LET'S TALK ABOUT MASS TRAPPING: IS IT SIMPLY A TOOL FOR CONTROL?

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ABSTRACT

8 Mass trapping, based on the use of traps with attractant baits inside, is one of the oldest approaches to direct insect control. The first traps date back to the 17th century in England and were light traps for lepidopterans, while the first papers on the attraction of insects to odours were published in Germany and the United States in the 19th century. The studies on the olfaction in insects increased along the 20th century and German researchers proposed the term "pheromones" in 1959 to describe some compounds utilized by insects to communicate. All this new information aided in the use of traps and attractants for monitoring purposes, as well as in the development of control tactics like mass trapping or attract and kill. Publications on mass trapping studies at the field level for various pests began to increase in the 1970s, and this trend continued in the following decades, peaking in 2020 with 311 papers published on mass trapping or some of its related aspects. These studies deal with the mass trapping of fruit trees, grapevines, olive trees, rice, cotton, citrus fruits, stored products, tea, and forest trees, among others. The majority focused on the use of attractants (pheromonal or food-based) as the system's foundation; however, others have employed alternative stimuli such as light of various wavelengths or colored sticky traps. According to the theoretical premise, mass trapping entails setting a high density of traps in the crop to be protected with the goal of killing a sufficiently large proportion of individuals to keep the pest population at levels that do not cause economic damage. Although, in practice, the application of this method is quite complex because there are several influencing factors, such as the effectiveness of the attractant (pheromonal, food-based, light, chromatic, etc.) and the trap design, the level of pest and its distribution in the field, the cost of the whole equipment, a thorough understanding of the biology of the insect pest and its relationship with the crop, and the proper design of the methodology for each crop species in which it will be used. Furthermore, two other factors must be considered: the first, making the mass trapping system compatible with the control of other pests and diseases, that is, introducing it into an integrated pest management plan; and the second, but not less important, gaining the farmer's trust. To demonstrate the practical application of mass trapping, two case studies will be presented: the development and implementation of a control system for the medfly (*Ceratitis capitata*) at the orchard and wide-area levels, and the current status of mass trapping for BMSB

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(*Halyomorpha halys*). Finally, the benefits and drawbacks of using mass trapping are examined considering the legal and social requirements of Europe in the 21st century.

Key words: mass trapping, traps, attractants

IZVLEČEK

POGOVARJAJMO SE O METODI MASOVNEGA LOVLJENJA: JE RES LE ORODJE ZA ZATIRANJE ŠKODLJIVCEV?

Masovno lovljenje, ki temelji na uporabi pasti s privabilnimi vabami v notranjosti, je eden od najstarejših pristopov neposrednega zatiranja žuželk. Prve pasti segajo v 17. stoletje v Anglijo in so bile svetlobne pasti za metulje, medtem ko so bili prvi članki o zanimanju žuželk za vonjave objavljeni v Nemčiji in ZDA v 19. stoletju. Število študij o vonju pri žuželkah se je v 20. stoletju povečalo in nemški raziskovalci so leta 1959 predlagali izraz feromoni, da bi opisali nekatere spojine, ki jih žuželke uporabljajo za komunikacijo. Vse te nove informacije so pomagale pri uporabi pasti in atraktantov za namene spremljanja, pa tudi pri razvoju taktik zatiranja, kot sta masovno lovljenje ali privabi in ubij. Publikacije o študijah masovnega lovljenja na prostem za različne škodljivce so se začele povečevati v sedemdesetih letih prejšnjega stoletja in ta trend se je nadaljeval v naslednjih desetletjih in dosegel vrhunec leta 2020 s 311 članki, objavljenimi o masovnem ulovu ali nekaterimi z njim povezanimi vidiki. Te študije se med drugim ukvarjajo z masovnim lovljenjem na sadnem drevju, vinski trti, oljki, rižu, bombažu, citrusih, skladiščnih proizvodih, čaju in med drugim tudi na gozdnem drevju. Večina objav se je osredotočila na uporabo atraktantov (feromonskih ali živilskih) kot temelj sistema; drugi pa so uporabili alternativne dražljaje, kot je svetloba različnih valovnih dolžin ali barvne lepljive pasti. V skladu s teoretično predpostavko masovno lovljenje pomeni nastavitev visoke gostote pasti v posevku, ki ga je treba zavarovati, s ciljem uničenja dovolj velikega deleža osebkov, da se populacija škodljivcev ohrani na ravneh, ki ne povzročajo gospodarske škode. Vendar je v praksi uporaba te metode precej zapletena, ker obstaja več dejavnikov, ki vplivajo na uspešnost, kot je učinkovitost atraktanta (feromonski, na osnovi hrane, svetloba, barvna lepljiva plošča itd.) in zasnova pasti, številčnost škodljivca in njegove porazdelitve na zemljišču, stroški celotne opreme, temeljito razumevanje bionomije škodljive žuželke in njenega odnosa s pridelkom ter pravilna zasnova metodologije za vsako vrsto pridelka, v kateri se bo metoda uporabljala. Poleg tega je treba upoštevati še dva dejavnika: prvi, da je sistem masovnega lovljenja združljiv z zatiranjem drugih škodljivcev in bolezni, to je, da se ga vključi v celostni načrt zatiranja škodljivcev; in drugi, a nič manj pomemben, pridobivanje zaupanja kmeta. Za prikaz praktične uporabe masovnega lovljenja bosta predstavljeni dve študiji primera: razvoj in uvedba sistema zatiranja breskove muhe (*Ceratitis capitata* Wied.) na ravni sadovnjaka in na širšem območju ter trenutni status masovnega lovljenja za marmorirano smrdljivko (*Halyomorpha halys*). Na koncu bodo predstavljene prednosti in slabosti uporabe masovnega lovljenja glede na pravne in družbene zahteve Evrope v 21. stoletju.

Ključne besede: masovno/množično lovljenje, pasti, privabila

Introduction

Mass trapping, based on the use of traps with attractant baits inside, is one of the oldest approaches to direct insect control. The English entomologist James Petiver used moving lights (lanterns) to attract moths as early as 1695 (Wilkinson, 1966). This method continued into the 18th century until Kirby and Spence (1815–26) popularized the idea of placing a lamp inside a window to use an entire room as a kind of "trap". Edward Doubleday (1837) successfully collected lepidoptera in the United States using a lighted bar with open windows. In the 1860s, the idea of a portable device arose, and the "American moth trap" was first described in 1866 by Englishman H. G. Knaggs. From this, a series of different devices were produced which facilitated the design of the traps that are used successfully today.
The first papers on the attraction of insects to the different odours produced by volatile substances date back as far as 1907 (W.M. Barrows, 1907) and 1916 (C.H. Richardson, 2016). This means that the importance of odours in insects has been known for more than a century. During the first half of the 20th century, there was an increase in the study of the physiological processes that regulate communication between insects and the compounds that attract them, while in 1959, the first paper proposing the use of the word "pheromones" was published (P. Karlson and M. Lüscher, 1959).
Mass trapping using lures to catch the maximum number of insects, has been devised by Steiner, 1952. Publications on mass trapping research for various pests at the field level began to increase in the 1970s, and this trend continued in the following decades, peaking in 2020 with 311 papers published on mass trapping or some of its connected aspects. These studies discuss mass trapping of fruit trees, grapevines, olive trees, rice, cotton, citrus fruits, stored products, tea, and forest trees, among others. The majority relate to the employment of attractants (pheromonal and sexual) as the system's foundation; however, others have employed alternative stimuli such as light of various wavelengths or coloured sticky traps.
According to the theoretical premise, mass trapping entails setting a high density of traps in the crop to be protected with the goal of killing a sufficiently large proportion of individuals to keep the pest population at levels that do not cause economic damage. However, in practice, the application of this method is quite complex because there are several influencing factors, such as the effectiveness of the attractant (pheromonal, food-based, light, chromatic, etc.) and the trap design, the level of pest and its distribution in the field, the cost of the whole equipment, a thorough understanding of the biology of the insect pest and its relationship with the crop, and the proper design of the methodology for each crop species in which it will be used. Furthermore, two other factors must be considered: the first, gaining the farmer's trust; and the second, but not less important, making the mass trapping system compatible with the control of other pests and diseases, that is, introducing it into an integrated management plan.
To show these steps from a practical point of view, a case study will be presented: the development and implementation of mass trapping for the medfly (*Ceratitis capitata* (Wied.)) both at the orchard and wide-area level.

Case-study on mass trapping for controlling *C. capitata*

The Mediterranean Fruit Fly (medfly), *Ceratitis capitata* (Wiedemann), is a major pest that causes economic damage to fruit and vegetables throughout the world and that can survive and reproduce in a large number of plants (Liquido et al. 1990, Líquido et al. 1997). High fruit damage occurs if no control methods are applied (Fimiani 1989), for which reason, fruit growers are obliged to spray frequently with insecticides to keep its population under control. The Girona fruit production area in the Northeast of Spain, is no exception and mass trapping has become an important tool for producing apples in general and essential for integrated and organic production systems (Escudero-Colomar and Frantantuono, 2011; Damos *et al.*, 2015).
As it was explained before, there are various steps involved in developing a system for mass trapping insects. The first and the basis of the entire system is a thorough understanding of the biology of the insect in the area and its relationship to the crop. Figure 1 depicts the population dynamics of *C. capitata* in the extreme north-east of Spain, namely in the province of Girona, where apples constitute the predominant fruit crop (Escudero-Colomar *et al.*, 2008). The harvesting period for the area's main apple varieties coincides with the peak of captures, or population growth, putting practically all fruit production at danger.

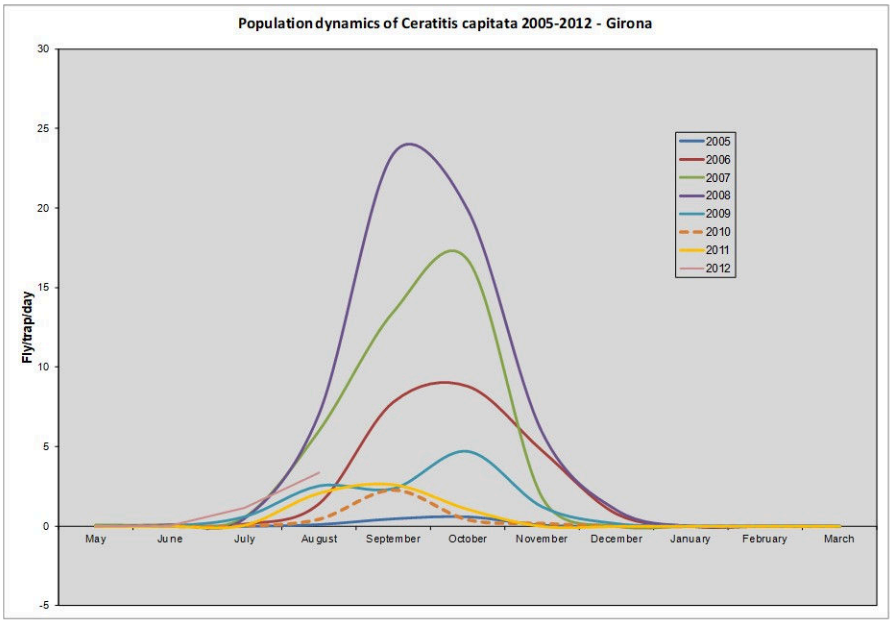

Figure 1: Population dynamics of *C. capitata* in Girona province, Spain.

This pattern of population dynamics has been recorded in the province of Girona, the extreme NE of Spain but, 300 km south, in the province of Tarragona, the insect presents two population peaks, one in July-August and another in September-October, with the second being higher than the first (Martínez-Ferrer *et al.* 2006), while 500 km south of Girona, in the province of Valencia, the pest maintains the two population peaks mentioned, but the first, that of July-August, is the highest (Alonso-Muñoz and García-Marí 2003). As a result, the population dynamics of *C. capitata* shift with latitude, which will have a significant impact on how and when mass trapping is used.
Another important consideration is what stage of insect development the mass trapping will target. In the case of medfly mass trapping, the adults will be targeted because the attractant was developed for them (Epsky *et al*. 1995), and they are the ones who produce damage. This approach is difficult to apply to the other developmental stages since the larva stage takes place inside the fruit and the pupa stage develops in the soil beneath the tree canopy.
The second significant aspect is the equipment that will be used for mass trapping. Not only must the lure be as attractive as possible in order to compete with the fruit for the insect's attraction, but the trap must also be chosen to attract the most insects while allowing for efficient diffusion of the lure's scent (Peñarrubia-Maria *et al.*, 2013).
Once found the best equipment, the third step is to assess at field the efficacy of the system, using several layouts of traps, e.g. homogeneous distribution or perimeter one (Cohen and Yuval, 2000; Vilajeliu *et al.*, 2007).

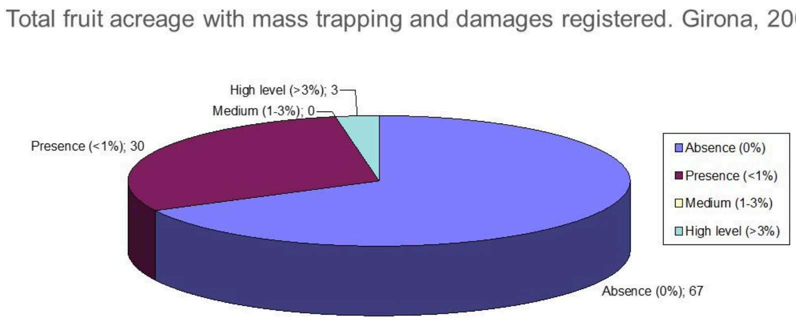

Figure 2: Damage registered in the compulsory fight against medfly in Girona fruit growing area in the year 2008.

Because pests generally have an aggregated distribution in the field and it can be difficult to determine where the biggest concentration of pests is, a uniform distribution of traps in the field is usually the best option. This is true for Medfly, but other insects may need alternative trap arrangements depending not only on their location in the field but also on the nature of the lures and the target crop (Drummond and Collins, 2020). Figure 2 depicts the field evaluation of the compulsory fight against the Medfly in

Catalonia at the end of 2008, the year with the highest level of population in the area (Figure 1). As can be seen in Figure 2, 67% of the acreage protected by mass trapping remained undamaged, while just 3% suffered damage greater than 3% and 30% had damage minor to 1%. The average number of insecticide sprayings throughout the total area where the system was implemented (1863.37 hectares) was just 1.1 insecticide.
Once the system's usefulness has been demonstrated, the fourth step, and an essential one, is to gain growers' trust before using it. In the case of severe pests, like the Medfly, the government can use aid policies to establish a mass trapping system, as Catalonia did from 2005 to 2011 (Table 1), allowing mass trapping to be applied on a large scale (Escudero-Colomar *et al.*, 2009).

Table 1: Funding for mass trapping devices in Catalonia's compulsory fight against medfly campaign. *DACC=Department of Climate Action, Food and Rural Agenda, Government of Catalonia. Source: DACC.

	FUNDING		
	TRAPS	ATRACTANTS	
2005	100 % DACC*	50 % DACC	50 % FRUIT GROWERS
2006	---	50 % DACC	50 % FRUIT GROWERS
2007	---	50 % DACC	50 % FRUIT GROWERS
2008	50% DACC	25 % DACC	75 % FRUIT GROWERS
2009	25% DACC – 75% FRUIT GROWERS		
2010	25% DACC – 75% FRUIT GROWERS		
2011	100% FRUIT GROWERS		
2012-Currently	100% FRUIT GROWERS		

The fifth step is to integrate mass trapping as a standard control tool into the crop's integrated management system (IP) (see https://iobc-wprs.org/ip-tools/integrated-production-objectives-and-principles/ ; https://iobc-wprs.org/eu-ipm-toolbox/?mc_cid=8639920bf1&mc_eid=d4fbdae022), making it compatible with other crop pest control methods.

Final considerations

Taking into account the Directive 2009/128/EC which aims to achieve sustainable use of pesticides in the EU by reducing the risks and impacts of its use, mass trapping is an excellent tool to help achieve this goal. As previously stated, mass trapping for medfly allowed for a reduction in insecticide use for this pest to only 1.1 per orchard and season, making an important contribution to achieving the goal and facilitating the production of agricultural food products (fruits, vegetables, cereals, and warehouse products) with significantly lower insecticide residue. Furthermore, mass trapping is more than just a method of control because it helps to reduce greenhouse gas emissions, as several pesticides leak gasses into the environment after application. As a result, mass trapping helps the EU meet its target of reducing greenhouse gas emissions by 55% by 2030 (https://climate.ec.europa.eu/eu-action/climate-strategies-targets/2030-climate-targets_en).

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