

Phenology and suppression of stem weevils (*Ceutorhynchus napi* Gyllenhal and *Ceutorhynchus pallidactylus* Marsham) in oilseed rape in northern Serbia

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SUMMARY

Stem weevils (*Ceutorhynchus pallidactylus* and *Ceutorhynchus napi*) are significant pests of oilseed rape that farmers regularly suppress by insecticide treatments intended against *Brassicoglyphis aeneus*. Recent studies have shown that in some regions of northern Serbia *C. napi* is dominant, while *C. pallidactylus* prevails in others. Increased damage from stem weevils has elicited an exploration of the situation and a study of their phenology and effects of insecticides in three differently managed fields: conventional, organic and integrated. New findings regarding the phenology of stem weevils show that both species were sporadically present in our experimental oilseed rape fields as early as during autumn (from the end of October 2010, BBCH 17-18). The main period of stem weevil settlement is the end of winter and early spring. Maximum flight of both weevil species was recorded on March 23 at the beginning of oilseed rape (OSR) stem elongation (BBCH 22-25), and one week later in the organic field. There were no significant differences in the number of settled weevils among the three differently managed fields. The insecticide treatment against *C. napi* was applied two weeks earlier than the usual treatment against *B. aeneus* and *C. pallidactylus*. Thus, it is clear that insecticide treatment directed against *B. aeneus* and *C. pallidactylus* is not effective against *C. napi*. In this way, such a practice can contribute to an increase in OSR damage, and density of the next generation of *C. napi*. A new generation of *C. pallidactylus* emerged from OSR fields in June 2011, while the majority of *C. napi* emerged in March of the following year.

Keywords: Stem weevils; Oilseed rape; Insecticides; Serbia

INTRODUCTION

Oilseed rape (OSR) stem weevils (*Ceutorhynchus napi* Gyllenhal and *Ceutorhynchus pallidactylus* Marsham) (Coleoptera, Curculionidae) are important pests throughout Europe. Their presence in OSR crops often motivates farmers to apply insecticides. Economic importance of OSR stem weevils is variable in Europe. In northern regions, *C. pallidactylus* is known as the main stem weevil pest, while *C. napi* dominates in south-eastern and central Europe (Williams, 2010). Their phenology and abundance are useful to know in order to achieve effective insecticide application.

The published data on stem weevils in the Pannonian plains (Hungary and northern Serbia) indicate that *C. pallidactylus* is the most abundant and economically very important pest (Marczali et al., 2007; Milovac et al., 2010). However, recent findings suggest that *C. napi* is actually the dominant stem weevil species in some regions (Bozsik, 2010; Sivčev et al., 2015). Although their phenology is similar, their chemical control is sometimes three weeks apart (Büchs, 1998). Therefore, this research aimed to determine the possible cause of *C. napi* domination and provide evidence on potentially changed phenology of *Ceutorhynchus* weevils in commercial oilseed rape fields located in the plain of northern Serbia.

MATERIALS AND METHODS

Experimental site

The trial was set up in northern Serbia (N45 57.280 E19 37.554) on a calcic chernozem soil of loamy texture. The climate is mild continental with total annual precipitation of 926.5 l/m² during 2010, 417.6 l/m² in 2011 and 434.1 l/m² during 2012. The mean annual temperature was 11.3°C in 2010, 11.8°C in 2011, and 12.3°C in 2012, according to data from Palić meteorological station (<http://www.hidmet.gov.rs>).

Experimental fields

Three commercial experimental fields (1 ha each) were sown with OSR on September 17, 2010, and with winter wheat (WW) on October 20, 2011 for the following season 2011/2012. These fields had never been planted with oilseed rape before. The OSR fields were managed according to conventional, integrated and organic production requirements. No herbicides,

foliar fungicides or molluscicides were applied in the OSR crop. Monitoring of pests with yellow water traps revealed that only *C. napi* exceeded threshold for insecticide treatment (EPPO, 2003). On March 25, 2011, the conventionally managed OSR field was sprayed with chlorpyrifos + cypermethrin (500 g/ha a.i. + 50 g/ha) and the field with integrated management with cypermethrin (40 g/ha a.i.). The organic field was sprayed with spinosad (96 g/ha a.i.) on April 6, 2011. Standard tractor sprayer with 300 l water/ha was used. The fallow period lasted from OSR harvest on June 21 until October 20, 2011 when WW was sown. The succeeding WW crops received no insecticide treatment and there were no differences in the management system applied in the three fields.

Sampling and identification

Stem weevils were sampled in the middle of each field, at points 50 m apart, using yellow water traps, emergence traps and plant dissection. The collected weevils were identified according to Freude et al. (1983) and Hoffmann (1954).

Yellow water traps

Yellow water traps (YWT) were used to monitor the autumn and spring immigration of adult weevils into the OSR fields. On October 2, 2010 (BBCH 12-13) three YWTs were set in each field and the traps were then checked 4 times until the end of November (BBCH 18-19) (October 20, November 1, November 10, November 30). On January 20 2011, four traps were placed in each field and sampling was performed at 2-4 weeks intervals as convenient. In the spring, sampling continued at 7 days interval until May 15, 2011. The YWTs were placed in the middle of each field, at 50 m distance from each other. The YWTs were mounted on metallic holders and were periodically raised to be always above crop level.

The repeated measures ANOVA was used to compare the mean counts of both weevils settled in each of three differently managed OSR fields, as recorded with YWTs. In order to fulfill the assumption of homogeneity of variances, data on *C. pallidactylus* were log transformed.

Plant dissection

To check the presence of stem weevil larvae, each leaf stalk, stem and plant root was dissected. Ten randomly selected OSR plants were sampled on 8 points from

each field in 2010 and 2011. In 2010, OSR plants were sampled and dissected on November 10, 2010 (BBCH 17-18) and November 30, 2010 (BBCH 18-19). In 2011, OSR plants were sampled and dissected three times: on April 12 (BBCH 55-57), on April 19 at the full flowering stage of OSR (BBCH 63-65), and on May 3 at the end of flowering (BBCH 69-71).

Emergence traps

The emergence of a new generation of stem weevils was monitored using 8 emergence traps (www.ecotech-bonn.de) in each field. The traps were placed at 8 sampling points in the middle of each field at 50 m distance from each other. The sampling period in OSR crops was from the end of flowering until harvest, and continued throughout fallow and the growing period of WW until its harvest. In OSR and WW, traps were checked every 7 to 14 days, while fallow traps were checked at about 4-week intervals.

RESULTS

Immigration of *C. napi* and *C. pallidactylus* into OSR fields

The flight pattern of immigrating *C. napi* and *C. pallidactylus* adults was similar (Table 1). Both species started to immigrate into the OSR fields at the end of October 2010 (BBCH 15-17). The number of autumn immigrating stem weevils caught in YWTs was small. We recorded 11 *C. pallidactylus* and 5 *C. napi* adults in all three fields. Next year, the activity of weevils was detected on February 12 (BBCH 19-20). Later immigration of weevils was interrupted by a spell of cold weather until the second half of March, when mass flight of both species started and reached its maximum on March 23, i.e. at the beginning of stem elongation (BBCH 22-25), and one week later in the organic field. By April 15 (BBCH 55-57), immigration of

Table 1. Mean counts of immigrating *Ceutorhynchus napi* (n=2265) and *Ceutorhynchus pallidactylus* (n=844) weevils in oilseed rape fields managed differently in 2010/2011 and recorded from YWTs at Stari Zednik, Serbia. (Org = organic management; Con = conventional management; Int = integrated management)

| Growth stage | Sampling date | <i>C. napi</i> | | | <i>C. pallidactylus</i> | | |
|--------------|---------------|----------------|------|-------|-------------------------|------|------|
| | | Org | Con | Int | Org | Con | Int |
| BBCH 11-12 | 1.10.10 | 0 | 0 | 0 | 0 | 0 | 0 |
| BBCH 14-15 | 10.10.10 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 20.10.10 | 0 | 0 | 0 | 0 | 1 | 0 |
| BBCH 16-17 | 30.10.10 | 0 | 0 | 0 | 1 | 0 | 0.5 |
| BBCH17-18 | 10.11.10 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 20.11.10 | 0 | 2.0 | 0 | 0 | 0 | 0 |
| BBCH 18-19 | 30.11.10 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 10.12.10 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 20.12.10 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 30.12.10 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 10.1.11 | 0 | 0 | 0 | 0 | 0 | 0 |
| BBCH 19-20 | 20.1.11 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 30.1.11 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 12.2.11 | 2.5 | 6.0 | 4 | 2.5 | 2.8 | 15.8 |
| | 20.2.11 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 28.2.11 | 0 | 0 | 0 | 0 | 0 | 0 |
| BBCH 22-25 | 10.3.11 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 23.3.11 | 22.8 | 96.0 | 142.3 | 72.3 | 28.3 | 32.0 |
| BBCH 50-51 | 30.3.11 | 148.8 | 74.3 | 37.3 | 32.0 | 4.3 | 3.0 |
| BBCH 55-57 | 7.4.11 | 47.3 | 4.0 | 2.0 | 24.0 | 0.7 | 0 |
| BBCH 60-61 | 15.4.11 | 0.0 | 0 | 0 | 0.0 | 0 | 0 |
| BBCH 67-69 | 27.4.11 | 6.0 | 3.0 | 3.5 | 0.0 | 0 | 0 |
| BBCH 71-73 | 4.5.11 | 0.0 | 0 | 0 | 0.0 | 0 | 0 |

C. pallidactylus into the OSR fields finished, while a few more specimens of *C. napi* were found by April 27, 2011 (BBCH 67-69). The counts of immigrating *C. napi* were 2.7 times higher than *C. pallidactylus*.

Infestation of the three differently managed OSR fields with *C. napi* weevils was similar. Mean counts (\pm s.e.) of *C. napi* weevils settled in the conventional (174.75 ± 13.0), integrated (181.75 ± 35.7) and organic (207.00 ± 17.2) fields did not differ significantly ($F(2,6) = 5.12$, $p = .623$). Infestation of the three differently managed OSR fields with *C. pallidactylus* showed a similar pattern. Mean counts (\pm s.e.) of *C. pallidactylus* weevils that settled in the conventional (35.7 ± 12.1), integrated (50.75 ± 14.0) and organic (123.75 ± 28.2) fields were not significantly different ($F(2,6) = 2.737$, $p = .143$).

Male/female ratio of immigrating stem weevils

At the beginning of stem weevil immigration in February (OSR in BBCH 19-20) the percentage of *C. napi* females was 33.3%, while *C. pallidactylus* accounted for 22.5% (Table 2). As soon as stem elongation started, the immigrating weevil population reached its maximum. In the period preceding the peak immigration flight, the percent of *C. napi* females was higher than *C. pallidactylus*. The maximum percentage of *C. napi* females was recorded on March 10-23 (BBCH 22-25) at the peak of immigration flight. In contrast to *C. napi*, the maximum of *C. pallidactylus* female percentage did not coincide with maximum immigration activity of the population. The percentage of *C. pallidactylus* females was gradually increasing and becoming predominant with 78% of the total number of adults at the end of colonization of OSR fields. In contrast to *C. napi*, the share of *C. pallidactylus* females was much greater in the post-peak flight period. The ratio of male/female adults of *C. pallidactylus* collected in YWTs over the complete sampling period January 30-April 7, was 0.8:1, while that of *C. napi* was 1.3:1.

Assessment of stem weevil larvae by dissection of OSR stems and leaf petioles

Dissection of OSR plants sampled in the autumn of 2010 showed that weevil larvae were not present. Weevil larvae were found in OSR plants only in spring 2011, over the period from April 12 (BBCH 19-20) until May 3, 2011 (BBCH 55-71).

The number of weevil larvae in OSR stems (BBCH 63-65) was clearly different from their counts after insecticide treatment (Figure 1). The effective insecticides chlorpyrifos+cypermethrin and cypermethrin significantly reduced the number of stem weevil larvae. However, treatment of the organically managed OSR field with spinosad insecticide was not efficient, since it resulted in infestation of 96.8% of all OSR test plants with an average of 18 larvae/stem (ranging 0-130 larvae/stem). In contrast, the conventionally managed OSR field, which was sprayed with chlorpyrifos+cypermethrin only had 6% of all test OSR plants infested with an average of 1 larva/stem. In the field with integrated management, which was sprayed with cypermethrin, only 2% of OSR stems were infested with one larva/plant on average.

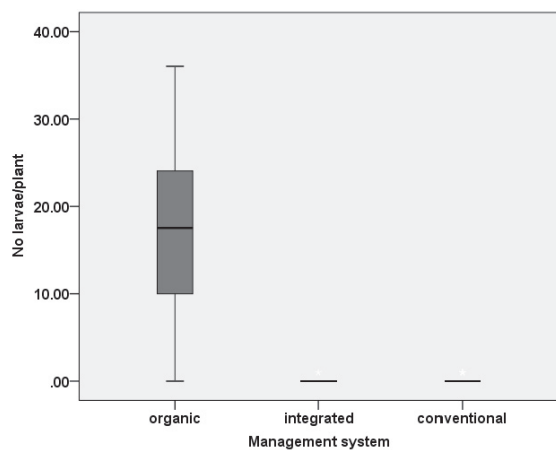


Figure 1. Number of OSR stem weevil larvae in different management systems

Table 2. Percentage of *C. napi* and *C. pallidactylus* females during immigration into OSR fields in 2011 (means for 12 YWTs).

| OSR growth stage | Sampling period | Percentage of ♀ | |
|------------------|-------------------------|-----------------|-------------------------|
| | | <i>C. napi</i> | <i>C. pallidactylus</i> |
| BBCH 19-20 | Jan. 30 - Feb. 12, 2011 | 33.3 | 22.5 |
| BBCH 22-25 | Mar.10 - Mar. 23, 2011 | 47.3 | 41.8 |
| BBCH 50-51 | Mar.23 - Mar. 30, 2011 | 38.8 | 71.0 |
| BBCH 55-57 | Mar.30 - Apr. 7, 2011 | 36.2 | 78.1 |

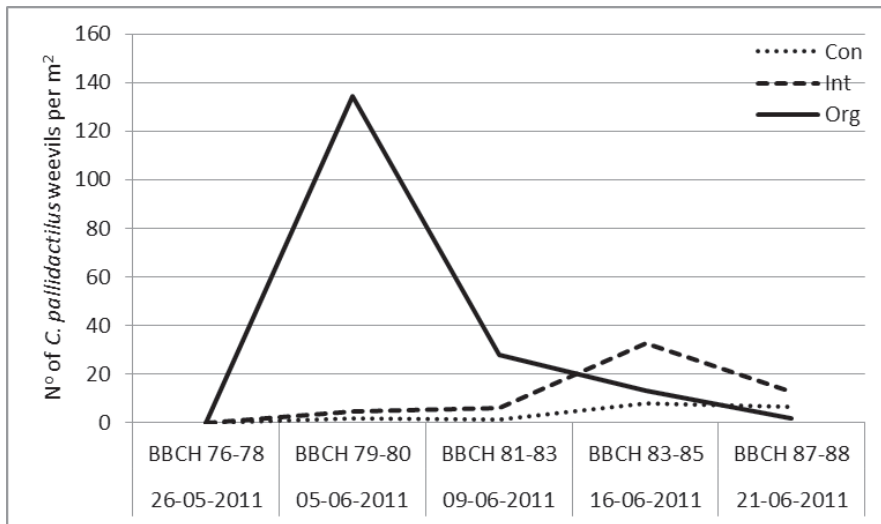


Figure 2. Emergence (specimens/m²) of *C. pallidactylus* weevils in OSR fields at Stari Zednik, 2011. (Mean of 8 emergence traps/field).

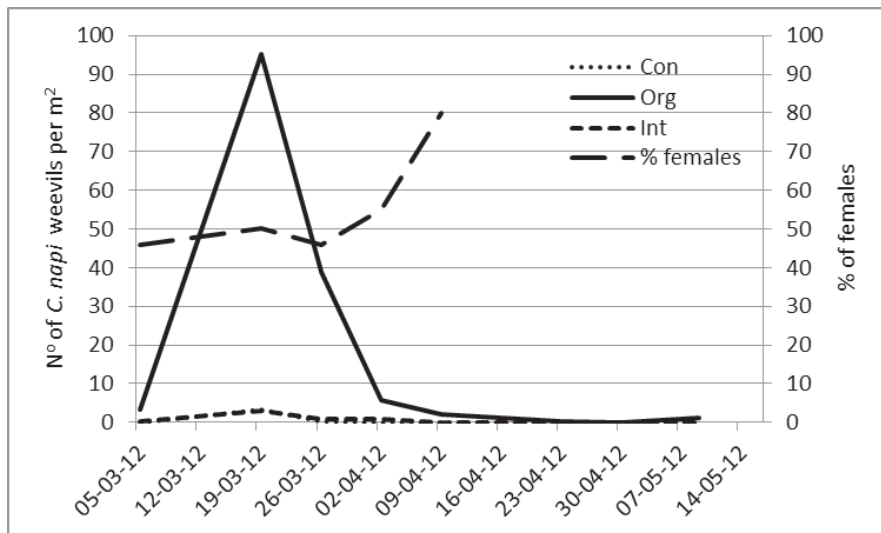


Figure 3. Emergence (specimens/m²) and % of *C. napi* females in WW fields (subsequent crop to OSR) in spring 2012, Stari Zednik. (Mean of 8 emergence traps/field).

Emergence of new stem weevil generation

The emergence of a new generation of *C. pallidactylus* beetles occurred during the OSR ripening stage at the beginning of June (BBCH 79-80), and ended by June 21 (BBCH 87-88) (Figure 2). A total of 177.0 weevils/m² emerged during that period. Over the fallow period in July and August, there were no weevils recorded in the emergence traps. However, one imago of *C. pallidactylus* was recorded on September 9, 2011 and another one on November 14, 2011 in one of the fields with subsequent winter wheat

grown at that time. In the spring of 2012 (March 26), one adult was found in an emergence trap again. The results infer that a great majority of *C. pallidactylus* adults emerged from the OSR fields before harvesting. However, a very small number of adults aestivated in soil of the OSR fields, so that only 3 adults were found in emergence traps in the autumn of 2011 and spring of 2012.

Emergence of the next generation of *C. napi* weevils was recorded in emergence traps located in the subsequent winter wheat crop in the spring of 2012. First adults were recorded in the emergence traps on March 5, 2012 (Figure 3).

Maximum emergence was recorded over the sampling period from March 12 until March 19, 2012. In total, 146.44 weevils/m² emerged in that period. No hatching adults of *C. napi* were noted during the summer and autumn of 2011. The male-to-female ratio of rape stem weevils which emerged during spring 2012 was 1:1.

DISCUSSION

The dominance of *C. napi* found in the study is associated with specific conditions in the region where our research was conducted which allowed such abundance. Insecticides, climate and alternative host plants were the factors potentially responsible for such development.

OSR fields are sprayed with insecticides as soon as in early spring. This treatment primarily targets *B. aeneus* and *Ceutorhynchus* stem weevils, and one treatment is usually sufficient for these most important pests (Williams, 2010). However, *C. napi* is more destructive and insecticides must be applied immediately after its high density is observed. When no monitoring with YWTs is conducted, a delayed insecticide application can miss a significant portion of *C. napi* weevils and the ensuing infestation of OSR fields can therefore increase dramatically. This is probably the most important reason for an increased damage observed in OSR production. Therefore, it is necessary to monitor stem weevil immigration into OSR fields in springtime very carefully in order to enable proper timing of insecticide treatments when the population density exceeds action threshold. In our trial, a single insecticide treatment was sufficient to control *Ceutorhynchus* stem weevils when infestation of OSR buds by *B. aeneus* was not high. However, pollen beetles usually do require a later insecticide treatment at the OSR young bud stage, the period when they are most harmful. Therefore, a shift regarding the dominance and pest status of stem weevils is significant since the timing of *C. napi* and *B. aeneus* control with insecticides can be very different. In our trial the difference in proper timing of control treatment of these two pest species was about 2 weeks.

Application of the “biological” insecticide spinosad under organic management has shown to be ineffective and in this study resulted in 96.8% of infested OSR plants. This is a very high potential for subsequent infestations, and organic production of OSR should consider more effective ways of stem weevil control.

Therefore, the use of ineffective or weakly effective insecticides can result in a buildup of stem weevil population density. Timely application of highly efficient insecticides, such as chlorpyrifos+cypermethrin and cypermethrin (Milovac et al., 2017) therefore has a strong impact on the abundance of these two OSR stem weevils.

Wild and especially cultivated plants of the family *Brassicaceae* are widely distributed in Europe, and oilseed rape is its most prominent crop plant with a production area of about 6 million hectares. Cultivation of oilseed rape in large areas induces mass occurrence of stem weevil populations (Günthart, 1949). In addition, a large number of different brassicaceous weeds are widespread on roadsides, in ruderal habitats or on arable land and they support weevil populations as alternative host plants. *Ceutorhynchinae* are showing preference for brassicaceous ruderal species. Preference for these hosts may explain a considerable number of *Ceutorhynchinae* species damaging cultivated plants (Korotyayev, 2006).

The role of weeds as alternative host plants is frequently neglected in phenology and population studies. *C. napi* and other *Ceutorhynchus* weevils are associated with brassicaceous weeds or arable crops. In years when OSR area declined, *Lepidium draba* L. was the preferred host plant responsible for the survival of weevil populations (Günthart, 1949). In the region in which our research was conducted, *L. draba* is a common and abundant weed. Other widespread brassicaceous weeds in this area are: *Sinapis arvensis* L., *Thlaspi arvense* L. and *Capsella bursa pastoris* (L.) Medik., the preferred plant species for adult feeding.

C. napi was found to be an exceptionally abundant weevil species whose dominance had not been previously recognized in the region. Recently, similar reports have come from climatically similar regions in Hungary and Romania (Bozsik, 2010; Bucur & Roşca, 2011) which caused us to consider the climate as one of the responsible factors for a shift in what we know about weevil abundance. Warmer regions of Central Europe are known as suitable for *C. napi* (Günthart, 1949).

Our findings that first adults of *C. napi* and *C. pallidactylus* immigrated into OSR fields as early as in October/November 2010, when OSR was at the growth stage BBCH 17-19, confirmed the projected earlier weevil emergence and their settlement in OSR fields (Junk et al., 2012). In northern countries, such as Latvia, the first stem weevils are usually recorded at the beginning of April. However, it also coincided with

the oilseed rape growth stage BBCH 18 and onwards (Grantiņa et al., 2011). So far, there have been no records of weevil migration into OSR fields during autumn. In this paper we provided evidence that first migration to OSR fields under warmer climate conditions may happen already during autumn. Considering the aspect of plant pest control, it is important that adaptation to climate changes may vary among different species regarding their range from becoming rare to disproportionately abundant (Putten et al., 2010). Climate change may therefore be expected to lead to a shift regarding the status of pests due to their changing abundance and dispersal.

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Fenologija i suzbijanje stablovnih rilaša (*Ceutorhynchus napi* Gyllenhal i *Ceutorhynchus pallidactylus* Marsham) u uljanoj repici na severu Srbije

REZIME

Ceutorhynchus pallidactylus i *Ceutorhynchus napi* su značajne štetočine uljane repice koje farmeri redovnu suzbijaju insekticidnim tretmanom protiv *Brassicoglyphis aeneus*. Nedavne studije su pokazale da u nekim regionima na severu Srbije dominira *C. napi*, a u drugim regionima *C. pallidactylus*. Povećane štete od stablovnih rilaša ukazale su na potrebu praćenja njihove fenologije, efekata insekticida i uticaj agrotehnike. Utvrđeno je po prvi put da je pojava ovih insekata (*C. napi* i *C. pallidactylus*) na poljima uljane repice već tokom jeseni, od kraja oktobra 2010 (BBCH 17-18). Glavni period kada oni naseljavaju uljanu repicu je tokom kraja zime i na početku proleća. Maksimalni let je zabeležen 23. marta, u vreme izduživanja stabla uljane repice (BBCH 22-25). U odnosu na primenjenu agrotehniku nije bilo značajnih razlika u broju insekata koji su doletali. Registrovan broj doletelih imaga *C. napi* bio je 2,7 puta veći nego *C. pallidactylus*. U skladu sa tim, insekticidni tretman je bio 25. marta 2011. Posledica dominacije *C. napi* je potreba za primenom insekticida oko 2 nedelje ranije u odnosu na termin kada se suzbijaju *B. aeneus* i *C. pallidactylus*. Stoga je jasno da konvencionalna jednokratna primena insekticida za suzbijanje *B. aeneus* nije efikasna protiv *C. napi* i da takva praksa doprinosi tako velikim razlikama u brojnosti ova dva rilaša. Nova generacija *C. pallidactylus* izleće već tokom juna meseca iz zemljišta sa uljanom repicom (BCH 76-88) dok glavina imaga *C. napi* izleće naredne godine u martu mesecu.

Ključne reči: Stablovi rilaši; Uljana repica; Insekticidi, Srbija