ABSTRACT. Species of thrips (Insecta, Thysanoptera) in two strawberry production systems in Rio Grande do Sul State, Brazil. Thrips are tiny insects responsible for the reduction of strawberry fruit quality. The work aimed to record and quantify the thysanopterofauna present in two strawberry production systems, low tunnel and semi-hydroponic. Leaves, flowers and fruits were collected weekly, from July 2005 to December 2006 in Caxias do Sul and Bom Princípio municipalities, RS. A total of 664 individuals were collected, representing two families, four genus and 10 species: Frankliniella occidentalis (Pergande, 1895), F. schultzei (Trybom, 1910), F. rodeos Moulton, 1933, F. simplex (Priesner, 1924), F. williamsi (Hood, 1915), F. gemina (Bagnall, 1919), Frankliniella sp., Thrips tabaci (Lindeman, 1888), Thrips tabaci (Lindeman, 1888), Caliothrips fasciatus (Pergande 1895) from Thripidae and Heterothrips sp. from Heterothripidae. Frankliniella occidentalis represented 89.7% of the samples with 95.8% of the species collected in flowers, 3.9% in fruits and 0.8% in leaves. The results show that flowers are the most important food resource for these insects on strawberry plants. Frankliniella rodeos, F. simplex, F. williamsi, C. fasciatus, and Heterothrips sp. are new records on strawberry for Brazil.

KEYWORDS. Fragaria x ananassa; species survey; thysanopterans.

RESUMO. Espécies de tripes (Insecta, Thysanoptera) associadas à cultura do morangueiro em dois sistemas de produção no Rio Grande do Sul, Brasil. Tripes são insetos diminutos responsáveis pela redução da qualidade dos frutos do morangueiro. O trabalho objetivou registrar e quantificar a tisanópterofauna presente em dois sistemas de produção de morangueiro, túnel baixo e semi-hidropônico. Folhas, flores e frutos foram coletados semanalmente, de julho de 2005 a dezembro de 2006 em Caxias do Sul e Bom Princípio, RS. Foram coletados 664 indivíduos pertencentes a duas famílias, quatro gêneros e 10 espécies: Frankliniella occidentalis (Pergande, 1895), F. schultzei (Trybom, 1910), F. rodeos Moulton, 1933, F. simplex (Priesner, 1924), F. williamsi (Hood, 1915), F. gemina (Bagnall, 1919), Frankliniella sp., Thrips tabaci (Lindeman, 1888), Thrips tabaci (Lindeman, 1888), Caliothrips fasciatus (Pergande 1895) de Thripidae e Heterothrips sp. de Heterothripidae. Frankliniella occidentalis representou 89,3% dos insetos e 95,8% dos gêneros e espécies coletados, destacando-se as flores com 89,7%, as folhas com 3,9% e os frutos com 0,8%. Os resultados sugerem que a alimentação dos tripes ocorre principalmente nas flores e frutos do morangueiro. Frankliniella rodeos, F. simplex, F. williamsi, C. fasciatus e Heterothrips sp. são novos registros na cultura para o Brasil.

PALAVRAS-CHAVE. Fragaria x ananassa; levantamento de espécies; tisanópteros.

Strawberries (Fragaria x ananassa Duchesne) (Rosaceae) are commercially produced in several countries such as France, Spain, United Kingdom, Germany, Poland, United States, Mexico, Guatemala, Ecuador, Chile, Argentina and Brazil, especially due to the attraction exerted by their red and aromatic fruits (Vieira 2001; Coll et al. 2006).

In Brazil, the area grown with strawberry is estimated in 3,500 ha, located mainly in the states of Minas Gerais (41.4%), Rio Grande do Sul (25.6%), São Paulo (15.4%), Paraná (4.7%), and Federal District (4%) (Calvete et al. 2005). In Rio Grande do Sul (RS), the area grown with strawberry is of 700 ha. The crop is grown mainly in low tunnel and more recently in a semi-hydroponic system (Emater 2004; Embrapa 2007). In the low tunnel system the seedlings are planted in the soil using beds covered with plastic and sustained by galvanized iron arches, forming a tunnel which main function is to protect the plants from rain, frost, UV rays, and to reduce the spread of pests and diseases (Embrapa 2005). The semi-hydroponic system is derived from the hydroponics system and is conducted inside plastic or glass greenhouses, and the plants are kept in shelves located at different heights (Embrapa 2007).

Several species of Thysanoptera infest strawberry plants reducing fruit quality in several countries, being spread mainly by plant commerce (Coll et al. 2006; Ripa et al. 2009). Moreover, the control of thrips in infested areas is not easy due to their small size, rapid population growth and cryptic habits that include polyphagy and parthenogenesis (Coll et al. 2006; Mound 2007).

The order Thysanoptera comprehends approximately 5,800 species, but only 1% causes economic losses in commercial crops (Mound & Marullo 1996; Mound 2007). The damage caused by thrips is due to lesions on plant tissue produced by the bite-sucking mouth-parts and by the transmission of pathogens (Mound & Kibby 1998; Moritz et al. 2004).
Several species are associated with strawberry crops in Australia, according to Steiner & Goodwin (2005). These authors recorded *Frankliniella occidentalis* (Pergande, 1895), *Frankliniella intonsa* (Trybom, 1895), *Frankliniella tritici* (Fitch, 1855), *Thrips atratus* (Haliday, 1836), *Thrips major* (Uzel, 1895), *Thrips tabaci* (Lindeman, 1888), *Thrips fuscipennis* (Haliday, 1836), *Thrips imaginis* (Bagnall, 1926), and *Scirtothrips dorsalis* (Hood, 1919). In Florida, USA, according to Mass (1998), the more important species damaging strawberry plants are *Frankliniella tritici* (Fitch) and *Frankliniella bispinosa* (Morgan, 1913). In California, *F. occidentalis* is the prevalent species feeding on strawberry blossoms and causing the stigmas and anthers to turn brown and wither prematurely (UC IPM 2008). In Italy, Marullo & Tremblay (1993) mention *F. intonsa* and *F. occidentalis* as highly polyphagous species, having the strawberry as a host plant. The damage attributed to these species is the distortion and atrophy of the fruit, caused by insect’s feeding on the flowers. In Brazil these injuries were studied by Nondillo et al. (2010). In Spain, Israel and Turkey, *F. occidentalis* is also reported to cause damage in strawberry flowers. In Turkey, among 14 identified species, *F. occidentalis* was the dominant specie with 97% of insect collected (Gonzáles-Zamora & García-Marí 2003; Coll et al. 2006; Atakan 2008).

In Brazil there is lack of information about the main species of thrips associated with strawberry plants especially in different production systems. In the state of Rio Grande do Sul few studies emphasize the thysanopterans on this crop. Thus, the main goal of this research was to identify and quantify thrips species associated with strawberry crops in low tunnel and semi-hydroponics systems in Rio Grande do Sul.

**MATERIAL AND METHODS**

Between July 2005 and December 2006, weekly samplings were carried out in three commercial strawberry fields cultivar Aromas, being two developed in low tunnel systems (areas A1 and A2), located in Souza Farm, Caxias do Sul municipality (29°10’S, 51°10’W) and one in semi-hydroponic system (area A3), located in Bom Princípio municipality (29°29’S, 51°21’W), in Rio Grande do Sul.

The areas A1 and A2, measuring 114 m x 70 m each, had 71 beds of 70 m in length and 1 m in width, each with two rows of plants disposed at a distance of 35 cm between rows and 27 cm between plants, with a total of 518 seedlings. In each area, ten sampling stations were established with a ray of 1 m for sampling purposes. A3 had 520 m², and 5,000 seedlings distributed in 22 benches of 40 m x 13 m each, with two rows of plants, with 114 seedlings/bench. In this area, ten sampling stations with a ray of 0.70 m were established.

From the planting date until the end of the second phenomenological cycle of the culture, samples were taken, collecting randomly one leaf, one flower and one fruit in each station from the same plant that were placed individually in plastic bags and taken to the laboratory. Flowers were collected when they were completely opened.

In the Entomology Laboratory of Embrapa Uva e Vinho in Bento Gonçalves, RS, adult and immature thrips were separated from the plants using a thin brush under stereomicroscope and placed in AGA (10 parts of ethyl alcohol 60%, one part of glacial acetic acid and one part of glycerin). In the Biology, Ecology and Biological Insect Control laboratory at the Federal University of Rio Grande do Sul (UFRGS), adults were mounted on microscopy slides according to Mound & Kibby (1998) and Moritz et al. (2004), and identified using specialized keys.

The number of individuals per area, plant part, sex, and species were recorded using a spread sheet of the statistical program SPSS. The data was subjected to descriptive analyses. The faunal index was based on the relative abundance (RA) according to the standard convention: rare if RA ≤ 0.01, intermediate if 0.1 ≤ RA < 0.01 and abundant if RA > 0.1.

Thrips specimens were deposited in the reference collection of Bioecolab/UFRGS and in the Entomology Laboratory of Embrapa Uva e Vinho, RS.

**RESULTS AND DISCUSSION**

A total of 982 individuals were collected between July 2005 and December 2006 in the three sampling areas. From these, 318 (47.9%) were immature individuals and 664 (52.1%) were adults. Among the adults, 517 (77.9%) were females and 147 (22.1%) were males. Immature individuals were more abundant in flowers, 304 (95.6%), than in fruits, 14 (4.4%). Immature individuals were not identified due to the lack of identification keys for this stage, particularly for Neotropical species. Identification keys are available only for adult females according to Moritz et al. (2007). However, the presence of larval instars, pre-pupae, pupae and eggs, generally on the underside of the sepals, characterizes the strawberry as a suitable host plant, a criterion adopted by Pinent et al. (2005). However, factors determining reproductive host plant for the thrips are not yet understood or poorly defined (Ripa et al. 2009).

Ten species of thrips were identified belonging to four genera and two families. In the family Thripidae were identified: *F. occidentalis*, *Frankliniella schultzei* (Trybom, 1910), *T. tabaci*, *Frankliniella rodeos* (Moulton, 1933), *Frankliniella simplex* (Priesner, 1919), *Frankliniella williamsii* (Hood, 1915), *Frankliniella gemina* (Bagnall, 1919), *Frankliniella sp.*, and *Caliothrips fasciatus* (Pergande, 1895). The family Heterothripidae was represented by *Heterothrips sp*.

The species *F. occidentalis*, with 593 records, represented 89.3% of all samples, with 95.8% collected in flowers, 8.4% in the leaves, and 3.7% in the fruits. Only *F. occidentalis* and *F. rodeos* occurred in the three areas, with the former being more abundant in the low tunnel systems A1 and A2, representing, respectively, 47.2% and 44.2%, and in the semi-hydroponic A3, 8.6% (Table 1).

Considering abundance of thrips in the three areas, *F. occidentalis* was the dominant species (relative frequency above 10%). *F. schultzei*, *F. rodeos*, and *T. tabaci* were inter-
Species of thrips in two strawberry production systems

Table I. Number and relative frequency of thrips species sampled on leaves, flowers, and fruits of strawberry, cultivar Aromas, cropped in low tunnel system (A1 and A2), Caxias do Sul municipality, and semi-hydroponics system (A3), Bom Princípio municipality, in the state of Rio Grande do Sul, Brazil, from July/2005 to December/2006.

<table>
<thead>
<tr>
<th>Family/Species</th>
<th>A1</th>
<th>A2</th>
<th>A3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Leaf</td>
<td>Flower</td>
<td>Fruit</td>
</tr>
<tr>
<td>Thripidae</td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td><em>Frankliniella occidentalis</em></td>
<td>0</td>
<td>0</td>
<td>268</td>
</tr>
<tr>
<td><em>Frankliniella schultzei</em></td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td><em>Thrips tabaci</em></td>
<td>0</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td><em>Franklinella rodeos</em></td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td><em>Franklinella simplex</em></td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td><em>Franklinella williamsi</em></td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><em>Caliothrips fasciatus</em></td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><em>Franklinella gemina</em></td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><em>Franklinella sp.</em></td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Heterothripidae</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Heterothrips sp.</em></td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>0</td>
<td>281</td>
<td>13</td>
</tr>
</tbody>
</table>
Frankliniella bispinosa (Pergande) causes serious damage to strawberry crops, while F. occidentalis, although more abundant, rarely causes expressive damage. In Brazil, F. occidentalis is considered a pest of several cultures since 1993, especially on industrial cut flowers, such as chrysanthemum and roses (Monteiro et al. 1999). There are records of F. occidentalis in the states of Alagoas, Pernambuco, Rio de Janeiro, Rio Grande do Sul, and São Paulo (Monteiro et al. 2001). In São Paulo, this species was recorded tanning and deforming peach fruits (Pinent et al. 2008). In the present research, the damage caused to the strawberry plant results from feeding mainly on flowers causing tanned areas on stamens and flower receptacles. Damage on fruits has not been described in the literature, probably due to low frequency (3.7%) of thrips on them, indicating that this is not a preferential food source. Nondillo et al. (2010) characterized the damage caused by F. occidentalis in flowers and fruits of strawberry of the same cultivar, concluding that F. occidentalis tans flowers and fruits, but is not responsible for deformations. Another species that deserves consideration is F. schultzei, broadly distributed in African and Asian countries, Australia, New Zealand and in the North, Central and South Americas, where it has been observed feeding on flowers, especially Asteraceae plants, and also on weeds that represent a good resource for the development of their populations (Moritz et al. 2007). Wilson et al. (1996) observed that specimens of F. schultzei are important predators of eggs of mites in cotton crops in some regions of Australia. In Brazil, according to Monteiro et al. (1999), F. schultzei preys on mites of the species Polyphagotarsonemus latus (Banks, 1904) (Acari, Tarsonemidae) and Tetranychus urticae (Koch, 1836) (Acari, Tetranychidae). In Paranapanema municipality, in the state of São Paulo, Pinent et al. (2008) observed F. schultzei damaging peach fruits. Pinent et al. (2007) recorded F. schultzei as the most abundant species on leaves, flowers and fruits of strawberry in Rio Grande do Sul. In the present work, the highest abundance of F. schultzei occurred in flowers from the semi-hydroponic system.

It is important also to mention the onion thrips, T. tabaci, originated probably from the east Mediterranean where, according to Monteiro et al. (1999), the onion, Allium cepa, Lineu (Liliaceae), is a native plant. T. tabaci is a common pest infesting several plants and feeding on larvae of other thrips and mites (Moritz et al. 2004). From a total of 280 species in this primitive genus of Thysanoptera, only four occur in Brazil (Monteiro et al. 2001). Mound (2005) considers that T. tabaci is losing its pest status because its population has decreased as well as its importance as vector of the tospovirus. In California, strawberry crops often have mixed colonies of thrips species including low percentage of T. tabaci (UC IPM 2008). This fact has also been observed in some strawberry production areas in Brazil. Pinent et al. (2007) recorded in Gaucho Highlands of Rio Grande do Sul small populations of T. tabaci in flowers of strawberry, representing only 2.5% of 356 specimens collected. In peach crops in Paranapanema, São Paulo, T. tabaci represented 7.0% of a total of 115 individuals comprising seven species (Pinent et al. 2008). In the present study, only 1.9% of the individuals occurred in strawberry flowers.

The highest abundance of thrips was recorded in the low tunnel system, totaling 294 (44.3%) adult specimens in A1 and 277 (41.7%) in A2. In the semi-hydroponic system (A3) 93 (14.0%) thrips specimens were recorded.

Different factors may interfere in the frequency of species in relation to different production systems, among them the presence of other crops or weeds, since thrips are easily carried by the wind rather than flying. The presence and absence of natural enemies is a relevant, but poorly studied aspect, deserving attention in future works. The semi-hydroponic system is a protected environment that makes it difficult the entrance of insects. However, it was found the same richness (six species) in this system than in the low tunnel production. Among the species recorded in our investigation, only F. occidentalis and F. schultzei have economical importance for the strawberry crop. F. rodeos, F. simplex, F. williamsi, C. fasciatus, and Heterothrips sp. are new records on strawberry plants in Rio Grande do Sul and Brazil.

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