Laboratory rearing of *Thrips tabaci* Lindeman: a review

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Ein Überblick über die Laborzuchtmethoden für *Thrips tabaci* Lindeman

1 Introduction

Thrips tabaci Lindeman 1889, the onion thrips is a cosmopolitan species (Moritz et al., 2001). Its development is a classic Terebrantia life cycle (Lewis 1997). It has hundreds of host plants (Priesner 1928; Bailey 1938; Mound 2007) but of these, the economically most important crop plants are: onion, cabbage, tobacco, pepper and tomato (Harris et al., 1935; Shelton et al., 1982; Shelton et al., 1983; Orosz et al., 2008; Mound 2007; Jenser 2001; Sakimura, 1937).

T. tabaci is a species complex that has different reproductive types. These are the thelytokous (asexual), the arrhenotokous (sexual), and the deuterotokous (asexual with male and female offspring) type (Jenser 2001; Brunner et al., 2004; Nault et al., 2006; Todai & Murai 2007; Kobayashi & Hasegawa 2012).

The laboratory rearing plays a key role for the bioassays and other investigations with this insect. The aim of this review is to briefly present the environmental factors that affect the thrips in a laboratory rearing, and to shortly summarize the methods that were used to rear this insect.

2 Environmental and other factors of thrips rearing

2.1 Light

Diapause is linked with light, but little is known about the diapause of this species complex (Murai 1990). We believe that light sources that have a broad light emission spectrum (with long and short wavelengths) (Feldmann et al., 2003) can cause excess humidity in small containers under certain circumstances. A climate chamber (MLR-352H Auro science consulting kft.) with vertical neon tubes has a strong light incidence into a box, vial, Petri dish or a similar rearing unit that is placed inside it. The body of these rearing units

Zusammenfassung

Thrips tabaci Lindeman (Thysanoptera: Thripidae) ist weltweit einer der bedeutendsten Schädlinge an verschiedenen Kulturpflanzen. Er ist auch ein Vektor des Tomatenbronzefleckenvirus (TSWV) und des Iris Yellow Spot Virus (IYSV), zwei Viruskrankheiten die große wirtschaftliche Schäden an Kulturen im Freiland als auch unter Glas verursachen. Wegen seiner geringen Größe und der unterschiedlichen Reproduktionstypen des *T. tabaci* ist es schwierig, ihn sicher und kosten- sowie zeiteffizient zu züchten. Ziel dieser Arbeit war, eine kurze Übersicht über die gängigen Methoden für Laborzuchten von *T. tabaci* zu geben.

Schlagwörter: *Thrips tabaci*, Insektenzucht, Umweltfaktor, Wirtspflanze.

Summary

Thrips tabaci Lindeman (Thysanoptera: Thripidae) is an important pest of various crops throughout the world. It is also a vector of tomato spotted wilt virus (TSWV) and iris yellow spot virus (IYSV) which can cause serious economic losses in many greenhouse and field crops. Due to its small size and the presence of various reproduction types of *T. tabaci*, it can be difficult to construct a secure, cost and time effective way to rear it. The aim of this work is to summarize and briefly present the available methods for laboratory rearing of *T. tabaci.*

Key words: *Thrips tabaci*, insect rearing, environmental factor, host plant.

is usually transparent while the top lid is generally thicker or non-transparent at all. Therefore a vertical light source allows a better illumination of such a container then a horizontal one. Our group experienced that the increased light incidence from a vertical light source creates excessive humidity in these rearing units. This phenomenon has a lower impact in a walk-in climate room with more distant, horizontal light sources. The shading of the vertical light sources in the same climate chamber significantly lowers the excessive humidity under the same environmental conditions (personal observation). The reasons of this phenomenon might be the elevated metabolism of the plant material due to the intense nearby light source or the decrease of the temperature during the scotophase. Also a greenhouse effect (incoming radiation easily passes through the plastic walls but the reflected infrared radiation has difficulty, thus warms the container) may take place inside the small containers. Horizontal light sources with more distance from the rearing units should preferably be used for *T. tabaci* rearing.

2.2 Temperature

The temperature optimum of the onion thrips is 23 °C (Murai 2000). The development time at this temperature is about 15 days from egg to adult stage. On the one hand, temperature influences the development, lifespan and mortality of the insect. On the other hand, it affects the aging of the food source (usually a leaf). Prange (2004) measured the respiration intensity of an intact cabbage head at different temperatures. At higher temperatures, the respiration intensity increased (figure 1). The author also noted that the smaller the leaf piece was, the higher the respiration intensity became. Based on this information it can be assumed that a leaf piece will deteriorate faster if it is smaller and kept at a higher temperature. The experience of our group led us to the conclusion that 23 °C are not adequate for onion thrips rearing, because the food source will deteriorate too fast. We believe that 20 °C should be used instead.

2.3 Humidity

Humidity plays a key role in the health of the rearing system, because high humidity favours both plant and insect diseases and generates water droplets that will trap thrips and kill them. We believe that in a closed or semi-closed rearing system humidity can only be controlled by the other factors: light, temperature, food source and the layout of the system. Lowering the humidity in a climate chamber will only have a little effect on the actual moisture inside a rearing system (personal observation).

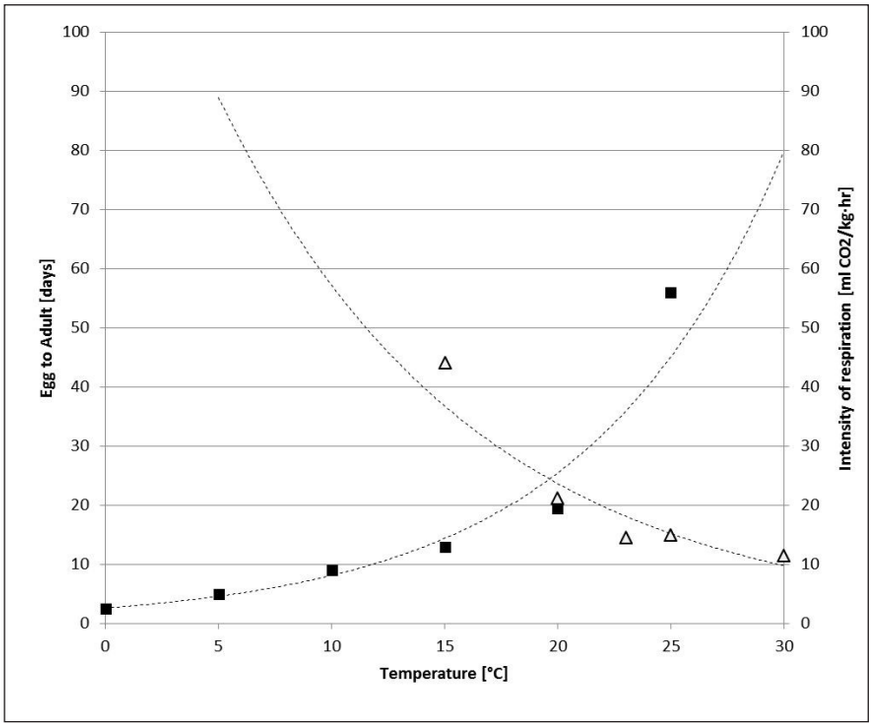

Figure 1: Mean development time of *T. tabaci* (triangle) (based on the cited works with development time data) and the respiration intensity of an intact cabbage head (square) (Prange 2004) on different temperatures

Abbildung 1: Durchschnittliche Entwicklungszeit von *T. tabaci* (Dreieck) (bezogen auf den zitierten Arbeiten mit der Entwicklungszeit -Daten) und die Atmungsintensität eines intakten Kohlkopf (quadratisch) (Prange 2004) auf verschiedenen Temperaturen

2.4 Humidity control

2.4.1 Ventilation

A well-ventilated rearing system requires one or more screened holes or frequent opening of the unit. Too much ventilation of a system can cause early desiccation of the food source (leaf or fruit), which can kill the eggs inside the drying plant tissue. Too low ventilation can cause excess moisture on the walls of the rearing unit. This can lead to unwanted plant and insect diseases and thrips death (we believe that they walk in it by accident and suffocate) (personal observation). Thrips that are transferred from diseased plant material can transfer the pathogen to the fresh plant material. This can cause an early deterioration and under certain circumstances even the collapse of the stock colony (personal observation). The plant material has to survive until the eggs hatch from it, which takes 4–5 days on 23 °C and 6–7 on 20 °C (Murai 1990).

2.4.2 Screening materials

The following materials were used to make screened openings for *T. tabaci* rearing units: fine mesh gauze 60 µm (Tadeschi et al., 2001; Murai & Loomans 2001), muslin (Deligeorgilis et al., 2006a), organdi (Arieche et al., 2006; Diaz Montano et al., 2012), nylon mesh 112 µm (Steiner & Goodwin, 1998), cotton batting (Harris et al., 1935), filter paper (Gawaad & Shazli, 1969), parafilm (Guzmán et al., 1996) and metal mesh (unpublished stock colony method of our group).

2.4.3 Water absorption

Too low ventilation can lead to elevated amounts of water. To avoid this, the size of the screened holes can be increased or a water absorbent can be put in the system (it can serve as a hiding place for pupae as well). The following materials were used for this purpose in *T. tabaci* rearing units: tissue paper (kitchen paper) (Steiner & Goodwin, 1998), blotting paper (Harris et al., 1935) and vermiculite (Steiner & Goodwin, 1998).

2.4.4 Water input

This can be a way to prolong the lifespan of the food source. By putting the leaf on a wet surface it will dry out slower (Koschier et al., 2002). In boxes, a small sponge in a Petri dish can be used (unpublished method of our group) The following materials were used in *T. tabaci* rearing units: filter paper (Fathi et al., 2011), tissue paper (Fekrat 2009), sponge (Fathi et al., 2011) sand (Lall & Singh, 1968) water agar (Koschier et al., 2002; Riefler & Koschier, 2009a) and cotton (Ghabn, 1948).

3 Stock culture

The methods listed here were used to rear large numbers of thrips. The purpose of the stock culture is to provide a continuous supply of thrips (usually of mixed age) for use in bioassays.

- Bean jar method, 10 papers (Tadeschi et al., 2001; de Kogel et al., 1997; Steiner & Goodwin 1998; de Kogel & Koschier 2002; Koschier et al., 2002; Martin et al., 2003; Nagata et al., 2004; Riefler & Koschier 2009a; Riefler & Koschier 2009b; Fathi et al., 2011)
- Potted plant with covering, 6 papers (Edelson & Magaro 1988; Stacey & Fellowes 2002; Liu 2003; Arieche et al., 2006; Deligeorgilis et al., 2006a; Fekrat et al., 2009; Diaz-Montano et al., 2012)
- Potted plant without covering, 5 papers (Belder & Agea, 2001; Stacey & Fellowes, 2002; Kumm & Moritz, 2006; Thungrabeab et al., 2006; Karadjova & Krumov, 2008)
- Box and other containers, 6 papers (Guzmán et al., 1996; Steiner & Goodwin, 1998; Stacey & Fellowes, 2002; Murai & Loomans, 2001; Inoue & Sakurai, 2006; Nault et al., 2006)
- Membrane method, 2 papers (Murai 2000; Murai & Loomans, 2001)
- Other methods, 2 papers (Lall & Singh, 1968; Gawaad & Shazli, 1969)

3.1 Bean jar method

The most common method to keep a stock colony. It is cheap and occupies not much space. The size of the glass jars varies from 250 to 1000 ml. A screened hole can be cut in the lid and moisture absorbent material can be placed on the bottom. The temperature interval is 15–25 °C, mainly used in climate chambers and climate rooms. The following host plant materials were used for this method: Leek leaves, bean pods, immature cucumber fruits, cabbage leaves or leaf ribs.

3.2 Potted plant with screening

It is a method that requires a potted living host plant and a cage. Plexi glass cages with screened openings, screened cages, cylindrical plastic or glass tubes and cone-tainers© (Stuewe & Sons, Inc.) have been used. The range of temperatures was 20–25 °C and the cages were usually kept in greenhouses. The following host plants were used: onion, cucumber, tobacco, Emilia sonchifolia L., and cabbage. This method requires considerable space and a well-isolated area where thrips-free new host plants are grown.

3.3 Potted plants without nets

A potted host plant, infested with thrips. This method was used in greenhouses and climate rooms. The following host plants were used: bean, leek, onion, and chrysanthemum. It requires considerable space and a well-isolated area where thrips-free new host plants are grown.

3.4 Miscellaneous methods using boxes and other containers

To name a few here, Murai & Loomans (2001) developed a well-functioning method using germinated bean seeds. Steiner & Goodwin (1998) created a well-made box with excellent ventilation. Lall & Singh (1968) used a cork table, onion plants and glass tubes. Gawaad & Shazli (1969) used a modified aphid rearing method with Ricinus communis L. seedling.

3.5 Membrane method

Murai and his colleges (1990) perfected this method for onion thrips rearing. The idea is to put a 10 % honey solution in water between two layers of parafilm and let the thrips pierce through the parafilm layers and feed on it. Interestingly, females will lay eggs through the parafilm layer. This egg can be collected and put back in the same system. It is a time consuming method but it offers great security. The artificial food eliminates most sources of plant and insect diseases. Eggs of other thrips species that might be introduced into a *T. tabaci* rearing unit with the plant material are not a problem here. It is a good method for reproductive mode determination or other work that needs securely checked individuals. A membrane can be applied on Petri dishes (Kumm & Moritz, 2006), and Eppendorf tubes as well (Cabrera-La Rosa & Kennedy, 2007).

4 Conducting bioassays

The following methods were used to conduct various studies with *T. tabaci*. They can serve to fulfil various requirements: provide larvae or adults of uniform age, determine the reproductive mode of a female adult, virus testing, observing the behaviour of the insect and so on. Some methods can be used for maintaining a stock colony (like big Petri dishes) (Riefler & Koschier, 2009a).

- Petri dish, 14 papers (Lall & Singh, 1968; Ghabn 1975; Jiménez & Roscandido, 1996; Tadeschi et al., 2001; Arieche et al., 2006; Nault et al., 2006; Chatzivassiliou et al., 2002; Koschier et al., 2002; Liu 2003; Cabrera-La Rosa & Kennedy, 2007; Kumm & Moritz, 2008; Fekrat et al., 2009; Mound & Tree, 2009; Riefler & Koschier, 2009a; Riefler & Koschier, 2009b; Jacobson & Kennedy, 2013).
- Vial, 8 papers (Harris et al., 1935; Edelson & Magaro, 1988; Salas 1994; Guzmán et al., 1996; Steiner & Goodwin, 1998; Murai & Loomans, 2001; Stacey & Fellowes, 2002; Arieche et al., 2006; Deligeorgidis et al., 2006a; Deligeorgidis et al., 2006b; Thungrabeab et al., 2006; Pourian et al., 2009; Fathi et al., 2011)
- Leaf cage, 2 papers (Sakimura 1932; Sakimura 1937)
- Eppendorf tube, 3 papers (Tedeschi et al., 2001; Chatzivassiliou et al., 2002; Cabrera-La Rosa & Kennedy, 2007; Li et al., 2014).

4.1 Petri dish

The most common method to conduct experiments with *T. tabaci*. The diameter of the dish varies from 5 to 14.5 cm. It can have a moisture absorption block and a ventilation block. The lid of the Petri dish can be tight fitting, parafilm sealed, or loose fitting. The following host plants were used: onion, tobacco, garlic, cucumber, E. sonchifolia, cabbage, leek, bean, and cotton. The range of temperatures was 15– 30 °C. Petri dishes were placed in climate chambers and climate rooms.

4.2 Vial

For sealing purposes cork or plastic stoppers, cotton balls, or parafilm can be used. The size varied from 6 ml to 200 ml. The following host plants were used: onion, rape, cucumber, tomato, bean pod, germinated bean seed, and leek. Temperature interval is 12–30 °C. Vials were placed in climate chambers and climate rooms.

4.3 Leaf cage

A good method to observe individual onion thrips. According to Sakimura (1937) it requires a small 2 cm2 piece of felt with a 1 cm2 diameter hole in it. This is put on the leaf surface. From the top and the bottom, a celluloid layer covers it and is fastened by a paper clip. Onion and E. sonchifolia were used as host plants. A Tashiro cage is a common cage design for mites, thrips, and other small insects (Tashiro 1967). It was modified by several other authors as well (Murai & Loomans, 1997).

4.4 Eppendorf tube

The top of the tube can be used to puncture leaf disks from the host plant, but cork borers are preferred because they can make a clean cut with a smooth surface. In this way the leaf disk will regenerate better prolonging its life and thrips larvae will have less hiding space as well. Pupae prefer to find shelter in the bottom of the tube. If excess moisture is present there, then extra care is needed to keep the thrips away from the water. Small and thin leaf disks can deteriorate quickly, which may cause increased egg mortality (personal observation). The following host plants were used for rearing: cabbage, tobacco (personal observation) and onion. Due to the small size of the tube it has to be opened frequently. This method is time consuming but it is a good solution when thrips isolation is needed (reproductive mode determination, virus testing etc.).

5 Conclusion

The laboratory rearing of this insect is the base for many bioassays researching thrips. There are many efficient ways to maintain a stock colony but it is important to note that every method has its own advantages and disadvantages. This is true about the methods for conducting bioassays as well. The goals and the environment one works with will determine the suitable methods for that type of research. A careful planning and testing will most likely help in the search.

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