Short Note

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Small mammals in discarded bottles: a new world record

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Progress of civilization entails creation of bigger volumes of waste which very often are dumped at inappropriate locations. The dynamically growing tourism associated to nature activities has generated in the last few decades many impacts in natural ecosystems. One problem is that the tourists leave many sorts of litter, and litter waste represents a serious threat for terrestrial and marine ecosystems. Every year, several tones of bottles, cans and other containers for beverages are produced, consumed, and dumped (most made from polyethylene, PET). Despite most containers can be recycled, in Europe there is still a low rate of recollection in the case of plastic containers (ie. PET) (Welle 2011). The increase of production and lack of degradability contributes to a serious problem regarding environmental accumulation and associated pollution (Shah *et al.* 2008).

Discarded bottles may represent a threat for natural ecosystems, but also for human health. 1) bottles are considered as reservoirs for larval stages of vector diseases (ie, dengue and malaria, Hoff and Foley 2001), 2) discarded bottles represent a pollution problem for ecosystems due to the long lasting effects of plastic materials before degradation (Shah *et al.* 2008), and 3) discarded bottles and cans may represent a threat to the small animals which are trapped and die inside them. In this latter case, several studies showed the deleterious effects of discarded bottles as a source of mortality for invertebrates (Sklodowski 2011, Kolenda *et al.* 2015) and small vertebrates (Benedict & Billeter 2004), some of them critically endangered (Davenport *et al.* 2001). Within the small vertebrates, small mammals (O. Soricomorpha and O. Rodentia) are amongst the most cited animals killed by discarded bottles (Morris & Harper 1965). Far of being a fluke, the role of discarded bottles on small mammal's deaths has for long intrigued investigators (Morris & Harper 1965). Even, collecting discarded bottles in the field has produced relevant information on the distribution of poorly known species (Morris 1970), being used as an ancillary technique for studying small mammal distribution (Pagels & French 1987).

In this Note, we review the literature searching for articles dealing with small mammals trapped by discarded bottles worldwide, adding a new record of a bottle containing the highest number of small mammals ever recorded.

A 2 L plastic bottle of carbonated soda was found in August 2014 in the municipality of La Farga de Bebié (Girona, Catalonia, Spain). The area is at 650 masl and is covered by beech forests (*Fagus sylvatica*) with mixed Scottish pines (*Pinus sylvestris*). The bottle was placed in a shady area, well covered by vegetation, and partially filled with rainwater (less than a third of its capacity). The neck of the bottle was pointing upwards, lying on a moderate slope (10 degrees), and its position made us to anticipate the probable presence of small mammals. At first look, the bottle contained a brownish broth resulting from the mixture of hair and bones of small mammals. The bottle was collected and brought to the laboratory to analyze its contents. The content of the bottle was separated by decantation under a jet of water and filtered with a sieve of 0.5 mm. All skeletal remains were dried and were put on a plasticine support to be identified under the microscope. The minimum number of small mammals present in the sample was counted from the skeletal remains following a standard procedure outlined elsewhere (ie., counting jaws and/or teeth to determine the minimum number of individuals captured, (Torre *et al.* 2013). Species identification was performed by means of an identification key (Gosálbez 1987). Since some cranial remains were in poor condition, wood mice (*Apodemus sylvaticus/flavicollis*) were not identified at the specific level, although they could

be separated by tooth criteria in the study area (Torre *et al.* 2015). A bibliographic search was performed in order to find articles showing information on the maximum number of small mammals trapped by a single bottle. The search only yielded 10 studies providing the information required.

The bottle found contained a total of 54 small mammals, and an undetermined number of small beetles. As a whole, the bottle contained 47 Wood mice (*Apodemus sp.*), 5 bank voles (*Myodes glareolus*), and 2 white-toothed shrews (*Crocidura russula*). As far as we know, this is the highest number of small mammals ever recorded from a single discarded bottle worldwide, after reviewing 10 studies (table 1). Furthermore, this is the first record for a single sample almost entirely dominated by rodents (96.3% of small mammals trapped).

The maximum number of small mammals contained within a single bottle in the literature ranged from 8 to 42 individuals, with an average of 26 ± 3.95 SE (n= 10). The maximum number came from a glass bottle found in the Medes Islands (Girona, Spain), which contained 42 small mammals (33 shrews and 9 rodents, Torre *et al.* 1998). All of the reviewed studies but one showed higher proportion for shrews than for rodents in the whole sample of discarded bottles analyzed (values ranging from 46.9% to 100%). Considering all the reviewed studies, shrews represented the 74% of small mammals trapped, and rodents represented the remaining 26%. The shrew *Blarina brevicauda* was the most trapped species (24.73%) in the USA, and the shrew *Sorex araneus* was the most trapped species (20.18%) in Europe. The first rodent species was *Myodes glareolus*, accounting for the 9.28% of all captures.

Some authors suggested that shrews are more easily trapped by bottles due to their lowest locomotory abilities (Torre *et al.* 1998), but rodents (ie. *Apodemus* spp.) are great jumpers/climbers. So, how can we explain such an amount of small rodents in the bottle? The trapping efficiency of discarded bottles depends on several factors: One of them is the angle of inclination of the bottles with respect to the ground (Morris & Harper 1965). When the neck of the bottle is pointing upwards (as was our case), animals can easily enter the bottle, but they can have problems to get out of it, especially when the interior of the bottle is wet (this was also the case). When the bottle has water inside, individuals may become drowned (Brannon & Bargelt 2013), or they may die of hypothermia after getting wet and being unable of thermoregulation. Another hypothesis to explain this huge number of individuals is that body decomposition generated some kind of hypoxia within the bottle, provoking the death of individuals almost immediately after getting inside it. Our findings also supported that the size of bottles was correlated to its ability to trap small mammals, being the largest containers those

Table 1. Maximum number of small mammals found within a single bottle in this study and 10 reviewed studies of discarded bottles (the new data are not included in the means).

Source	Country	Maximum in a single bottle	Shrews	Rodents
This study	Spain	54	2	52
Torre et al 1998	Spain	42	33	9
Debernardi et al. 1997	Italy	32	???	???
Morris 1970	Great Britain	28	???	???
Platt et al. 2014	USA	25	25	0
Brannon et al 2010	USA	22	???	???
Brannon & Bargelt 2013	USA	19	???	???
Benedict & Billeter 2004	USA	19	???	???
Pagels & French 1997	USA	17	17	0
Morris 1965	Great Britain	15	8	7
Hamed & Laughlin 2015	USA	8	8	0
TOTAL	Mean (SE)	26 (3.95)	16 (3.55)	11 (6.12)

with the highest number of individuals and larger species found (Morris 1970). Despite all the species found dead in the bottle are widely distributed in the area and don't have conservation concern, discarded bottles may affect some endangered populations of species with reduced ranges, like the Canary shrew *Crocidura canariensis* in Fuerteventura (Schuster 2014). Moreover, the review pointed out a biased pattern of discarded bottles towards temperate areas in the northern hemisphere, suggesting that further investigations need to be performed in order to find discarded bottles in other areas.

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