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IZVORNI ZNANSTVENI ČLANCI **ORIGINAL SCIENTIFIC PAPER**

FAUNA OF THE CETONIID BEETLES (Coleoptera: Cetoniidae) AND THEIR DAMAGES ON PEACH FRUITS IN ORCHARDS OF NORTHERN DALMATIA, CROATIA

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The beetles *Cetonia aurata* and *Potosia cuprea* belonging to the subfamily Cetoniinae (Coleoptera: Cetoniidae) are present in peach orchards in Northern Dalmatia, Ravni kotari region. They are often described as flower pest ("Rose chafers, flower beetles"), and are thought not to be significant as fruit pests. However, during the last ten years some serious damage to fruit has been observed. Since this damage occurs when the fruits are ripening, insecticides cannot be used. There are no literature data about the amount of the damage or how to monitor the damage. This paper describes our monitoring of the population dynamics of the *Cetonia aurata* and *Potosia cuprea*, and the method for calculating the damage to fruit suitable for the orchards in this area. The study was conducted during the spring and summer of the year 2005, 2006 and 2007 in the Ravni kotari region, near the villages of Prkos and Smilčić. We used Csalomon® VARb3k funnel traps. We took into consideration the population dynamics of the *Cetonia aurata* and *Potosia cuprea*, the determination of the other trapped members of the subfamily Cetoniinae, as well as the damage percentage of each cultivar.

Cetoniidae, *Cetonia aurata, Potosia cuprea, Tropinota hirta, Oxythyrea funesta*, peaches, population dynamics, and attractant traps

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Kukci *Cetonia aurata* i *Potosia cuprea* (zlatne mare) pripadaju potporodici Cetoniinae (Coleoptera: Cetoniidae), prisutni su u voćnjacima breskve

i nektarine na području Ravnih kotara. U literaturi se najčešće opisuju kao štetnici cvijeta, što potvrđuje i naziv na engleskom jeziku ("Rose chafers, flower beetles"), a navodi se da mogu uzrokovati i neznatne štete na plodovima. Ipak, tijekom posljednih desetak godina uočeno je da u pojedinim godinama mogu uzrokovati i ozbiljnije štete na plodovima breskve i nektarine. Budući da te štete nastaju u vrijeme dozrijevanja ploda, nikako se ne mogu primijeniti insekticidi. Literatura ne spominje gotovo nikakve podatke o veličini šteta ni o načinu praćenja i izračuna šteta. U ovom istraživanju obuhvatili smo utvrđivanje dinamike populacije zlatnih mara te osmislili i u praksi primijenili vlastitu metodu praćenja i izračuna šteta na plodovima pogodnu za voćnjake ovog područja. Istraživanje je provedeno tijekom proljeća i ljeta 2005., 2006. i 2007. godine na području Ravnih kotara, na lokalitetu Prkos i dijelom na lokalitetu Smilčić. Dinamika populacije zlatnih mara utvrđena je s pomoću lovki s atraktantom Csalomon® VARb3k. U radu je prikazana dinamika populacije vrsta *Cetonia aurata* i *Potosia cuprea*, analiza ulova ostalih pripadnika potporodice Cetoniinae te prikaz šteta po sortama.

Cetoniidae, *Cetonia aurata, Potosia cuprea, Tropinota hirta, Oxythyrea funesta*, breskve, dinamika populacije, lovke

Introduction

The beetles *Cetonia aurata* and *Potosia cuprea* belong to the subfamily Cetoniinae (family Cetoniidae, superfamily Scarabaeoidea). They are present in peach orchards of northern Dalmatia in great number. This also shows the ecological diversity, which is very well preserved in this area.

The Croatian literature data about these beetles are quite poor. They have been commonly mentioned as beetles that are often present in peach orchards, but always with a remark that they cause some damages. They are described as beetles attracted to flowers that also appear on ripe fruit. Miksic (1965), one of the great European scarabeologists, describes them as a heliophylic beetles that are present on flowers, ripe fruit and sweet plant sap.

There are few species belonging to the subfamily Cetoniinae (flower beetles) that can be found in orchards, and they show a tendency to diminish because of the specialization in agricultural production and the renewal of the old and neglected orchards, while they show an increase in the edges of the agricultural areas and in the forests.

The species that can be found are primarily those that are less specialised and do not depend much on environmental conditions, so they adapt themselves to different biotopes. Among these, the most important are *Cetonia aurata au-*

rata (L., 1758), *Potosia cuprea obscura* (Andersch, 1797), *Tropinota hirta hirta* (Poda, 1761) and *Oxythyrea funesta* (Poda, 1761). Baraud (1992) even mentions *Cetonischema speciosissima* (Scòpoli, 1786) as a species quite common in orchards of the Balkans, while it is in Italy species typical of the older forests (Dutto, 2005, 2007).

Their biology differs and depends on the species: some complete their development in a few months, while others need more than a year. The eggs are laid in substrates rich with organic matter of rotten vegetation origin. The larvae of the melolonthoid type, with the phytosaprophagous or xilosaprophagous trophic regime, go through three stages before they finish their metamorphosis in the pupa. The metamorphosis in the pupal stage takes place in a small cell built in the soil which is made by the last larval instar and consists of excrements and amalgamated substrate (Dutto, 2005, 2007). The different climate and substrate conditions, of course, affect the development time. The adults are typical termophiles and are more or less specialised in their trophic regime, which is almost always however based on liquids and substances with a high content of sugar. The trophic recourse of Cetoniidae can be represented by pollen which contains around 37% of sugar (Contessi, 2004), nectar, plant sap which comes out of the cortex injuries, mature fruits, honey and honey dew (Paulian & Baraud, 1982).

The Cetoniid beetles are also known as fig pests, but almost without any economical importance.

In the agricultural sense some Cetoniid species become pests. This can happen in the cases of progradation or ambient alternations such as early springs, drought periods or the presence of uncultivated areas close to orchards.

The damage in orchards and vineyards caused by Cetoniid species can be observed at the following phenological stages: (i) bud germination, (ii) flowering, (iii) immature fruit and (iv) mature fruit.

The flower beetles posses a mouth apparatus that is not very sclerified and is not adapted for penetration of resistant plant tissue. We can say with certainty that damage on flowers are not caused by mouth apparatus but by the devastating activity of the dentate tibiae, which causes slitting of the floral organs until they are destroyed, especially when a number of beetles are present on the flower, which leads to a intraspecific competition (Viggiani, 1926, Tremblay, 2000). The damage to fruit and to young vegetative parts on the other hand, are always strongly connected with the erosive action of the mouth apparatus (Jannone, 1947).

However, concerning fruit damage, it is important to mention the wasps (*Vespa crabro* and *Vespula* ssp.) that can start or open the wound to fruit and thus make a direction for *Cetonia / Potosia* or that can aggravate a wound already started by *Cetonia* and *Potosia*.

Jannone (1947) mentions the damage caused by *Tropinota* and *Oxythyrea* to the fruit of the almond (*Prunus amygdalus*), the peach (*Prunus persica*) and lupine plant stems (*Lupinus* sp.). Geunnelon (1959) and Sherief et al. (2003) report on the damage caused by the same species to apple flowers (*Malus communis*).

Oxythyrea and *Tropinota* attacks to the flowers and fruits of sweet cherry (*Prunus avium*) are reported (Kutinkova et al., 2004), to citruses (*Citrus* spp.) (Cutuli et al., 1985), caraway (*Carum carvi*) (Hussein, 2002) and on strawberry (*Fragaria vesca*).

Damage to grape buds caused by *Tropinota squalida squalida* (Scòpoli, 1763) in Sardinia are reported by Ortu et al. (2001, 2003).

None of the above mentioned authors list *C. aurata aurata* and *P. cuprea* as culprits for the damage, as primary pests. However, damage caused by *C. aurata* has been observed in Piemonte (Italy) in 1993 on mature peach fruit (Dutto obs. Pers.). Toth et. al. (2005) report the damage caused by *C. aurata* and *P. cuprea* to peach fruit as a possible serious problem in Hungary. The latest monitoring was conducted in Croatia (Ražov et al. 2008), where the damage percentage to peach and nectarine fruits caused by *Cetonia aurata* and *Potosia cuprea* was registered from 0 up to 7%.

These beetles cannot be efficiently suppressed with insecticides because they are very resistant. Most insecticides cannot be applied during flowering without affecting honeybees, bumblebees or other beneficial species. Also, almost no insecticide can be applied during the ripening period because of the waiting period of the insecticide.

The aim of this research was to find out the population dynamics of *Cetonia auratra* and *Potosia cuprea*, and the exact damage to the fruits that they made during a three year period. The results should discover weather it is possible to monitor the beetles and to control the damage with the attractant traps.

Materials and Methods

Locations

The monitoring of the Cetoniinae beetles was conducted during the spring and summer of the years 2005, 2006 and 2007 on 3 locations in North Dalmatia,

in the vicinity of Zadar. This area is a coastal part, 50 km from the sea toward the north east named Ravni kotari. The area is mostly flat, very suitable for agriculture and with a very long tradition in orchard and vegetable production.

The first location was a peach orchard near Prkos village – Prkos 1, where monitoring and damage analysis were conducted in the 2005 – 2007 period. Total surface of the orchard was 0.25 ha with the following cultivars: peaches May Crest, Glohaven, Suncrest and nectarines Caldesi 2000, Maria Aurelia. The rootstock is GF 677. The second location was a peach orchard near Smilčić village, where the monitoring was conducted in 2005. Total surface of the orchard was 0.26 ha, with the following nectarine cultivars: Spring Red, Stark Redgold, Maria Aurelia, Venus. The rootstock is also GF 677. The third part of the trial, which refers to the damage analysis, was conducted also in the other peach orchards near Prkos village –Prkos 2, in the 2005 – 2007 period. This orchard was some 250 m away from the orchard with the traps. This orchard served as a control orchard. The cultivars are unknown, but the ripening time took place about July 15 – 20, which is 7 – 10 days later than the Red Haven cultivars which are considered to be standard cultivars in peach production in Ravni kotari area (Medin, 1998.). This ripening time suits the ripening time of the Maria Marta cultivars, which are also very well represented in the peach orchards in Ravni kotari.

Traps

We used the Csalomon® VARb3k funnel traps. The trap consist of three major plastic parts: The upper part, trap funnel and bottom container. The upper part is light blue, which is the optimal visual attractant cue for *Cetonia aurata / Potosia cuprea,* and contains a floral attractant bait for *Cetonia/Potosia*. This bait is composed of 100 µl phenethyl alcohol + 100 µl methyl eugenol + 100 µl trans anethol. (Toth et al. 2003; Schmera et al. 2004; Tóth et al. 2005; Vuts et al. 2007). The trap funnel and bottom container are transparent. The beetles are collected in the bottom container, which is made with three small holes Ø3 mm, so that the rain water can leak out.

The traps were set on a sunny place on the peach tree, at about 1.2 – 1.5 m height. We set four traps in Prkos 1. and also four traps in Smilčić. The traps were set 15 m from each other, in different rows.

In the year 2005, we set the traps on June 1, and removed them on August 6. In order to see the life of the bait in these conditions, the same bait was used in the whole monitoring period. In 2006, we set the traps on May 22, and removed

them on September 15. The baits were changed 2 times, on July 4 and August 4. In 2007, we set the traps on May 8, and removed them on August 30. The baits were also changed 2 times, on June 8 and July 6.

Population Dynamics Monitoring

Traps were inspected twice weekly, when captured insects were collected and analysed.

Damage Monitoring

There is no actual method for Cetoninae damage analysis, so we developed our own method suitable for the orchards in this area. Damage was analysed by the following method: We marked 8 trees of each cultivars (peach or nectarine) and checked 25 fruits per tree, 8 fruits from the first branch floor, 9 fruits from the second branch floor and again 8 fruits from the third branch floor, at the time ripening. Each fruit of each cultivar was visually inspected, and if we noticed any damage typical of *Cetonia / Potosia*, we would consider this as one damaged fruit. We counted the damage percentage using the formula:

D = df / af x 100 (%)
D – damage percentage
df – number of damaged fruits
af – number of inspected fruits

All together, at the three locations (Prkos 1– traps, Prkos 2 – control and Smilčić – traps) we checked 8 trees and 200 fruits of each cultivar on the checking date of the cultivars, on the following dates: 2005: June 3, 8 and 28, July 1, 15 and 22, and August 6; 2006: May 27, June 12, July 4, 19 and 23 and August 4; 2007: May 26, June 8, July 2, 11 and 20 and August 8.

Damage Typical for *Cetonia* and *Potosia*

Damage typical of *Cetonia* and *Potosia* looks like a shallow lesion of diameter 0.5 – 2 cm on the surface of the peach or nectarine fruit (up to 1.5 cm) caused by biting. This lesion was made by beetle mandibles (mouth apparatus). In the case of damage started by the beetle, the lesion is not very big, because fruit is not mature yet. If the fruit is quite mature and soft, the lesion can be deeper and bigger. If the damage is caused by a bird, the beak will leave the traces, which are sharper and deeper, and can be clearly distinguished, so this type of damage is not considered.

Results and Discussion

Analysis of Cetoniinae species

The bait was specific for *Cetonia* and *Potosia* species, but also some other insects from the subfamily Cetoniinae were captured; they had found the trap as a shelter, or were just partly attracted.

According to the determination, besides the *C. aurata aurata* and *P. cuprea obscura,* we also found *Tropinata hirta hirta* and *Oxythyrea funesta*.

Population Dynamics

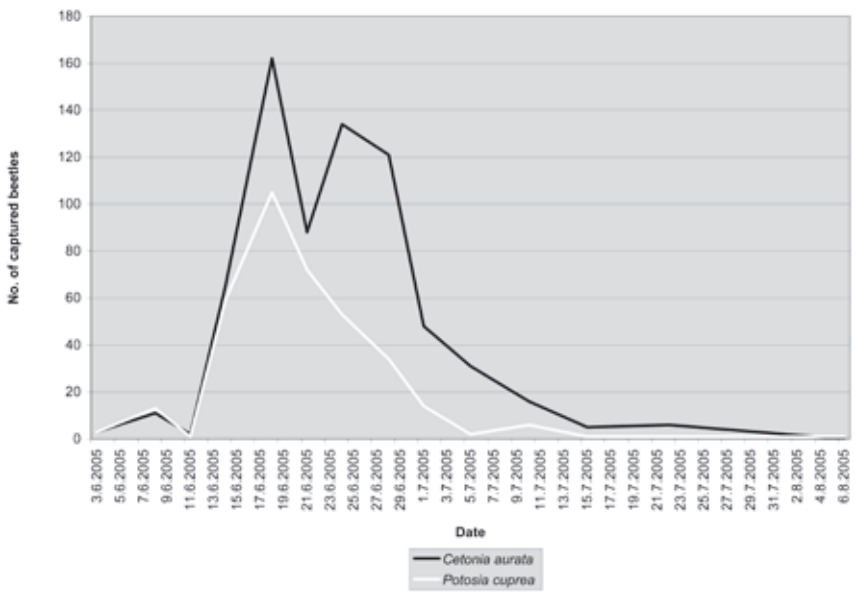

Figure 1. Population Dynamics Prkos 2005

The monitoring period was 66 days in 2005, (Figure 1) 116 days in 2006, (Figure 2) and 114 days in 2007 (Figure 3). Every year in Prkos 1 we observed the first trapped beetles right after the trap setting. Although this could show that the beetles appeared even earlier than the traps were set, and that the traps should have been set earlier, the small number of trapped beetles at the beginning shows that obviously these were one of the first specimens. In 2005, the number of tra-

pped beetles rose progressively until the June 18, when we observed the biggest catch – 162 specimens of *C. aurata* and 105 specimens of *P. cuprea.* In the next check we observed a decrease, and then an increase again by June 24 and 28. After that date there was a decrease again until the July 22, when we captured the last specimens of *C. aurata* and August 6 when we captured the last specimens of *P. cuprea*. Concerning *C. aurata* in Prkos orchard, two peaks can be observed, and only one peak concerning *P. cuprea*. However, both diagrams are parabolic shaped. The total catch in 2005 in Prkos 1 was 692 specimens of *C. aurata* and 365 specimens of *P. cuprea*. We noticed quite irregular catches in 2006 (Figure 2). The total number of trapped beetles was quite small compared to the previous year. The dynamic diagram is sinusoid shaped. The total number of trapped beetles was 30 specimens of *C. aurata* and 49 specimens of *P. cuprea*. The last specimens of *C. aurata* were noticed on July 23, and of *P. cuprea* on September 5. In 2007 we noticed again the first catches right after the trap setting, with a rise until June 12 when we observed the biggest catches of *C. aurata* – 104, with one more peak on June 19 with the catch of 101 specimens (Figure 3). Concerning *P. cuprea*, the peak was reached on June 12 with the catch of 44 specimens. The last

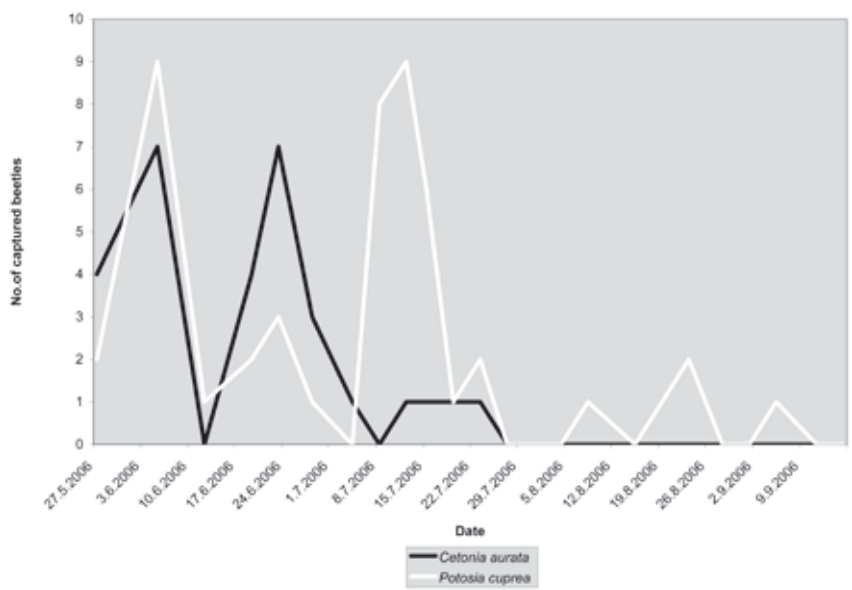

Figure 2. Population Dynamics Prkos 2006

specimens of *C. aurata* were noticed on July 20, and *P. cuprea* on August 3. The total number of trapped beetles was 523 specimens of *C. aurata* and 189 specimens of *P. cuprea*. The dynamic diagram is parabolic shaped again.

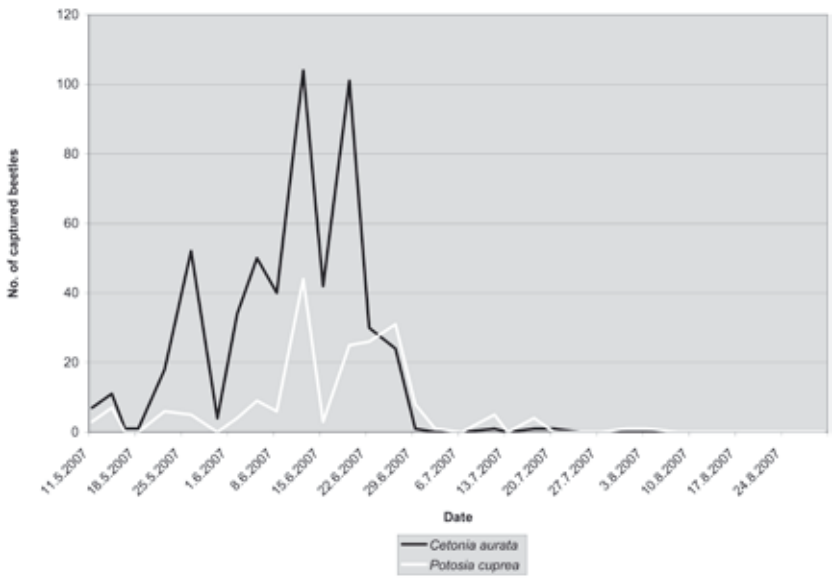

Figure 3. Population Dynamics Prkos 2007

In Smilčić in 2005, there was a different situation (Figure 4). Although it was a similar location – a similar sized peach orchard, we captured only a few beetles. We captured the first samples just after the trap settings again, but their appearance was quite irregular with a sinusoid shaped diagram. The biggest catches were only 4 specimens of *C. aurata* (June 8) and 3 specimens of *P. cuprea* (June 28). The last *C. aurata* specimens were caught on July 1, and *P. cuprea* on August 6. The total catch in Smilčić was 15 specimens of *C. aurata* and 10 specimens of *P. cuprea*.

All together we captured 1245 specimens of *C. aurata* and 603 specimens of *P. cuprea* in Prkos 1. and 15 specimens of *C. aurata* and 10 specimens of *P. cuprea* in Smilčić. The total number of captured beetles on both locations was 1260 specimens of *C. aurata* and 613 specimens of *P. cuprea*.

Concerning the other members of the Cetoniinae subfamily, in Prkos 1 orchard, we found the following Table 1.

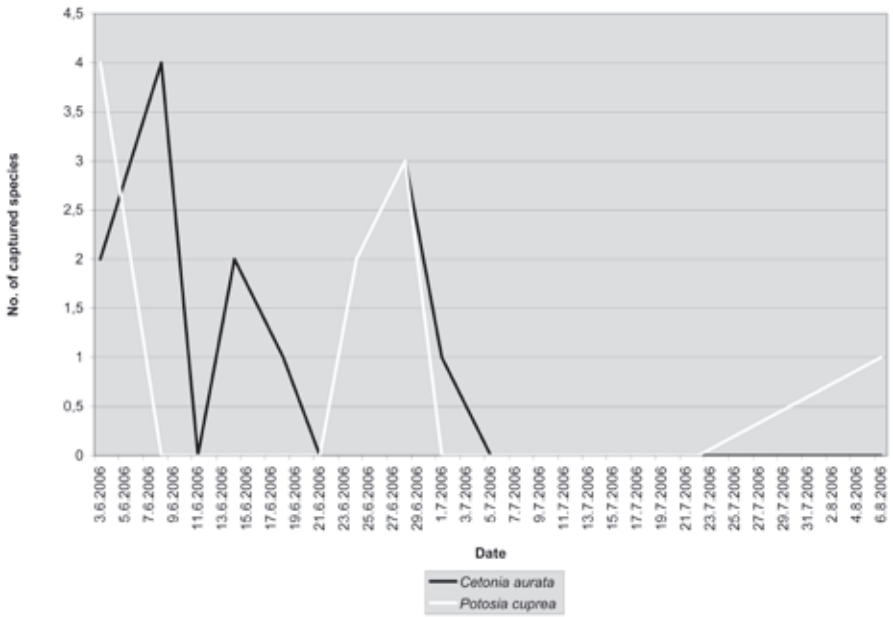

Figure 4. Population Dynamics Smilčić 2005

Table 1. The other species from the Cetoniinae subfamily trapeed in Prkos 1. orchard

		Prkos 1.		Smilčić
Year	Dates	*Tropinota hirta*	*Oxythyrea funesta*	*Tropinota hirta*
2005	8.06.	1	1	1
	21.06.	0	1	0
	28.06.	0	3	0
	1.07.	0	3	0
	5.07.	0	2	0
	10.07.	0	2	0
2006	23.07.	0	1	0
2007	11.05.	2	0	0
	14.05.	5	2	0
	22.05.	1	0	0
	26.05.	3	1	0
	5.06.	1	0	0
	Total	13	16	1

The species that was caught in the largest amount was *Cetonia aurata* (1260 specimens), followed by *Potosia cuprea* (613 specimens), *Oxythyrea funesta* (16 specimens) and *Tropinota hirta* (14 specimens).

For some reason, the total number of all trapped beetles in 2005 was smaller in Smilčić than in Prkos 1. The reason for this is probably due to spraying and the insecticides that were used. There are a few big peach, apple and cherry orchards in the vicinity of Smilčić, where bigger amounts of insecticides are used. Possibly some of these insecticides were broad spectrum (*dimethoat, alfacypermetrine, chlorpyriphos methyl, phosalon*) and this affected the total insect fauna. In the Prkos area there are mostly smaller family-owned peach, apple and sour cherry orchards together with vineyards. Spraying is less used in this area because most of the producers grow their orchards in an extensive way.

Damage Analysis

In 2005, some percentage of damaged fruits occurred in the orchard with the traps in Prkos, and in the control orchard with no traps. There was no damage in Smilčić, which is not surprising since there were not many beetles in the traps (Table 2). In the orchard with the traps in Prkos, the first damage was noticed on June 28, on cultivars Caldesi 2000, when the percentage of the attacked fruits was 1%, and after that on July 1 on the same cultivars, 2%. This was the biggest damage in this orchard that year. On July 15 we noticed 1% damage on the variety Glohaven. There was no damage on the other cultivars (Maycrest, Suncrest and Maria Aurelia). If we take consideration that the peak of rose chafers catch was on June 18 (*Cetonia* and *Potosia*), and then again between June 24 and 28 (*Cetonia*), followed with high number of trapped beetles until July 15, this is the reason for the damage to the cultivars Caldesi 2000 and Glohaven, which ripen in that period.

Table 2. Damaged peach fruits in percentage (%) near Prkos village

Year	Peach orchard with traps (Prkos 1.)	Peach orchard without traps Control (Prkos 2.)
2005	4	9
2006	0	5.5
2007	5	16

In the control orchard (without traps), the first damage was recorded on July 1 (1%). Since peaches ripened between July 15 and 20, the biggest damage was

recorded on July 15 (5%), followed by 3% on July 22. After that date the fruit was harvested. This cultivar ripened some 20 days later than the recorded *Cetonia / Potosia* catch peak in the orchard with the traps that was 250 m away, which means that the attack might have been even bigger if the cultivar in the control orchard had been ripened earlier.

In 2006, there was no damage in the Prkos orchard with the traps, corresponding to the small number of beetles trapped that year. In the control orchard we noticed 2.5 % on July 4 and 3% of damaged fruits on July 19.

In 2007 we observed 3 % damaged fruits of Maycrest on June 8 and 2 % of damaged fruits of Suncrest on July 20. In the control orchard we noticed 8 % of damaged fruits on July 2, which is probably a consequence of the large amount of beetles noticed at the end of June. We also noticed 7 % on July 11 and 1 % on July 20. Considering the catch peaks which took places on July 12 and 19, and the catch amount majority between July 2 and 29, the damage at these ripening dates is understandable.

Although Cetoniid beetles do not represent the primary phytophags, *Cetonia aurata, Potosia cuprea, Oxythyrea funesta, Tropinota hirta* and *T. squalida* can cause locally and economically important damage.

The damage is expressed as smaller production, whether because of bad flower pollination or because of flower abortion, if the damage occurs during the flowering period. Concerning the fruit, there is more damaged fruit that can not be distributed to the market; besides that, in specific cases suberificated spots or deformations may occur, as a consequence of a damaged ovary during the flowering.

Unfortunately, if the damage occurs during the flowering, it is impossible to control the damage or to establish the decision threshold since a lot of flowers will fall because of physiological weakening. Sherief et al. (2003) established the decision threshold for apples, 22% of attacked fruits, while for sweet cherries Kutinkova and Radoslav, (2004) suggest an intervention when 3 – 5 individuals/100 flower rosettes are present, or when 5% of racemes are visibly damaged.

When it comes to the fruits, it is easier to establish the decision threshold because every damaged fruit has to be removed and cannot be sent to the market. It is necessary to make an intervention when 2 – 5 % of damaged fruits are present. Of course, in this case the only things that can be applied are attractant traps.

There is no insecticide that can be applied in this period because flower beetles are very resistant to insecticides, and the fruit has to be harvested.

Conclusions

Monitoring of population beetles *Cetonia aurata* and *Potosia cuprea* from the subfamily Cetoniinae was succesfuly conducted during the spring and summer of the year 2005, 2006 and 2007, on 3 locations in the Zadar vicinity.

Csalomon® VARb3k funnel traps were used for monitoring population dynamic.

Damage to peach fruit caused by Cetoniinae beetles was also analysed.

Attractant traps can be successfully used for monitoring, mass trapping and damage prevention.

Our study shown us that *Cetonia aurata* and *Potosia cuprea* could be a primary pest on peach fruit, causing serious damage.

Members of the subfamily Cetoniinae that have been trapped and determined are *Cetonia aurata, Potosia cuprea, Tropinota hirta* and *Oxythyrea funesta*.

Beetles mass trapping with specific traps and baits could reduce damage to the fruit.

The fruit damage treshold is 2 – 5 % of damaged fruits.

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