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Thrips species occurring in red raspberry, *Rubus idaeus* L., in South Norway

Jiunn-Luh Tan[1,2*], Nina Trandem[3], Zhibo Hamborg[3], Jana Fránová[4], Dag-Ragnar Blystad[3], and Rostislav Zemek[2]

[1] Department of Zoology, Faculty of Science, University of South Bohemia, 37005 České Budějovice, Czech Republic. [2]Institute of Entomology, Biology Centre CAS, 37005 České Budějovice, Czech Republic. [3] Division of Biotechnology and Plant Health, Norwegian Institute of Bioeconomy Research (NIBIO), 1431 Ås, Norway. [4] Institute of Plant Molecular Biology, Biology Centre CAS, 37005 České Budějovice, Czech Republic.

***Correspondence** should be addressed to Jiunn Luh Tan: jiunnluh@gmail.com

Abstract

Aim of study: Thrips in raspberry crops are receiving attention in Scandinavian raspberry production because of the increasing sighting of their presence in the flowers. Specific information on thrips species occurring in raspberry and their damage potential is scarce, making thrips management challenging. Therefore, this study aimed to identify thrips in the flowers of cultivated raspberry, *Rubus idaeus* L., in South Norway.

Area of study: Sogndal, Luster and Frogn, Southern Norway

Material and methods: Adult thrips were sampled from eight commercial raspberry orchards in the counties Vestland and Viken in June-July 2022. Thrips were mounted using Hoyer's medium and a total of 213 specimens were morphologically identified.

Main results: Five species of thrips were found, *Thrips fuscipennis* Haliday, *Thrips major* Uzel, *Thrips flavus* Schrank, *Thrips vulgatissimus* Haliday and *Thrips brevicornis* Priesner. Most specimens were *T. flavus*, followed by *T. fuscipennis* and *T. vulgatissimus*.

Research highlights: Among the five species found, only *T. fuscipennis* has previously been reported in cultivated raspberry, but all five species are associated with flowers of many plants. The findings imply a larger and more geographically varied thrips fauna on raspberry than currently documented. This should be taken into account in future studies on thrips management in raspberry.

Additional keywords: agriculture; horticulture; Thripidae; thrips species composition; *Thrips flavus*; *Thrips fuscipennis*; *Thrips vulgatissimus*

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Introduction

The global production of raspberries was approximately 950 thousand tons in 2022 (FAO, 2023) and the global import and export volume increased by 50% and 56% respectively, from 2012 to 2019 (Bojkovska et al., 2021). This indicates an increasing demand for raspberries. The annual production of raspberries in Norway is approximately two thousand tons, with 'Glen Ample' being the dominant cultivated variety (Akšić et al., 2022; FAO, 2023). The production of raspberries is consistently challenged by various pests and diseases, and thrips is one of them (Tan et al., 2022). Thrips in red raspberry, *Rubus idaeus* L., has been receiving more attention in Scandinavian raspberry production the last few years. They are more frequently observed in flowers and fruitlets, concurring with presumed thrips damage on the berries. In addition, thrips crawling in the lids of fresh market berry punnets lead to

negative feedback from customers. The possible reasons for the increase in thrips abundance include less pesticide use during flowering as well as higher frequency of heat waves and higher average temperature across Europe during summer (Chapman et al., 2019; Sánchez-Benítez et al., 2022). In addition, altered growing techniques, such as plastic tunnels and black polyethylene mulch, could provide a better environment for overwintering thrips, increasing their survival rate and thus leading to more rapid resurgence of thrips populations during spring (Nielsen et al., 2021; Sampson et al., 2021). Changes in global climate are also predicted to promote migration of thrips, causing an invasion of new species (Mukherjee et al., 2023). These factors highlight the importance of studying and monitoring the species composition of thrips in economically important crops, such as raspberry.

Several species of thrips have been reported on raspberry, and among them are the cosmopolitan pests *Frankliniella occidentalis* (Pergande) and *Thrips tabaci* Lindeman. In addition, *Tenothrips frici* (Uzel), *Thrips imaginis* Bagnall, and *Thrips fuscipennis* Haliday, have been found in raspberry. Among these five species, *T. imaginis* is not present in Europe (Mound & Masumoto, 2005; CABI, 2023). In Norway, *Thrips tabaci* and *T. fuscipennis* are widely distributed in the southern part (Kobro, 2013, 2022), whereas *F. occidentalis* has only been reported as an indoor species (Gertsson, 2015) and *Te. frici* was found recently (Kobro & Ulitzka, 2021). In Portugal, several other polyphagous thrips species have been reported on sticky traps in greenhouse cultivated raspberry. These include *Thrips major* Uzel, *Thrips flavus* Schrank, *Thrips angusticeps* Uzel, *Tenothrips discolor* Karny, and *Frankliniella tenuicornis* (Uzel). In addition to these phytophagous species (suborder Terebrantia), thrips belonging to the predatory genus *Aeolothrips* (suborder Tubulifera) were also found on the traps (Mateus, 2016).

It is hypothesized that there are more species of thrips present on raspberry than those documented in the literature. To date, the thrips fauna of raspberry in Scandinavia has not been specifically investigated. The objective of this study was therefore to identify thrips present in the flowers of cultivated red raspberry in South Norway. Knowing the most common species present is important for further studies of damage potential and management of thrips in raspberry, including the possibility of virus vectoring.

Material and methods

Sampling of thrips

The sampling was carried out during June and July 2022 in three sampling areas consisting of eight sampling sites in total, seven in Vestland county and one in Viken county (Table 1). Most of the Norwegian raspberry production takes place in Vestland county. The latitude of sampling areas was in the range of 59°40'15.1" N to 61°29'44.7" N, and the longitude 6°50'6.7" E to 10°40'47.4" E. Adult thrips were collected from open field cultivated raspberry flowers, most of them in 'Glen Ample', as this is the dominant cultivar in Norway. Raspberry flowers were randomly selected and examined for the presence of adult thrips. Flowers with thrips (Figure 1) were placed into small plastic bags. More flowers were collected in sites with higher thrips density.

The thrips were transferred from the flowers to 70% ethanol (diluted from 96% ethanol, VWR chemicals, France) using a paint brush, sorted according to sampling site, and kept at 4°C until mounted for morphological identification. The number of thrips to be mounted were selected as evenly as possible throughout all sampling sites, but limited by the number of samples available.

Mounting and identification of thrips

The mounting method was modified from ThripsWiki (2013) and Tan et al. (2016). The thrips were transferred from 70% ethanol into 3% sodium hydroxide (NaOH) for maceration. Pale-colored thrips were soaked for 3-4 hours and darker-colored thrips overnight (15-17 hours). The macerated thrips were then transferred to distilled water added with a drop of Tween® 80 (Sigma-Aldrich, Darmstadt, Germany) and soaked overnight. A drop of Hoyer's microscope slides mounting medium (Entomopraxis, Barcelona, Spain) was then placed on a round glass cover slip (diameter: 12 mm, Assistant, Sondheim, Germany) and the thrips positioned with the ventral side up in the drop. Another drop of Hoyer's solution was placed on a glass slide (size: 7.6 × 2.5 cm, Waldemar Knittel Glasbearbeitungs GmbH, Bielefeld, Germany) before inverting it and placing it gently over

Table 1. Sampling sites (South Norway), date of sampling, and the relative distribution of identified specimens.

Sampling area	Sites[1]	County	Date of sampling	Specimens[2] N (in %)
Sogndal	3	Vestland	28 June 2022	95 (44.6)
Luster	4	Vestland	29 June 2022	64 (30.0)
Frogn	1	Viken	7 July 2022	54 (25.4)

[1] Sites: number of sites in the sampling area. [2] Specimens: total number of samples being identified in the sampling area.

Figure 1. Example of thrips-infested raspberry flowers in Norway, photo by D.-R. Blystad.

the cover slip. Once the two drops of Hoyer's solution merged, the glass was turned around and the thrips could be adjusted by moving the cover slip if not properly positioned. The slides were left at room temperature until the mountant was dry. The ready slides were ringed with nail varnish and labeled.

The thrips were identified using the morphological identification key in Mound et al. (1976, 2018) and Kirk (1996). The thrips specimens were examined with a Peraval Interphaco microscope (Carl Zeiss, Jena, Germarny) under 197× to 1575× magnification. Voucher slides are deposited at the Institute of Entomology, Biology Centre of the Czech Academy of Sciences, České Budějovice.

Results and discussion

A total of 213 adult female thrips were identified morphologically (Table 2). Five species of thrips were found: *Thrips fuscipennis* Haliday, *Thrips major* Uzel, *Thrips flavus* Schrank, *Thrips vulgatissimus* Haliday, and *Thrips brevicornis* Priesner. Among these five species, *T. flavus* was the most abundant, followed by *T. fuscipennis* and *T. vulgatissimus*. *Thrips fuscipennis* is the only species previously reported on raspberry (Raspudić et al., 2009; Bennison et al., 2020), but *T. major* and *T. flavus* have been found on sticky traps in greenhouse cultivated raspberry in Portugal (Mateus, 2016). All five species have been reported to be present in Norway (Kobro, 2013). In general, the thrips distribution concurred to that reported by Kobro (2022). Even though *T. fuscipennis* was the second most abundant species among the identified specimens, it was only found in Frogn. This matches its distribution, which is more concentrated in the south-eastern area of Norway where Frogn is located. Although *T. tabaci* and *F. occidentalis* are present in Norway (Gertsson, 2015) and have been reported on raspberry in other countries (Leach & Isaacs, 2018; CABI, 2023), they were not found in this study. This was probably because all the sampling sites were open field raspberry, and these two species tend to be most abundant in raspberry cultivated in tunnel (Gertsson, 2015; Mateus, 2016; Leach & Isaacs, 2018).

The presence of *T. major* and *T. flavus* in raspberry is well within expectation, as they are associated with a wide range of flowering plants in Europe, and are known to feed on many species of Rosaceae plants, including other species of *Rubus*, like blackberry and loganberry (Alford, 2014). Besides Rosaceae, *T. flavus* is also known to cause economic damage to a wide range of crops in other plant families, such as Gramineae, Solanaceae and Leguminosae (Sun et al., 2023). *Thrips major* is often found together with adults of other thrips in flowers, among them are *T. fuscipennis*, *T. flavus*, and *T. vulgatissimus* (Morison, 1957). To date, *T. major* is only regarded as minor pest in general (Velez-Gavilan, 2022). *Thrips major* and *T. fuscipennis* are quite common pests of strawberry, and their damage can result in malformed fruits, causing some economic losses (Alford, 2014; Nielsen et al., 2021). Besides strawberry, *T. fuscipennis* infests a wide range of other host plants that belong to the family Rosaceae (Bennison et al., 2020). *Thrips vulgatissimus* is found in flowers of many plants too, especially in small white flowers, such as certain species

Table 2. The species, number of individuals and sampling area of the identified thrips.

Species	No. of individuals	Sampling area[1]		
		Sogndal	Luster	Frogn
Thrips brevicornis	3		×	×
Thrips flavus	124	×	×	×
Thrips fuscipennis	39			×
Thrips major	18	×		×
Thrips vulgatissimus	29	×	×	

[1] × indicates that the species was found at the sampling area.

of Caryophyllaceae (Mound & Masumoto, 2005). It has also been reported on strawberry in Denmark, but only in small numbers (Nielsen et al., 2021). In Norway and Sweden, it is one of the most widely distributed thrips species (Kobro, 2013; Gertsson, 2015). *Thrips vulgatissimus* has been categorized as a relative important pest of barley, wheat and buckwheat in China and the United States (Reitz et al., 2011). The least common thrips in our study was *T. brevicornis*. It is described as a polyphagous thrips (Vierbergen et al., 2010) and is present in many flowers in Norway (Kobro, 2013). In addition to being flower-living, this species along with *T. flavus* and *T. fuscipennis*, are known as meadow-living and heliophilous (Masarovič et al., 2022). This implies that these thrips can also survive on alternative flowering plants in the surrounding of the orchards. The pest status of these species in raspberry is still unknown, and therefore, further investigation on their level of threat in this crop is important.

As a conclusion, only one out of the five species found in this study was previously documented on raspberry, thus confirming the hypothesis that more species of thrips were present on raspberry than currently documented. Although more evidence should be collected to investigate their pest status in raspberry, this study demonstrates the lack of information on thrips species occurring on this crop. Such records of species are also important because invasion of new species are occurring frequently and shift of thrips distribution has also been predicted due to climate change (Mukherjee et al., 2023). Therefore, the results will serve as an important thrips species reference in raspberry for future studies. Recommended further studies includes the pest status of these thrips, their potential as raspberry virus vectors, and to continue monitoring the thrips species composition in raspberry. Since all the sampling orchards were open-field, species composition in tunnel-cultivated raspberry should be studied to compare the species composition. Knowing more on the species composition can help to make better decision in thrips management especially after the adoption of the European Green Deal 2030.

Data availability: The authors confirm that the data supporting the findings of this study are available within the article.

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