Original Article

Pattern and shape effects of orchid flower traps on attractiveness of *Thrips palmi* (Thysanoptera: Thripidae) in an orchid farm

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**ARTICLE INFO**

Article history:
Received 4 October 2016
Accepted 32 May 2017
Available online xxx

Keywords:
Design
Response
Sizes
*Thrips palmi*
Trap patterns

**ABSTRACT**

*Thrips palmi* Karny is widely distributed and causes damage to orchid flowers. Orchid varieties in the genera *Dendrobium* and *Mokara* are different in shape. This study determined if different trap patterns which reflect flower shape may affect the attractiveness to thrips. The shapes of *Dendrobium* and *Mokara* orchid flowers were characterized and the numbers of flowers per raceme were counted in inflorescences in order to design realistic trap patterns. Four patterns (A, B, C and D) of flower traps were made by increasing the petal area. The mean number of *T. palmi* in flower pattern A was significantly lower than for flower patterns B, C and D (p < 0.05). The numbers of *T. palmi* in flower traps increased with flower petal area (r = 0.63, p < 0.05), but decreased with increasing length of flower contour (r = −0.56, p < 0.05). Six patterns (B1, B2, B3, B4, B5 and B6) of inflorescence traps were created by increasing the numbers of flowers per raceme. The numbers of *T. palmi* increased with increased numbers of flowers per raceme, pattern area and length of contour (r = 0.74, p < 0.05). Thus, inflorescence patterns and sizes affected the numbers of *T. palmi* attracted. The results of this research indicated that not only the patterns but also the sizes of traps were important factors for attractiveness to thrips. This information may be useful in designing and monitoring control programs for *T. palmi*.

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Introduction

Thrips are very small insects commonly found in many crops and ornamental plants (Lewis, 1997). Agricultural crops provide opportunities for quick colonization and establishment of large populations of thrips, and some species become economically important pests (Punderburk, 2002). They damage a large number of crops by colonizing their flowers and as a result, flowers become deformed, then turn brown and become streaked and discolored (Lewis, 1973; Childers, 1997). Most thrips are pests of commercial plants; for example, *Frankliniella occidentalis* (Pergande) causes damage to greenhouse crops throughout the world (Mainali and Lim, 2010). *Scirtothrips perseae* Nakahara has been recorded as an economic pest of avocados (Hoddle et al., 2002). *Thrips tabaci* Lindeman is an economic pest that can reduce onion yields.

*Thrips palmi* Karny is a polyphagous insect found to damage economic crops and ornamental plants in Asia, Europe and the USA and to date has been reported to infest more than 50 plant species in various families such as the Cucurbitaceae, Solanaceae, Fabaceae and Orchidaceae (Dentener et al., 2002), and is a serious pest of flowers of several orchid types in many countries including the USA (Hata et al., 1991), Japan (Kawai, 1995; Murai, 2002) and Thailand (Kajita et al., 1996). *T. palmi* feeds inside newly expanding leaves and developing young inflorescence (Piiluek and Wongpiyasatid, 2010) and is also found in open blooms deep inside the flower and petal folds (Hata et al., 1991). As a result of the infestation, orchid flowers become deformed and heavily scarred. Damage caused by *T. palmi* is an important problem in the flower trade industry, especially with orchid cut flowers from Thailand (Vierbergen, 2001). *T. palmi* has become a global quarantine pest in European countries, the USA and Japan and most detection has been related to imported ornamentals with 79% in Europe and 85% in the USA (European and Mediterranean Plant Protection Organization, 2006).

Substantial differences among orchid varieties in thrips densities have been associated with large differences in flower/inflorescence shape and structure (Hata et al., 1991). In Thailand, where orchid flowers are exportable products, *T. palmi* has been found infesting many *Dendrobium* varieties including *Dendrobium Sonia*, *Dendrobium Sensational Purple* and *Dendrobium Lervia* (Maketon et al., 2014). However, *T. palmi* infestation of other Thai commercial orchid varieties has not been reported, even when heavily

Please cite this article in press as: Pinkesorn, J., et al., Pattern and shape effects of orchid flower traps on attractiveness of *Thrips palmi* (Thysanoptera: Thripidae) in an orchid farm, Agriculture and Natural Resources (2017), https://doi.org/10.1016/j.anres.2017.11.006
infested *Dendrobium* Sonia is grown nearby (second author personal observation). The patterns and shapes of flowers have been investigated as attractive visual cues for thrips (Moreno et al., 1984; de Jager et al., 1995). Differences in the flowers and inflorescences of chrysanthemums affected the preferences of *F. occidentalis* (de Jager et al., 1995). Therefore, flower/inflorescence characteristics are considered to be important visual cues for attracting thrips. *Dendrobium* Sonia inflorescences comprise flowers with wide overlapping sepals and petals giving the inflorescences a compact, dense appearance. In contrast, *Mokara* inflorescences contain flowers with comparatively narrower sepals/petals and therefore have a more spindly, sparse appearance.

The purpose of this study was to determine if the shape and structure of orchid flower and inflorescence traps affect attraction of a *T. palmi* population. Firstly, the shapes of *Dendrobium* and *Mokara* flowers were characterized along with the number of flowers per raceme of plants from an orchid farm. Secondly, these characteristics were used to construct *Dendrobium* and *Mokara* flower and inflorescence-mimicking traps. Finally, field experiments were conducted on an orchid farm to determine the responses of the *T. palmi* population to these traps.

**Materials and methods**

**Study site**

The study site was located in Nakhon Pathom Province, Thailand (13°46'N, 100°16'E). The experimental area was arranged in a 65 m width × 90 m length section in the orchid orchard. Orchid varieties in the genera *Dendrobium* and *Mokara* were chosen which are economically important as cut flowers for export. These consisted of *Dendrobium* Sonia (Den_pur), *Dendrobium* White Fairy (Den_whi), *Mokara* Calypso (Mok_pur), and *Mokara* Sayan Duangporn (Mok_yel).

**Design of trap patterns and sizes**

For each orchid variety, 30 flowering plants were randomly selected from the orchid farms. The number of flowers per raceme of the inflorescence was counted and the flowers were photographed. The digital photographs were downloaded onto a computer and the shapes and sizes of the flowers were measured using the ImageJ 1.46r software package (Rasband, 2012). Both flower and inflorescence trap patterns and sizes were designed based on orchid characters to test the hypotheses that an increase in flower sizes and altered patterns can affect their attractiveness to thrips. Four flower trap patterns were designed and named A, B, C and D. To increase the flower area, the center of the flower was represented by a regular hexagon and circumscribed by a circle with a radius of 0.35 cm. Each side of the hexagon was 0.4 cm long (Fig. 1). The width of petals on both sides was placed in categories increasing by increments of 1.2 cm, from 0.4 cm, 1.6 cm, 2.8 cm and 4.0 cm (named A, B, C and D, respectively) as shown in Figs. 1 and 2. All petals of each pattern were located within a circle with a radius of 3.5 cm.

For the inflorescence traps, flower pattern B was considered to be closest to the patterns of the four orchid varieties (Table 1 and Table S1) with a median shape area range of 20.58–31.82 cm² and length of shape contour range of 28.44–41.75 cm. The number of flowers per raceme was determined from the modal numbers of the four orchid inflorescence varieties (Table S2). Thus, the number of flowers per raceme in traps varied, with 3, 5, 7, 9, 11 and 13 for patterns B1, B2, B3, B4, B5 and B6, respectively (Fig. 2). Then, trap pattern areas and lengths of contour were investigated as provided in Table 1.

The trap patterns and sizes were reproduced and printed on paper (21 cm × 29.70 cm) using the color of the flower/inflorescence (blue) and background (green) which proved to be the most attractive to *T. palmi* based on the experiments of Pinkesorn (2015). All printed traps were placed on 21 × 29.70 cm polyvinyl chloride boards. Orchid plants were grown on benches under shade cloth within farms; the benches were divided into 7 m × 10 m rectangular units of orchid plants. Then, all traps were coated with Tangle-Trap® (The Tanglefoot Company; Grand Rapids, MI, USA) insect trap coating and hung 1 m above the center of each unit. Traps were set in a completely randomized design among units. The experiments were conducted with four replications for 7 d in every other month for one year. For each experiment, thrips were removed and counted from flower and/or inflorescence and background areas of traps for analyses.

**Data analyses**

Shape parameters of the orchid flowers were compared among orchid varieties using the Kruskal-Wallis test. If significant differences were found, then pairwise comparison tests were used to test post hoc results as well. Differences between mean numbers of thrips captured from various trap patterns were compared using one-way analysis of variance. If significant differences were found, then the least significant difference (LSD) test was used to conduct post hoc comparisons. Data were transformed to normality using log10(x + 1). The correlations between the numbers of *T. palmi* and parameters of flower/inflorescence trap patterns/sizes were determined using Pearson’s correlation. All analyses were conducted using the Statistix 9 software package (Analytical Software, 2013).

**Results**

**Design and measurement of flower and inflorescence-mimicking traps**

Flower trap pattern A represented a polyetalous flower with an area 19.72 cm² and length of contour 38.40 cm. Patterns B, C, and
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