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Can Flower chafers be monitored for conservation purpose with odour traps? (Coleoptera: Cetoniidae)

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Abstract

Monitoring is becoming an increasingly important for nature conservation. We tested odour traps for the monitoring of Flower chafers (Cetoniidae). These traps have been designed for eradication or monitoring the beetles in Mediterranean orchards where these beetles can be present in large numbers. Therefore, it is unclear whether these traps can be used to monitor these species in Northern Europe at sites where these species have relatively low population sizes. Odour traps for *Cetonia aurata* Linnaeus, 1761 and *Protaetia cuprea* Fabricius, 1775 were tested in five sites in Belgium and odour traps for *Oxythyrea funesta* Poda, 1761 and *Tropinota hirta* (Poda, 1761) at one site. In total 5 *C. aurata*, 17 *Protaetia metallica* (Herbst, 1782) and 2 *O. funesta* were captured. Furthermore, some more common Cetoniidae were found besides 909 non-Cetoniidae invertebrates. I conclude that the traps are not interesting to monitor *C. aurata* when the species is relatively rare. However, the traps seem to be useful to monitor *P. metallica* and to detect *O. funesta* even if it is present in low numbers. However, it is important to lower the high mortality rate of predominantly honeybee and bumblebees by adapting the trap design.

Keywords: Cetoniidae, monitoring, odour traps, *Cetonia aurata*, *Protaetia metallica*, *Oxythyrea funesta.*

Samenvatting

Monitoring wordt in toenemende mate belangrijk binnen het natuurbehoud. Hier testen we geur vallen voor de monitoring van gouden torren (Cetoniidae). Deze vallen werden ontwikkeld voor het verwijderen of opvolgen van deze kevers in mediterrane boomgaarden waar deze kevers talrijk aanwezig kunnen zijn. Daardoor is het onduidelijk of deze vallen ook gebruikt kunnen worden voor de monitoring van deze soorten in Noord-Europa op plaatsen waar deze soorten relatief lage populatiedichtheden hebben. Geurvallen voor *Cetonia aurata* Linnaeus, 1761 en *Protaetia cuprea* Fabricius, 1775 warden getest in vijf sites in België en geurvallen voor *Oxythyrea funesta* Poda, 1761 en *Tropinota hirta* (Poda, 1761) op één plaats. In totaal werden 5 *C. aurata*, 17 *Protaetia metallica* (Herbst, 1782) en 2 *O. funesta* gevangen. Verder werden een aantal meer algemene Cetoniidae gevangen, naast 909 andere invertebraten. Ik besluit dat de vallen niet interessant zijn voor de monitoring van *C. aurata* wanneer de soort relatief zeldzaam is. De vallen lijken echter bruikbaar voor de monitoring van *P. metallica* en om de aanwezigheid van *O. funesta* vast te stellen zelf wanneer deze slechts in zeer lage aantallen aanwezig is. Het is echter belangrijk om de hoge mortaliteit van voornamelijk honingbijen en hommels te verlagen door de val verder aan te passen.

Résumé

La surveillance des espèces devient de plus en plus importante dans un souci de conservation de la nature. Nous avons testé des pièges olfactifs, habituellement utilisés pour contrôler ou éradiquer des cétoines (Cetoniidae) dans les vergers méditerranéens, afin de savoir s'ils pouvaient être utilisés pour assurer un monitoring des populations de cétoines en Europe du Nord, alors que pour certaines espèces, les populations sont relativement faibles. En Belgique, des pièges olfactifs pour *Cetonia aurata* Linnaeus, 1761 et *Protaetia cuprea* Fabricius, 1775 ont été testés dans cinq sites et des pièges olfactifs pour *Oxythyrea funesta* Poda, 1761 et *Tropinota hirta* (Poda, 1761) dans un site. Au total 5

C. aurata, 17 *Protaetia metallica* et 2 *O. funesta* ont été capturés. Par ailleurs, d'autres Cetoniidae plus fréquents ont été trouvés, ainsi que 909 autres invertébrés. Je conclus que ces pièges ne sont pas intéressants pour surveiller *C. aurata* lorsque l'espèce est relativement rare. Par contre, ils semblent être utiles pour surveiller *P. metallica* et détecter *O. funesta* même si elles sont présentes en faible quantité. Cependant, il serait important de les adapter afin de réduire le taux élevé de mortalité des abeilles solitaires et des bourdons.

Introduction

Monitoring is increasingly accepted as an obligate element of nature conservation within (inter)national conservation policy and legislation, e.g. European habitat directive. Besides habitat monitoring, it is important to monitor a set of species that require particular microhabitat to obtain a reliable trend of the overall biodiversity (e.g. GRIFFITHS *et al*., 1999, CULMSEE *et al*., 2014). Insects are more and more included in monitoring schemes to meet this target despite the fact that good monitoring methods for these insects often are still lacking. The habitat directive, for example, included many insects that previously had been studied rather poorly, e.g. *Limoniscus violaceus* (Müller, 1821) and *Osmoderma eremita* (Scopoli, 1763). The first species is found in an increasing number of sites since it was included in the habitat directive likely because more effort is spend to find this species (GOUIX *et al*., 2012). While, innovative monitoring techniques like pheromone sampling (SVENSSON *et al*., 2003) or sucking up larvae (BUBLER & MÜLLER, 2009) led to better monitoring techniques for *O. eremita*.

For Flanders (Northern Belgium) a monitoring system for species was set up (ADRIAENS *et al*., 2011), including Flemish priority species besides species listed in the habitat and bird directive. These priority species were selected based on their European red list status, their relative population size in Flanders compared to Europe, their national protection status and/or their habitat requirements. In total, 55 priority species were selected, besides 68 habitat directive species and other species which require European reporting (DE KNIJF *et al.*, 2014, bird directive species have their own monitoring system). This list includes 29 invertebrates of which 2 are beetles, i.e. *Lucanus cervus* (Linnaeus, 1758) and *Cetonia aurata* Linnaeus 1761, besides 11 butterflies, 10 dragonflies, 2 spiders, 2 grasshoppers and 2 moths. The Flemish monitoring standard for these species was clarified in DE KNIJF *et al*. (2014). For the monitoring of *C. aurata*, the use of odour traps is suggested.

The CSALOMON® VARb3 trap developed by the Plant Protection Institute of the Hungarian Academy of Sciences looks like a small funnel trap with a blue coloured trapping vane. This colour has been optimized to best attract *C. aurata* and *Protaetia cuprea* Fabricius, 1775 (TÓTH *et al*., 2005, VUTS *et al*., 2010). Furthermore, the trap is baited with a cotton containing 3-methyl eugenol, 1-phenylethanol and (E)-Anethol (derivatives from flowers, further referred to as ME- trap) that are selected to best attract the target species (TÓTH *et al*., 2005). Besides the trap for these two species, a similar trap is available which is optimised for *Oxythyrea funesta* Poda, 1761 and *Tropinota hirta* (Poda, 1761), having another colour (yellow, TÓTH *et al*., 2005) and odour (lavandulol and 2-phenylethanol, PH-trap, VUTS *et al*., 2008). Originally, the traps have been designed for eradication or monitoring of the beetles in Mediterranean orchards where they can be present in large numbers and can cause damage to the flowers and fruits.

In Flanders, *C. aurata* is often believed to be quite rare, hence its protected status in Belgium. In reality, it is locally rather common and especially during the last decade the populations are clearly expanding (THOMAES *et al*., 2015b). As this species has a broad habitat using both broadleaved dead wood and hollow trees, it can be interpreted as a good overall indicator for saproxylic organisms (but see discussion). *Protaetia metallica* (Herbst, 1782) is locally present in Belgium (RENNESON *et al*., 2012). As *P. metallica* is quite similar to *P. cuprea* and both are frequent flower visitors, it is likely that the traps also work for *P. metallica* despite we have no knowledge of test on this particular species. *Oxythyrea funesta* was found quite common all over Belgium till the beginning of the previous century and becoming rare and withdrawing to the Calcareous region in southern Belgium at the middle of previous century (JANSSENS, 1960; GROOTAERT *et al*., 2010). The last Flemish record was from 1949 (GROOTAERT *et al*., 2010) but there are some recent records for Flanders (www.waarnemingen.be). However, it remains unclear whether this species has re-established in Flanders. *Tropinota hirta* is known only from a handful of historic records from Brussels and the

Hautes Fagnes (JANSSENS, 1960; GROOTAERT *et al*., 2010) with a last record in 1949. In 1978 a single specimen was found originating from 'exotic' compost in Schaarbeek (Brussels, BAGUETTE *et al*., 1985).

As the traps have mainly been used in areas where large populations of the species are present to eradicate them instead of monitoring low population sizes, it is uncertain whether these can be used to monitor these species in regions with relatively low population sizes. Furthermore, the attractiveness of the trap might differ as for example flight activity is lower or odour evaporation might be lower in our climate. Finally, it was unclear whether these traps would yield many by-catches and what was the mortality rate of the captured specimen as VUTS *et al*., (2010) only evaluates the number of Cetoniidae species. Consequently, the main research question is, can odour traps be used to monitor Flower chafers (Cetoniidae) in more northern regions where the species are present in relatively low amounts? This question includes following hypotheses: 1) Does the method yield enough specimen of *C. aurata* and *P. metallica* to evaluate a population trend over the years? 2) Are the numbers of by-catches (non-Cetoniidae) low enough? and 3) What is the mortality rate of catches and by-catches? There are no clear cut-off levels in our hypotheses as it is an exploratory research and results also depends for example on the number of traps that are placed in a site. Finally, for *O. funesta*, the goal was to find out whether populations had re-established in Flanders.

Material and methods

Site selection

In total six sites were selected in Flanders, five for the CSALOMON® VARb3 trap optimised for *C. aurata* (ME-trap) and one with traps for *O. funesta* trap (PH-trap, Table 1, Fig. 1). Sites for the ME-traps were selected from sites managed by the Flemish Agency for Nature and Forest where *C. aurata* was known to be present with a good spread within the distribution of the species. Sites included both locations where *P. metallica* or *Gnorimus nobilis* (Linnaeus, 1758) is present and absent and various habitats (Table 1). The site for the PH-trap was selected from the sites where *O. funesta* has recently been recorded (www.waarnemingen.be) and Den Battelaer, a nature reserve managed by Natuurpunt, was selected. For each site a volunteer was asked to follow up the traps.

Table 1. Selected sites with their coordinates, habitat, species known to be present (Ca: *Cetonia aurata* L, 1761; Gn: *Gnorimus nobilis* (L., 1758); Of: *Oxythyrea funesta* Poda, 1761 and Pm: *Protaetia metallica* (Herbst 1782)) and trap type installed.

Name	Village, coordinates	Habitat	Species	Trap
Geraardsbergen (Ger)	Geraardsbergen, 50.763°N, 3.880°E	Replanted forest plot within residential urban area	Ca	ME
Raspaillebos (Ras)	Geraardsbergen, 50;765°N, 3.931°E	Grassland within a forest	Ca	ME
Zoniënwoud (Zon)	Hoeilaart, 50.770°N, 4.433°E	Grasslands within a forest	Ca, Gn	ME
Den Battelaer (Bat)	Mechelen, 51.051°N, 4.433°E	Wet grassland, nettle, bramble, schilf and dikes	Ca, Of?	PH
Kalmthoutse heide (Kal)	Kalmthout, 51.376°N, 4.449°E	Forest edge in mixed landscape with heathland and forest	Ca, Pm	ME
Mechelse heide (Mec)	Maasmechelen, 50.970°N, 5.646°E	Forest edge in mixed landscape with heathland and forest	Ca, Pm	ME

Trapping

In each site, four traps were placed from 12-14 may to 23 June 2014, except the PH-traps which were deployed till 28 July 2014 at Den Battelaer and at the site of Geraardsbergen the traps were placed from 1 April to 29 July 2014 to cover a broader range of the season. The odour of the traps of Den Battelaer and Geraardsbergen were replaced every 3 to 4 weeks. The ME-traps were connected to bamboo sticks and placed at about 1,5m height nearby attractive flowers for the target species while PH-traps were fixed just above ground level at the border of flower rich meadows as suggested in the trap instructions. The traps were either placed on a single transect with 10m between traps (Geraardsbergen, Raspaillebos, Kalmthoutse heide), at two transects with 10m between traps (Zoniënwoud, Den Battelaer) or individually (Mechelse heide). This was done to get an idea of the variability between traps depending on the distance. However, due to the low amount of captured beetles (see results), it is not possible to explore this.

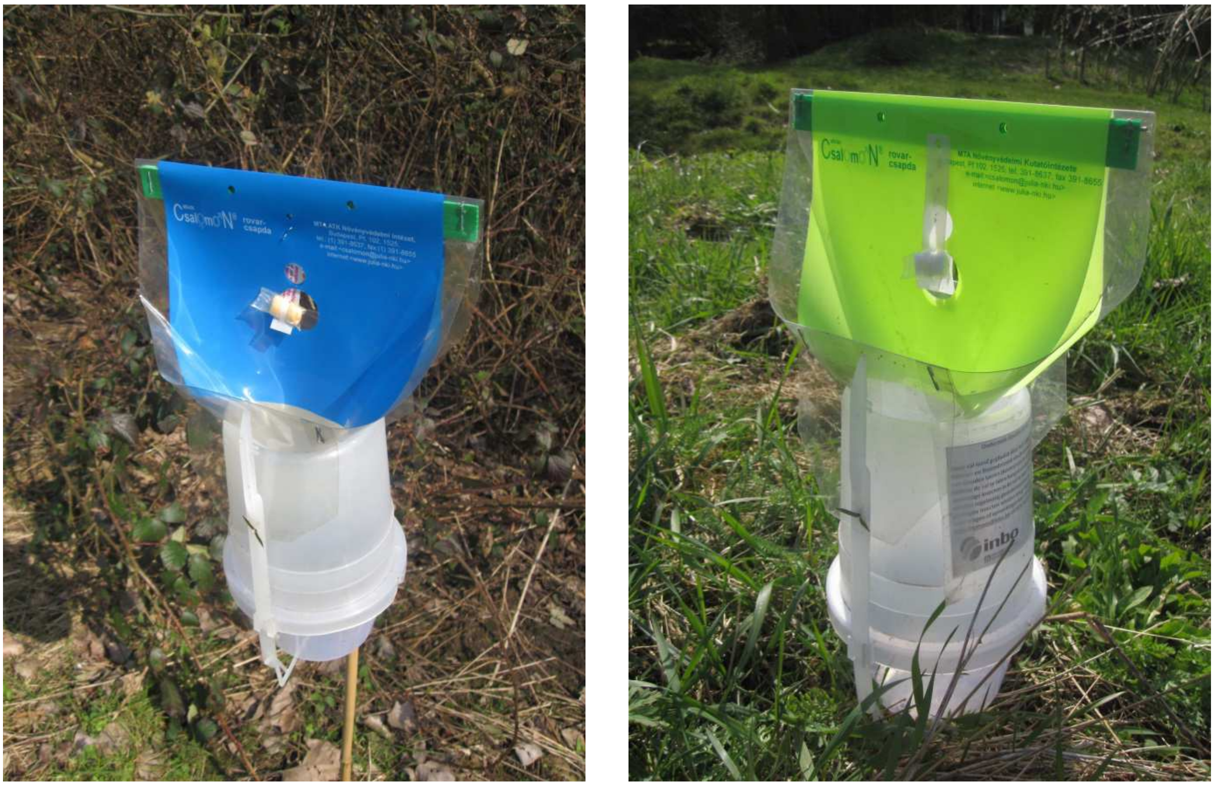

Fig. 1. A CSALOMON® VARb3 trap optimised for *Cetonia aurata* L., 1761 (left) and for *Oxythyrea funesta* Poda, 1761 (right) installed in the field.

The traps were checked minimally twice a week by volunteers. For each trap, the number and species of Cetoniidae was determined. An easy determination key for Cetoniidae potentially occurring in Belgium was provided to the volunteers, rare species were collected and determination of other species was checked on photos. Other species were determined to the level of order and counted. Sometimes further determination of this material was done by the volunteers or is based on photos or collected specimen. At some sites, also mortality was recorded.

Results

An overview of the captured Cetoniidae is given in Table 2. In total only 5 *C. aurata* and 17 *P. metallica* were captured. Furthermore, common species like *Valgus hemipterus* Linnaeus, 1758, *Trichius fasciatus* Linnaeus, 1758 and *Trichius gallicus* Germar, 1829 were captured but also two specimen of *O. funesta* were found, each at a different site.

Table 2. Total number (mean/trap ± s.d.) of different Cetoniidae captured at the different sites (Table 1). For Geraardsbergen both the results of the full trapping period (FP) as for the shorter period (SP) representing the same period as for the other sites is given.

Species	ME-trap						PH-trap
	Ger	Ger	Ras	Zon	Kal	Mec	Bat
Number of days	FP: 120	SP: 42	42	42	42	42	77
Cetonia aurata L, 1761	2 (0.5±0.58)	1 (0.25±0.5)	0	3 (0.75±0.96)	0	0	0
Protaetia metallica (Herbst 1782)	0	0	0	0	0	17 (4.25±3.95)	0
Valgus hemipterus L, 1758	14 (3.5±1.73)	6 (1.5±1.29)	0	0	0	1 (0.25±0.5)	0
Trichius fasciatus L, 1758	0	0	0	0	0	1 (0.25±0.5)	0
Trichius gallicus Germar, 1829	12 (3±1.41)	1 (0.25±0.5)	0	0	0	0	0
Oxythyrea funesta Poda, 1761	1 (0.25±0.5)	1 (0.25±0.5)	0	0	0	0	1 (0.25±0.5)
Total	29	9	0	3	0	19	1

For *C. aurata*, the presence was only detected in 2 out of 5 places, where the species is known to be present. For Kalmthoutse heide and Raspaillebos traps were possibly placed in a too shade environment. Even in the two successful sites, traps yielded only meanly 0,25 to 0,75 specimen. For *P. metallica* the traps seem to be much better, yielding 17 specimen in one site (Fig. 2). Besides Mechelse heide, this species is also known to be present at the Kalmthoutse heide but as mentioned before the traps where possibly hanging in a less ideal habitat. Most *T. gallicus* (11/12) were captured in Geraardsbergen at the end of June and in July, thus phenology might explain low catches of this common species at other sites. The *T. fasciatus* at Mechelse heide reflects its eastern distribution pattern (THOMAES *et al*., in prep.). *Oxythyrea funesta* was found at Den Battelaer where a small population seems to be establishing and even in Geraardsbergen where the species has not been recorded before.

Fig. 2. Catch of a trap at the Mechelse Heide with 4 *Protaetia metallica* (Herbst 1782), several bumble-bees and *Misumena vatia* (Clerck, 1757).

In total, at least 909 other invertebrates were found in the traps (Table 3). The by-catches of Den Battelaer were not registered giving only an indication of some groups. At nearly all sites, Hymenoptera were most frequently captured including mainly Honeybee (*Apis mellifera* Linnaeus, 1758), wild bees and different bumblebees (e.g. *Bombus terrestris* (Linnaeus, 1758) and *Bombus magnus* Vogt, 1911). The second important group were either Diptera (e.g. *Rhingia campestris* Meigen, 1822) or Coleoptera. The Coleoptera included mainly flower visiting Longhorn beetles (e.g. *Rutpela maculata* Poda, 1761 and *Stenurella melanura* Linnaeus, 1758), besides the Flower chafers. It is not unlikely that some species were not registered to the precise order as some species might be misleading for volunteers, for example *Volucella bombylans* Linnaeus, 1758 was found in the Kalmthoutse heide. Also *Chrysoperla carnea* Stephens, 1836 (Neuroptera) was frequently present in some sites, it was absent in Geraardsbergen while in other sites it was maybe included within the Diptera. The Lepidoptera included mainly diurnal flower visiting butterflies, e.g. *Carterocephalus palaemon* (Pallas, 1771), *Gonepteryx rhamni* Linnaeus, 1758 and *Aglais io* (Linnaeus, 1758), besides some moths, e.g. *Lacanobia oleracea* Linnaeus, 1758. Other groups were most likely captured accidently. However, some species like *Misumena vatia* (Clerck, 1757), a spider which catches insects at flowers, might have been attracted as well.

The mortality rate was unfortunately, badly recorded by the volunteers. For the Cetoniidae, nearly all beetles were captured alive (mortality rate was close to 0% at Geraardsbergen, Raspaillebos, Den Battelaer and Zoniënwoud and 21% at Mechelse heide). However, for the by-catch the mortality rate was in general quite high, 62 ± 8% at Kalmthoutse heide and comparable in other sides. Mainly Honeybees, bumblebees and flies were found dead in the traps. Despite the fact that the trap had drainage holes and traps were checked at least twice a week, most casualties were found after rainfall due to drowning.

Discussion and conclusion

Even if the results of Raspaillebos and Kalmthoutse heide are ignored, a low number of *C. aurata* was found. Especially when the high number of field visits (about 12 times during 42 days) are taking into account. Therefore, we can conclude that this method of trapping is rather inefficient, even when ten traps would be used at a single site as it was originally designed (DE KNIJF *et al*., 2014). Alternatively, *C. aurata* could be monitored by walking a standardised transect while looking at the flowering bushes, using fruit, wine and/or beer baited traps. Based on my personal experience, it is obvious to find more specimen with looking at the flowering bushes when similar effort (time) would be spend. Walking a transect of about 200m along flowering bushes might thus be a better method for monitoring *C. aurata,* at least in Belgium where numbers are still fairly low compared to the Mediterranean regions.

Table 3. Total number of by-catches captured at the different sites (Table 1).

Species(group)	Ger	Ras	Zon	kal	Mec	Totaal
Carabidae	1					1
Nicrophorus vespilloides Herbst, 1783	1					1
Thanatophilus sinuatus Fabricius, 1775	1					1
Dendroxena quadrimaculata Scopoli, 1771					1	1
Elateridae				1	4	5
Coccinellidae	1					1
Pyrochroa sp.	1					1
Hoplia philanthus Fuessly, 1775				3	2	5
Alosterna tabicolor DeGeer, 1775					1	1
Rutpela maculata Poda, 1761	3	1			2	6
Clytus arietis Linnaeus, 1758		1				1
Stictoleptura fulva DeGeer, 1775	1					1
Stenurella melanura Linnaeus, 1758	1				3	4
Other Cerambycidae (incl. Oedemeridae)	37	15		1	1	54
Curculionidae	2			1		3
Other Coleoptera	1	3		4		8
Subtotal Coleoptera	50	20	0	10	14	94
Blattodea					1	1
Dermaptera				1		1
Diptera	42	114		10	2	168
Hemiptera	23					23
Hymenoptera	334	115	56	32	5	542
Lepidoptera	9	9	2	4	4	28
Neuroptera		30		9		39
Araneae	5			6	2	13
Totaal	463	288	58	72	28	909

In contrast to *C. aurata*, the traps seem to work better for *P. metallica*. This might be explained by the fact that the local population of *P. metallica* at the Mechelse heide is maybe quite high. One of the traps was placed next to a nest of *Formica* sp. (where the larvae of *P. metallica* develop) and yielded four *P. metallica* compared to one to three specimen caught in the other traps. As it is often difficult and destructive to study myrmecophilous species, this trap seems an interesting non-invasive alternative to study the presence of this species near *Formica* nest. *Oxythyrea funesta* was detected by capturing one specimen despite the population at Den Battelaer is very low. The volunteer visited Den Battelaer nearly daily but did not found the species on any other occasion by looking at the flowers. Only two other records at the site and two records at nearby sites indicate a locally re-established population (THOMAES, in prep.). Finally, one specimen of this species was caught at Geraardbergen, i.e. at the office of INBO where I worked for about ten years. Despite the regular encounters with all the other Cetoniidae captured at this site, I have never found *O. funesta* here. Likely, this is explained by a recent colonisation of Flanders by *O. funesta* (THOMAES, in prep.), which is also manifesting in many other countries (e.g. HORAK *et al*., 2013; TAMUTIS & DAPKUS, 2013). Finally, there are some recent records of *Gnorimus nobilis* (Linnaeus, 1758) from Zoniënwoud but this rare specimen was not recorded in the traps. As this species is locally rare, it is difficult to make conclusions upon this fact.

Another issue for evaluating the use of the traps is the number of by-catches and the mortality rate. Both the number of by-catches and the mortality rate are considered as quite high, especially among Honeybees and bumblebees. Probably, the mortality rate can be lowered by improving the drainage and creating hiding places inside the traps so that insects can stay dry during the rain and can escape drowning. Overall the mortality maybe rather low considering the real abundance of the insects. However, it might be experienced as unacceptable to catch a lot of pollinators by nature lovers who are asked to volunteer in the monitoring. If the monitoring would be performed as currently designed (DE KNIJF *et al*., 2014) by monitoring 20 sites with 10 traps at each site, it would kill about 3.500 invertebrates ((288+58+72+28) invertebrates captured *20/4 sites *10/4 traps * 62% mortality rate) each year. In Geraardsbergen more than 300 Hymenoptera were captured in four traps and 120 days which might raise concern on the number of pollinators that suffer from trapping Cetoniidae with a lot more traps at Mediterranean orchards (1 trap/150m² is mentioned for eradication purposes in the guidelines of the traps). This means that in an orchard of 10 ha, more than 50.000 Hymenoptera would be killed if the traps where deployed for 120 days. Therefore, it seems at least important to minimise the period of trapping to an absolute minimum, if possible avoiding the flowering period (but that is also the period of the most important damage) of the orchard and avoiding trapping when bee hives are placed.

Finally, It can be argued weather *C. aurata* is an ideal species. Especially as it is becoming more and more common. In many other places in Europe where the species is common, it is known to be develop in compost heaps and even flower pots with compost, so it can be expected that this species will further expands its habitat use when it becomes more and more common in Flanders. Therefore, an alternative could be to selected another species that is widely accepted as a good indicator for saproxylic species in Europe and is easily monitored, e.g. *Elater ferrugineus* Linnaeus, 1758 (RANIUS, 2002; SVENSSON *et al*., 2012; ZAULI *et al*., 2014; THOMAES *et al*., 2015a).

I conclude that the traps are not very interesting to monitor the abundance of *C. aurata* when the species is relatively rare as in Belgium. However, the traps seem to be useful to monitor the abundance of *P. metallica* and to detect the presence of *O. funesta* even if it is present in low numbers. However, it is important to lower the high mortality rate by adapting the trap design.

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