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Scientific paper

Population Dynamics of Pre-Imaginal Stages of Olive Fruit Fly *Bactrocera oleae* Gmel. (Diptera, Tephritidae) in the Region of Bar (Montenegro)

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SUMMARY

Olive fruit fly is the most harmful pest of olive fruits and important for oil production. Damage involves yield reduction as a consequence of premature fruit drop, but also a reduced quality of olive oil and olive products. There is little available data regarding the biology of *Bactrocera oleae* in Montenegro. Knowledge of the pest life cycle and development would improve optimization of insecticide application timing and protection of fruits, and reduce adverse effects on the environment.

Investigation was conducted on the Žutica variety in an olive grove located in Bar during a three-year period. Population dynamics of the pre-imaginal stages and level of fruit infestation were monitored from mid-July until the end of October.

The results of this three-year investigation showed that the beginning of infestation was always at the end of July. It was also found that, depending on environmental conditions, the level of infestation was low until the end of August. In September and October it multiplied, and reached maximum by the end of October.

Regarding infestation structure, eggs and first instar larvae were the dominant developmental stages of the pest until the middle of September. From mid-September until mid-October all developmental stages (eggs, larvae, pupae) were equally present in infested fruits. Pupae, cocoons and abandoned galleries prevailed until the harvest.

Keywords: Olive fruit fly; Pre-imaginal stages; Infestation

INTRODUCTION

Bactrocera oleae Gmel. is the most important olive pest. Regarding fruit production intended for processing into oil, damage can be quantitative and qualitative. Quantitative damage caused by larval feeding and premature fruit drop results in yield reduction. Qualitative damage is reflected in oil quality deterioration as a consequence of altered chemical parameters and organoleptic characteristics of olive fruits.

A particular type of damage, which is very important for production of table olives, is the aesthetic damage of fruits resulting from fly oviposition punctures.

Distribution and reproductive ability of the fly varies depending on enviromental conditions. On the Montenegrin seaside, *B. oleae* is present from the beginning of July to the end of December. In certain years, flight period lasted longer and adults were captured until the middle of January (Hrnčić et al., 2007; Perović et al., 2007, 2009). The number of generations per year varies, and two or three usually develop. Regarding generation overlaps, it is difficult to distinguish them clearly (Mijušković, 1955; Mijušković et Mirčetić, 1957). In years with particularly favorable enviromental conditions, the fly causes serious damage in olive production (Mijušković, 1999).

The aim of this study was to determine the dynamics of pre-imaginal stages of olive fly and the percentage of infested fruits in order to determine an optimal timing for control measures.

MATERIAL AND METHODS

Investigation was conducted on the variety Žutica in an experimental olive grove at the Center for Subtropical Cultures in Bar during a three-year period (2004-2006). The main characteristics of Žutica variety are small fruits, high oil content in fruits and early ripening. Population dynamics of the pre-imaginal stages and fruit infestation were monitored from the beginning of July until the end of October. In that period, 40 fruits per sample were collected weekly from four different trees and examined in the laboratory under stereomicroscope. The following parameters were determined: number of eggs, larval instars (L1, L2 and L3), pupae, empty coccons and abandoned galleries in fruit.

Mean daily temperature (°C) and precipitation (mm) were also monitored during this trial. Meteorological data used in the paper were obtained from the Republican Hydrometeorological Service, Bar Center, about 500 m away from the experimental grove.

RESULTS AND DISCUSSION

On the Montenegrian seaside, *B. oleae* overwinters as pupae in soil and adults in treetops in olive groves. Eclosion of overwintering pupae occurs at the end of March and the beginning of April. New adults, as well as overwintering adults, are not able to continue reproduction before olive fruits have become attractive for oviposition. It usually occurs at the end of June and the beginning of July. High temperatures at the beginning of July are limiting for olive fly development, particularly for eggs and L1 larvae The beginning of infestation in all three years was detected at the end of July.

In 2004, the first L1 larvae were found on 27th July, which was considered as the beginning of infestation (Table 1). First instar larvae were present in the first decade of August and first pupae were detected on 17th August. During July and August, the level of fruit infestation was below 5%. Low infestation level (14.4%) continued into the first and second decades of September, and it increased to 37.5% in the third decade. Infestation increased rapidly in October, reaching 97.5%. The highest number of eggs was recorded on 28th September (25 in total), and the highest number of L1 larvae (102 in total) seven days later. A maximum number of L2 and L3 larvae was recorded on 12th October, when the first abandoned galleries were found. The number of pupae, empty coccons and abandoned galleries highly increased in the second half of October, and peaked on 26th October (28 pupae, 12 empty coccons and 80 abandoned galleries).

Development and reproductive ability of olive fruit fly are highly affected by environmental conditions. Temperature is one of abiotic factors that regulate olive fly abundance. High temperatures affect younger developmental stages. Temperatures limiting the development of young stages (eggs, larvae) are 9-11°C (minimum) and 31-33°C (maximum). Mean daily temperatures above 30°C can destroy up to 80% of eggs and L1 larvae. The optimal temperature for pupal development is 22-25°C (Lopez-Villalta, 1999), while a temperature of -10°C persisting for 48 hours causes devastation of up to 95% of pupae in soil (Pucci et al., 1982).

Air humidity is also important for development of the fly's pre-imaginal stages, particularly when it is combined with high temperature over long periods. Olive fruits then lose their moisture, which makes survival of the pre-imaginal stages difficult, and shriveled fruits are not suitable for oviposition. Temperatures ranging from 20 to 26°C and monthly precipitation of 100 mm in July, August and September are favorable for development of all stages of olive fruit fly, while high summer temperatures and drought usually limit and delay population increase of *B. oleae* (Ricci et Ballatori, 1982).

Mean daily temperatures, precipitation and levels of fruit infestation in 2004 are shown in Figure 1. Low infestation in September was a consequence of high temperatures and drought in the period from 14th August to 20th September. After the first abundant rainfalls in the third decade of September, the level of infestation increased rapidly.

Table 1. Dynamics of pre-imaginal stages of *B. oleae* and level of fruit infestation (%) in 2004

Data	Eggs	L1	L2	L3	Pupae	Empty coccons	Abandoned galleries	Infestation (%)
06. VII	0	0	0	0	0	0	0	0.0
13. VII	0	0	0	0	0	0	0	0.0
20. VII	0	0	0	0	0	0	0	0.0
27. VII	0	5	0	0	0	0	0	3.2
02. VIII	0	2	0	0	0	0	0	1.2
09. VIII	0	2	0	0	0	0	0	1.2
17. VIII	0	0	0	0	2	0	0	1.2
24. VIII	0	0	0	0	0	0	0	0.0
31. VIII	0	0	0	0	0	2	0	1.2
07. IX	0	2	0	3	2	0	0	4.4
14. IX	2	2	0	0	15	4	0	14.4
21. IX	9	3	0	7	4	0	0	14.4
28. IX	25	21	4	0	3	7	0	37.5
05. X	7	102	5	5	2	6	0	79.4
12. X	0	55	32	34	9	3	14	91.9
19. X	0	7	18	13	16	4	78	85.0
26. X	0	5	26	5	28	12	80	97.5

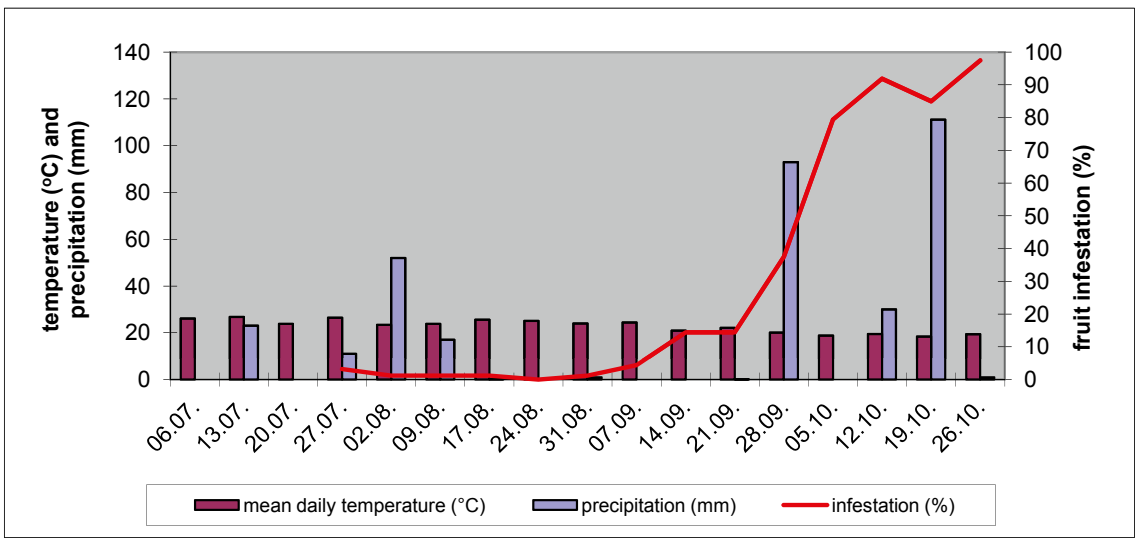

Figure 1. Level of fruit infestation (%) and meteorological data in 2004

In 2005, infestation began on 26th July when first eggs were found (Table 2). The level of infestation was low (up to 5%) until the middle of August. From the end of August it gradually increased and reached 38.7% by the end of September. All developmental stages of the pest were equally present in infested fruits from the beginning of September. The first abandoned galleries were recorded on 30th August. Infestation in October was high, as much as 49.4-78.4%. The number of pupae, empty coccons and abandoned galleries was the highest in this period also.

Table 2. Dynamics of pre-imaginal stages of *B. oleae* and level of fruit infestation (%) in 2005

Data	Eggs	L1	L2	L3	Pupae	Empty coccons	Abandoned galleries	Infestation (%)
06. VII	0	0	0	0	0	0	0	0.0
14. VII	0	0	0	0	0	0	0	0.0
20. VII	0	0	0	0	0	0	0	0.0
26. VII	1	0	0	0	0	0	0	3.2
02. VIII	0	2	2	0	0	0	0	5.0
09. VIII	0	0	1	0	0	0	0	1.2
16. VIII	1	0	0	0	0	0	0	1.2
23. VIII	0	0	0	0	0	0	0	1.2
30. VIII	2	6	0	0	1	2	1	7.5
06. IX	4	3	5	1	0	4	1	10.6
13. IX	14	11	3	0	3	1	0	20.0
20. IX	0	4	8	12	5	1	6	23.9
27. IX	5	11	3	3	26	4	10	38.7
04. X	12	13	6	1	36	9	10	54.4
11. X	5	23	10	6	20	7	8	49.4
18. X	4	23	8	8	25	30	28	78.4
01. XI	3	11	4	17	12	12	53	70.0

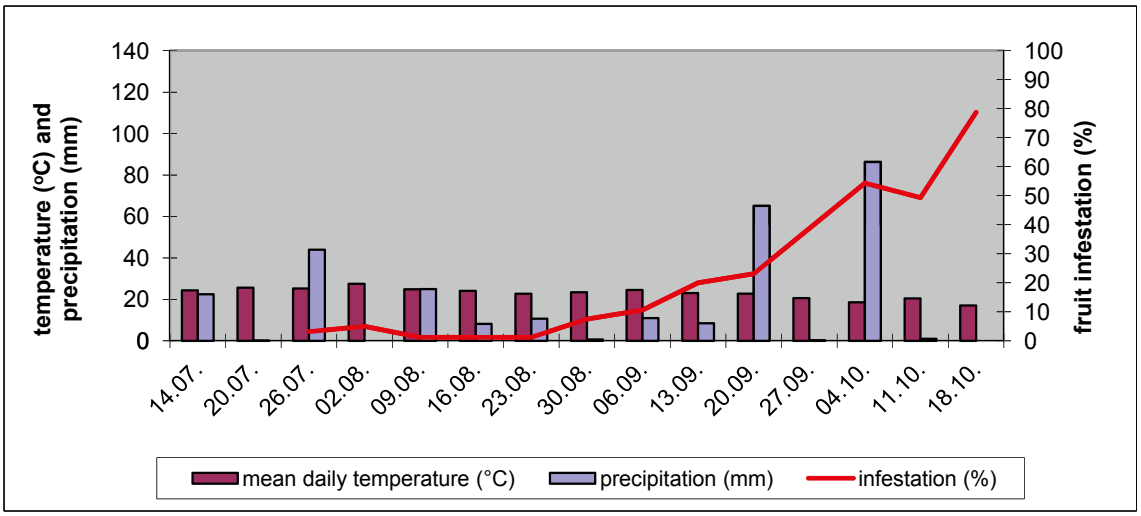

Figure 2. Level of fruit infestation (%) and meteorological data in 2005

Low infestation in 2005, below 25% until the middle of September, was a consequence of unfavorable environmental conditions for olive fruit fly development, such as high temperatures and monthly precipitation below 100 mm (Figure 2). After the first abundant rainfalls at the end of September, the level of infestation increased rapidly.

In 2006, first eggs and L1 larvae were detected on 2nd August, which was considered the beginning of infestation (Table 3). The first oviposition maximum was reached seven days later. Infestation level was low during August, below 10%. The second oviposition maximum was on 30th August, and the third on 20th September. At the beginning of September, infestation was 38.1%. From 5th to 13th September infestation stagnated, but started increasing from mid-September and reached maximum (99.4%) by the end of October. The highest number of L1 and L2 larvae was found on 27th September, and L3 seven days later. The number of pupae, empty coccons and abandoned galleries highly increased during October. The first abandoned galleries were registered on 6th September and they were constantly present until the harvest.

Table 3. Dynamics of pre-imaginal stages of *B. oleae* and level of fruit infestation (%) in 2006

Data	Eggs	L1	L2	L3	Pupae	Empty coccons	Abandoned galleries	Infestation (%)
06. VII	0	0	0	0	0	0	0	0.0
13. VII	0	0	0	0	0	0	0	0.0
19. VII	0	0	0	0	0	0	0	0.0
26. VII	0	0	0	0	0	0	0	0.0
02. VIII	1	1	0	0	0	0	0	1.3
09. VIII	4	1	0	0	0	0	0	6.3
15. VIII	2	4	0	5	3	0	1	9.4
23. VIII	0	3	2	1	2	1	0	6.3
30. VIII	17	17	0	0	0	0	0	25.0
05. IX	7	25	19	0	1	6	1	38.1
13. IX	2	3	9	14	22	6	6	38.8
20. IX	21	28	6	3	42	8	9	71.9
27. IX	0	39	48	5	23	9	19	89.4
04. X	0	11	6	30	35	33	30	91.9
11. X	0	6	12	6	65	20	50	99.4
18. X	0	7	5	4	73	23	41	95.6
25. X	3	5	3	5	57	39	47	99.4

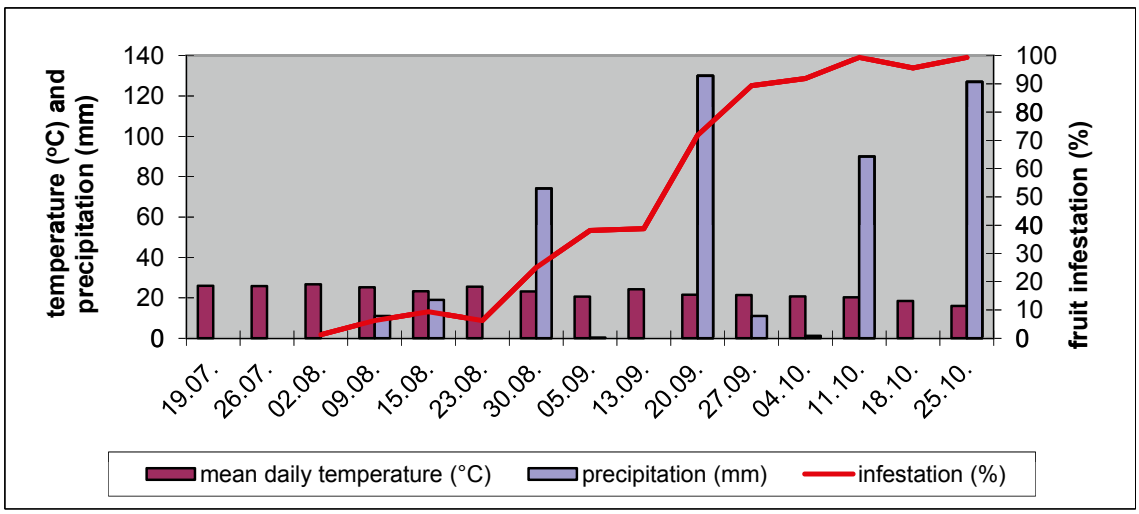

Figure 3. Level of fruit infestation (%) and meteorological data in 2006

In 2006, enviromental conditions also highly affected the level of fruit infestation.

Infestation began in the first days of August, i.e. a week later than in the previous two years, and it was caused by high temperatures and insufficient precipitation in July (Figure 3). After the first abundant rainfalls at the end of August, infestation increased rapidly.

The results of our three-year investigation showed that infestation began at the end of July. By the end of August, depending on environmental conditions, the level of fruit infestation reached 5-20%. In September and October, infestation multiplied, with an exception occurring in September 2004 when it was below 20%, as a result of drought, which lasted from 10th August until 20th September. In all three years of investigation, infestation exceeded 75% by the end of October. Our results showed that the developmental cycle of olive fruit fly in Montenegro corresponds to its cycle in other Mediterranean countries with similar enviromental conditions: Croatia (Škarica et al., 1996; Kotlar et Bičak, 2005), Slovenia (Podgornik et al., 2007, 2008), Central Italy (Spanedda et Terrosi, 2004) and Greece (Basilios et al., 2002).

In infestation structure, eggs and L1 larvae were dominant until the middle of September. From mid-September until mid-October, all developmental stages of the pest (eggs, larvae and pupae) were equally present in infested fruits, while pupae, empty coccons and abandoned galleries prevailed in the period until the harvest. In 2004, the first abandoned galleries were found on 20th October, in contrast to 2005 and 2006 when they were already present in September. This leads to an assumption that the warm autumn of 2004 gave larvae no signal of an approaching overwintering period, so that a majority of population continued development into the adult stage. Flight period lasted until the middle of January 2005 and it caused a population reduction that year. A similar phenomenon was reported by Spanedda and Terrosi (2004) in Central Italy, where the last generation of *B. oleae* in 2002 continued developing, so that the adult stage overwintered instead of the usual pupal stage. Adult population was completely destroyed by low winter temperatures, which caused an absence of infestation in the following year in spite of favorable enviromental conditions for pest development and many fruits.

In the observed three-year period, the highest infestation level was in 2006 (100%) and the lowest in 2005 (79%).

REFERENCES

Basilios, E., Pantazi-Mazomenou, A., & Stefanou, D. (2002). Attract and kill of the olive fruit fly Bactrocera oleae in Greece as a part of an integrated control system. *IOBC/wprs Bulletin*, 25(9), 137-146.

Hrnčić, S., Pucci, C., Spanedda, A.F., Terrosi, A., Perović, T., Lazović, B., & Adakalić, M. (2007). Application of forecasting models of olive fly (*Bactrocera oleae* Gmel.) (Diptera, Tephritidae) infestation in Montenegro. *IOBC/wprs Bulletin*, 30(9), 285-288.

Kotlar, A., & Bičak, L. (2005). Dinamika leta maslinine muhe Bactrocera Cacus oleae Rossi na području Dubrovačko-neretvanske županije. *Pomologia Croatica*, 11(1), 53-67.

Lopez-Villalta, M.C. (1999). Olive pest and disease management. In: *Proceedings International Olive Oil Council*, Madrid, Spain, pp. 23.

Mijušković, M. (1955). Ogledi suzbijanja maslinine mušice parationskim sredstvima na Crnogorskom primorju. *Zaštita bilja*, 31, 45-49.

Mijušković, M. (1999). Bolesti i štetočine suptropskih voćaka. Univerzitet Crne Gore, Biotehnički institut, Podgorica, Crna Gora.

Mijušković, M., & Mirčetić, S. (1957). Mogućnost suzbijanja maslinine mušice parationskim sredstvima. *Zaštita bilja*, 39(40), 23-42.

Perović, T., Hrnčić, S., Spanedda, A.F., Terrosi, A., Pucci, C., Lazović, B., & Adakalić, M. (2007). Control trials of *Batrocera oleae* (Gmel) (Diptera Tephritidae) in the district of Bar in Montenegro. *IOBC/wprs Bulletin*, 30(9), 153-158.

Perović, T., Hrnčić, S., & Inđić, D. (2009). Flight dynamics of olive fly *Bactocera oleae* (Gmel.) (Diptera, Tephritidae) in the region of Bar. *Pomologia Croatica*, 15(3-4), 77-86.

Podgornik, M., Bandelj-Masvar, D., Jančar, M., Bučar-Miklavčić, M., & Tomassone, D. (2007). Nova metoda spremljanja pojava oljčne muhe (*Bactrocera oleae* L.) v Slovenski Istri v okviru projekta SIGMA. In *Interreg IIIA. Izvlečki referatov 8. slovenskega posvetovanja o varstvu rastlin*, Radenci, Slovenia, pp. 70-78.

Podgornik, M., Tomažić, I., Jančar, M., Miklavčić, B.M., & Masvar, B.D. (2008). Oljčna muha v slovenski Istri (*Bactrocera oleae* Gmelin). In *Zbornik referatov 2. slovenskega sadjerskega kongresa z mednarodno udeležbo*, Krško, Slovenia, pp. 169-174.

Pucci, C., Forcina, A., & Salmistraro, D. (1982). Incidenza della temperatura sulla mortalita degli stadi preimmaginali, sull impupamento all interno delle drupe e sull attivita dei parassiti del *Dacus oleae* (Gmel). *Frustula Entomologica*, nuova serie, 4, 143-155.

Ricci, C., & Ballatori, E. (1982). Dinamica di popolazione degli adulti di *Dacus oleae* (Gmel.) Secondo incontro sul *Dacus olea* (Gmel.), Perugia. *Frustula Entomologica*, nuova serie, 4, 45-75.

Spanedda, A.F., & Terrosi, A. (2004). Population dynamics of *Bactrocera oleae* adults in Central Italy. V International Symposium on Olive Growing. *Acta Horticulturae*, 791, 611-618.

Škarica, B., Žužić, I., & Bonifačić, M. (1996). *Maslina i maslinovo ulje visoke kakvoće u Hrvatskoj*. Tipograf, Rijeka, Hrvatska.

Dinamika populacije predimaginalnih stadijuma muve masline *Bactrocera oleae* Gmel. (Diptera, Tephritidae) na području Bara

REZIME

Najveće štete u proizvodnji maslina i maslinovog ulja pričinjava muva masline. Štete se ogledaju u smanjenju prinosa usljed prijevremenog otpadanja ploda, ali i u smanjenju kvaliteta maslinovog ulja i proizvoda od masline. O biologiji *Bactrocera oleae* u Crnoj Gori malo je podataka. Saznanja o razvojnom ciklusu ove štetočine doprinijela bi optimizaciji vremena primjene insekticida a time i boljoj zaštiti ploda, te smanjenju štetnih efekta na životnu sredinu.

Istraživanja su sprovedena u zasadu masline sorte žutica u Baru, u trogodišnjem periodu. Dinamika populacije predimaginalnih stadijuma i nivo infestacije ploda praćeni su od početka jula do kraja oktobra.

Početak infestacije u sve tri godine istraživanja konstatovan je krajem jula. Do kraja avgusta, zavisno od uslova sredine, infestacija je niska. U septembru i oktobru višestruko se povećava i najveća je krajem oktobra.

U strukturi infestacije do sredine septembra dominiraju jaja i larve (L1). Od sredine septembra do sredine oktobra prisustvo svih razvojnih stadijuma (jaje, larva, lutka) štetočine u plodovima je ujednačeno, nakon čega preovladavaju lutke, lutkine košuljice i napuštene galerije.

Ključne reči: Muva masline; predimaginalni stadijum; infestacija