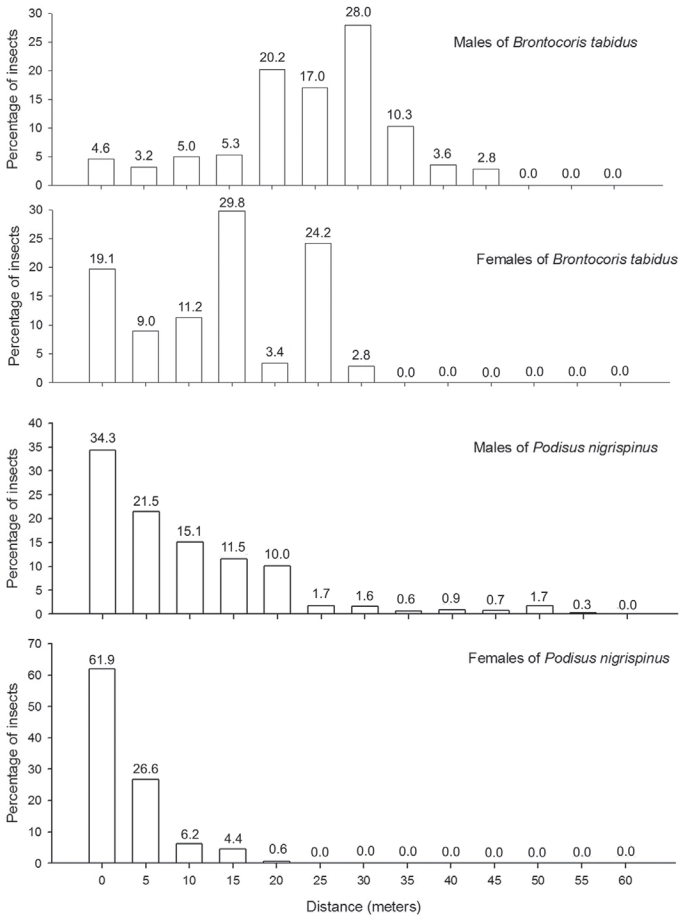

Fig. 5. Distribution of the predators *Brontocoris tabidus* and *Podisus nigrispinus* (Heteroptera: Pentatomidae) males and females in a clonal eucalyptus plantation (*Eucalyptus grandis* × *Eucalyptus urophylla*) 7 d after release.

The gradual increase in distance traveled by the *B. tabidus* and *P. nigrispinus* predators over the 7 d may be influenced by prey availability, where they continue to search until a food source is found. The farther distance traveled by *B. tabidus* and *P. nigrispinus* males confirms the greater mobility of this sex because they are smaller and lighter than their female counterparts, as reported similarly for *Deois flavopicta* (Stål) (Hemiptera: Cercopidae) (Sujii et al. 2000). Besides, heteropteran females spend the majority of their adult stage reproducing, whereas dispersal and foraging are secondary behaviors (Clutton-Brock & Vicent 1991; Dukas et al. 2006). The greater abundance of *B. tabidus* individuals between 15 to 30 m from the release point indicates greater dispersal capacity to search for defoliator caterpillar outbreaks. Although *P. nigrispinus* dispersal behavior appeared to be limited, it was collected in great numbers at distances > 10 m from release points. Therefore we suggest that both predators could be released at a maximum number of points in *Eucalyptus* plantations to increase foraging and colonization in order to increase the effectiveness of biological control programs.

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