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Factors influencing the success of capturing European brown bears with foot snares

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Abstract

Management of free-ranging wildlife may include the capture of animals, with the implication that the capture process is optimized, both logistically and economically and in a way that avoids animal suffering, injury or accidental mortality. Studies targeting the optimization of trapping techniques are scarce, especially when focusing on large European mammals. Therefore, to fill this knowledge gap, we aimed to evaluate key factors that help determine brown bear capture success. This was done by analysing a complete data set from 23 years of capturing free-living Eurasian brown bears in Croatia by using Aldrich-type foot snares. Results showed significantly higher capture efficiency when traps were located at permanent feeding sites when compared to temporary feeding sites. Also, the use of a trail trap design was significantly more efficient in capturing bears than using a cubby set. Finally, results showed that trapping was more efficient when we bait the traps more frequently and when we implemented longer trap-sessions, with at least 14 days.

Key Words: Aldrich traps, Brown bear, Capture efficiency, Capture success, Ursus arctos, Croatia

1. Introduction

Studies focused on free-ranging animals and their management usually require the need for temporary, hands-on opportunities to collect biological samples (e.g., ectoparasites; Nyeema et al. 2014), assess physiological condition (Macdonald et al. 2002) and/or install monitoring devices (e.g., radio tracking collars; Kays et al. 2015). The basic requirements when trapping wildlife (e.g., when using snares, foot hold traps, box traps or helicopter darting) are that the animal does not become excessively stressed, injured or accidentally killed, and that they are able to resume normal activities after being handled by researchers and managers (Arnemo et al. 2006; Sikes and Gannon 2011). Additionally, trapping campaigns are logistically and financially demanding, and therefore, there is a generalized and paramount need to optimize capturing methodology.

Trapping efficiency is a fundamental consideration in assuring reduced human disturbance on wildlife and it should be optimised to avoid unintentional injury or mortality of target and non-target species. Additionally, the optimisation of trap efficiency and selectivity may be crucial in avoiding population decline and regional/national extinction of species in small and endangered populations (Virgós et al. 2016), such as carnivores. Large carnivores as the brown bear (*Ursus arctos*), can be especially difficult to capture and handle, exhibit elusive behaviour, avoid human interaction and when threatened can display aggressive behaviours, which can cause injuries to people handling them (Cattet et al. 2003; Nowak 2005; Powell 2005). This is particularly important to consider when trapping bears and other large carnivores (Nowak 2005) as several species and populations are classified as threatened (e.g., the Abruzzi brown bears; Colangelo et al. 2012) and any unnecessary disturbance caused by an inefficient trapping campaigns can induce additional harm. The spring-activated Aldrich foot snare trap (Reagan et al. 2002) is a commonly used device to capture several carnivore species throughout the world, including all species of bears (Flowers 1977), African lions (*Panthera leo*; Frank et al. 2003), jaguars (*Panthera onca*) and pumas (*Puma concolor*; Cassaigne et al. 2016). The basic structure of this device allows for changes in settings according to the trap specificities (e.g., trigger sensitivity, spring strength and speed, cable quality, shock absorbing springs etc.) and trapping design type (cubby, trail) (Flowers 1977;

Huber et al. 1996). Trapping technique vary with the characteristics of the trapping site and may include adjustment of baiting method (e.g., the use of pre-baiting, bait type, etc.) and the construction of guiding components, used to direct the animal to step into the loop of the snare (Flowers 1977; Huber et al. 1996).

Due to the risks involved in live trapping mammals, especially when targeting low density populations (Virgós et al. 2016), the sampling design of trapping studies should follow strict guidelines to assure the animal's well-being and the compliance of ethical practise. For example, the number of traps set should allow researchers to monitor them at realistic intervals, to assure animals are kept in traps for minimal amounts of time, while optimizing the capture success; and trap setting (e.g., location, design, etc.) must assure minimal capture of non-targeted taxa, but guarantee that trapping success for the target species remains high (Sikes 2016). Thus, selecting the appropriate trapping protocol that assures the compliance of guidelines set by Sikes (2016) is crucial. Deviations from such guidelines and using alternate trap settings may increase the likelihood of injury. For example, Proulx et al. (2012) showed that different trap types and settings caused distinct physical injury, as well as altering selectivity and efficiency. Further, Cattet et al. (2003) found that minimizing pursuit, restraint and drug induction times for grizzly bear trapping can reduce physiologic effects (e.g., increase in body temperature, alteration of acid-base balance, loss of body water and muscle injuries) on captured individuals. However, few published studies have used the biochemical analyse of collected samples to optimize capture success of large carnivores (Powel and Proulx 2003; Powel 2005).

Our objective was to evaluate the effects of various types of Aldrich foot snare trap settings (see in detail Aldrich foot snare in Huber et al. 1996) on trap efficiency. Based on 23 years of trapping data from free-living brown bears captured in Croatia since 1981, we assessed what mechanisms of trap efficiency were more influential in capture success. We expect a higher capture efficiency at permanent feeding sites since resources are constantly available which induces higher visiting rates (Wheat and Wilmers 2016) and when using a trail set design, as it is usually more efficient at capturing brown bears than a cubby set (Huber et al. 1996). Additionally, we expect to see some seasonal effect, as bears are more active during spring, immediately after hibernation and cub weaning time (Evans et al. 2016). It is also known that the use of pre-baiting and additional bait increases bear visits and therefore the efficiency of capturing brown bears (Johnson and Pelton 1980). Any evidences of activity in the trap sites, like site visits by bears or other mammals, bait eaten and sprung events are good signs of increased changes of capturing bears (Brongo et al. 2005; Huber et al. 1996). Therefore, we hypothesized that capture efficiency would be influenced by: H1 - trap design (e.g. trap site, trap set and season; Lemieux and Czetwertynski 2015); H2- bait design (e.g. bait type, pre-baiting; Johnson and Pelton 1980); H3- trap events (e.g. evidences of activity in the trap sites; Huber et al. 1996); and H4 - a combination of the factors linked to H1-H3.

2. Materials and Methods

a. Study area

The study was carried out in Croatia, in south-central Europe (Fig. 1). All brown bear habitats in Croatia are located within the Dinaric Mountain Range, which runs parallel to the Adriatic Sea and ranges from Slovenia, in the north-west, to North Macedonia, in south-eastern Europe. Consequently, Croatia shares part of the Dinara-Pindos bear population with a total of nine countries comprising one of the 10 bear populations in Europe (Huber et al. 2008). The mean estimated population in Croatia is 930 bears (Skrbinšek et al. 2017) in a range of over 11,000 km^2, which represents 20 % of the country’s area and 34 % of its forests. Within this range, bears permanently occupy 9,253 km^2, whereas 2,571 km^2 has only occasional bear presence (Huber et al. 2008). Altitude in the Croatian part of the Dinara Mountains varies, from sea level to 1,831 m. Forest covers about 70% of the mountain range, which is dominated by a mixture of beech (*Fagus sylvatica*), fir (*Abies alba*) and spruce (*Picea abies*), although depending on elevation and exposure, other tree communities may be present (Table 1). Depending on elevation, average monthly temperatures range from -2.6 °C in January, when snow may be present for 60–165 days (Bertović and Martinović 1981), to 17.0 °C in July (Makjanić 1971). The bear range can be divided in two subregions: Gorski Kotar (GK) and Lika (LI) (Table 1). Rough estimates show that the overall bear densities are higher in Gorski kotar (≥10 bears/100 km^2) than in Lika (≤10 bears/100 km^2; Huber et al. 2019).

b. Study design and data collection

We collected bear capture data in two periods of active trapping efforts: 1981-1990 and 2003-2017. The capturing effort had to be divided in those two periods due to the occurrence of war during the breakup of former Yugoslavia from 1991 until 1995. Consequently, no research projects were implemented until 2001. Bear capture results from the first period were summarized and published by Huber et al. in 1996. Trapping in both periods were carried out during two seasons, spring/summer (15^{th} February-15^{th} August) and autumn (16^{th} August-15^{th} December). For each trap session (i.e. defined as the overall trap sites used to capture a bear in a particular area, a trapping season in an area), the trapping effort varied, as a different number of trap sites were established, ranging from 1-16 at both permanent bears feeding sites (N=124) or at temporarily established baiting sites (N= 40). In Croatia, like in several other European countries where bears are hunted, there is a tradition of feeding bears not only for the purpose of hunting, but also for keeping them away from villages, for monitoring and for eco-tourism purposes. In the 1960s, such practices began through the implementation of permanent feeding sites in Croatia (Huber et al.1996).

Opportunistic baiting sites were established by the relevant Croatian brown bear research team, with particular focus on areas where there was a higher frequency of bears. Such trap sites with temporary baiting were located within protected areas, such as national parks, where bears were not previously fed ($N_{GK}=11$; $N_{LI}=113$) or outside protected areas where permanent baiting-sites were already established ($N_{GK}=36$; $N_{LI}=4$). In the first trap period (i.e., 1981-1990), researchers chose the sites according to two main criteria: presence of recent sign of bear activity in the area and presence of several large trees adequately spaced to fix trapping cables around them (and to allow the setting of a cubby trap). During the second trap period (i.e. 2003-2017), two additional criteria were added: presence of the mobile phone network (GSM) for transmitting text messages when traps were activated; and proximity to roads, to allow for immobilization of the animal from the car, using a dart gun. At each trap site, we set 1-10 Aldrich snare traps, with a mean of three snares per site and a total of 416 Aldrich snares set.

Two basic trap sets were implemented: cubby and trail as described by Flowers (1977) and Huber et al. (1996). The cubby design includes an area fenced by branches around the bait with one or more entrances where the snares are placed (Fig.2A). Trails consist of one or more snares in a line with bait in between, but without artificial fencing (Huber et al. 1996; Fig.2B). The ratio between cubby and trail trap sets varies between Lika (88:28) and Gorski Kotar (12:34), respectively. At both types of feeding sites (i.e. permanent and temporary) bait was primarily composed of road-killed wildlife (e.g., roe deer, *Capreolus capreolus*, and wild boar, *Sus scrofa*), slaughterhouse by-products, domestic animal carcasses, as well as corn and other grains. At the permanent feeding sites, bait was supplied by local hunters during the full hunting season (October-December, March-April). At the trap sites established on temporary feeding grounds, the bait was placed by the bear research team up to approximately 14 days prior to setting traps (pre-baiting) or on the same day the trap was set. Re-baiting occurred as soon as the original bait had been eaten by bears or other animals. Since 2015, remotely triggered cameras were also set on the trap sites to enhance monitoring efficiency. Before 2015, monitoring was carried out by daily visits to the trap sites, where all bear and other animal visits to the site, as well as incidences of traps sprung and bait eaten, were recorded at every visit. The data were organised into two datasets: by trap site (where all daily events from the set Aldrich snares were summarised per site) and by trap session (where all trap site events of a particular area were combined per session). The trap site dataset was used to compare the site-specific parameters linked to the variability of the trapping success (as capturing success can be dependent on structural and ecological variables as the trap site's characteristics (Proulx 2012), and to increase robustness of the analysis.

c. Data analysis

To obtain insights into capture success and efficiency variation, we performed a 2-sample test for equality of proportions with continuity correction (Z-test for proportions; Sprinthall 2011) between 1) seasons (spring/summer and autumn); 2) regions (GK and LI); 3) site type (permanent feeding sites and temporary feeding sites); 4) trap set (cubby and trail) and; 5) study periods (1981-1990 and 2003-2017). We also did a Pearson's chi-square test variation between males and females' number of captures while accounting for the population sex ration (Table 1). Thus, for each variable group we compared the proportion of:

Capture success: $\frac{\text{captures}}{\text{trap-nights}}$;

Capture efficiency: $\frac{\text{bear visits}}{\text{captures}}$.

Trap-night is defined as the number of snares active during each night (e.g., three snares active for one night = three trap-nights). The coefficient of capture success allowed to account for sites with no captures, but several trap-nights (Capture success=0). On the other hand, sites with no bear captures and/or visits were excluded from the capture efficiency analysis (capture efficiency=undefined value). A capture success coefficient was calculated per trap site and per trap session.

Further, we used a modelling approach to assess the combined effect of several covariates on capture success (Table 2). We first, tested collinearity between predictors using the Variance Inflation Factor (VIF; Zuur et al. 2007). The variables with VIF>5 – Nanimal_visits (VIF=36.98) and Ntrap_nights (VIF=17.17) - were considered significantly correlated and we excluded the Nanimal_visits, which had a higher VIF value, from the analysis (Zuur et al. 2007). Once excluded, we recalculated the VIFs for the remaining variables, and Ntrap_nights was the only variable that remained with a VIF value higher than the threshold of a VIF >5. The models were built with the non-collinear variables (i.e excluding both Nanimal_visits and Ntrap_nights). To identify effects that may be masked by how data was combined, we analysed capture success variations by trap session (N=45) and by trap site (N=164). In both cases, three series of models were built according to the pre-defined working hypotheses: Trap design [H1; use of permanent bear feeding sites vs. baiting at temporary sites, the trap region, season and trap design (trail or cubby]; Bait design (H2; bait type, frequency of re-baiting and use of pre-baiting); Trap events (H3; frequency of target animal visits, frequency of sprung snares and frequency of bait eaten) (variables used in each models are all described in Table 2). For each hypothesis, the model selection criterion was based on the Akaike´s Information Criterion, corrected for small sample size (AICc), where the best selected models followed a ΔAICc <2 criterion (Burnham and Anderson, 2002). When more than one suited model per hypothesis fulfilled this criterion, we used a model averaging approach (Burnham and Anderson, 2002). To test if a combination of the variables included in the best models of each hypothesis would produce a better fitted model, we formulated a fourth hypothesis (H4): variation in the dependent variables is mostly determined by a combination of factors associated to distinct trap approaches – trap and bait design, and trap events. Thus, for the fourth hypothesis we only considered the variables included in the best selected models of the previous hypotheses (H1 to H3), whose 95% confidence interval of their coefficients did not include the zero, to avoid incorporating uninformative parameters (Arnold 2010). However, in cases where just one best model was selected, we could not estimate the 95% CI. In such situations, in order to not discredit meaningful variables, we included all those variables in the hybrid model (H4). Variables' interactions were also included in the hybrid model. The same best model selection procedure described above was applied for the hybrid models. We then compared the AICc values of the best models in each of the four hypotheses to assess those more fitted to our data (i.e. lower AICc values; Burnham and Anderson 2002). For the final best fitted model, we estimated the relative importance of each variable (sum of the Akaike weights of all best models that included the variable; Arnold 2010).

All statistical analysis were performed using R 3.2.3 (R Core Team 2015), using the packages "fmsb" (Nakazawa 2017), "lme4" (Bates et al. 2015), "MuMIn" (Barton 2016), "Hmisc" (Harrell 2015), "effects" (Fox 2003), "AER" (Kleiber and Zeileis 2017) and "blmeco" (Korner-Nievergelt et al. 2015).

3. *Results*

a. Trap efforts, wildlife trap visits and captures

During both trap periods (1981-1990 and 2003-2017), 416 Aldrich snares were set at 164 sites, across 2,994 days, and comprising a total of 7,298 trap-nights. These trap sites were included within a total of 45 trap sessions in the GK and LI regions combined (Table 3). The average number of trap sites per trap session was 3.6±3.0, and the mean number of traps/snares set by trap session and by trap site was 9.2±6.3 and 2.5±1.7, respectively.

Trap sites on average were visited by bears once every 32 trap-nights, representing at least 242 bear visits, corresponding to 62% of all animal visits. In the remaining visits to the trap sites (i.e. 181 animal visits), we managed to identify the occurrence of dogs (*Canis lupus familiaris*), red foxes (*Vulpes Vulpes*), European badgers (*Meles meles*), wild boars (*Sus scrofa*) and birds (mostly common ravens, *Corvus corax*).

We registered a total of sixty-three (63) bear captures ($N_{1981-1990}$=37, $N_{2003-2017}$=26), including two bears that escaped from a trap in 1983 (both accidentally broke the steel cable). Thirty percent of the captured bears were females, whereas 70% were males (23 bears were subadults and 25 adults). On average, the first bear was captured on the 14th day of trapping (range 1-42, SD=10) and on the 50th trap-night (range 2-222, SD=49). The overall mean capture success was 115 trap-nights per bear capture (Table 3). We also captured one wild boar in 2017 and nine dogs from 1982 to 1987.

b. Capture success variation

We detected a significant difference in capture success between the two regions where traps were set (χ^2 = 5.595, df = 1, *P* = 0.018). Capture success was greater in Gorski Kotar (prop=0.006; 80 trap-nights/capture) than in Lika (prop=0.013; 148 trap-nights/capture). In addition, capture success was also greater when a trail set design was implemented (χ^2= 4.30, df = 1, *P* =0.04; prop=0.012, 84 trap-nights/capture) than with a cubby set (prop=0.007, 144 trap-nights/capture). The site type also influenced capture efficiency (χ^2 = 184.54, df = 1, *P* <

0.001), with higher capture efficiency recorded when permanent feeding sites were used for setting the traps (prop=0.427, 90 trap-nights/capture) when compared to temporary feeding sites (prop=0.724, 132 trap-nights/capture). We also detected that the number of captured males was significantly higher than the number of captured females (χ^2 =6.13, df=1, *P* =0.01). Lastly, capture success did not differ between the study periods (χ^2=3.70e^{-29}, df = 1, *P* > 0.99) or between seasons (χ^2= 3.68, df = 1, *P* =0.94). Regarding capture efficiency, no differences were found when comparing all four explanatory variables (all *P* > 0.05).

c. Factors influencing bear capture success per trap session and trap site

We built a total of 56 models predicting the capture success per session. From these overall models, eight, five and four were considered best models (ΔAICc <2) for hypothesis H1, H2 and H3, respectively (Table 4). The best overall model only included bait design variables (H2), however none of the variables had a 95% CI of the averaging coefficients that did not include zero. Therefore, no conclusion can be made regarding the predictors of capture success at the trap session level.

Regarding the trap sites' capture success, from the total of 56 models, we identified that the best models for our hypothesis were four for H1 and H3 and three for H2 (Table 4). From all candidate variables included in all hypotheses, only the variables Ndays and Nadd_bait where included in the hybrid hypothesis, as the 95% CI of their averaging coefficients did not include zero. All three hybrid models produced were considered the best models, as they had the lowest AICc value. The average hybrid model included not only the variables Ndays and Nadd_bait, but also their interaction (Ndays*Nadd_bait). However, the variable Ndays and the corresponding interaction were the only variables with a 95% CI of the coefficients that did not include zero. Thus, we can infer that the capture success was lower with the increase of trap days, yet if that increase was reinforced with the addition of bait, the success of capture increased (Table 4).

4. Discussion and conclusion

Between 1981 and 2017, it took an average of 32 trap-nights for a bear visit at trapping sites and 115 trap-nights to capture a bear. In comparison to Huber et al. (1996), a study from which part of our data was obtained (1981-1990), less trap-nights were needed to have a bear visit (N=22), with more trap-nights required (N=120) to have a capture. Although the capture success (i.e. capture/trap-nights) increased slightly in the second period, it was not statistically significant. We observed similar capture success during second period despite having lower visitation rates, which is likely to be explained by the acquired experience of the bear research team (i.e. best selection of trap sites, improved practice in setting the trap designs) over time, which remained with the same team leader during both periods.

Our results suggest that Gorski Kotar is a more efficient region to trap bears in Croatia, due to the higher number of captures with less field effort. Most of the Croatian bear population occurs at higher density in Gorski Kotar (Skrbinšek et al. 2017) which may increase the chances of capturing bears in that area (Huber et al. 2019). In addition, results from our study showed that permanent feeding sites were a better choice for capturing bears opposed to temporary feeding sites where bears are fed, which may be because they are not familiarised with supplementary food from anthropogenic sources on those temporary sites. Permanent feeding sites are frequently visited by bears and most individuals are not only accustomed to find food at such sites, but are also habituated to human signs of presence, such as scents (Wheat and Wilmers 2016), since human presence is regular at these sites. In novel baiting sites, the presence of human provided food is recent and human smells and eventual other signs are also not familiar, so are more seldom visited by bears. Thus, the chance of successful bear capture is greatly reduced, due to a lower probability of visitation linked to an unfamiliarity of food availability and/or to the fact that any unfamiliar smell (i.e. human scent) increase precaution in the way animals use the space, making any capture more difficult (Johnson and Pelton 1980; Huber et al. 1996). A higher capture success at permanent feeding sites may also explain why there was a higher capture success in Gorski Kotar, as permanent bear feeding sites were used for trapping more frequently than in the Lika region.

Regarding the trap set design, trail sets were shown to be the more efficient methodology for brown bear capture. Although trail sets had less bear visitations, they had higher incidences of successful captures when compared to the cubby set design. This may be due to the fact that bears are accustomed to visiting ~~such~~ permanent feeding sites, even when there is no freshly displayed food, evident in visible trails along the common approaching routes (Long et al. 2008). In support, previous studies from Huber et al. (1996) and Flowers (1977) that described the use of small cubby traps, found that fewer bear visits were observed at the cubby set, compared to trail sets. This was attributed to bear avoidance of all man-made structures (Huber et al. 1996), as to set a cubby trap we need to considerably change the surrounding by adding branches and dead trees to create a closed space only accessible by a few entrances points where the traps were set (Fig. 2). Instead, for trail sets we use the pre-existing animal trails and so minimal changes are made to the environment. Our results also show that male bears are more easily captured than females. Even though, we don´t have the age information for every captured bear, 65% of the identified subadults were males, and this sex-age structure is frequently more prone to be captured, due to their more curious and less vigilant behavior (Elfström et al. 2014), which can be influencing the high capture rate of male bears. Thus, individual characteristics as age, gender and reproductive status can be can influence bear activity patterns (Parres et al. 2020), and, therefore, shape the capturing success. We incorporated a multivariable modelling approach to account for the synergistic effects of relevant factors that could influence the capture success, as well as their interactions. No clear conclusion could be drawn regarding the capture success per trap session, as the model averaging coefficients did not provide clear evidence of the effect of the considered covariates on capture success (positive/negative; as the 95% CI of the variables included the 0). However, some influence is evident regarding site type (i.e. within permanent feeding sites) and pre-baiting, which seem to have some positive effects on capture success. This influence is not strong and it is likely that other variables not considered in the analysis may also be contributing to the detected pattern. For example, the age structure and reproductive status of captured animals per site, as mentioned above, population size and density between the two periods, as well as food availability, human presence and conspecific interactions might also be driving the capture pattern (Gupta et al. 2017; Parres et al. 2020). Even though our results did not show any influence of season in bear capture rate, hibernation and hyperphagia patterns influence bear movements and food choices, and should be considered when defining bear trapping strategies (Mano 1995).

When we consider capture success per trap site, we were able to infer that increasing the number of days a trap was active did not improve the probability of successful bear capture. Yet, if the increase of days is reinforced with the addition of bait, capture success is improved. Thus, implementing longer trap sessions is only an adequate measure to increase the capture success if accompanied by regular baiting of traps. The converse is also true; increasing the baiting frequency without extending trap sessions will result in decreased capture success (see Table 4). This may be related to reduced bear tolerance to human presence (Zarzo-Arias et al. 2017). Every time bait is added, the researcher must visit the trap site, thereby disturbing the location and leaving odoriferous clues of their presence behind, which can deter bears, thus preventing bear visits during the following days.

From anecdotal evidence, there is some suggestion that in order to mitigate such effects caused by human disturbance to the trap site (e.g., anthropogenic noise, odoriferous cues, modifying natural structures etc.), it may be beneficial to implement a delay in trap activation. Thus, immediately after traps are set, there should be period of inactivation so disturbances to the site are reduced over time, resulting in increased bear visitations post-activation. However, implementing this procedure comes at a cost of number of days when the site is not active.

As a conclusion of our study we suggest that researchers should: 1) locate traps at permanent bear feeding sites where available [being maintained by humans or located at food resource rich patches – e.g., wild berries (i.e. *Prunus avium*, *Rubus fruticosus*) or beechnuts (*Fagus* spp.) patches (Pereira et al. 2021)]; 2) preferably use a trail trap design; 3) frequently bait the traps; and 4) implement longer trap-sessions, with at least 14 days, as it is the average time to capture the first bear.

We believe that the results and implications from our study may contribute to improved methodology needed to capture brown bears using foot snares. Consequently, our results may reduce financial and field investments associated with bear research using invasive approaches. We also hope it can prompt other researchers to publish their results on bear trapping and how they optimized their trapping techniques.

Author contributions

DH and SR conceived of the presented idea and data collection. JP contributed to the data collection in 2017. JP and LMR performed the data analysis and results interpretation. JP took the lead in writing the manuscript together with LMR. NB contributed significantly to editing and English language reviewing. All authors provided critical feedback to the manuscript.

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Conflict of interest statement

The corresponding author confirms on behalf of all authors that there have been no financial interests that might influence the interpretation of our results or in the conclusions, implications, or opinions stated.

Compliance with ethical standards

Bear trapping in Croatia was performed under the relevant permits since the start of the project. Permits were issued by the Ministry for Nature Protection and Energy (the most recent one: UP/1-612-07 /19-48/76 (URBROJ: 517-05-1-1-19-2, issued 02.04.2019, valid until 31.03.2021) and the Ministry of Agriculture (the most recent one: UP/I 232-03/19-01/102 (URBROJ 525- 11/1029-19-2, issued 26.04.2019, valid until 31.12.2019).

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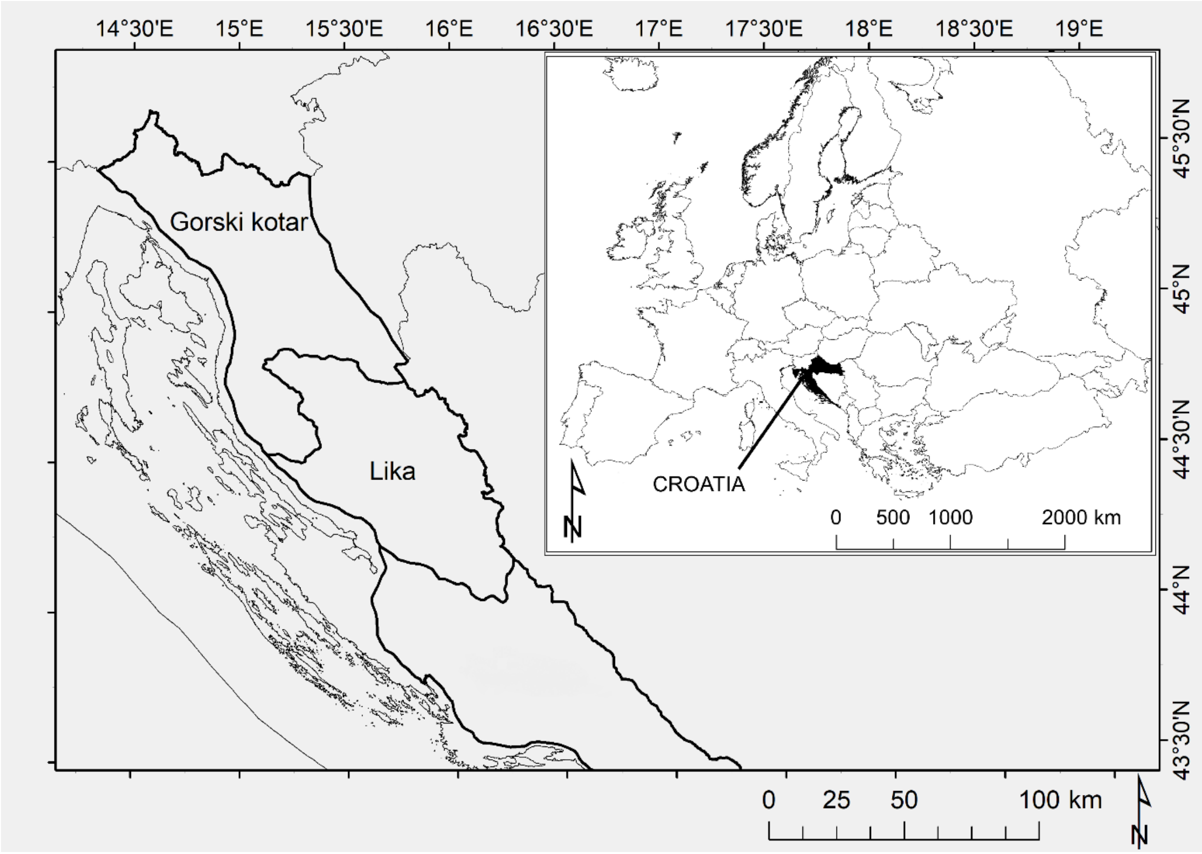
Figure captions

Figure 1. Study-area – region of Gorki Kotar and Lika in Croatia.

Figure 2. Illustrates two basic trap setting designs A) European cubby and B) Trail set. The Aldrich snare trapping cables are fixed around anchor trees and the bait is placed in the centre. In A) guiding branches are fencing the area where the bait is placed.

544 
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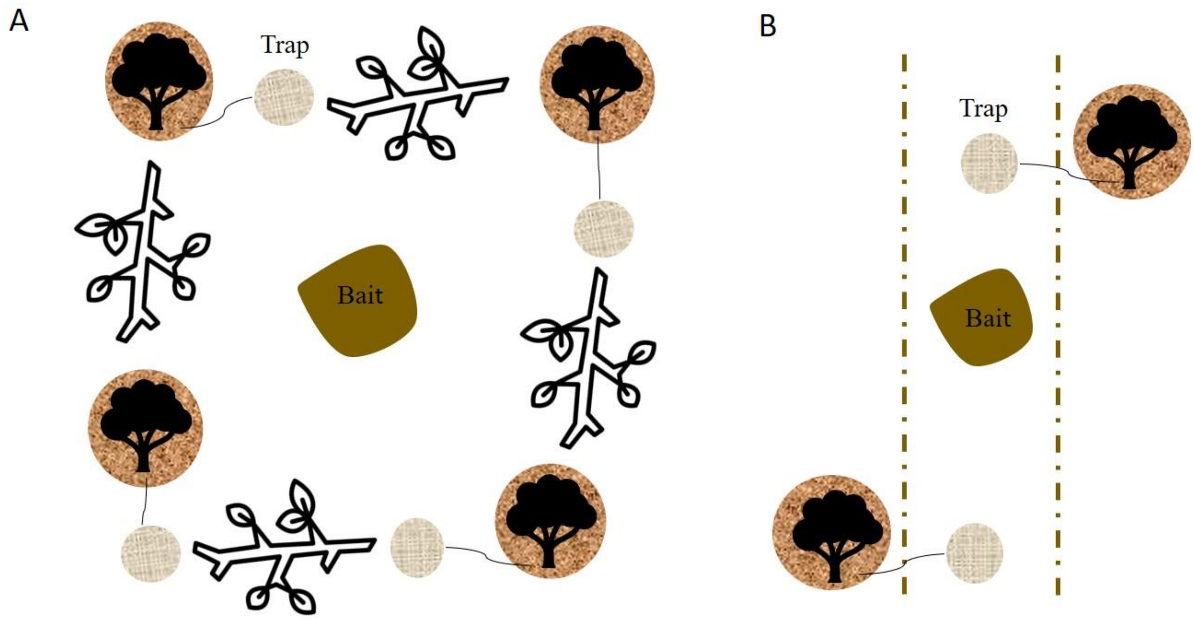

Figure 2

Table 1: Characteristics and habitat descriptors of the Gorski Kotar and Lika study areas, as well as bear population inhabiting both areas (Huber and Roth 1986; Kusak and Huber 1998; Huber et al. 2008a; Skrbinšek et al. 2017).

Descriptor	Gorski Kotar	Lika
Area (km^2)	1796	8183
Supplementary feeding	Yes	Yes
Permanent bear presence area (km^2)	1495	8077
Approximate bear population (both regions)*	937 (846-1072)	
Estimated adult sex ratio (F:M)	58%:42%	
Average elevation (m)	737	849
Average annual temperature (^oC)	7,6	9,3
Average annual precipitation (mm)	3770	1360
Estimated natural vegetation cover (%)	66	75
Road density (km/km^2)	1,91	[a]

[a] Denotes unknown

* Information regarding bear population numbers are only available for entire Croatian population, as the bear population is continuous (not fragmented), so only the overall densities may be compared.

Table 2: Dependent (shaded in gray) and independent variables collected per trap site. The independent variables are organized according to the corresponded model hypothesis.

Hypothesis	Variables	Abbreviation	Variable Type	Description
	No of captures	Ncap	Dependent; Numerical, Countable	Sum of the number of captures
	Capture success	Ecap	Dependent; Numerical, Coefficient	No of trapping-nights/No of captures
H1 – Trap Design Hypothesis	No of trap nights	Ntrap_nights[b]	Independent; Numerical, Countable	No of days x Total no of traps
	No of days	Ndays	Independent; Numerical, Countable	No of days the traps were active
	Region	Reg	Independent; Categorical	Gorski Kotar or Lika [a]
	Site type	Stype	Independent; Categorical	Outside feeding site or Feeding site
	Total no of traps	Ttraps	Independent; Numerical, Countable	Total traps set per trap session or per trap site
	Trap set	Tset	Independent; Categorical	Cubby or Trail
	Season	Season	Independent; Categorical	Spring or Autumn
H2 – Bait Design Hypothesis	Pre-baiting	Pbait	Independent; Categorical	Pre-baiting or No pre-baiting
	No of additional bait	Nadd_bait	Independent; Numerical, Countable	Number of times a bait was added
	Type of bait	Tbait	Independent; Categorical	6 categories of bait type: Farm meat; Wild meat; Refuses; Farm meat+Refuses; Wild meat+other; other; No bait
H3 – Trap Events Hypothesis	Bait eaten by bear	Bait_eaten	Independent; Numerical; Countable	Number of confirmed times bait was eaten by bears
	No of Sprungs	Nsprung	Independent; Numerical; Countable	Number of missed sprung snares

No of bear visits	Nbear_visits	Independent; Numerical; Countable	Number of bears' visited the trap site
No of animal visits	Nanimal_visits[b]	Independent; Numerical; Countable	Number of all animal visitations at the trap site

[a] Variable just used for the overall data analyze

[b] Variable excluded from the analyze due to high collinearity with the other independent variables

Table 3: Summary table of brown bear capturing data in Croatia.

		No Trap-sites	No Trap-seasons	No Trap-nights	No Bear visits	No Captures	Capture success*	Capture efficiency **
Period	1981-1990	118	29	4337	161	37	117	4
	2003-2017	46	16	2961	81	26	114	3
Region	Lika	117	26	4898	152	33	148	5
	Gorski Kotar	47	19	2400	90	30	80	3
Set design	Cubby	101	20	4902	162	34	144	4
	Trail	63	25	2415	82	29	84	4
Season	Autumn	55	18	1706	64	14	122	5
	Spring	109	27	5592	178	49	114	4
Site type	Permanent F. site	40	18	2156	77	24	90	3
	Temporary F. site	124	27	5142	165	39	132	4

* Trap-nights/Capture

** Bear visits/Capture

550

Table 4: Averaged model coefficients for variables included in the best combined models (β – variables coefficients; SE – coefficient Standard Error; t-value - z value test scores; P – significance; 95% CI - 95% confidence intervals; RI – Relative importance). See variables´ abbreviation and description in table 1.

	Best models averaging variables coefficients					
	β	SE	t-value	P	95% CI	RI
Capture success (per session) model						
Intercept	0,023	0,007	3,402	<0.001	[0.009, 0.036]	-
Stype	-0,01	0,008	1,118	0,263	[-0.028, 0.001]	0,689
Nadd_bait	<-0.001	<0.001	1,516	0,129	[-0.001, <0.001]	0,532
Pbait	0,008	0,007	1,117	0,264	[-0.006, 0.023]	0,292
Capture success (per trap site) model						
Intercept	0,036	0,007	5,065	<0.001	[0.016, 0.047]	-
Ndays	-0,001	<0.001	-2,672	0,008	[-0.164, 0.002]	0,846
Nadd_bait	-0,009	0,004	-2,227	0,027	[-0.002, <0.001]	0,614
Ndays*Nadd_bait	<0.001	<0.001	2,006	0,046	[<0.001, <0.001]	[a]

[a] For interactions we cannot estimate RI