Pestic. Phytomed. (Belgrade), 27(4), 2012, 269–281
DOI: 10.2298/PIF1204269S

UDC: 632.7:591.1:632.937+632.951
Review paper

Rhagoletis cerasi Loew (Diptera: Tephritidae) – Biological Characteristics, Harmfulness and Control

Svetomir Stamenković[1], Pantelija Perić[2] and Drago Milošević[3]

[1]University of Priština, Faculty of Agriculture, Kopaonička bb, 38219 Lešak, Serbia
[2]Institue of Pesticides and Environmental Protection, Banatska 31b, 11080 Belgrade, Serbia (pantelija.peric@pesting.org.rs)
[3]University of Kragujevac, Faculty of Agronomy, Cara Dušana 34, 32000 Čačak, Serbia

Received: June 7, 2012
Accepted: October 9, 2012

SUMMARY

The European cherry fruit fly, *Rhagoletis cerasi* Loew (Diptera: Tephritidae), is a highly destructive pest in sweet and sour cherry orchards with a distribution area throughout Europe and the temperate regions of Asia. It occurs regularly in all production regions of these fruit species in Serbia, damaging up to 10% of cherries in commercial production, while damage can go up to 100% in orchards and on solitary threes unprotected by control measures.

In Serbia, European cherry fruit fly most often attacks and damages fruits of the late-ripening cultivars of sweet cherry (Van, Stela, Hedelfinger, Bing, Lambert, Drogan's Yellow). After a sweet cherry harvest, adults migrate to sour cherry where they continue feeding and ovipositing in half-mature sour cherries (prevailingly the domestic ecotype Oblačinska). During their activity period, larvae damage the fruits, so that they can no longer be consumed either fresh or processed. The high percentage of sour cherries damaged by *R. cerasi* has become a factor limiting exports because the intensity of infestation of this fruit exceeds permissible limits. Pesticide use for controlling this pest, especially in integrated production, is based on a very poor selection of insecticides which cause problems with residual ecotoxicity. Consequently, alternative measures for controlling European cherry fruit fly have been intensively studied over the past few years.

This work surveys up-to-date results of various studies on the European cherry fruit fly as a very important pest in Serbia and other South and Mid-European countries. The work contains detailed descriptions of its biological characteristics, flight phenology, infestation intensity and possibilities of fly control in sweet and sour cherry production areas.

Keywords: *Rhagoletis cerasi*; Biological characteristics; Harmfulness; Control

INTRODUCTION

Sweet and sour cherry production has great economic importance for Serbia. The bulk of its output is designated for export, thus the cultivation of these fruit species is gaining in importance. In 2008, Serbia was listed 16th among the world's top sweet cherry producers with a share of about 2% of world production, while it placed 7th in sour cherry production with a share of 7% (FAO, 2010).

Belgrade District is the leading region in Serbia in sweet cherry production, accounting for 19.64% of average domestic production, and is followed by Mačva (7.82%), Niš (5.26%), Braničevo (5.22%) and Bor Districts (5.02%). Regarding sour cherry production, the biggest share is again produced in Belgrade District (11.53%), followed by Niš (8.80%), Jablanica (7.35%), Šumadija (7.29%), Western Bačka (7.00%), Mačva, Toplica and Podunavlje Districts (Sredojević, 2011).

Over the past four decades, the number of sour cherry trees has increased in Serbia more than eightfold and the production tenfold. The reason for such an expansion in cultivation of this fruit species was the introduction of a domestic ecotype, Oblačinska sour cherry, which accounts for about 60% of overall production among all sour cherry varieties (Mratinić, 2002; Nenadović-Mratinić et al., 2006).

Concerning relevant harmful organisms in Serbia, the European cherry fruit fly, *Rhagoletis cerasi* Loew (Diptera: Tephritidae), is a permanent constraining factor for the production of sweet and sour cherries of high quality. Initial research of the biology and infestation intensity of *R. cerasi* in our region was conducted in the vicinity of Belgrade during 1954-1955 (Mitić-Mužina, 1960). Živanović (1978) later focused on its elevated population abundance and a possibility to control it by olfactory baits. Data from researches conducted by Stamenković et al. (1986, 1996a, 1996b, 2006) also revealed a high abundance and harmfulness of the European cherry fruit fly, as well as sensitivity of certain cultivars of sweet and sour cherry. Over the past several years, research of the flight phenology, harmfulness and possibilities for control of *R. cerasi* on Oblačinska sour cherries was carried out in Toplica District (Ilić, 2010; Stamenković et al., 2010, 2011).

In other parts of Europe, *R. cerasi* has been known as a pest for a long time, and was mentioned for the first time back in 1540 (Kobel, 1933). A number of researchers have studied its biology and population dynamics, as well as methods to control this important pest (Frank, 1891; Menegaux, 1898; Berlese, 1906; Verguin, 1928; Jancke and Bohmel, 1933; Wiesmann, 1933b, Thiem, 1934, Boller, 1966b; Boller and Prokopy, 1976, Engel, 1976; Bogdan, 1981; Vasev, 1983; Katsoyannos et al., 1986; Ranner, 1988b; Aluja and Boller, 1992; Raptopoulos et al., 1995; Riegler and Stauffer, 2002; Daniel, 2009).

At the end of the last and the beginning of this century, control of *R. cerasi* required the use of pesticides (one or two treatments) in many European countries (Leski, 1963; Boller and Ramser, 1971; Remond and Boller, 1975; Beratlief et. al., 1981; Bogdan, 1981; Fimiani et. al., 1981; Agee et al., 1982; Vita et al., 1982; Kneifl, 1983; Vasev, 1983; Zumzeoglu et. al., 1987; Edland, 1990; Riegler, 2002; Vogt, 2002; Schwarz et al., 2003; Olszak and Maciesiak, 2004; Kovanci and Kovanci, 2006; Kutuk and Ozaslan, 2006). Additionally, sweet and sour cherry production has been increasingly challenged throughout Europe, especially in recent years, by low damage thresholds that have rendered only 2% of infested fruits on the market acceptable for fresh consumption, and up to 6% for industrial processing. As a result, many producers sell their cherries at much lower prices, and thus sustain serious financial losses. Such a low level of acceptability was therefore the main reason for introducing preventive chemical control. On the other hand, European Union Directives that prohibit the „old" insecticides have now brought about a decrease in fruit quality. Currently, only a few insecticides are being used, and their application is under debate due to problems with residual ecotoxicity for humans and beneficial organisms (Daniel, 2009).

Integrated and organic production of sweet and sour cherry currently involve the use of yellow sticky traps, crop netting and common cultivating measures. However, this strategy does not always provide a satisfactory protection of fruits. Hence, in the last few years, alternative methods of control of the European cherry fruit fly have been intensively studied and applied, such as the entomopathogenic fungus *Beauveria bassiana Balsamo (*Daniel, 2009; Daniel and Wyss, 2009) and entomopathogenic nematodes (Koppler et al., 2003; Herz et al., 2006).

BIOLOGICAL CHARACTERISTICS OF *R. cerasi*

Taxonomy, distribution and host plants

Tephritidae are one of two fly families known as „fruit flies" and its members are distributed worldwide, having over 4000 described species that belong to about

500 genera (Headrick and Goeden, 1998). The family is divided into two main subgroups, based on the type of diet needed for larval development: fruit feeders (frugivores) and non-fruit feeders (non-frugivores). Members of the first subgroup utilize cellulose and fruit pulp for larval development, while members of the other subgroup feed on live plant tissues, such as stems, roots, leaves or seeds, and they often form galls.

Frugivores are also divided into two sub-groups: univoltine oligophagous species with a long winter diapause in temperate zones (*Rhagoletis* sp.), and multivoltine polyphagous species without an obligatory diapause from warmer regions (*Bactrocera* sp. and *Anastrepha* sp.) (Bateman, 1972). There are significant differences in the mating systems, host finding, dispersal flight activity and attraction to food baits or host plant odours among members of this group.

The main characteristic of the polyphagous species life cycle is that they appear occasionally during a long period of the year, but they are unpredictable regarding temporal and spatial distribution. Adults are very mobile, with a life span longer than three months and a high fecundity (> 1000 eggs per female). Polyphagous species have several generations per year and are capable of spending the unfavourable period of the year in diapause (Fletcher, 1987).

Oligophagous species are predictable in time and space, but their life cycle is short during the year. The biology of these species is seasonally synchronized with the development of their host plant fruits, which is important for their mobility and adult reproductive potential (Zwolfer, 1983). Adult emergence and life span are closely correlated with the host plant phenology (Boller and Prokopy, 1976). There is usually only one generation per year, with a long obligatory winter diapause (Bateman, 1972). The fecundity of oligophagous species is lower than that of polyphagous species, producing 300-400 eggs per female (Boller and Prokopy, 1976). Due to a potential competition in the larval stage, females usually lay only one egg per fruit and mark the host with a pheromone after oviposition. Mating of these species usually depends on male resourcefulness and begins with forced copulation (Sivinski and Burk, 1989).

The genus *Rhagoletis* Loew consists of 65 described species, the majority of which are oligophagous and attack only a few biologically closely related host plants. They are pests of economic importance and, apart from *R. cerasi*, they include the American species *R. cingulata* Loew, *R. indifferens* Curran and *R. fausta* Osten Sacken as the most frequent on sweet cherry, followed by *R. pomonella* Walsh on apple, *R. mendax* Curran on blueberry, and *R. completa* Cresson and *R. suavis* Loew on walnut (Boller and Prokopy, 1976).

In literature, *R. cerasi* is also known under various synonyms: *Musca cerasi* L, *R. cerasorum* (Dufour), *R. liturata* (Robineau-Desvoidy), *R. signata* (Meigen), *Spilographa cerasi* L., *Trypeta signata* (Meigen), *Urophora cerasorum* Difour and *U. liturata* Robineau-Desvoidy (Frank, 1891; White and Elson-Harris, 1992).

R. cerasi has a wide area of distribution. It is present in all European countries and the temperate regions of Asia (Zumreoglu et al., 1987; Edland, 1990; White and Elson-Harris, 1992; Jaastad, 1994; Kutuk and Ozaslan, 2006). White and Elson-Harris (1992) determined two races of *R. cerasi*: northern and southern. The southern race is present in Italy, Switzerland and South Germany, while the northern race migrates from the Atlantic Ocean to the Black Sea. Between these two races of *R. cerasi*, a one-way cytoplasmic incompatibility is present, so that the progeny originating from southern females and northern males are fertile, while the progeny of southern males and northern females are sterile (Boller et al., 1976; Matolin, 1976; Ranner, 1988; Boller, 1989a; Blumel et al., 1991; Riegler, 2002; Riegler and Stauffer, 2002).

The European cherry fruit fly originates in an area around the Mediterranean Sea and in countries of that region it has a special economic importance (Fimiani et al., 1981). Studies on its distribution, biology and control measures have been reported from Turkey (Zumreoglu, 1986; Kutuk and Ozaslan, 2006), Romania (Cardei and Rominger, 1997), Hungary (Voigt, 1997), Switzerland (Aluja and Boller, 1992; Boller et al., 1998), Austria (Ranner, 1988a), Poland (Olszak and Maciesiak, 2004), and all the way to Western Norway, where it was first found in 1991 (Jaastad, 1994).

In the Balkan Peninsula, European cherry fly was first reported in Dalmatia (Tominić, 1954) and the Belgrade environs (Mitić-Mužina, 1960). In Serbia, this pest has continuously spread from its initial habitat in the western part of the country (Stamenković and Stamenković, 1986; Stamenković et al., 1996b; 2006) southward and southeastward. Over the last few years, *R. cerasi* has become a serious problem in sour cherry production in some new areas and a limiting factor for sour cherry exports with an infestation intensity of up to 20% in commercial orchards (Ilić, 2010; Stamenković et al., 2011).

According to data obtained from several European countries, *R. cerasi* develops in fruits of cultivated sweet and sour cherries and certain wild plant species. The most common host plant species belong to the genus *Prunus* sp. (Rosaceae: *P. cerasus*, *P. avium*, *P. padus*, *P. serotina* and *P. mahaleb*) (Thiem, 1934; Mitić-Mužina, 1960; Leski, 1963), followed by the genera *Lonicera* sp. (Caprifoliaceae: *L. xylosteum*, *L. tartarica* and *L. alpigena*) (Mik, 1898; Thiem, 1932; Wiesmann, 1938; Thiem, 1939; Mitić-Mužina, 1960; Ranner, 1987a; White and Elson-Harris, 1992) and *Berberis* sp. (Berberidaceae (*B. vulgaris*) (Mitić-Mužina, 1960).

Adult emergence and activity

R. cerasi develops only one generation per year. Pupae overwinter in soil at 2-5 cm depth, sometimes even in the surface layer under a host plant canopy. Pupal development and timing of adult emergence depend on soil temperature, altitude and latitude, incline and type of soil, soil plant cover and other environmental factors (Thiem, 1934; Wiesmann, 1934b; Mitić-Mužina, 1960; Leski, 1963; Kovanci and Kovanci, 2006). Also, the timing of adult emergence is determined by the host plant from which the pupae originated (Thiem, 1940; Boller and Bush, 1974; Haisch and Forster, 1975; Ranner, 1988a), and by temperature during winter diapause (Wiesmann, 1950; Haisch, 1975; Haisch and Chwala, 1979).

Adults normally emerge in the spring, often after a rainy period when they can easily penetrate soil, although it usually happens on sunny days (Jancke and Bohmel, 1933; Wiesmann, 1933b) preferably in late morning hours (Thiem, 1935; Baker and Miller, 1978). Females emerge several days earlier than males because males require higher temperature (Wiesmann, 1933b; Thiem, 1935; Speyer, 1941; Haisch and Forster, 1975).

According to literature data, the eclosion of European cherry fruit fly in the temperate continental climate (France, Switzerland, Bulgaria, Serbia, Georgia) begins in mid-May (Wiesmann, 1934, 1936; Popov, 1954; Kalandadze and Bagdavadze, 1956; Ribault, 1957; Mitić-Mužina, 1960). However, Tominić (1954) reported a fly eclosion beginning on April 20th in greenhouses without heating in Dalmatia in 1952, while in 1953 it was recorded on April 16th. The author assumed that adults probably appeared outdoors ten days later, i.e. at the end of April.

Prior to oviposition, adults go through a maturation period during which they need carbohydrates, proteins and water for nourishment. Flies usually feed in the morning and rest on the back of leaves during the night and the period of daytime inactivity (Haisch and Forster, 1975). The duration of pre-oviposition is strongly dependent on temperature and lasts from six to 13 days (Wiesmann, 1935b; Bohm, 1949; Leski, 1963). Boller (1966a) recorded a pre-ovipostion period lasting six and 10 days at 23°C and 18°C, respectively. Apart from temperature, the female feeding status and fruit maturity phase may also influence the start of oviposition. According to Sprengel (1932a), eggs can be laid only during the phase when cherries turn from green to yellow, when stones are hardened and pulp thickness exceeds 5 mm.

The life span of flies under laboratory conditions depends on the type of diet, size and abundance of flies, and can last up to 100 days (Ranner, 1988b). It is difficult to estimate the life span of adult flies in natural environment because of unpredictible environmental effects, but in most cases it lasts between four and seven weeks (Samoggia, 1932; Sprengel, 1932a; Wiesmann, 1933b; Bohm, 1949), setting the total annual adult flight phenology to 7-11 weeks (Jancke and Bohmel, 1933; Bohm, 1949; Stamenković et al., 1996a).

According to Mitić-Mužina (1960), females live several days after oviposition and than die. Males usually end their lives before females. The average life of females was found to be 15, and of males 0-11 days. Also, a longer maximum life span was recorded for females (8-22 days) than for males (5-16 days).

Based on biology studies of the European cherry fruit fly in Belgrade and its environs (Zemun, Grocka, Smederevo), Mitić-Mužina (1960) concluded that the flight of this species under our local conditions lasted about 2 months (began in mid-May and ended in the first half of July). Adults stayed in orchards in which they had emerged from the soil and flew farther away from it only when it was not possible to satisfy their physiological needs (such as feeding and ovipositing) in the closest range.

In the period from 1987 to1992, Stamenković et al. (1996b) conducted a detailed research of the flight phenology of European cherry fruit flies in Western Serbia (localities Čačak and Ljubić). During 1987, the first adult emergence was recorded at the end of June, and their activity lasted until the middle of July. Total duration of flight was 48-53 days, while peak activity was recorded in mid-June. A significantly longer flight period occurred during the last three years of research, lasting about 70 days.

Stamenković et al. (2011) also reported data from their latest research conducted in 2007-2010 on the flight phenology of European cherry fruit fly in Serbian commercial sweet cherry orchards at the locality Banjica (Čačak-Moravica District) and in commercial sour cherry orchards at the localities Donja Stražava, Novo Mesto and Podina (Prokuplje-Toplica District). The first adult emergence in that study was recorded from May 1st to 11th in the region of Prokuplje, while in the region of Čačak it was from May 15-25th. Flight lasted until July 20th in the Čačak region and July 19 th in Prokuplje. Total flight period at all sites in Toplica District lasted 36-73 days, and 50-61 days in the region of Čačak. The peak of adult activity was recorded in the first half of June in the Čačak region, while it was in most cases recorded at the end of May in the Prokuplje region. A significant result of this research is evidence that European cherry fruit flies on Oblačinska sour cherries in the Prokuplje region appeared 10-15 days earlier than on sweet cherries in the Čačak region.

Under conditions of relatively stable orchards, where flies can safely overwinter under perennial hosts, there are very few reasons for adults to migrate to long distances. In environments in which oviposition substrates are plentiful, adults tend to remain within a close range and their movement is determined by the normal activities of feeding, mating and ovipositing (Wiesmann, 1933b; Katsoyannos et al., 1986). Adult activity depends on weather conditions, and the highest mobility is recorded during warm, sunny days with low relative humidity (Sprengel and Sonntag, 1932). On rainy days, most flies stay hidden in the grass and under the trees, while rare individuals remain in the hidden parts of tree canopy (Wiesmann, 1934b).

However, some literature data show that European cherry fruit flies may also migrate to long distances during their flight period. Tominić (1954) reported having collected European cherry fruit flies from different fruit species that were more than 100 meters away from the nearest sour cherry tree. Also, Mitić-Mužina (1960) found adults on peaches about 150 meters away from the nearest sweet cherry trees. The peaches were severely infested by aphids and the flies remained on the fruits probably to feed on honey dew. The surrounding trees of sweet cherries were of middle ripening and already harvested. According to observations of this author, *R. cerasi* make longer flights only when they cannot satisfy their physiological needs.

Wiesmann (1935b) and Leski (1963) estimated that maximum adult mobility was 300 and 350 m in their respective researches. Boller (1969) determined in targeted experiments that 82% of adults had returned from 100 m distance, while only 0.7% returned from a distance of 500 m. However, laboratory tests showed that adults were capable of flying several kilometers within 24 hours when in need (Remund and Boller, 1975). In orchards, flies usually move only to the neighbouring trees of later ripening cultivars (Leski, 1963), and from there to *Lonicera* sp bushes (Katsoyannos et al., 1986).

Intensity of attack on different hosts

Females of the European cherry fruit fly lay the majority of eggs in fruits that have already turned red, and a fewer number in green fruits of hosts. They insert eggs with ovipositor under fruit epidermis and deposit them in the mesocarp. Although a female is able to lay several eggs into one fruit, only one, rarely two larvae can fully develop in each of them. Hatched larvae feed shortly on the spot, and then penetrate towards the fruit stone where they continue to feed until they are fully developed. During feeding, larvae pollute fruits with feces, thus making them unacceptable for fresh consumption or for processing. After development has completed, the larva makes an exit opening of 1 mm size, which also allows spores of the *Monilinia fructigena* H fungus to penetrate the fruits. In this way, indirect damage is also made as the infected fruit rottens and decays (Garić and Stamenković, 1990).

European cherry fruit flies damage fruits of various host plants and infestation intensity depends on a synchronization of adult flight and the period of fruit ripening of certain plant species. Orchard exposure, type of soil and conditions in the surface layer also influence the time of adult emergence to some extent. These factors may slow down or accelerate fly emergence, and slightly change the ratio of healthy and maggoty fruits, especially on early-ripening hosts. However, the crucial factor influencing infestation intensity on any plant species (cultivar) is the ripening period of fruits.

During 1954-1955, Mitić-Mužina (1960) conducted a detailed research of the European cherry fruit fly biology in the environs of Belgrade and Smedervo to determine to what extent certain host species were endangered in that area. The research showed that cultivars ripening at the end of May or the beginning of June (Early May, Early Lyon) mostly avoided strong infestation by European cherry fruit fly. The number of maggoty fruits of these cultivars was about 6%. Maggoty cherries of medium ripening cultivars (e.g. Germersdorfer) reached 12%. Among the cultivars of late ripening, a high percentage of maggoty fruits was recorded on Drogan's Yellow, as much as 24.2 and 64.7% of infested cherries at harvest in the two years. The percentage of maggoty fruits rapidly increased in late harvests, thus rendering them unprofitable. Trees of that cultivar mostly stayed unharvested, which further contributed to pest retention in some orchards (Mitić-Mužina, 1960).

Mitić-Mužina (1960) also found that different sour cherry cultivars were far less attractive to the European cherry fruit fly than corresponding sweet cherry cultivars. In her research, infestation intensity on the former cultivars did not exceed 8%. Special attention was focused on data about the cultivar Marela, on which the percentage of maggoty fruits ranged from 0.2 to 6.9%. The phenomenon of sour cherries having such a low percentage of maggoty fruits has also been recorded by several authors in Crimea and Dagestan (Kalandadze and Bagdavadze, 1956). However, Maraska was found in Dalmatia to be infested up to 62% (Tominić, 1954).

In many European countries, the intensity of attack by the European cherry fruit fly exceeds tolerance thresholds (Beratlief et al., 1981; Bogdan, 1981; Vasev, 1983; Zumreoglu et al., 1987; Edland, 1990). According to Stamenković et al. (1996a), all sweet cherry cultivars monitored in their study between 1984 and 1993, except some early ripening ones, were damaged by *R. cerasi*. The intensity of attack ranged from 0.9% (Asenova Rana) to 100% (Hedelfinger). Infestation intensity was determined by cherry colour and the time of ripening of different cultivars. Higher infestation intensity was found on yellow cherry cultivars (Drogan's Yellow, 42.2%) as adult flies are attracted to yellow colour.

During a 10-year study in Western Serbia, the highest intensity of attack on sweet cherries was recorded in 1984 and 1992 (Stamenković et al., 1996a). In 1984, high infestation intensity was recorded on the cultivars Stela 40.3%, Hedelfinger 46.0%, Sue 50.0%, Lambert 52.5%, Drogan's Yellow 65.2% and Van 68.9%. In 1992, even higher intensity was recorded on the cultivars Van 76.0%, Bing 78.0%, Drogan's Yellow 81.0%, Lamberta 83.0% and Hedelfinger 100%. The highest number of damaged cherries was found on the southern side of trees, and the lowest on the northern side. Cherries at the top of tree canopy that were well exposed to sunshine were more damaged than those inside the canopy, which indicates that fruit flies favour well-illuminated tree parts. The data showed that sweet cherry production in orchards comprising different cultivars without any measure to control European cherry fruit fly had no economic justification (Stamenković et al., 1996a).

Data obtained from other countries have shown that European cherry fruit flies can also develop on fruits of certain wild plants, besides the cultivated varieties of sweet and sour cherry, primarily on *Lonicera* sp., *Berberis* sp., *Prunus mahaleb* L. and *Prunus padus* L. However, the fly does not attack all of these hosts to the same extent and in all regions. A species that is significantly infested in one region can hardly be considered a host in another. That is the case of *Lonicera* sp., which is rarely attacked in Crimea but becomes more frequently infested in other regions (Kalandadze and Bagdavadze, 1956).

Tominić (1954) reported that Mahaleb cherry and different Lonicera species were rarely attacked in Dalmatia, while in Germany they were the main hosts in the native flora. According to Tominić (1954), such pattern of preferred hosts of the European cherry fruit fly is a result of climatic factors and the fruit ripening phase coinciding with flight of this fly species.

In the environs of Belgrade and Smederevo, according to data reported by Mitić-Mužina (1960), Mahaleb cherry was the least infested of wild hosts (3-7%), while Lonicera was usually even more infested than the most frequent sweet cherry cultivars. Bushes with 100% infested fruits were also recorded in that research. Also, in 25% of all cases, the number of eggs laid on a single fruit was higher than 10.

CONTROL MEASURES

During the 20th century, new strategies became necessary for controlling various harmful organisms. Important research was initiated to study control measures against *R. cerasi,* and studies were usually synchronized with periods of pest population increase. High population density of European cherry fruit fly is normally found during a period of four to five years, including an interval of very low density. Such fluctuations in population density were simultaneously recorded throughout Central Europe, while a detailed report was made in Switzerland for the period between 1929 and 1969 (Boller et al., 1970).

At the beginning of several significant attacks by the European cherry fruit fly in Europe, research mainly focused on studying pest bionomy and behaviour. Initial and most efficient measures of *R. cerasi* control consisted of focusing on early and complete cherry fruit harvest and on cultivating early-ripening cultivars (Sprengel, 1932a; Wiesmann, 1934a). During that period, popular methods also included a complete destruction of infested fruits, as well as soil insecticide applications. One of the important measures was also a recommendation to eradicate wild and other hosts of *R. cerasi*, which raised a considerable debate and revealed disagreements among researchers (Wiesmann, 1937; Thiem, 1939).

Chemical control

The first group of insecticides, including the most important pyrethrin, rotenone and lead arsenate, was assessed in combination with food baits for adult flies (Berlese, 1906; Sprengel, 1932b; Wiesmann, 1934b). Pyrethin and rotenone were not found to have satisfactory efficacy, while lead arsenate, due to its high toxicity to humans and the environment, was not considered an acceptable solution in most European countries (Sprengel, 1932a). Significant results were achieved only later, when DDT was put to use (Wiesmann, 1943; Fenili and Zocchi, 1954; Schwope, 1957), and organophosphates and carbamates were developed and used in practice (Fenili, 1951; Bartolini and Zocchi, 1957).

In Serbia, the use of insecticides is a necessary measure for control of *R. cerasi* populations. Despite conventional cultivation measures, there is always a part of population left that needs to be destroyed with insecticides. Prior to insecticide treatment, an optimum time for application is determined by monitoring adult flight and oviposition. Treatment must be done before larvae bury into cherries. The best results in controlling European cherry fruit fly are achieved with treatments at the beginning of fruit ripening, when cherries turn from green to yellow. Currently, preparations based on deltmethrin, dichlorvos, dimethoate and acetamiprid are most frequently used in sweet and sour cherry commercial orchards since they are officially registered in Serbia (Janjić and Elezović, 2010).

During 2009-2010, Stamenković et al. (2011) tested insecticides from different chemical groups for *R. cerasi* control. Besides conventional insecticides (organophosphates and synthetic pyrethroids), some relatively new compounds (acetamiprid and spinosad) were also tested. Depending on orchard, the efficacy of these two chemicals ranged from 75.6% to 90.7%. The highest efficacy among all tested preparations was found for acetamiprid (Kestrel) 84.9-90.7%, acetamiprid (Wizzaard) 79.7-86.2% and deltamethrin (Decis) 81.9-82.2%. A lower efficacy was achieved in treatments with spinosad (Laser), tebufenozide (Rebus) and dimethoate (Perfektion).

Olszak and Maciesiak (2004) tested the efficacy of a similar insecticide group in controlling *R. cerasi* in Poland during 1998-2002. Depending on orchard, they achieved high efficacy levels with acetamiprid and thiacloprid, which ranged from 98.5% to 100%. However, the efficacy of fenoxycarb and spinosad was significantly lower. One fenoxycarb application in the last decade of May was found to have a very low efficacy of only 32%. Better results were achieved with spinosad since the number of maggoty cherries was reduced by 55-58%. These authors obtained even better results when they applied thiacloprid in the first, and spinosad in the second treatment. The combination of these two chemicals, applied at a 13-day interval, resulted in almost 99% efficacy.

At the end of the last and beginning of current century, *R. cerasi* crossed the threshold of economic importance in many European countries, so that pesticides (one or two treatments) for its control became a necessary measure (Beratlief et al., 1981; Bogdan, 1981; Kneifl, 1983; Vasev, 1983; Zumreoglu et al., 1987; Edland, 1990; Jaastad, 1999; Kovanci and Kovanci, 2006). However, the European Union Directives proscribing the „old“ insecticides have resulted in cherry fruit production of inferior quality. At this moment, dimethoate is still a standard for *R. cerasi* control in Switzerland as the cheapest efficient method. In Germany, on the other hand, this substance is no longer registered for use in fruit production due to problems with residual ecotoxicity to humans and beneficial organisms (Daniel, 2009).

Biological control

The use of yellow sticky traps, pheromones, crop netting and common cultivating measures in integrated and organic production of sweet and sour cherry presents an alternative to chemical control against *R. cerasi*. However, this strategy does not give satisfactory effects in practice in terms of control because damages exceed the established thresholds. This is why more attention is given to studying the known natural enemies as an alternative solution for controlling *R. cerasi*. There is a great number of parasitoid and predacious species that are potential natural regulators of R. *cerasi* and populations of similar fruit fly species, but they have not been sufficiently explored. Recently, a number of researches have been carried out and satisfactory results have been reported on the most significant antagonistic organisms of *R. cerasi*, such as entomopathogic fungi (Daniel, 2009; Daniel and Wyss, 2009) and entomopathogenic nematodes (Koppler et al., 2003; Herz et al., 2006). Regarding other microorganisms (viruses and bacteria), there is no available data in literature on their effectiveness against *R. cerasi*.

In a study by Daniel (2009), the efficacy of six fungi isolates against different stages of *R. cerasi* was determined under laboratory and field conditions. The isolates used belong to the genera *Metarhizium*, *Isaria* and

Beauveria. The results were encouraging since all tested isolates, except *Isaria farinosa* Dicks, caused high mortality of *R. cerasi*. Virulence significantly varied among the fungus isolates and developmental life stages of *R. cerasi*. The effect on the L3 larval stage was insignificant, and none of the tested isolates caused mortality higher than 25%. As opposite to larvae, adult flies were found to be very sensitive to all fungal isolates tested. High mortality of 90-100% during the pre-ovipositing period caused by *B. bassiana* and *I. fumosorosea* Wize led to a significant reduction in oviposition. Also, soil treatment with entomopatogenic fungi demonstrated a high efficacy of 42-83%, and oviposition was reduced 39-73%, depending on fungal isolate (Daniel, 2009).

Under field conditions, the strategy of soil treatment with entomopathogenic fungi for the control of emerged adults, the use of certain equipment for attraction and extermination of adult flies and foliar application of isolates as mycoinsecticides were also assessed (Daniel, 2009). The results provide a solid basis for determining the best strategy for securing a high quality of sweet cherries. Also, it was pointed out in the conclusions that four treatments of *B. bassiana* (product: Naturalis-L) made an adequate and economically feasable strategy for controlling *R. cerasi* (Daniel, 2009).

A large number of parasitoids and predators have been registered for the control of fruit flies. According to data from several studies so far, over 20 species of *R. cerasi* larval and pupal parasitoids have been described (Hoffmeister, 1993; Lopez et al., 1999; Sivinski et al., 2001). The most significant species are *Opius magnus* Fischer causing 10-30% (Monako, 1984) and *Opius rhagleticolus* Sachtl. causing 22-32% of *R. cerasi* larval parasitism in Poland (Leski, 1963). Mitić-Mužina (1960) determined three parasite species (*O. rhagoleticolus*, *O. testaceus* Wesmael and *Aspilota* sp.) when rearing pupae that had been collected from natural environments in Serbia, and the level of parasitism was low, only 3.3%. However, pupa parasitoids have greater importance in Central Europe, the most significant being *Phygadeuon wiesmanni* Sachtl. (Wiesmann, 1933a; Vogel, 1950). According to literature data, this parasitoid was found in one study to cause pupae mortality that was as high as 72% (Boller, 1966b; Engel, 1976).

Wiesmann (1933b) identified two *Odontothrips* sp. predator species that attack *R. cerasi* eggs in a relatively low percentage of 10%. Far more importance is given to larval predators (as soon as they leave cherries) than to predators of pupae and young adults (immediately after eclosion). Ants are named as one of the most important predators, as well as insects belonging to the families Carabidae and Staphylinidae (Wiesmann, 1935a; Boller, 1966b).

ACKNOWLEDGMENTS

This study was carried out as part of the Project TR 31043, which is financially supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia.

REFERENCES

Agee, H. R., Boller, E., Remund, U., Davis, J. C. and Chambers, D. L.: Spectral sensitivities and visual attractant studies on the Mediterranean Fruit Fly, *Ceratitis capitata* (Wiedemann), Olive Fly, *Dacus oleae* (Gmelin), and the European Cherry Fruit Fly, *Rhagoletis cerasi* (L) (Diptera, Tephritidae). Journal of Applied Entomology, 93: 403-412, 1982.

Aluja, M. and Boller, E.F.: Host marking pheromone of *Rhagoletis cerasi*: field deployment of synthetic pheromone as a novel cherry fruit fly management strategy. Entomologia Experimentalis et Applicata, 65: 141-147, 1992.

Baker, C.R.B. and Miller, G.W.: Effect of temperature on postdiapause development of 4 geographical populations of European Cherry Fruit Fly (*Rhagoletis cerasi*). Entomologia Experimentalis et Applicata, 23: 1-13, 1978.

Bartolini, P. and Zocchi, R.: Esperienze di lotta contro la *Rhagoletis cerasi* L. nel 1957. Redia, 42: 349-358, 1957.

Bateman, M.A.: The ecology of fruit flies. Annual Review of Entomology, 17: 493-518, 1972.

Beratlief, C., Ionescu, C. and Mustatea, D.: Observations on the effectiveness of the visual traps in the monitoring of treatments against the cherry fly (*Rhagoletis cerasi* L.). Bulletin de l'Academie des Sciences Agricoles et Forestieres, 10: 93-102, 1981.

Berlese, A.: Probabile methodo di lotta efficace contro la *Ceratitis capitata*, *Rhagoletis cerasi* ed altri Tripetidi. Redia, 3: 386-388, 1906.

Blumel, S., Keck, M., Nowotny, N., Fiedler, W. and Russ, K.: Nachweis und Therapie von Rickettsia-like organisms (RLO's) in den Ovarien der Europäischen Kirschfruchtfliege (*Rhagoletis cerasi* L.; Trypetidae): ein Beitrag zur Frage der unidirektionalen Kreuzungssterilitat dieser Art. Pflanzenschutzberichte, 52: 41-47, 1991.

Bogdan, L.I.: How to control the cherry fruit fly. Zaschita rastenii, 11: 28-35, 1981.

Böhm, H.: Untersuchungen über die Lebensweise und Bekämpfung der Kirschfliege (*Rhagoletis cerasi* L.). Pflanzenschutzberichte, 3: 177-185, 1949.

Boller, E.: Beitrag zur Kenntnis der Eiablage und Fertilität der Kirschenfliege *Rhagoletis cerasi* L. Mitteilung der Schweizerischen entomologischen Gesellschaft, 38: 195-202, 1966a.

Boller, E.: Der Einfluss natürlicher Reduktionsverfahren auf die Kirschenfliege *Rhagoletis cerasi* L. in der Nordwestschweiz, unter besonderer Berücksichtigung des Puppenstadiums. Schweizerische landwirtschaftliche Forschung, 5: 154-210, 1966b.

Boller, E.: Neues über die Kirschenfliege: Freilandversuche im Jahr 1969. Schweizerische Zeitschrift für Obst- und Weinbau, 105: 566-572, 1969.

Boller, E.: Cytoplasmatic incompatibility in *Rhagoletis cerasi*. In: Fruit flies their biology, natural enemies and control. (A.S. Robinson, G. Hooper, eds). Elsevier, Amsterdam, 1989a, p. 69-74.

Boller, E. and Bush, G.L.: Evidence for genetic variation in populations of the European Cherry Fruit Fly, *Rhagoletis cerasi* (Diptera: Tephritidae) based on physiological parameters and hybridization experiments. Entomologia Experimentalis et Applicata, 17: 279-293, 1974.

Boller, E. and Prokopy, R.J.: Bionomics and management of *Rhagoletis*. Annual Review of Entomology, 21: 223-246, 1976.

Boller, E. and Ramser, E.: Die Zucht der Kirschenfliege (*Rhagoletis cerasi* L.) auf künstlichen Substraten. Schweizerische Zeitschrift für Obst- und Weinbau, 107: 174-183, 1971.

Boller, E., Haisch, A., Russ, K., and Vallo, V.: Economic importance of *Rhagoletis cerasi* L., the feasibility of genetic control and resulting research problems. Entomophaga, 15: 305-313, 1970.

Boller, E., Katsoyannos, B.I. and Hippe, C.: Host races of *Rhagoletis cerasi* L. (Dipt., Tephritidae): Effect of prior adult experience on oviposition site preference. Journal of Applied Entomology, 122: 231-237, 1998.

Boller, E., Russ, K., Vallo, V. and Bush, G.L.: Incompatible races of European Cherry Fruit Fly, *Rhagoletis cerasi* (Diptera-Tephritidae), their origin and potential use in biological control. Entomologia Experimentalis et Applicata, 20: 237-247, 1976.

Cardei, E. and Rominger, E.: Research concerning phytosanitary protection of cherry tree plantation at the Iasi Fruit-growing Research Station. Cercetari Agronomice in Moldova, 30(2): 133-139, 1997.

Daniel, C.: Entomopathogenic fungi as a new strategy to control the European cherry fruit fly *Rhagoletis cerasi* Loew (Diptera, Tephrtidae). Thesis. Universitat Munchen, Munich, Germany, 2009, pp. 1-171.

Daniel, C. and Wyss, E.: Susceptibility of different life stages of the European cherry fruit fly, *Rhagoletis cerasi*, to entomopathogenic fungi. Journal of Applied Entomology, 133: 473-483, 2009.

Edland, T.: Exotic pests (5) Cherry fruit fly *Rhagoletis cerasi* L. Gartneryrket, 80: 16-18, 1990.

Engel, H.: Untersuchungen über die Besatzdichte der Kirschfruchtfliege (*Rhagoletis cerasi* L.). Zeitschrift für Pflanzenkrankheiten und Pflanzenschutz, 83: 53-58, 1976.

FAO, 2010: http://faostat.fao.org.

Fenili, G.A.: Nuovo contributo alla conoszenza delle biologia della mosca delle ciliege (*Rhagoletis cerasi* L.) ed ai mezzi di lotta cotro di essa. Redia, 36: 267-275, 1951.

Fenili, G.A. and Zocchi, R.: Esperienze di lotta contro la *Rhagoletis cerasi* L. Redia, 39: 301-308, 1954.

Fimiani, P., Frilli, F., Insera, S., Monaco, R. and Sabatino, A.: Coordinated investigations on aspects of the biology of *Rhagoletis cerasi* L. in Italy. Boolittino del laboratorio di Entomologia Agraria, 38: 159-211, 1981.

Fletcher, B.S.: The biology of Dacine fruit flies. Annual Review of Entomology, 32: 115-144, 1987.

Frank, B.: Über die Kirschenfliege *Spilographa cerasi* und ihre Bekämpfung. Zeitschrift für Pflanzenkrankheiten, 1: 284-287, 1891.

Haisch, A.: Zur Puppendiapause der Kirschenfliege *Rhagoletis cerasi* L.- I. Beeinflussung der diapausierenden Puppen durch unterschiedliche Temperaturen und verschieden lange Kälteexpositionen. Journal of Applied Entomology, 79: 1-11, 1975.

Haisch, A. and Chwala, D.: Über den Einfluss wechselnder Temperaturen auf den Diapause-Ablauf der Europäischen Kirschfruchtfliege *Rhagoletis cerasi* (Diptera, Trypetidae). Entomologia Generalis, 5: 231-239, 1979.

Haisch, A. and Forster, S.: Zur herkunftsspezifischen Diapause-Ausprägung der Europäischen Kirschfruchtfliege, *Rhagoletis cerasi* (Diptera: Trypetidae). Entomologia Germanica, 12: 137-148, 1975.

Headrick, D.H. and Goeden, R.D.: The biology of nonfrugivorous tephritid fruit flies. Annual Review of Entomology, 43: 217-241, 1998.

Herz, A., Koppler, K., Vogt, H., Elias, E., Katz, P. and Peters, A.: Biological control of the cherry fruit fly, *Rhagoletis cerasi* L. (Diptera, Tephritidae) by use of entomopathogenic nematodes: first experiences towards practical implementation. Proceedings of the 12th International Conference on Cultivation Technique and Phytopathological Problems in Organic Fruit Growing (Eco-fruit), Weinsberg, 2006, pp. 67-72.

Hoffmeister, T.: The parasitoid complexes of frugivorous fruit flies of central Europe. In: Fruit flies: Biology and management. (M. Aluja, P. Liedo, eds.), Springer Verlag, New York, 1993, pp. 125-127.

Garić, R. and Stamenković, S.: Effect of some abiotic and biotic factors on the incidence of *Moniliana* spp. on sweet cherry fruits. Jugoslovensko voćarstvo, 24: 67-72, 1990 (in Serbian with an English summary).

Ilić, N.: Brojnost, štetnost i nove mogućnosti u suzbijanju *Ragoletis cerasi* L. (Diptera: Trypetidae). Doktorska disertacija, Poljoprivredni fakultet, Lešak, 2010.

Jaastad, G.: First registration of the cherry fruit fly, *Rhagoletis cerasi* (L.) in western Norway: distribution size and origin of the population. Norwegian Journal of Agricultural Sciences, 8(3-4): 203-214, 1994.

Jaastad, G.: Distribution, rases and management of the European cherry fruit fly (*Rhagoletis cerasi* L.) in Norway. IOBC/wprs Bulletin, 22(11): 69-74, 1999.

Jancke, O. and Bohmel, W.: Beitrag zur Biologie und Bekämpfung der Kirschenfliege. Arbeiten der biologischen Reichsanstalt, 20: 443-456, 1933.

Janjić V. and Elezović I.: Pesticidi u poljoprivredi i šumarstvu u Srbiji. Društvo za zaštitu bilja Srbije, Beograd, 2010 (in Serbian).

Kalandadze, L.P. and Bagdavadze, A.I.: Biologičeskie osobenosti višnevoj muhi (*Rhagoletis cerasi* L.) v Gruzijskoj SSR. Zoologičeskij žurnal, Moskva, 1956, 8: 1177-1185.

Katsoyannos, B.I.: Female attraction to males in *Rhagoletis cerasi (*Diptera-Tephritidae). Environmental Entomology, 5: 474-476, 1976.

Katsoyannos, B.I., Boller, E. and Benz, G.: Das Verhalten der Kirschenfliege, *Rhagoletis cerasi*, L., bei der Auswahl der Wirtspflanzen und ihre Dispersion. Mitteilung der Schweizerischen entomologischen Gesellschaft, 59: 315-335, 1986.

Kneifl, V.: A more effective chemical control of the cherry maggot (*Rhagoletis cerasi*) in cherry trees. Sbor. ÚVTIZ, Ochrana rostlin, 19: 133-138, 1983 (In Czech).

Kobel, F.: Eine Notiz über das Vorkommen der Kirschenfruchtfliege im 16. Jahrhundert. Schweizerische Zeitschrift für Obst- und Weinbau, 42: 255, 1933.

Koppler, K., Peters, A. and Vogt, H.: Initial results in the application of entomopathogenic nematodes against the European cherry fruit fly *Rhagoletis cerasi* L. (Diptera: Tephritidae). IOBC/wprs Bulletin, 23(3):13-18, 2003.

Kutuk, M. and Ozaslan, M.: Faunistical and Systematical Studies on the Trypetinae (Diptera: Tephritidea) in the Turkey Along with a New Record to Turkish Fauna. Munis Entomology & Zoology, 1(2): 173-178, 2006.

Kovanci, O.B. and Kovanci, B.: Effect of altitude on seasonal flight activity of *Rhagoletis cerasi* flies (Diptera: Tephritidae). Bulletin of Entomological Research, 96: 345-351, 2006.

Leski, R.: Studia nad biologia i ecologia nasionnicy tzresniowki *Rhagoletis cerasi* L. (Diptera: Trypetidae). Polskie Pismo Entomologiczne Seria B, Zeszyt 3-4(31-32): 153-240, 1963.

Lopez, M., Aluja, M. and Sivinski, J.: Hymenopterous larval-pupal and pupal parasitoids of *Anastrepha* flies (Diptera: Tephritidae) in Mexico. Biological Control, 15: 119-129, 1999.

Matolin, S.: Mechanism causing incompatibility between different strains of *Rhagoletis cerasi* (Diptera, Tephritidae). Acta Entomologica Bohemoslovaca, 73: 289-292, 1976.

Menegaux, R.: Le ver de cerises. Le Naturaliste, 212, 1898.

Mik, J.: Zur Biologie von *Rhagoletis cerasi* L. nebst einigen Bemerkungen über die Larven und Puparien der Trypetiden und über die Fühler der Musciden-Larven. Wiener Entomologen Zeitung, 17: 279-313, 1898.

Mitić-Mužina, N.: Results of investigations of the biology of the cherry fly (*Rhagoletis cerasi* L.) in the surroundings of Belgrade. Plant Protection, 60: 29-53, 1960 (in Serbian with an English summary).

Monaco, R.: L'*Opius magnus* Fischer (Braconidae), parassita di *Rhagoletis cerasi* L. su *Prunus mahaleb*. Entomologica, 19: 75-80, 1984.

Mratinić, E.: Višnja. Vizartis, Beograd, 2002.

Nenadović-Mratinić, E., Milatović, D. and Đurović D.: Biological properties of tart cherry cultivars in the region of Belgrade. Proceedings of XXIth Conference of Improvement in Fruit and Grape Production, Belgrade, Serbia, 2006, pp. 24-29 (in Serbian with an English summary).

Olszak, R.W. and Maciesiak, A.: Problem of cherry fruit fly (*Rhagoletis cerasi*) in Poland – flight dynamics and control with some insecticides. Integrated plant protection in stone fruit, IOBC/wprs Bulletin, 27(5): 91-96, 2004.

Popov, P.: Rezultati ot nabljudenijata na vrhu pojavata na čeresovata muha (*Rhagoletis cerasi* L.) v Sofijsko prez 1953 godina. Bilten po rastitelna zaštita, God. VI, Kn. I. Sofia, 1954.

Ranner, H.: Untersuchungen zur Biologie und Bekämpfung der Kirschfruchtfliege, *Rhagoletis cerasi* L. (Diptera, Trypetidae)-I. Die Bedeutung der wilden Wirtspflanzen für die Epidemiologie und die ökologische Differenzierung der Kirschfruchtfliege. Pflanzenschutzberichte, 48: 42-51, 1987.

Ranner, H.: Untersuchungen zur Biologie und Bekämpfung der Kirschfruchtfliege, *Rhagoletis cerasi* L. (Diptera, Trypetidae) - III. Statistischer Vergleich der Schlupfperioden und Schlupfraten der Kirschfliege. Pflanzenschutzberichte, 49: 17-26, 1988a.

Ranner, H.: Untersuchungen zur Biologie und Bekämpfung der Kirschfruchtfliege, *Rhagoletis cerasi* L. (Diptera, Trypetidae) - IV. Statistiche Auswertung von Kreuzenversuchen mit Kirschfliegen verschiedenen Alters and Puppengewichts, verschiedener Wirtspflanzenherkunft und Rassenzugehörigkeit. Pflanzenschutzberichte, 49(2): 74-86, 1988b.

Raptopoulos, D., Haniotakis, G., Koutsaftikis, A., Kelly, D. and Mavraganis, V.: Biological activity of chemicals identified from extracts and volatiles of male *Rhagoletis cerasi*. Journal of Chemical Ecology, 21: 1287-1297, 1995.

Remund, U. and Boller, E.F.: The development and potential of a new visual trap for the cherry fly, *Rhagoletis cerasi* L. Zeitschrift für Angewandte Entomologie, 77(4): 348-353, 1975.

Ribault, G.: La mouche de la cerise peut rester deux hivers en diapause. Phytoma, 93: 16, 1957.

Riegler, M.: Der Endosymbiont Wolbachia (alpha-Proteobacteria) in der europäischen Kirschfruchtfliege *Rhagoletis cerasi* (Diptera, Tephritidae): Populationsdynamik und Einfluss auf die Populationsgenetik. PhD thesis, Universität für Bodenkultur, Wien, 2002, pp. 1-83.

Riegler, M. and Stauffer, C.: Wolbachia infections and superinfections in cytoplasmically incompatible populations of the European cherry fruit fly *Rhagoletis cerasi* (Diptera, Tephritidae). Molecular Ecology, 11: 2425-2434, 2002.

Samoggia, A.: Nota sulla *Rhagoletis cerasi* L. Bollettino del Laboratorio di Entomologia del R. Instituto Superiore Agrario, 5: 22-48, 1932.

Schwarz, D., Bruce, A.M., Gunther, B.H., Emst, F.B. and Hoffmeiter, T.: A second case of genetic host races in Rhagoletis? A population genetic comparison of sympatic host populations in the European cherry fruit fly, *Rhagoletis cerasi*. Entomologia Experimentalis of Applicata, 108: 11-17, 2003.

Schwope, D.: Untersuchungen zur Anwendung des Wirkstoffnebelverfahrens bei der Bekämpfung der Kirschfruchtfliege (*Rhagoletis cerasi* L.). Wissenschaftliche Zeitschrift der Martin-Luther-Universität Halle-Wittenberg, 6: 615-622, 1957.

Sivinski, J. and Burk, T.: Reproductive and mating behavior. In: Fruit flies their biology, natural enemies and control. (A.S. Robinson, G. Hooper, eds.), Elsevier, Amsterdam, 1989, pp. 343-351.

Sivinski, J., Vulinec, K. and Aluja, M.: Ovipositor length in a guild of parasitoids (Hymenoptera: Braconidae) attacking *Anastrepha spp.* Fruit Flies (Diptera: Tephritidae) in Southern Mexico. Annals of the Entomological Society of America, 94: 886-895, 2001.

Speyer, W.: Beobachtungen über das Zahlenverhältnis der Geschlechter bei der Kirschfruchtfliege (*Rhagoletis cerasi* L.). Zeitschrift fur Pflanzenkrankheiten und Pflanzenschutz, 51: 330-332, 1941.

Sprengel, L.: Biologische und epidemiologische Untersuchungen als Grundlage für die Bekämpfung der Kirschfruchtfliege *Rhagoletis cerasi* L. Gartenbauwissenschaft, 6: 541-553, 1932a.

Sprengel, L.: Die Bekämpfung der Kirschfruchtfliege (*Rhagoletis cerasi* L.). Anzeiger für Schädlingskunde, 8: 47-51, 1932b.

Sprengel, L. and Sonntag, K.: Der Flug der Kirschfliege (*Rhagoletis cerasi* L.) in seiner Bedeutung zu Fruchtreife und Witterung, mit grundsätzlichen Erörterungen über die Erfassung der Wetterfaktoren. Anzeiger für Schädlingskunde, 8: 1-10, 1932.

Sredojević, Z.: Ekonomska evaluacija proizvodnje trešnje i višnje u Srbiji. Zbornik radova III savetovanja Inovacije u voćarstvu, Beograd, 2011, pp. 5-20 (in Serbian with an English summary).

Stamenković, S., Garić, R., Milenković, S., Nikolić, M. and Stamenković, T.: Susceptibility of some sweet sherry-cultivars to *Rhagoletis cerasi* L. (Diptera, Trypetidae). Acta horticulture, 410: 555-560, 1996a.

Stamenković S., Ilić N., Perić P. and Marčić D.: Fenologija leta trešnjine muve (*Rhagoletis cerasi* Loew) i mogućnosti suzbijanja u nekim rejonima Srbije. Zbornik rezimea X savetovanja o zaštiti bilja, Zlatibor, 2010, pp. 128-129 (in Serbian).

Stamenković, S., Milenković, S. and Stamenković, T.: Population Dynamics of *Rhagoletis cerasi L.* (Diptera, Trypetidae) in western Serbia. Acta horticulture, 410: 561-563, 1996b.

Stamenković, S., Perić, P., Marčić, D. and Ilić, N.: Biology, Harmfulness and Control of Cherry Fruit Fly (*Rhagoletis cerasi* L.) in Serbia. Book of abstacts II BSFG – Fruit Quality, Health and Environment, Pitesti, Romania, 2011, pp. 63.

Stamenković, S. and Stamenković, T.: Dinamika populacije trešnjine muve *Rhagoletis cerasi* L. (Diptera, Trypetidae). Jugoslovensko voćarstvo, 75-76: 595-600, 1986 (in Serbian with an English summary).

Stamenković, S., Stamenković, T. and Ranković, M.: Vodič zaštite voćaka i vinove loze. Institut za istraživanja u poljoprivredi „Srbija" – Centar za voćarstvo i vinogradarstvo, Čačak, 2006 (in Serbian).

Thiem, H.: Heckenkirschen und Sauerdorn als Wirtspflanzen der Kirschfruchtfliege (*Rhagoletis cerasi* L.). Nachrichtenblatt für den Deutschen Pflanzenschutzdienst, 12: 41-43, 1932.

Thiem, H.: Beiträge zur Epidemiologie und Bekämpfung der Kirschfruchtfliege (*Rhagoletis cerasi* L.). Arbeiten über Physiologische und Angewandte Entomologie Berlin Dahlem, 1: 7-79, 1934.

Thiem, H.: Untersuchungen zur Biologie der Kirschfruchtfliege (*Rhagoletis cerasi* L.) und ihrer Wirtspflanzen. Arbeiten über Physiologische und Angewandte Entomologie Berlin Dahlem, 2: 24-49, 1935.

Thiem, H.: Über die Bedeutung der wilden Wirtspflanzen der Kirschfruchtfliege (*Rhagoletis cerasi* L.) für die Verbreitung und Bekämpfung des Schädlings. Arbeiten über Physiologische und Angewandte Entomologie Berlin Dahlem, 6: 350-359, 1939.

Thiem, H.: Über die Bedeutung der wilden Wirtspflanzen der Kirschfruchtfliege (*Rhagoletis cerasi* L.) für die Verbreitung und Bekämpfung des Schädlings. Arbeiten über Physiologische und Angewandte Entomologie Berlin Dahlem, 7: 67-79, 1940.

Tominić, A.: Investigations on the cherry fruit fly in Dalmatia. Plant Protection, 23: 44-62, 1954 (in Serbian with an English summary).

Vasev, A.: Assessment of losses caused by pests and diseases and the effectivenees of plant protection measures in cherry ochards. Gradinarska i lozarska nauka, 20: 10-19, 1983.

Verguin, J.: La mouche de cerises, *Rhagoletis cerasi* L.: Sa biologie, les moyens de la combattre. Revue de zoologie agricole et appliquee, 27: 17, 1928.

Vita, G., Rossi, R. and Carpita, A.: Valutazione in campo dell'efficacia di una trappola chemio-cromo-tropica per la cattura della mosca delle ciliege, *Rhagoletis cerasi.* Redia, 65: 319-327, 1982.

Vogel, W.: Untersuchungen über parasitische Hymenopteren der Kirschenfliege. Mitteilung der Schweizerischen entomologischen Gesellschaft, 13: 195-199, 1950.

Vogt, H.: Expertenkolloquium Kirschfruchtfliege. BBA Dossenheim, 27.-28. Nov. 2001. Nachrichtenblatt Deut. Pflanzenschutzdienst, 54: 77-79, 2002.

Voigt, E.: Monitoring cherry fruit fly (*Rhagoletis cerasi*) using yellow traps. IOBC/wprs Bulletin, 20(6): 50-53, 1997.

White, I.M. and Elson-Harris, M.M.: Fruit flies of economic significance: their identification and binomics. CAB International, Oxon, 1992, pp. 601.

Wiesmann, R.: Ein Parasit der Kirschfliege (*Rhagoletis cerasi* L.). Mitteilung der Schweizerischen entomologischen Gesellschaft, 15: 553-557, 1933a.

Wiesmann, R.: Untersuchungen über die Lebensgeschichte und Bekämpfung der Kirschenfliege *Rhagoletis cerasi* Linné-I. Mitteilung. Landwirtschaftliches Jahrbuch der Schweiz, 711-760, 1933b.

Wiesmann, R.: Die Kirschfliege und ihre Bekämpfung. Schweizerische Zeitschrift für Obst und Weinbau, 43: 545-550, 1934a.

Wiesmann, R.: Untersuchungen über die Lebensgeschichte und Bekämpfung der Kirschenfliege *Rhagoletis cerasi* Linné-II. Mitteilung. Landwirtschaftliches Jahrbuch der Schweiz, 281-338, 1934b.

Wiesmann, R.: Die Fauna des Grasbodens unter den Kirschenbäumen. Schweizerische Zeitschrift für Obst- und Weinbau, 44: 244-246, 1935a.

Wiesmann, R.: Ergebnisse dreijähriger Untersuchungen über die Biologie und Bekämpfung der Kirschfliege *Rhagoletis cerasi* L. in der Schweiz. Anzeiger für Schädlingskunde, 11: 97-103, 1935b.

Wiesmann, R.: Untersuchungen über die Lebensgeschichte und Bekämpfung der Kirschenfliege *Rhagoletis cerasi* Linné - III. Mitteilung Untersuchungen und Versuche aus dem Jahre 1934. Landwirtschaftliches Jahrbuch der Schweiz, 1936, pp. 811-858.

Wiesmann, R.: Das Wirtspflanzenproblem der Kirschenfliege *Rhagoletis cerasi* L. Landwirtschaftliches Jahrbuch der Schweiz, 51: 1031-1044, 1937.

Wiesmann, R.: Befällt die Kirschfliege ausser der Kirsche auch andere Wirte und welche Bedeutung haben diese Wirte. Schweizerische Zeitschrift für Obst und Weinbau, 47: 348-352, 1938.

Wiesmann, R.: Neue Untersuchungen über die Bekämpfung der Kirschenfliege, *Rhagoletis cerasi* L. Schweizerische Zeitschrift für Obst- und Weinbau, 52: 232-252, 1943.

Wiesmann, R.: Untersuchungen über die Diapause der Puppe der Kirschenfliege *Rhagoletis cerasi* L. (Dipt. Trypetid.). Mitteilung der Schweizerischen entomologischen Gesellschaft, 23: 207-225, 1950.

Živanović, V.: Experiences with the application of Prokobol III and Rebell olfactory traps for catching of cherry fruit fly (*Rhagoletis cerasi* L.). Plant Protection, XXIX (3): 279-284, 1978 (in Serbian with an English summary).

Zumreoglu, A.: Three years population studies of the European cherry fruit fly (*Rhagoletis ceraci* L.)with special reference by means of Rebel traps in the western part of Turkey, 165. Proceeding of the CEC/IOBC, Hamburg, 1986, p. 221.

Zumreoglu, A., Tezcan, H. and Cakici, M.: Investigations on the efficiency of various traps and lure systems against the main fruit flies *(Diptera, Tephritidae)* of economic importance in Izmir Province. Entomoloji Kongresi Bildirileri, 1987, pp. 377-386.

Zwölfer, H.: Life systems and strategies of ressource exploitation in tephritids. In: Fruit flies of economic importance (R. Cavalloro, ed.), Balkema, Rotterdam, 1983, pp. 16-30.

Rhagoletis cerasi Loew (Diptera, Tephritidae) – biološke karakteristike, štetnost i suzbijanje

REZIME

Evropska trešnjina muva, *Rhagoletis cerasi* Loew (Diptera: Tephritidae), veoma destruktivna štetočina u zasadima trešnje i višnje, rasprostranjena je širom Evrope i u umerenim regionima Azije. Redovno se javlja u svim proizvodnim područjima ovih vrsta voćaka u Srbiji, oštećujući do 10% plodova u komercijalnoj proizvodnji, a u zasadima i na pojedinačnim stablima gde se ne sprovode mere zaštite i do 100%.

Trešnjina muva u uslovima Srbije najčešće napada i oštećuje plodove kasnih sorata trešnje (Van, Stela, Hedelfinger, Bing, Lambert, Drogan's Yellow). Po završenoj berbi trešanja imago prelazi na višnju i nastavlja sa ishranom i ovipozicijom u poluzrele plodove višnje (najzastupljenija: domaći ekotip oblačinska višnja). Svojim aktivnostima larve oštećuju plodove i oni postaju neupotrebljivi za ishranu u svežem stanju, ali i za preradu. Visok procenat oštećenih plodova višnje delovanjem *R. cerasi* je ograničavajući faktor izvoza, jer je intenzitet napada na plodovima iznad dozvoljene granice. Primena pesticida za kontrolu ove štetočine, posebno u integralnoj proizvodnji, ograničena je na veoma mali izbor insekticida, čija se primena vezuje za probleme ekotoksičnosti ostataka. Zbog toga se poslednjih godina sve više proučavaju alternativne metode za kontrolu populacije trešnjine muve.

U radu su prikazani dosadašnji rezultati proučavanja evropske trešnjine muve, vrlo značajne štetočine u Srbiji i drugim zemljama južne i srednje Evrope. Detaljno su opisane biološke karakteristike, fenologija leta, intenzitet napada i mogućnosti suzbijanja muve u područjima gajenja trešnje i višnje.

Ključne reči: Trešnjina muva; biološke karakteristike; štetnost; suzbijanje