

Small mammal sampling incidents related to wild boar (*Sus scrofa*) in natural peri-urban areas

I. Torre, S. Cahill, J. Grajera, A. Raspall, M. Vilella

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Abstract

Small mammal sampling incidents related to wild boar (Sus scrofa) in natural peri-urban areas. The wild boar (*Sus scrofa*) has recently shown continuous population increases in many countries, leading to a rise in conflicts with human activities, including habituation to people and urban areas. Wild boar can disrupt the sampling of small mammals by reducing the number of potential captures. In this study we analysed whether sampling incidents recorded within a small mammal monitoring programme (SEMICE, www.semice.org) might be related to the density of wild boar in a network of protected parks. Our results suggested a peri-urban effect that was independent of wild boar densities in the protected parks; the number of damaged traps increased (rendering them inoperable for captures) and potentially resulted in underestimates of small mammals due to fewer functioning traps in the study area. We hypothesised that this high rate of damage to traps in a small and localised area in a peri-urban park could be related to wild boar associating human presence with greater opportunities to obtain food items of anthropogenic origin.

Key words: Live traps, Trap damage, Synurbization, Population, Underestimation, Collserola Park

Resumen

Incidentes en el muestreo de pequeños mamíferos relacionados con la presencia del jabalí (Sus scrofa) en zonas naturales perirurbanas. Desde hace poco tiempo, las poblaciones de jabalí (*Sus scrofa*) de muchos países han venido aumentando de forma constante, lo que ha dado lugar a conflictos con las actividades humanas, como su habituación a las personas y a las zonas urbanas. Los jabalíes pueden interferir en el muestreo de pequeños mamíferos, ya que reducen las capturas potenciales. En este estudio analizamos si los incidentes registrados en el muestreo realizado en el marco de un programa de seguimiento de pequeños mamíferos (SEMICE, www.semice.org) podrían estar relacionados con la densidad de jabalíes en una red de parques protegidos. Nuestros resultados sugirieron que la ubicación periurbana ejercía un efecto independiente de la densidad de jabalíes en los parques, que hacía aumentar el número de trampas dañadas (no disponibles para la captura) y que podría producir la subestimación del tamaño de las poblaciones de micromamíferos debido a la menor disponibilidad de trampas. Presumimos que esta alta tasa de ataques a las trampas en una zona pequeña y localizada podría estar relacionada con la posibilidad de que, en el caso del parque periurbano, los jabalíes puedan asociar la presencia humana con más oportunidades de obtener alimentos de origen antrópico.

Palabras clave: Trampas de vivo, Daños a trampas, Sinurbización, Población, Subestimación, Parque de Collserola

Rebut: 25 V 21; *Conditional acceptance:* 6 IX 21; *Final acceptance:* 8 XI 21

Ignasi Torre, Joan Grajera, Marc Vilella, BiBio Research Group, Natural Sciences Museum of Granollers, c/Francesc Macià 51, E-08402 Granollers, Spain.– Seán Cahill, Alfons Raspall, Consorci del Parc Natural de la Serra de Collserola, ctra. de l'Església 92, E-08017 Barcelona, Spain.

Corresponding author: I. Torre: itorre@mcng.cat

ORCID ID: I. Torre: 0000-0002-4803-9524; M. Vilella: 0000-0002-0732-0985



Introduction

Wild boar (*Sus scrofa*) populations are currently expanding both in distributional range and number in many countries (Keuling et al., 2017; Massei et al., 2015). In Europe, this increase is considered due to a variety of reasons, such as increasingly mild winters (Bieber and Ruf, 2005; Geisser and Reyer, 2005; Vetter et al., 2015), rural abandonment, reforestation of marginal land, and the expansion of crops, such as maize (Geisser and Reyer, 2005), that provide food and cover (Colino–Rabanal et al., 2012). Traditional recreational hunting is declining and is insufficient to restrain the population growth of wild boar (Massei et al., 2015). Furthermore, wild boar can display compensatory population responses when hunting pressure is high (Gamelon et al., 2011; Servanty et al., 2011). Synurbization of wild boar is a recent phenomenon. Their presence is increasing in ever-expanding [peri] urban environments where they can often thrive on a combination of both natural and anthropogenic food sources, and may become habituated to the presence of people (Cahill et al., 2012; Putman et al., 2014; Náhlik et al., 2017; González–Crespo, 2021).

While foraging, wild boars can have a negative impact on sampling protocols used to estimate small mammal abundance by interfering with traps (Focardi et al., 2000) and increasing the number of sprung traps (Torre et al., 2019). Although sprung traps reduce the sampling effort, this effect is usually ignored in calculations of population estimates for small mammals (Beauvais and Buskirk, 1999). Consequently, the population size of small mammals could be underestimated if the number of effective traps available is reduced due to sampling interference by wild boar.

In this article, we analysed the influence of wild boar foraging activity on the sampling of small mammal populations through incidents related to trap disruption. We speculated that sampling incidents recorded within a small mammal monitoring programme (SEMICE, www.semice.org) might be related to the abundance of wild boars, since foraging intensity (i.e., rooting) would presumably be higher with greater presence of wild boar (Mori et al., 2020). As a result, random trap encounters should increase. We also expected that higher sampling incidents would result in a lower number of captures of small mammals due to reduced trap availability. Furthermore, we analysed other sampling incidences, especially those related to the activity of the small mammals themselves, with regard to the number of captures recorded.

Material and methods

We used the information generated by the SEMICE small mammals monitoring scheme (www.semice.org) at 21 sampling stations situated in seven protected parks located in the broader region surrounding the city of Barcelona. The SEMICE sampling programme has been operative since 2008 at more than 150 sampling stations situated in Spain and Andorra.

The aim of the programme is to monitor common small mammal species with high detectability so as to compute reliable estimates of population change (Torre et al., 2018). As a citizen science monitoring programme (Torre et al., 2021), our collaborators are encouraged to select sampling areas close to their homes, located –whenever possible– in protected natural areas, and choosing habitats that are representative of those present in the surroundings. The SEMICE live-trapping scheme consists of two annual trapping sessions, each one spanning three days. These sessions are based on grids of 36 traps (Longworth and Sherman) arranged in intercalated positions, separated by 15 m, and covering an approximate effective area of 1 ha. Longworth traps (Penlon Ltd., Oxford, UK) are aluminium box traps that consist of two separate sections that need to be joined when setting: a tunnel with a trigger, and a nest box with enough space for placing food and bedding material. Sherman traps are aluminium box traps (23 × 7.5 × 9 cm; H. B. Sherman Traps Inc., Tallahassee, FL, USA) that have a weight-sensitive trigger that closes the door when an animal steps on it. Both traps are widely used, and their performance has been tested (Sibbald et al., 2006; Torre et al., 2019). The traps were baited, provided with hydrophobic cotton for bedding, and concealed under vegetation to provide thermal insulation. We used the information available from 152 sampling sessions (trapping bouts of three days each) conducted between spring 2016 and spring 2020 at 21 different sampling stations (mean: 7.24 sessions/sampling station). Each station was equipped with 36 trap positions.

We defined three kinds of trap incidents depending on the agent that caused them: those related to traps being moved or damaged by either (i) wild boar or by (ii) mesocarnivores, and (iii) those mostly related to small mammal activity. Incidents related to wild boar and mesocarnivores can be determined by the signs found at the trap location and the general condition of traps (fig. 1), and by using indirect clues of recent activity around the traps, such as rooting by wild boar and animal faeces. Incidents related to small mammal activity can be determined either from open traps with animal signs, i.e. traps that were not sprung but show clear evidence of use by small mammals (i.e. faeces, cotton removed, etc.), or from unopened closed traps that were sprung but without any capture. The incidents were assigned to the most likely causative agent according to the observers' criteria; almost all the information was recorded by professional biologists with at least 10 years of field experience. For the analyses, we considered five response variables: wild boar incidents, mesocarnivore incidents, and three incidents related to small mammals themselves; open traps with signs, closed traps without capture, and the sum of both open and closed traps. Calculations were based on each sampling session (three days) at each sampling station (36 traps), resulting in 108 trap–nights per sampling unit ($n = 152$). While open traps with signs could be unambiguously assigned to small mammals,



Fig. 1. A, small mammal traps damaged by wild boar in Collserola Natural Park. Sherman traps were more prone to serious damage than Longworth traps. The marks of the two lower incisors can be seen in the dented Sherman traps. B, damage caused by foxes *V. vulpes* (and other mesocarnivores) can be differentiated by the marking of the canines and by the bending of the extremes of the traps to gain access to the interior (Garraf Park).

Fig. 1. A, trampas para pequeños mamíferos dañadas por jabalíes en el Parque Natural de Collserola. Las trampas Sherman eran más propensas a sufrir daños graves que las Longworth. Se pueden observar las marcas de los dos incisivos inferiores en las trampas Sherman deformadas. B, los daños provocados por zorros, V. vulpes (y otros mesocarnívoros) se pueden diferenciar por las marcas de los caninos y porque los extremos de las trampas están doblados para poder acceder al interior (Parque del Garraf).

closed traps were assigned to small mammals' activity when other evident signs of interference by large animals were absent, although their closure might possibly have been caused by other uncontrolled factors (i.e., wind, rain, etc.). For this reason, these two types of incidents were also analysed separately to account for this possible source of unknown variation. Each model had one fixed factor, namely the season when the sampling took place (autumn or spring), and a fixed covariate, the number of small mammal captures at each sampling unit. However, for incidents caused by wild boar, we added three

other explanatory variables: the protected park as a fixed factor (a nominal variable with seven levels), the campaign ordinal number (each station was sampled on a maximum of nine occasions during four consecutive years), and mean wild boar density in each park (a categorical variable with three levels) as fixed covariates. Data on the densities of wild boar for each protected park were obtained from the results of the seasonal hunting returns, reported by Rosell et al. (2019) for 2016–2019, from the official Catalan wild boar monitoring programme (Rosell et al., 2018). For our study, we defined

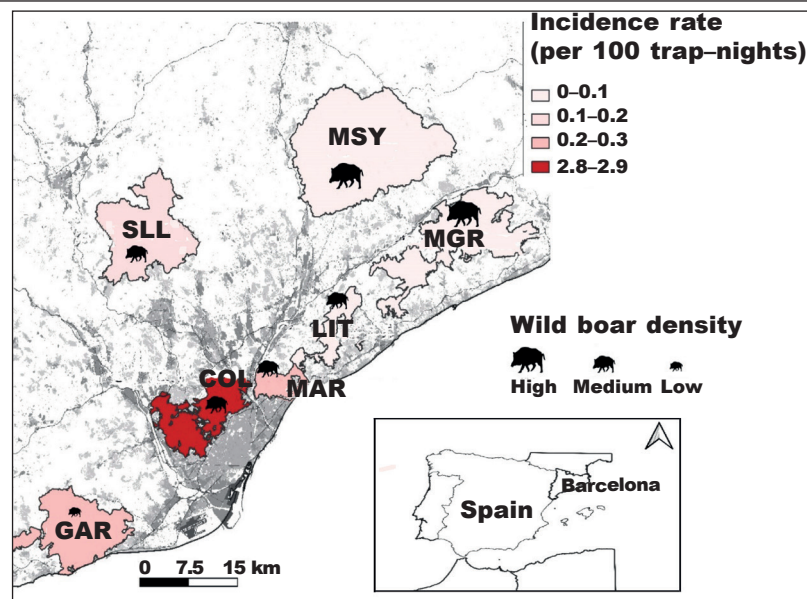


Fig. 2. Incidence rates of wild boar contact with small mammal traps according to average wild boar densities (individuals hunted/km²: low: < 5 indiv/km²; medium: 5–10 indiv/km²; high: > 10 indiv/km²) in seven protected parks in the region of Barcelona: COL, Serra de Collserola; LIT, Serralada litoral; MGR, Montnegre i el Corredor; SLL, Sant Llorenç del Munt i l'Obac; GAR, Garraf; MAR, Serralada de Marina; MSY, Montseny.

Fig. 2. Índices de incidencia del jabalí en las trampas para pequeños mamíferos en función de la densidad media de jabalí (individuos capturados/km²; baja: < 5 indiv/km²; media: 5–10 indiv/km²; alta: > 10 indiv/km²) en siete parques protegidos en la región de Barcelona. (Para las abreviaturas de los parques, véase arriba).

three categories of density accordingly for each protected park (fig. 2) as either: 'low' (< 5 indiv/km²), 'medium' (5–10 indiv/km²) or 'high' (> 10 indiv/km²). All five response variables were simple counts (i.e., number of traps affected by animal activity during each sampling session) and were considered to follow a Poisson error distribution (O'Hara and Kotze, 2010). However, a goodness-of-fit test performed with the `goodfit` function of the R package `vcd` (Meyer et al., 2021) showed a better fit to a negative binomial distribution. For each response variable, we built generalized linear mixed models (GLMM) by means of the `glmer.nb` function from the `lme4` package (Bates et al., 2015), considering the 21 sampling stations as a random factor. We constructed models resulting from all combinations of explanatory variables using the `dredge` function of the `MuMIn` package for R (Bartoń, 2015), and we selected models with $\Delta AICc < 2$ as being meaningful. These models were used to interpret which explanatory variables were most likely to influence small mammal trap incidents. Pseudo-R² values (trigamma method) of the selected models were calculated with the same R package. Response variables were graphically represented as incidents per 100 trap-nights in order to be comparable with other methodologies.

Results

During the study period, we recorded 872 incidents for 16,416 trap-nights (5.3%). Most incidents (82.3%) were related to the activity of small mammals themselves (traps not sprung or sprung without capture), while the remainder were attributed to larger animals (17.7%) which had moved the traps. Of these, 63 incidents were assigned to mesocarnivores and 91 were assigned to wild boar. Of the latter incidents, 47 were major attacks (broken traps with irreparable damage, fig. 1A), and the remaining 44 were related to minor attacks (mostly reparable damage), showing knocks and dents to traps, perhaps merely caused unintentionally by wild boars while foraging. Most wild boar incidents (82.4%) occurred in Collserola Natural Park, located on the outskirts of the city of Barcelona. The number of traps involved in wild boar incidents represented 2.88 ± 2.73 (SD, range 0–9.53) incidents per 100 trap-nights in Collserola, while such incidents were irrelevant in the other six protected parks (0.13 ± 0.43 traps per 100 trap-nights). The GLMM analysis confirmed that incidents caused by wild boar were mostly associated with the selected predictors (62% of deviance), being higher in Collserola than in the other parks sampled in the province of Barcelona: the probability of incidence was twenty

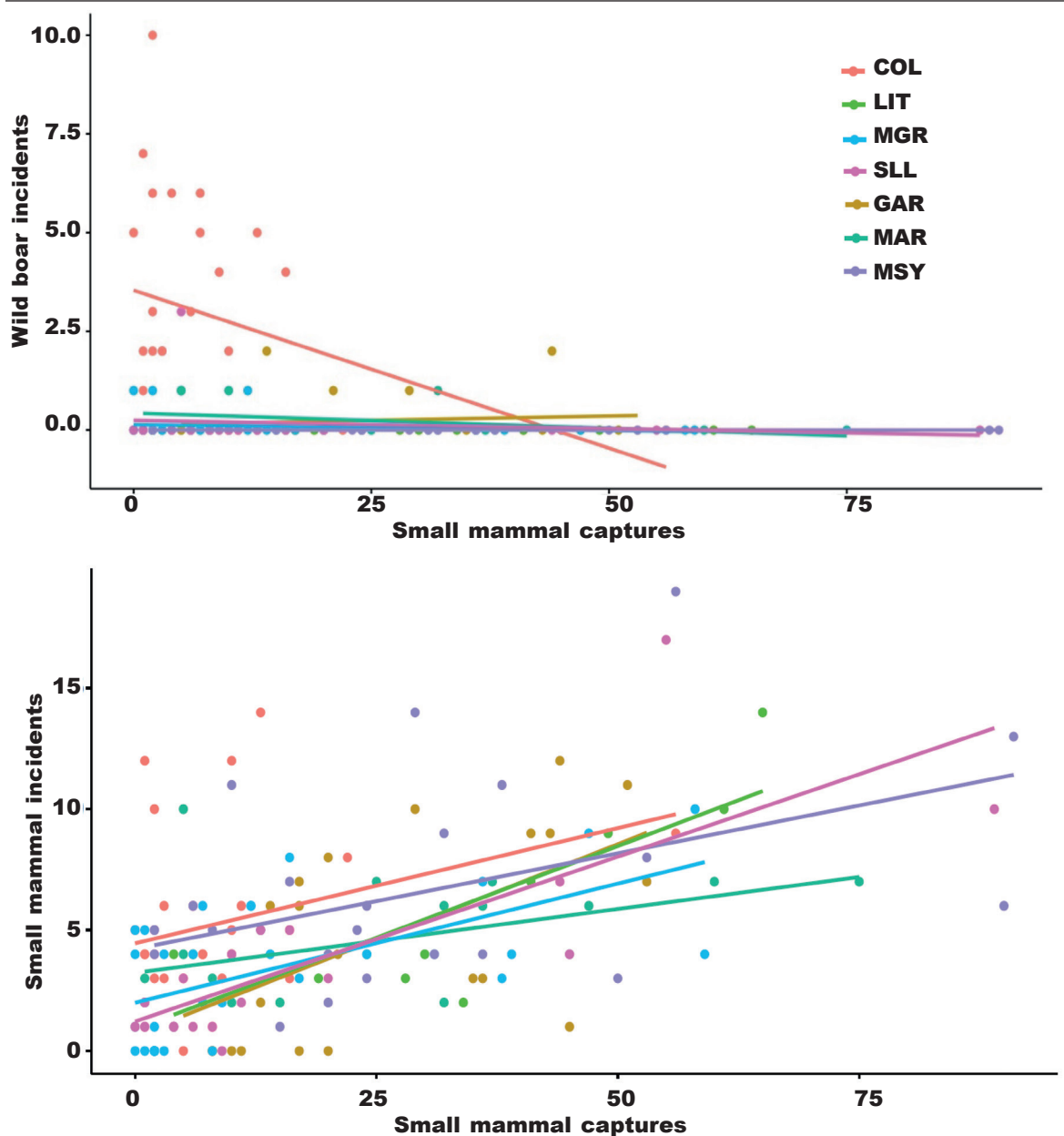


Fig. 3. A, sampling incidences related to wild boars in the seven protected parks; B, other sampling incidences not caused by large animals (traps sprung and not sprung with signs) were related to small mammal captures in all parks. (For abbreviations of the seven parks, see fig. 2)

Fig. 3. A, incidencias en el muestreo relacionadas con jabalíes en los siete parques protegidos; B. en todos los parques se produjeron otros incidentes de muestreo que no fueron provocados por animales de gran tamaño (trampas cerradas y abiertas con signos) en relación con capturas de pequeños mamíferos. (Para las abreviaturas de los siete parques, véase fig. 2).

times higher, and out of 47 major attacks which resulted in irreparable damage to traps, 35 (74.4 %) occurred in Collserola (table 1, fig. 3A). The output of the analysis also showed that incidents caused by wild boar increased over time (from spring 2016 to spring 2020) in the study area, and that the number of small mammal captures was only negatively linked

to wild boar incidents in Collserola (table 1, fig. 3A). However, the density of wild boar did not affect the frequency of trap incidents. In fact, parks with low densities of wild boar showed roughly similar incidence rates to those observed in parks with high densities, as well as to those in parks with intermediate densities, except for Collserola (fig. 2). In contrast, it was

not possible to interpret the effect of mesocarnivores on sampling incidents owing to the low explanatory power of the model (1% deviance by fixed factors). Sampling incidents—other than those caused by large animals—were positively associated with the number of captures of small mammals (table 1, fig. 3B). This positive association was observed in both types of incidents, especially among those reporting open traps with activity signs, but also when traps were sprung without capture, suggesting that most of the latter incidents were also related to the activity of the small mammals themselves.

Discussion

A review by Barrios–García and Ballari (2012) highlighted the fact that the foraging activity of wild boar (i.e., rooting) has an important impact on other animal communities. Amori et al. (2016) showed wild boar activity had strong negative effects on the abundance of small mammals, and especially so among ground–dwelling species (Mori et al., 2020). Foraging by wild boar could affect the population size of small mammals in two ways, either by direct effects, such as the destruction of their burrows and predation on individuals (Casula et al., 2017; Focardi et al., 2000), or by indirect effects, such as competition for food, alteration of rodent behaviour, and modification of vegetation that provides shelter for small mammals (Fagiani et al., 2014; Sunyer et al., 2016). In this study, we showed that the behaviour of wild boar, and specifically the sampling incidents they caused, could also affect our live–trapping estimates of the population size of small mammal communities by reducing the number of traps available to capture animals during field sampling. Our results indicate that the abundance of small mammals could potentially be underestimated if the incidence of trap disruption is high due to wild boar activity. Although trap disruption by wild boars has previously been mentioned by other authors (Focardi et al., 2000), no study has yet evaluated its possible impact on population estimates of small mammal communities. Nevertheless, the indirect impact of large animals on these estimates was considered as negligible overall, owing to the fact that only a small number of traps were affected by wild boar (0.59 ± 1.57 incidents per 100 trap–nights), and even fewer by mesocarnivores (0.41 ± 1.08 incidents per 100 trap–nights). Indeed, sampling incidents related to the SEMICE monitoring programme in the same study area were deemed irrelevant (Torre et al., 2019).

When traps were found open but with evident signs of activity (cotton outside the trap, faeces inside, etc.), these incidents were generally attributed to the small mammals themselves, and our analysis confirms an association between small mammal abundance (capture rates) and rates of such incidents. However, incidents involving traps that are found sprung with no capture also seem to be positively linked to their abundance, as small mammals may also accidentally activate traps during external interactions with them

(e.g. faeces are sometimes located on top of traps), or simply because the trap door has closed too soon after their entry into the trap.

Surprisingly, however, trap incidents caused by wild boar were unrelated to this species' density, suggesting that in most protected parks wild boar either ignored or simply did not find traps while foraging. Similarly, some authors suggest that the impact of wild boar on natural habitats is unrelated to density (Adams et al., 2019). Moreover, in our study we show a 'Collserola effect', with a high incidence of damage caused by wild boar to small mammal traps in this park, independently of wild boar density, and contrasting with only occasional observations of such incidents in most other parks. Therefore, other reasons might explain why attacks by wild boar were significantly higher in Collserola Natural Park, an area where only moderate densities of wild boar were recorded (Rosell et al., 2019) during this study period. Collserola is located in the immediate vicinity of Barcelona, and wild boar in this park are generally accustomed to high human presence (Cahill et al., 2012). Used traps are clearly impregnated with the odour of the small mammals and of the baits used, possibly making them novel targets for wild boar while foraging. Thus, we hypothesised that this high rate of attacks on traps in a small and localised area could be related to the possibility that in Collserola, synurbic wild boars might already associate human presence with increased opportunities to obtain food items of anthropogenic origin. In effect, wild boar are known to frequently exploit such resources in (peri)urban areas of this park and are often fed, either directly or indirectly, by humans (Cahill et al., 2012; Castillo Contreras, 2019; González–Crespo, 2021). Also, recent studies on visitor use in Collserola Natural Park estimated a total of five million visits per year in 2019 (Fariás–Torbidoni and Morera, 2020). Wild boar are thus accustomed to high human presence in this park, and animals that already associate humans with food might more readily examine objects displaying human odour. Currently, they readily explore and obtain food items from within closed structures such as rubbish bins (pers. obs.). On the other hand, in protected parks with a lower urban influence and less frequented by people, wild boar are, as yet, likely to be more wary of human odours. Also of note in Collserola Natural Park was the observation that disruption of small mammal traps by wild boar was negatively linked to capture success, thus potentially causing slight underestimates of population size for small mammals if high trap failure rates are not properly considered during calculations. Indeed, in one sampling session in Collserola, the number of disrupted traps accounted for almost 10% loss of total traps available for capturing small mammals. Although competition among small mammals for available traps may be trivial during periods of low population abundance, trap failure might result in significant population underestimation during periods of high abundance due to lower trap availability (Beauvais and Buskirk, 1999; Torre et al., 2019). Therefore, in areas with high trap disruption caused by wild boar (or other animals), statistical

Table 1. Generalized linear mixed models (GLMM) with negative binomial error distribution selected according to $\Delta AICc < 2$ for each response variable: wild boar, mesocarnivore and small mammal incidents (TO, trap open; TC, trap closed; TO+TC, trap open + closed) ($n = 152$ in all cases). Small mammal captures and season (spring as reference level) are two explanatory variables used in all models. For wild boar incidents, two other explanatory variables were added: the campaign ordinal number and a factor indicating the park to which the station belonged (Collserola as reference level). Model β coefficients and their standard error in brackets, AICc, $\Delta AICc$ and pseudo- R^2 (marginal and conditional) values are presented (** $p < 0.001$, * $p < 0.01$, $p < 0.05$).

Tabla 1. Modelos mixtos lineales generalizados con distribución de los errores binomial negativa seleccionada de acuerdo con $\Delta AICc < 2$ para cada variable de respuesta: jabalí, mesocarnívoros e incidentes relacionados con los pequeños mamíferos (TO, trampa abierta; TC, trampa cerrada; TO+TC, trampa abierta + cerrada) ($n = 152$ en todos los casos). Las capturas de pequeños mamíferos y la estación (la primavera se utiliza como nivel de referencia) son dos variables explicativas empleadas en todos los modelos. En el caso de los incidentes provocados por jabalíes, se añadieron otras dos variables explicativas: el número ordinal de la campaña y un factor que indicaba el parque al que pertenecía la estación (se tomó Collserola como referencia). Los valores de los coeficientes β del modelo y su error estándar se presentan entre corchetes, AICc, $\Delta AICc$ y pseudo- R^2 (marginal y condicional) (** $p < 0,001$, * $p < 0,01$, $p < 0,05$).

Type of incidents	Wild boar		Mesocarnívoros		Small mammals				
					TO	TC	TO+TC		
(Intercept)	0.19 (0.43)	0.54 (0.37)	-0.89* (0.36)	-1.18** (0.45)	-1.50*** (0.28)	0.87*** (0.15)	0.80*** (0.17)	0.89*** (0.15)	1.00*** (0.13)
Captures	0.04* (0.02)	-0.05** (0.02)	- (0.01)	0.01 (0.01)	0.04*** (0.00)	0.01*** (0.00)	0.01*** (0.00)	0.02*** (0.00)	0.02*** (0.00)
Season	0.56 (0.33)	- (0.41)	-1.01* (0.42)	-0.90* (0.42)	0.49* (0.21)	- (0.12)	0.12 (0.12)	0.18 (0.11)	-
Campaign	0.16* (0.06)	0.15* (0.06)							
Park									
Garraf	-1.90*** (0.54)	-1.75** (0.52)							
Litoral	-33.11 (34.99E5)	-36.79 (19.06E6)							
Marina	-2.19*** (0.61)	-2.01*** (0.60)							
Montnegre	-3.27*** (0.63)	-3.23*** (0.63)							
Montseny	-38.37 (13.70E6)	-32.55 (18.93E5)							
Sant Llorenç	-2.69*** (0.65)	-2.59*** (0.64)							
AICc	216.57	217.10	247.90	249.06	391.70	693.46	694.72	744.78	745.35
$\Delta AICc$	0	0.54	0	1.15	0	0	1.26	0	0.57
Pseudo- R^2 marg.	0.62	0.68	0.01	0.01	0.25	0.09	0.10	0.25	0.23
Pseudo- R^2 cond.	0.62	0.68	0.04	0.04	0.36	0.27	0.28	0.44	0.42



Fig. 4. Prototype protective guards against wild boar attacks made from galvanized steel. Their size allows insertion of small to medium-sized commercial traps (Longworth/Heslinga and medium-sized Sherman traps, the last shown in the photos).

Fig. 4. Prototipo de cubierta de protección frente a los ataques de jabalí hecha de acero galvanizado. Su tamaño permite albergar trampas comerciales de tamaño pequeño y mediano (trampas Longworth o Heslinga y trampas Sherman medianas como las que muestran las imágenes).

techniques need to be applied to control for potential biases in the estimates of small mammal population sizes (Beauvais and Buskirk, 1999).

In such areas, traps should either be placed inside fenced areas (Focardi et al., 2000; Sunyer et al., 2016), or each trap should be individually protected by some form of cover, such as the prototypes now currently used in our study area. These comprise galvanized steel covers staked to the ground (fig. 4). In the main, the damage that wild boar produced to traps was irreparable, making them inoperative after

major attacks. Damage caused by wild boar to small mammal traps in the Collserola Park represented a cost of €1,650 over the four-year the period (roughly €400/year), and an even higher total accumulated amount if we include damages incurred before this study and the added administrative time loss and costs due to procurement of new replacement traps. Thus, if successful, the current use of fixed protective guards against attacks by wild boars (fig. 4) might be a significant financial saving if the small mammal monitoring programme continues in this region, con-

sidering that each trap protection unit currently costs €23; an entire sampling grid of 36 traps could be protected through the investment of €828. Nonetheless, the existing prototype design of these new protective guards will likely require further improvement and monitoring before their effectiveness at mitigating trap damage can be sufficiently guaranteed. In addition, given that incidents were only frequently observed in one protected park (Collserola), future research would ideally seek to confirm our hypothesis regarding the synurbization of wild boar as a driving factor behind increased damages to small mammal traps in highly frequented peri-urban natural areas.

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References

- Adams, P. J., Fontaine, J. B., Huston, R. M., Fleming, P. A., 2019. Quantifying efficacy of feral pig (*Sus scrofa*) population management. *Wildlife Research*, 46: 587–598, Doi: [10.1071/WR18100](https://doi.org/10.1071/WR18100)
- Amori, G., Luiselli, L., Milana, G., Casula, P., 2016. Negative effect of the wild boar (*Sus scrofa*) on the population size of the wood mouse (*Apodemus sylvaticus*) in forest habitats of Sardinia. *Mammalia*, 80(4): 463–467, Doi: [10.1515/mammalia-2015-0023](https://doi.org/10.1515/mammalia-2015-0023)
- Barrios-García, M. N., Ballari, S. A., 2012. Impact of wild boar (*Sus scrofa*) in its introduced and native range: A review. *Biological Invasions*, 14: 2283–2300, Doi: [10.1007/s10530-012-0229-6](https://doi.org/10.1007/s10530-012-0229-6)
- Bartoň, K., 2015. *MuMIn: Multi-Model Inference R package*, version 1.15.6.
- Bates, D., Mächler, M., Bolker, B., Walker, S., 2015. Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, 67: 1–48, Doi: [10.18637/jss.v067.i01](https://doi.org/10.18637/jss.v067.i01)
- Beauvais, G. P., Buskirk, S. W., 1999. Modifying estimates of sampling effort to account for sprung traps. *Wildlife Society Bulletin*, 27: 39–43.
- Bieber, C., Ruf, T., 2005. Population dynamics in wild boar *Sus scrofa*: ecology, elasticity of growth rate and implications for the management of pulsed resource consumers. *Journal of Applied Ecology*, 42: 1203–1213.
- Cahill, S., Llimona, F., Cabañeros, L., Calomardo, F., 2012. Characteristics of wild boar (*Sus scrofa*) habituation to urban areas in the Collserola Natural Park (Barcelona) and comparison with other locations. *Animal Biodiversity and Conservation*, 35: 221–233, Doi: [10.32800/abc.2012.35.0221](https://doi.org/10.32800/abc.2012.35.0221)
- Castillo Contreras, R., 2019. Urban wild boar. Drivers of presence, phenotypic responses and health concerns. PhD thesis, Universitat Autònoma de Barcelona.
- Casula, P., Luiselli, L., Milana, G., Amori, G., 2017. Habitat structure and disturbance affect small mammal populations in Mediterranean forests. *Basic and Applied Ecology*, 19: 76–83, Doi: [10.1016/j.baae.2016.11.003](https://doi.org/10.1016/j.baae.2016.11.003)
- Colino-Rabanal, V. J., Bosch, J., Muñoz, M. J., Peris, S. J., 2012. Influence of new irrigated croplands on wild boar (*Sus scrofa*) road kills in NW Spain. *Animal Biodiversity and Conservation*, 35.2: 247–252, Doi: [10.32800/abc.2012.35.0247](https://doi.org/10.32800/abc.2012.35.0247)
- Fagiani, S., Fipaldini, D., Santarelli, L., Burrascano, S., Del Vico, E., Giarrizzo, E., Mei, M., Taglianti, A. V., Boitani, L., Mortelliti, A., 2014. Monitoring protocols for the evaluation of the impact of wild boar (*Sus scrofa*) rooting on plants and animals in forest ecosystems. *Hystrix*, 25: 31–38, Doi: [10.4404/hystrix-25.1-9314](https://doi.org/10.4404/hystrix-25.1-9314)
- Farías-Torbidoni, E., Morera, S., 2020. *Estudi d'aflluència, freqüentació i caracterització dels visitants-usuaris del Parc Natural de la Serra de Collserola*. Consorci del Parc Natural de Collserola. ISBN: 978-84-09-20167-9. Published report (in Catalan). DOI: [10.13140/RG.2.2.27890.12485](https://doi.org/10.13140/RG.2.2.27890.12485)
- Focardi, S., Capizzi, D., Monetti, D., 2000. Competition for acorns among wild boar (*Sus scrofa*) and small mammals in a Mediterranean woodland. *Journal of Zoology*, 250: 329–334.
- Gamelon, M., Besnard, A., Gaillard, J. M., Servanty, S., Baubet, E., Brandt, S., Gimenez, O., 2011. High hunting pressure selects for earlier birth date: wild boar as a case study. *Evolution, International Journal of Organic Evolution*, 65: 3100–3112, Doi: [10.1111/j.1558-5646.2011.01366.x](https://doi.org/10.1111/j.1558-5646.2011.01366.x)
- Geisser, H., Reyer, H. U., 2005. The Influence of Food and Temperature on Population Density of Wild Boar *Sus Scrofa* in the Thurgau (Switzerland). *Journal of Zoology*, 267: 89–96, Doi: [10.1017/S095283690500734X](https://doi.org/10.1017/S095283690500734X)
- González-Crespo, C., 2021. The Synurbization of Wild Boar in the City of Barcelona, Spain. PhD thesis, Universitat Autònoma de Barcelona, <http://www.tdx.cat/handle/10803/671607>
- Keuling, O., Podgórski, T., Monaco, A., Melletti, M., Merta, D., Albrycht, M., Genov, P. V., Gethöffer, F., Vetter, S. G., Jori, F., Scalerà, R., Gongora, J., 2017. Eurasian Wild Boar *Sus scrofa* (Linnaeus, 1758). In: *Ecology, Conservation and Management of Wild Pigs and Peccaries*: 202–233 (E. Meijaard,

- M. Melletti, Eds.). Cambridge University Press, Cambridge, Doi: [10.1017/9781316941232.023](https://doi.org/10.1017/9781316941232.023)
- Massei, G., Kindberg, J., Licoppe, A., Gačić, D., Šprem, N., Kamler, J., Baubet, E., Hohmann, U., Monaco, A., Ozoliņš, J., Cellina, S., Podgórski, T., Fonseca, C., Markov, N., Pokorný, B., Rosell, C., Náhlik, A., 2015. Wild boar populations up, numbers of hunters down? A review of trends and implications for Europe. *Pest Management Science*, 71: 492–500, Doi: [10.1002/ps.3965](https://doi.org/10.1002/ps.3965)
- Meyer, D., Zeileis, A., Hornik, K., 2021. *Package vcd: Visualizing Categorical Data*. R–package version 1.4–9.
- Mori, E., Ferretti, F., Lagrotteria, A., La Greca, L., Solano, E., Fattorini, N., 2020. Impact of wild boar rooting on small forest-dwelling rodents. *Ecological Research*, 35(4): 675–681, Doi: [10.1111/1440-1703.12113](https://doi.org/10.1111/1440-1703.12113)
- Náhlik, A., Cahill, S., Cellina, S., Gál, J., Jánoska, F., Rosell, C., Rossi, S., Massei, G., 2017. Wild Boar Management in Europe: knowledge and practice. In: *Ecology, Conservation and Management of Wild Pigs and Peccaries*: 339–353 (E. Meijaard, M. Melletti, Eds.). Cambridge University Press, Cambridge, Doi: [10.1017/9781316941232.033](https://doi.org/10.1017/9781316941232.033)
- O'Hara, R. B., Kotze, D. J., 2010. Do not log–transform count data. *Methods in Ecology and Evolution*, 1: 118–122, Doi: [10.1111/j.2041-210X.2010.00021.x](https://doi.org/10.1111/j.2041-210X.2010.00021.x)
- Putman, R. J., Langbein, J., Watson, P., Green, P., Cahill, S., 2014. The management of urban populations of ungulates. In: *Behaviour and Management of European Ungulates*: 148–177 (R. Putman, M. Apollonio, Eds.). Whittles Publishing, Dunbeath, Caithness, Scotland.
- Rosell, C., Pericas, B., Colomer, J., Navàs, F., Colomer, A., 2019. *Programa de seguiment de les poblacions de senglar a Catalunya. Temporada 2018–2019*. Departament d'Agricultura, Ramaderia, Pesca i Alimentació, Generalitat de Catalunya. Unpublished report (In Catalan).
- Rosell, C., Ruiz–Olmo, J., Navàs, F., Cama, A., Guinart, D., Bassols, E., Vargas, M. J., 2018. Catalan wild boar monitoring programme: Lessons learned after 20 years. In: *Book of Abstracts of the 12th International Symposium on Wild boar and other Suids*: 67 (J. Drimaj, J. Kamler, Eds.). Mendel University in Brno, Czech Republic), <https://wmrg.ldf.mendelu.cz/en/29183-book-of-abstracts>
- Servanty, S., Gaillard, J. M., Ronchi, F., Focardi, S., Baubet, É., Gimenez, O., 2011. Influence of harvesting pressure on demographic tactics: implications for wildlife management. *Journal of Applied Ecology*, 48: 835–843, Doi: [10.1111/j.1365-2664.2011.02017.x](https://doi.org/10.1111/j.1365-2664.2011.02017.x)
- Sibbald, S., Carter, P., Poulton, S., 2006. Proposal for a National Monitoring Scheme for Small Mammals in the United Kingdom and the Republic of Eire. *The Mammal Society Research Report*, 6: 1–90.
- Sunyer, P., Muñoz, A., Mazzerole, M. J., Bonal, R., Espelta, J. M., 2016. Wood mouse population dynamics: Interplay among seed abundance seasonality, shrub cover and wild boar interference. *Mammalian Biology*, 81: 372–379, Doi: [10.1016/j.mambio.2016.03.001](https://doi.org/10.1016/j.mambio.2016.03.001)
- Torre, I., López–Baucells, A., Stefanescu, C., Freixas, L., Flaquer, C., Bartrina, C., Coronado, A., López–Bosch, D., Mas, M., Míguez, S., Muñoz, J., Páramo, F., Puig–Montserrat, X., Tuneu–Corral, C., Ubach, A., Arrizabalaga, A., 2021. Concurrent Butterfly, Bat and Small Mammal Monitoring Programmes Using Citizen Science in Catalonia (NE Spain): A Historical Review and Future Directions. *Diversity*, 13: 454, Doi: [10.3390/D13090454](https://doi.org/10.3390/D13090454)
- Torre, I., Raspall, A., Arrizabalaga, A., Díaz, M., 2018. SEMICE: An unbiased and powerful monitoring protocol for small mammals in the Mediterranean Region. *Mammalian Biology*, 88: 161–167, Doi: [10.1016/j.mambio.2017.10.009](https://doi.org/10.1016/j.mambio.2017.10.009)
- 2019. Evaluating trap performance and volunteers' experience in small mammal monitoring programs based on citizen science: the SEMICE case study. *Mammalian Biology*, 95: 26–30, Doi: [10.1016/j.mambio.2019.01.004](https://doi.org/10.1016/j.mambio.2019.01.004)
- Vetter, S. G., Ruf, T., Bieber, C., Arnold, W., 2015. What Is a Mild Winter? Regional Differences in Within–Species Responses to Climate Change. *Plos One*, 10: e0132178, Doi: [10.1371/journal.pone.0132178](https://doi.org/10.1371/journal.pone.0132178)