LIFE DINALP BEAR

Population level management and conservation of brown bears in northern Dinaric Mountains and the Alps

LIFE13 NAT/SI/000550

Feeding site use and food type preference of brown bears in Slovenia

Study design, implementation and analysis as part of Action C.7.: Supplemental feeding of bears with carrion and Action C.5.: Establishment and optimization of an integrated, population-level surveillance of brown bear conservation status. Preparation of the report as part of Action D.1.: Monitoring of bears exhibiting conflict behaviour and effectiveness of mitigation measures in conflict hot-spot areas.

Prepared by Patricia M. Graf and Klemen Jerina

Contributors: Dejan Bordjan, Urša Fležar

Suggested Citation:
Graf, P.M., Bordjan, D., Fležar, U., Jerina, K. (2018) Feeding site use and food type preference of brown bears in Slovenia, prepared within the LIFE DINALP BEAR Project (LIFE13 NAT/SI/0005): 29 pp.

July 2018

Univerza v Ljubljani

110 Lovska zveza Slovenije

ZAVOD za GOZDOVE SLOVENIJE
Slovenia Forest Service

Table of contents

Figure legend

Table legend

Abstract

Year-round artificial feeding of brown bears (*Ursus arctos*) has a longstanding tradition in Slovenia. The main feed types used were maize and carrion, until 2004 when feeding livestock carrion was banned. This was accompanied by strong public concern, due to the general belief that carrion is more attractive to bears and, thus, more effective for diverting bears from settlements. In the years 2016 and 2017, we supplied n = 19 feeding sites interchangeably with maize and wildlife carrion such as road kill and game offal, to test the assumption that bears prefer carrion. Simultaneously, camera traps were set up to record bear presence at feeding sites. Time was split into five-minute intervals and bear presence was defined as the number of pictures showing a bear. In addition, we tested whether bear counts derived from camera trap data were comparable to traditional count data from high stands, which are preformed three times a year since 2004 (brown bear monitoring on permanent counting sites). On average, bears were present at carrion feeding sites for 2.02% of the time and for 1.51% of the time at maize feeding sites. Moreover, bears were using feeding sites for 1.90% of the time in the year 2017 and for 1.59% of the time in the year 2016. The final model included the informative interaction between the food type carrion and the year 2017, which suggests that bear presence at carrion feeding sites was higher mainly in the year 2017. Females with cubs behaved similarly to other bears and used carrion feeding sites increasingly in 2017. In general, feeding site use was highest during the summer months and peaked between 9 pm and 10 pm on a daily basis. Cohen's kappa values for comparing camera trapping data and count data from high stands indicate a moderate agreement between the datasets. In 2017, natural foods were scarce and this may have triggered the higher use of carrion feeding sites during this year. Artificial feeding remains controversial and should only be practised when it's desirable effects prevail, which include diverting bears from human settlements, monitoring and baiting for hunting. Carrion plays an important role in food webs and we suggest to provide carrion when it is readily available and can be transported to feeding sites without considerable effort. Bears may profit from this in particular during years when natural food sources are scarce. In summary, future studies evaluating the effectiveness of artificial feeding should take the availability of natural food into account.

Izvleček

Krmljenje medveda (*Ursus arctos*) ima v Sloveniji dolgo tradicijo. Na krmišča se je tradicionalno polagalo zlasti koruzo in mrhovino domačih živali (predvsem goveda in konjev). Krmljenje z mrhovino pa se je leta 2004 prepovedalo, kar je sprožilo močne pomisleke, saj v javnosti prevladovalo mnenje, da je krmljenje z mrhovino učinkovit ukrep zmanjševanja konfliktov med medvedom in človekom. Da bi testirali domnevo, da imajo medvedje raje mrhovino od krme rastlinskega izvora, smo v letih 2016 in 2017 na 19 izbranih krmiščih izmenjaje v enem letu zalagali le koruzo, v drugem pa ob koruzi še mrhovino (povoženih divjih živali ter ostankov po iztrebljenju uplenjene divjadi; zlasti srnjadi in jelenjadi). Rabo krmišč s strani medveda smo nepretrgoma obe leti spremljali s foto-pastmi. Čas smo razdelili na 5 minutne intervale in definirali prisotnost medveda kot število slik, na katerih se je medved pojavil. Hkrati smo analizirali tudi ali je število medvedov ugotovljeno s foto-pastmi primerljivo s tradicionalnim preštevanjem medvedov, ki se sistematično izvaja trikrat na leto od leta 2004 dalje (spremljanje medveda na stalnih števnih mestih). V povprečju so bili medvedi prisotni na krmiščih z mrhovino 2.02% časa in na krmiščih s koruzo 1.51% časa. V letu 2017 so krmišča uporabljali 1.90% časa, v letu 2016 pa 1.59% časa. Končni model je vseboval informativno interakcijo med mrhovino in letom 2017, kar nakazuje, da so medvedi pogosteje uporabljali krmišča z mrhovino predvsem v letu 2017. Samice z mladiči so podobno kot ostali medvedje pogosteje uporabljale krmišča z mrhovino v letu 2017. V splošnem so bili medvedje pogosteje zabeleženi na krmiščih v poletnih mesecih z viškom aktivnosti med deveto in deseto uro zvečer. Podatki (ugotovljene dnevne frekvence) števila medvedov s fotopastmi in tradicionalnim preštevanjem se zmerno ujemajo; razlike je mogoče razložiti s prednostmi/hibami vsake od obeh metod. Krmljenje se ne sme izvajati stihijsko, oz se ga sme uporabljati le takrat in tam, ko želeni učinki krmljenja (odvračanje medvedov od naselij, štetje, privabljanje zaradi lova) presegajo neželene. Mrhovina je pomemben del naravnih prehranskih spletov in na podlagi naših izsledkov predlagamo, da se mrhovino divjih živali (zlasti povoženih) lahko polaga takrat, ko je sicer na voljo in se jo lahko brez večjega napora dostavi na krmišče. Medvedje bi lahko imeli od tega koristi predvsem v letih, ko je v okolju zelo malo naravno dostopne hrane.

1 Introduction and aim

Artificial feeding of bears as a management strategy has a longstanding tradition in Slovenia and is mainly practised for diverting bears from human settlements, but also used for hunting and population monitoring. While there is general controversy over the efficacy of artificial feeding, locals share the firm conviction that feeding reduces human-bear conflicts. This led to the establishment of numerous feeding sites which are distributed across the entire country and supplied with food year-round. Feeding sites are also used for counting bears from high stands three times per year. These data are used for estimating yearly population density and structure, which can be linked to relative population dynamics over the years. Moreover, valuable data on reproduction such as the number of females with cubs, as well as the number of cubs per female are gathered. Counting from high stands is a cost-effective method for population monitoring, but the precision of estimated parameters is yet unknown (Marenče & Jerina 2007).

For a long time, successful bear hunts at feeding sites indicated the bears' use of artificial food. The actual use of feeding sites was first documented for 33 GPS-collared bears in the years 2005 to 2009; bears spent on average 6.8 % of their time at feeding sites and visited a feeding site on 11.8 % of all nights (Jerina et al. 2012). However, feeding sites in the forest did not prevent bears visiting human settlements or pastures. Furthermore, dietary analyses based on bear scats confirmed that approximately one-third of the total annual dietary content consisted of artificial food (Kavčič et al. 2015). Generally, artificial food was mainly used during spring when other food sources where scarce (Kavčič et al. 2015).

In the past, maize and livestock carrion were the most common feed types supplied at feeding sites. Following Slovenia's entry into the European Union in 2004, a ban on feeding bears with livestock carrion was issued. Due to the widespread notion that carrion is more attractive to bears than other lures, this action engendered public concern about increasing conflict levels. However, a study by Kavčič et al. (2013) showed that sheep depredation rates were not higher after the ban, when taking into account increasing bear and sheep numbers over the years. Moreover, they showed that usage indexes of feeding sites did not depend on food type during the pre- and post-ban period. Generally, livestock carrion was found to be less important than natural foods such as insects and wild ungulates (Kavčič et al. 2015).

A great amount of wildlife carrion, including roadkill and offal of harvested ungulates, is removed from the ecosystem every year. Carrion has an important function in natural ecosystems and is a valuable food resource for a wide range of animal species, including bears. Feeding bears with wildlife carrion complies with EU regulations and, thus, provided the opportunity for a detailed examination of the bears' preference for feed types. Using camera traps, we monitored bear presence at feeding sites continuously throughout two years, to test the assumption that carrion is more attractive to bears. Moreover, we compared data from traditional bear counts to the data gathered by camera traps simultaneously to evaluate the advantages and drawbacks of each method.

The objectives of the present study were to:

- Obtain continuous data on feeding site use by bears throughout two years
- Determine whether bears prefer feeding sites supplied with wildlife carrion
- Compare data from traditional bear counts with camera trapping data

2 Methods

2.1 Study area and experimental setup

The study was conducted within the LIFE DINALP BEAR project area in the Dinaric Mountains in Slovenia. In the years 2016 and 2017, camera traps (IR PLUS BF HD UV 565, Fototrappolaggio, Italy) were deployed at 22 existing feeding sites within 11 hunting grounds which were distributed over the core bear range (Figure 1). Feeding sites were selected based on good wildlife carrion availability (for details see Action A.5., Mohorović et al. 2015), high local bear density (Jerina et al. 2013) and the local hunting grounds' willingness to cooperate since hunters were maintaining the sites.

In accordance with traditional feeding practices, feeding sites were supplied with either maize only, or both maize and carrion (hereinafter referred to as "wildlife carrion"). Wildlife carrion supplied to the feeding sites consisted of roadkill and/or game offal of ungulates including roe deer, red deer and chamois. In the first year, half of the feeding sites (n =11) were randomly selected and supplied with maize, while the other half (n =11) was supplied with wildlife carrion. After a year, the feed type was changed at each site. For logistical purposes, two neighbouring feeding sites were paired, thereby enabling cooperation between neighbouring

hunting grounds to provide wildlife carrion to the sites. Feeding sites were supplied with food continuously throughout the year, although carrion provision depended also on availability and was higher during autumn.

Camera traps were placed at a distance of approximately 5 metres to the feeding site and angled so that all patches with food were covered. At two sites, two cameras were used as carrion and maize feed patches were too far apart to be covered with only one camera. Cameras were triggered by a passive infrared motion sensor (PIR) sensor and set to take pictures every 5 minutes in the presence of an object for 24 hours a day. After each picture, cameras were also programmed to record a short video sequence of 30 seconds. The infrared sensor allowed for recordings at night and was chosen to keep the disturbance to animals at a minimum.

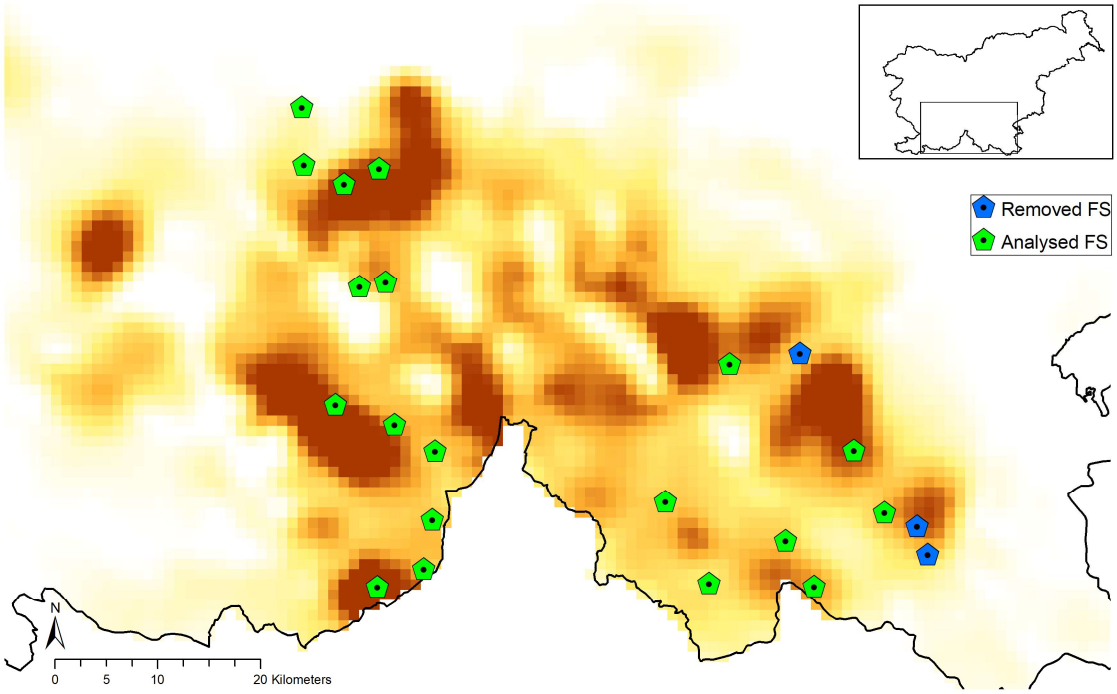

Figure 1: Map of n = 22 feeding sites used for monitoring food type preference of bears. Green symbols depict camera trap and feeding site locations, respectively, which were used for analysis. Blue symbols show feeding sites which were not included in the analysis. Yellow to brown shades show the bear density (95% of all Slovenian bears live in the area shown), with darker colours indicating higher densities.

2.1.1 Data preparation and statistical analysis

All images were inspected manually to determine the number of bears per picture. For females with cubs, the number of cubs and their age, i.e. first year of life or second year of life, were recorded. Images of other animal species visiting the feeding sites were also analysed, but not assessed within this report. If an animal could not be determined by image inspection alone, the short video sequence was used for verification, however, some recordings were still indeterminable. All data was stored in a database, for each image we included picture ID, date, time, feeding site and processor ID. We also conducted a blind test using Cohen's kappa (Cohen 1960) and percentage agreement to assess inter-rater agreement between two raters for n = 1265 random images. Data from malfunctioning cameras, e.g. cameras which were programmed incorrectly or just recording videos, were removed from analysis. Moreover, we excluded data from three feeding sites from analysis; at feeding site Predale, the carrion feed patch where a separate camera was placed was further than 500 metres away from the maize feeding patch, and was thus not included in the analysis, at feeding site Šenberg, cameras were repeatedly stolen and for feeding sites Kuzlina ravan and Miklerji, images could not be analysed due to technical problems (Figure 1).

2.1.2 Feeding site preference according to food type

Due to the large amount of data gathered during the two study years (see Appendix 1), a subsample consisting of every third picture was used for this analysis. For examining the presence and absence of bears with respect to different food types, each day was split into a continuous time scale with 5-minute intervals. These 5-minute intervals correspond to the camera settings for the minimum sampling interval between two consecutive pictures. All 5-minute intervals with bear presence were assigned the number 1. All other 5-minute intervals, including those without a camera trap image, or those with images containing no animals or other animal species than bears, were assigned the number 0. To account for the subsampling procedure applied to bear images, all 5-minute time intervals without bears were also subsampled and only every third interval was included in the analysis.

Most cameras were not working throughout the winter months, thus we excluded the months December, January and February from analysis. In 94.6% of all cases, an image just showed a single bear visiting the feeding site (females and cubs were counted as one unit). For this

reason, bear presence at feeding sites was analysed using generalised linear mixed models (GLMM) with a binomial response, with 1 coding for "bear present" and 0 coding for "no bear present". Food preference of females with cubs as an important social unit was also analysed in a separate GLMM analysis. Predictors for bear presence were food type (maize or wildlife carrion), consecutive day in the year (both as linear and quadratic term) to account for seasonal differences, the year, and circadian time, in one model as cosine transformed time to generate linear predictions, and in a separate model as time distance to sunrise and sunset, to account for preferred feeding site use during dusk or dawn. For cosine transformations, we first ran a regression model without intercept to determine which adjustment of time was needed to shift the peak in feeding site use to the inflection point at the maximum cosine of 1. As a result, we added 2.2 hours to the original time units before transforming the time. For the predictor distance to sunrise and sunset, we derived data on civil twilight for Ribnica municipality, which lies within our study area. We determined whether a bear visit was closer to sunrise or sunset, and then divided this time interval by either length of the night for data points at night or length of the day for data points collected during daytime. By default, minus-signs were used for data points collected during the night and plus-signs for data points during the day. The interaction between food type and year was also included in the model. Feeding site ID was used as a random factor to account for repeated measurements at the sites. All continuous predictors were scaled and centred to account for different scales between the variables. The most parsimonious model was selected by comparing differences in the Akaike Information Criterion (AIC) (Burnham & Anderson 2003).

2.1.3 Comparison of count data and camera trap data

Yearly bear counts are conducted systematically at 176 feeding sites distributed over the entire bear range. Thus, visual count data for 9 of the feeding sites used in this study were also available for the two study years. Counting was carried out during full-moon nights from high stands three times per year, once during spring and twice during autumn, on one day each between 6 pm and midnight. Camera trap data was subsampled to conform to the same date and time intervals. All images taken within the counting periods were analysed for determining bear presence. Successive images recording a bear, as well as all bear recordings within a maximum time interval of 30 minutes were classified as one visit by the same individual (Rovero & Zimmermann 2016). Cohen's kappa statistics for inter-rater agreement were used

to compare bear numbers derived from visual counting to bear numbers determined by camera trap recordings. A separate analysis was conducted for females with cubs.

3 Results

In the raw dataset, a total number of 77427 images from n = 19 different feeding sites were analysed, which included 14168 images with bears visiting the feeding sites (Table 1). In 2016, bears were detected on average on 16% of all pictures, in 2017 on average on 21% of all pictures (Table 1).

Table 1: Summary table showing the total number of analysed pictures (including other animal species or pictures with no animals) and the number of pictures with bears as a percentage for n = 19 feeding sites in 2016 and 2017. The column camera trap days refers to the total number of days where camera traps were working during the two study years.

	2016		**2017**		**Total**
Feeding site	*Analysed pictures*	*Bear pictures*	*Analysed pictures*	*Bear pictures*	*Camera trap days*
Mošenik	3264	4%	3339	8%	548
Lesna gorica	1376	58%	1499	46%	425
Zagabrnice	163	1%	480	10%	159
Svinjski žleb	1857	9%	1087	25%	460
Borovnica	4290	11%	5344	8%	556
Jelovci	3365	12%	1948	11%	571
Skalčna pot	2018	4%	1433	8%	431
Kujavič	789	40%	863	35%	191
Predale	1876	12%	1677	10%	316
Bezgovice	2494	20%	2153	39%	314
Hrib	1409	26%	1336	41%	434
Pogoreli vrh	4098	29%	3140	16%	437
Janezova koča	1960	12%	3085	25%	495
Rjavi pesek	1521	13%	1758	51%	531
Vala	1249	16%	1535	44%	224
Kalič	2320	21%	1862	25%	413
Podlesje	2274	7%	2278	5%	391
Peči	1810	7%	454	9%	276
Belica	1588	21%	2435	18%	251
Total	**39721**	**16%**	**37706**	**21%**	**7423**

Most camera traps worked throughout the whole year apart from the winter months, yielding a good overview over the seasonal use of feeding sites during the two study years (Table 1, Figure 2). The results for the blind test showed that the tested n = 1265 images which were available for comparison between two independent raters ranged from 0 to 3 bears. The agreement between two raters was very good, with weighted kappa $\kappa = 0.8$ and a percentage agreement of 94.1%.

Figure 2: Camera trap data from n = 19 feeding sites in 2016 and 2017. Lines indicate periods were cameras were working.

For analysis, we used 11441 images with bears (excluding winter months and some feeding sites, see 2.2). The share of females within the analysed bear pictures accounted for 1114 images (855 images of females with cubs in their first year of life, 259 images of females with cubs in their second year of life, Figure 3). In terms of social units visiting the feeding sites, females with cubs of all ages accounted only for 10% of the total number of visiting bears (a female with cubs is counted as one social unit, Figure 3).

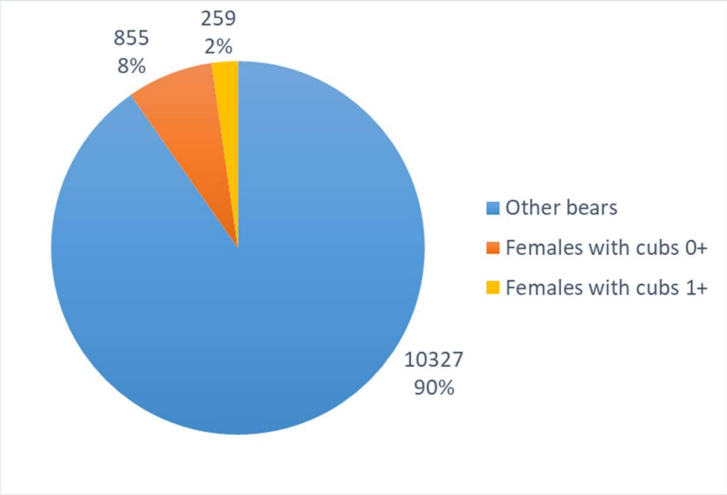

Figure 3: Distribution of bear social units visiting n = 19 feeding sites. Other bears excluding females with cubs are shown in blue, females with cubs in their first year of life are shown in orange, females with cubs in their second year of life are shown in yellow.

Overall, there was considerable variation in the use of individual feeding sites, with the proportion of 5-minute intervals with bear presence being highest at Pogoreli vrh (Table 2). In addition, feeding site use varied according to food type, year, season and circadian time (Table 3). Generally, there was a higher bear presence at feeding sites with carrion and bears used feeding sites more in the year 2017 (Table 3). Bear presence was highest during the summer months and in the early evening (Table 3).

Table 2: Bear presence at n = 19 feeding sites as a proportion of 5-minute intervals with bear presence compared to 5-minute intervals without bear presence.

Feeding site	***Percentage of time with bear presence***	***Feeding site***	***Percentage of time with bear presence***
Mošenik	0.55%	*Pogoreli vrh*	4.14%
Lesna Gorica	3.10%	*Janezova koča*	1.99%
Zagabrnice	0.22%	*Rjavi pesek*	1.92%
Svinjski žleb	0.67%	*Vala*	3.31%
Borovnica	1.47%	*Kalič*	2.24%
Jelovci	0.94%	*Podlesje*	0.66%
Skalčna pot	0.36%	*Peči*	0.68%
Kujavič	2.90%	*Belica*	3.09%
Bezgovice	3.73%	*Predale*	1.29%
Hrib	1.75%		

Table 3: Bear presence at n = 19 feeding sites according to food type, year, season and circadian time as a proportion of 5-minute intervals with bear presence compared to 5-minute intervals without bear presence.

Food type	***Percentage of time with bear presence***
Maize	1.51%
Carrion	2.02%
Year	
2016	1.59%
2017	1.90%
Month	
March	0.76%
April	1.08%
May	1.97%
June	2.42%
July	2.25%
August	2.47%
September	1.85%
October	1.30%
November	0.74%
Time of the day	
0 am - 3 am	2.37%
4 am - 7 am	0.87%
8 am - 11 am	0.25%
12 pm - 3 pm	0.32%
4 pm - 7 pm	2.12%
8 pm - 11 pm	4.61%

3.1 Food type preference of bears

The full GLMM model for the response variable bear presence (= all bears including females) with all predictors and the interaction between food type and year (see section 2.2.1.) was the most parsimonious model (Table 4). Within the two models were circadian time was used alternatively either as cosine transformed time or time distance to sunrise and sunset, only cosine transformed time was informative and thus included in the full model. Bear presence at feeding sites increased throughout the year was highest during the summer between June and August (Table 4, Figure 4). As expected, feeding site use throughout the year followed a concave function, which was supported by the informative squared term for consecutive day

in the year. In general, bears tended to use carrion feeding sites more and bear presence was higher in the year 2017, but a closer look at the feed use for each year revealed a higher use of carrion feeding sites particularly in the year 2017 (Figures 5, 6). More specifically, carrion feeding sites were increasingly used during the period from May until August 2017 (Figure 5). This was also supported by the informative interaction between the food type carrion and the year 2017 in our model (Table 4, Figure 6), which in turn states that there was a smaller difference in use of carrion and maize feeding sites in the year 2016. Due to the informative interaction, the simple effect for feeding site use in the year 2017 can be interpreted only with regard to maize feeding sites, which were less used in 2017.

Table 4: Model terms for predicting overall bear presence at n = 19 feeding sites included in the most parsimonious model. All continuous numerical predictors were scaled and centered, coefficients should thus be interpreted accordingly. β = beta coefficent, σ = standard error, LL & UL = lower and upper limit of the 95% confidence interval after Wald, $\bar{x}$ = unscaled mean for continous predictors, s = unscaled standard deviation for continous predictors

Model terms	β	σ	LL	UL	$\bar{x}$	s
day_sc*	2.056	0.073	1.913	2.200	205	73
day_sq_sc*	-2.126	0.073	-2.270	-1.983	47427	30338
carrion1	-0.008	0.055	-0.116	0.101		
year2017*	-0.155	0.053	-0.259	-0.051		
cos_time_sc*	1.050	0.013	1.024	1.076	0.004	0.708
carrion1:year2017*	0.828	0.103	0.627	1.029		

* *informative model terms*, day_sc *continous day in a year scaled*, day_sq_sc *continous day in a year squared and scaled*, carrion1 *food type carrion*, year *2017*, cos_time_sc *time cosine transformed and scaled*

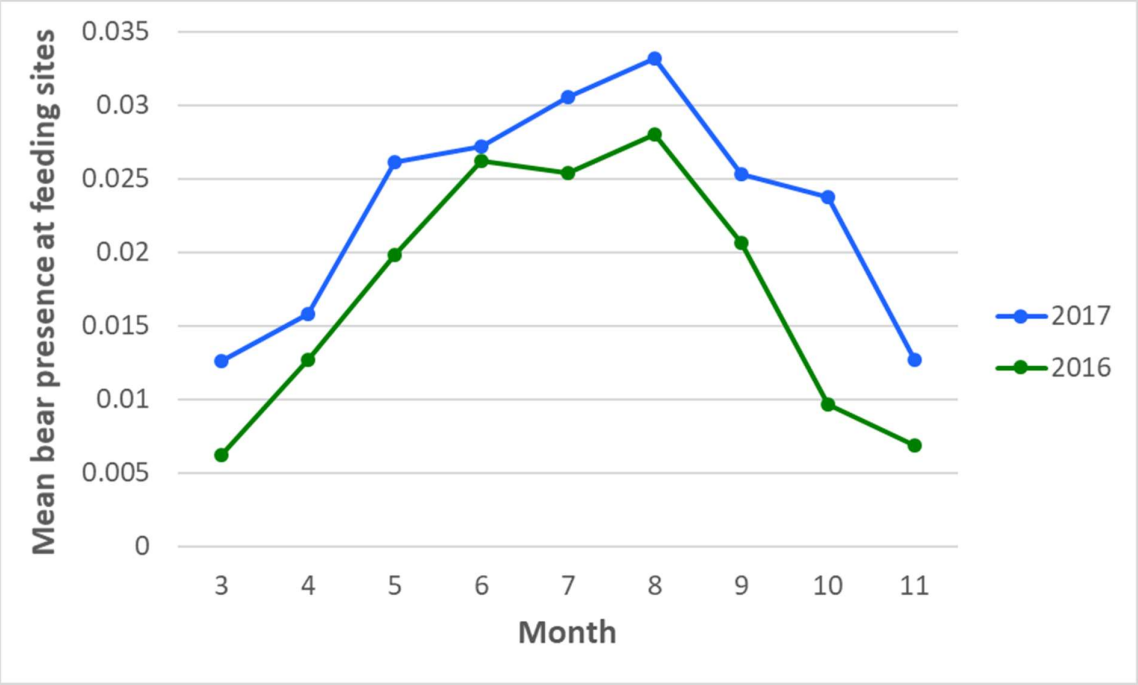

Figure 4: Mean monthly feeding site use at n = 19 feeding sites in the years 2016 (green line) and 2017 (blue line).

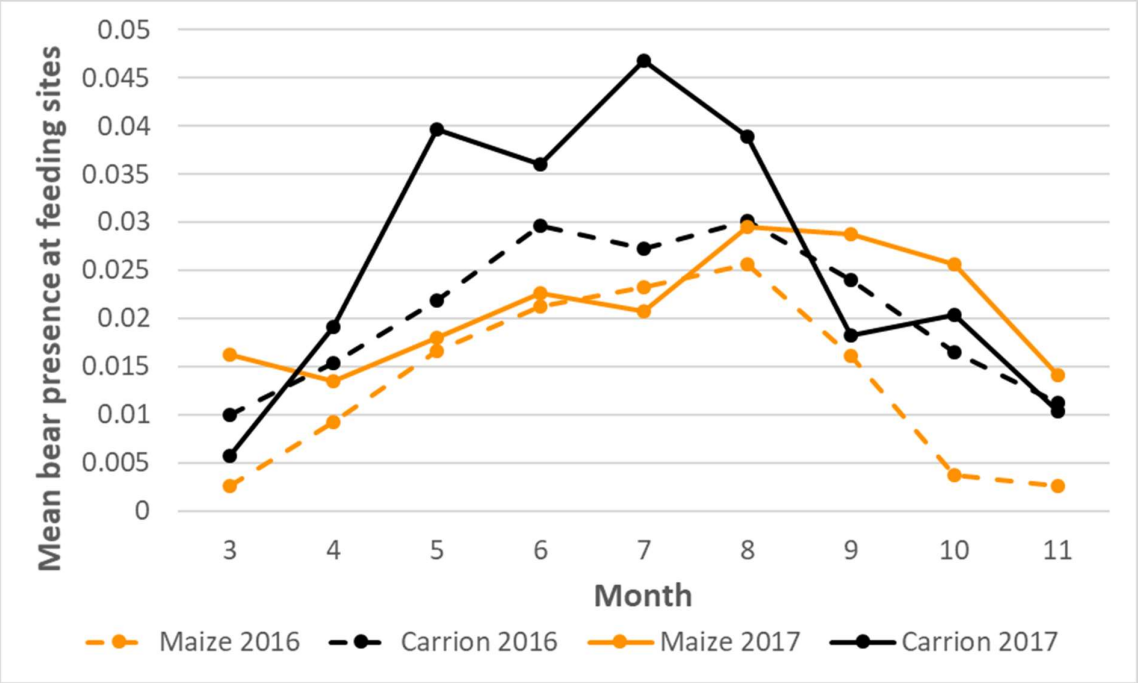

Figure 5: Mean monthly feeding site use according to food type (orange lines = maize, black lines = carrion). Dashed lines represent feeding site use in 2016, solid lines represent feeding site use in 2017.

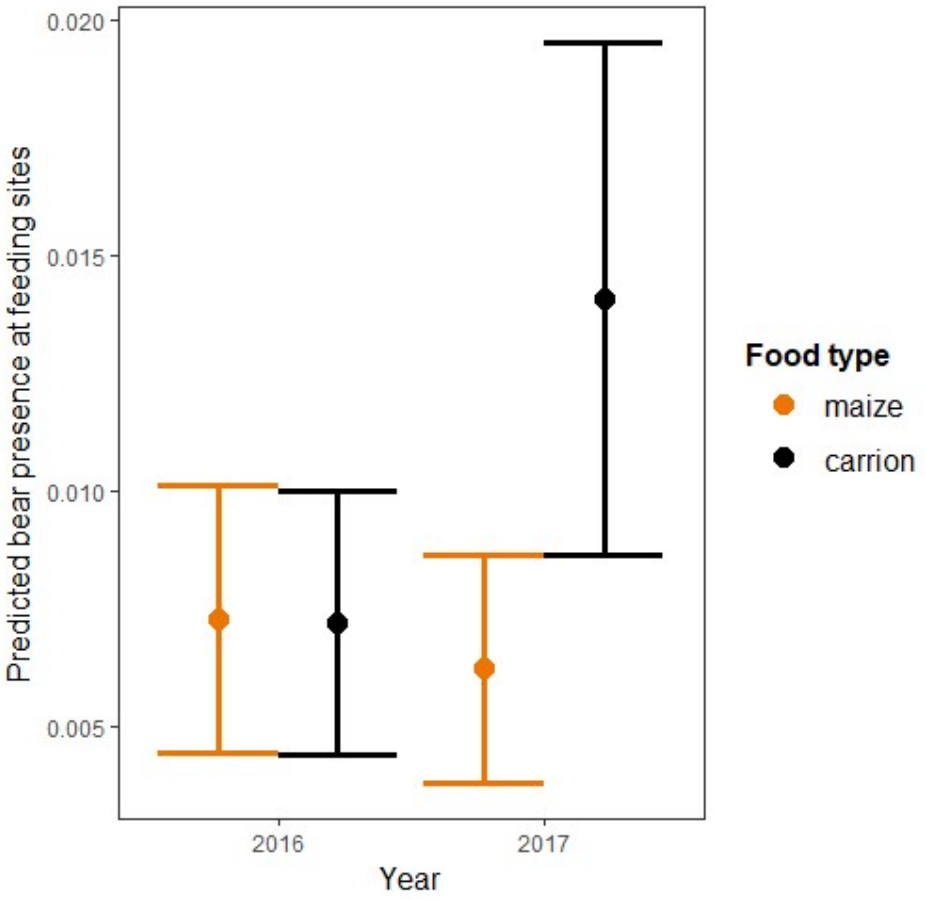

Figure 6: Interaction plot for predicted bear presence at n = 19 feeding sites according to food type (orange = maize, black = carrion) and year. The 95% confidence intervals reflect only the variance of the fixed effects, not the random effect.

Circadian feeding site use was best described by the variable cosine transformed time (Table 4) and was thus independent of changes in sunset and sunrise throughout the year. In both years, hourly feeding site use peaked between 9 pm and 10 pm in the evening and feeding sites were only rarely used during daytime (Figure 7). A comparison of the monthly and daily feeding site use revealed that bears used feeding sites primarily during the first half of the night throughout the whole year (ca. 5 pm - midnight, Figure 8). However, bears tended to come earlier in the afternoon during late summer and autumn (Figure 8).

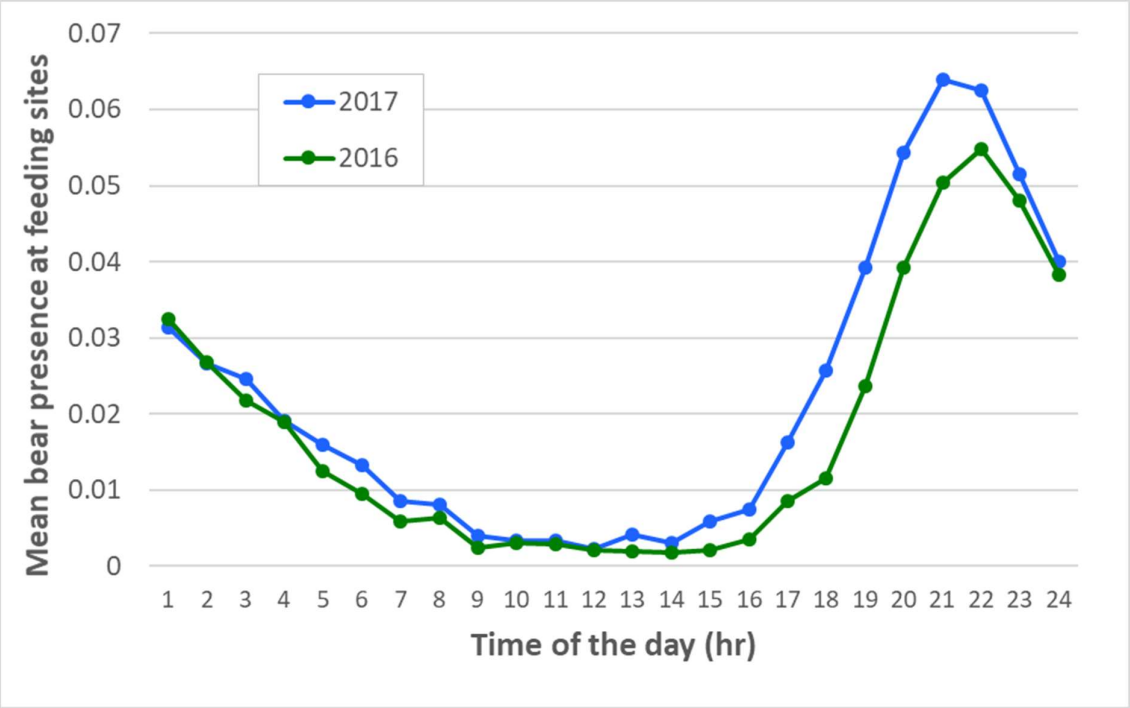

Figure 7: Mean hourly feeding site use in the years 2016 (green line) and 2017 (blue line).

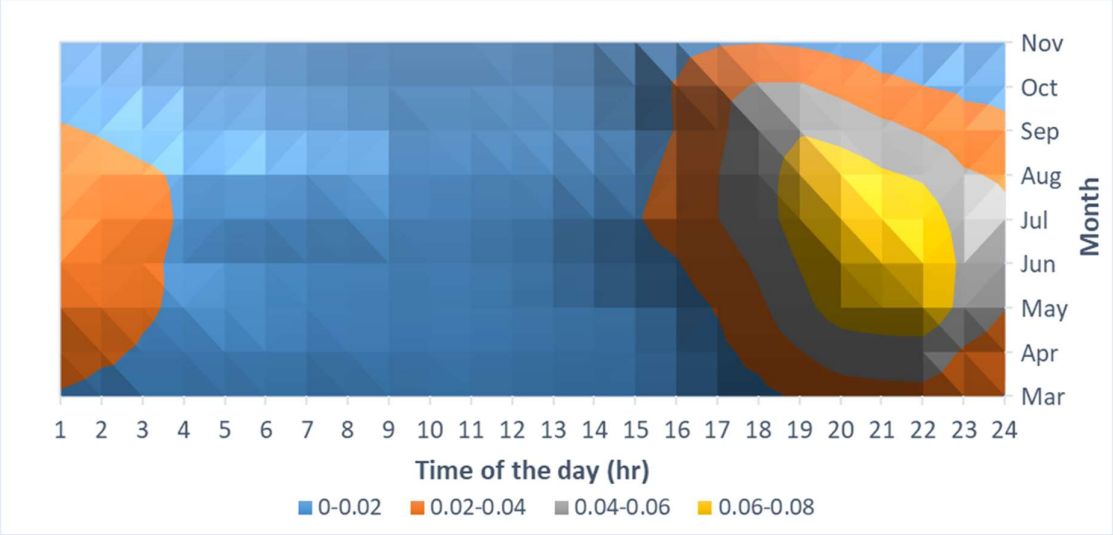

Figure 8: Mean monthly and hourly feeding site use in the years 2016 and 2017. Colours represent the average number of bears present at a certain point in time.

3.2 Food type preference of females with cubs

Feeding site use throughout the years differed among social units. Feeding site use of all bears excluding females with cubs followed a concave shape, where feeding site use increased during the spring months, peaked during summer and decreased again in autumn (blue line, Figure 9). Females with cubs in their first year of life showed a different pattern and used feeding sites only rarely during spring (orange line, Figure 9). In contrast, females with cubs in their second year of life showed an increased use of feeding sites during spring but used feeding sites less during summer (yellow line, Figure 9).

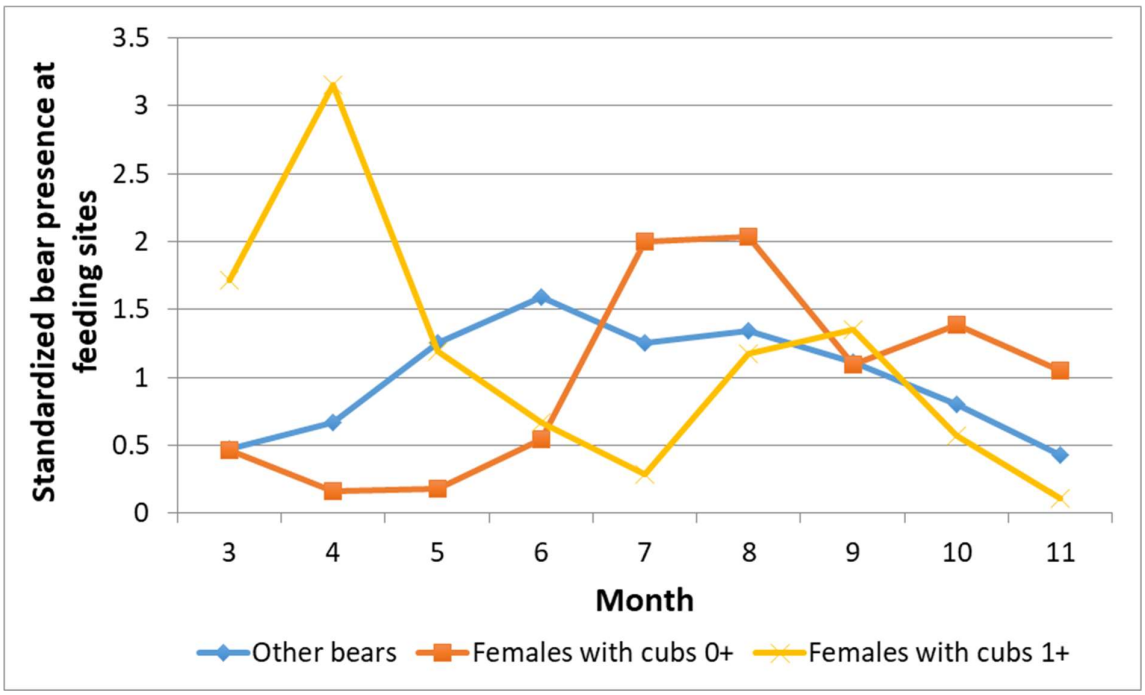

Figure 9: Mean monthly feeding site use of different social units during the years 2016 and 2017. Mean values were standardized for comparsion of females with cubs and other bears.

The most parsimonious GLMM model for feeding site use of females with cubs of both age categories was also the full model including all predictors (see section 2.2.1). Again, cosine transformed time was a better predictor for feeding site use than the time distance to sunrise and sunset and was thus included in the final model. Feeding site use of females with cubs of both age categories was similar to that of other bears, however the concave shape of daily feeding site use during both years was less pronounced that for other bears (Tables 4, 5). In addition, the informative interaction effect between the year 2017 and the food type carrion was more pronounced than for other bears (Tables 4, 5). Similar to other bears, females with cubs also used feeding sites mainly during the night with a peak between 9 pm and 10 pm (Table 5). The informative simple effect for the food type carrion shows that females with cubs used carrion feeding sites less in the year 2016.

Table 5: Model terms for predicting the presence of female bears with cubs at n = 19 feeding sites included in the most parsimonious model. All continuous numerical predictors were scaled and centered, coefficients should thus be interpreted accordingly. β = beta coefficent, σ = standard error, LL & UL = lower and upper limit of the 95% confidence interval after Wald, $\bar{x}$ = unscaled mean for continous predictors, s = unscaled standard deviation for continous predictors

Model terms	β	σ	LL	UL	$\bar{x}$	s
day_sc*	1.584	0.218	1.156	2.012	205	73
day_sq_sc*	-1.313	0.210	-1.725	-0.901	47427	30338
carrion1*	-0.649	0.194	-1.029	-0.269		
year2017	0.013	0.192	-0.364	0.389		
cos_time_sc*	1.044	0.042	0.963	1.126	0.004	0.708
carrion1:year2017*	1.485	0.359	0.781	2.189		

* *informative model terms*, day_sc *continous day in a year scaled*, day_sq_sc *continous day in a year squared and scaled*, carrion1 *food type carrion*, year *2017*, cos_time_sc *time cosine transformed and scaled*

3.3 Comparison of count data and camera trap data

For comparing count and camera trapping data, we used a total of n = 26 observations per day, irrespective of date and feeding site location (bold numbers, Table 4). The weighted kappa statistics for measuring agreement between the two counts was $\kappa = 0.6$, which corresponds to a moderate agreement between counts from high stands and camera trap data. For five feeding sites, a minimum number of 3 observations was available for comparison, which we used to calculate separate agreement measures for these locations. For feeding site Bezgovice, the agreement between bear counts (n = 4 pairs) was poor with a weighted kappa of $\kappa = -0.15$, for feeding site Hrib (n = 4 pairs) the agreement was moderate with a weighted kappa of $\kappa = 0.5$, for feeding site Janezova koča (n = 6 pairs) agreement was good with a weighted kappa of $\kappa = 0.7$, for feeding site Predale (n = 3 pairs) agreement was also moderate with a weighted kappa of $\kappa = 0.55$ and for feeding site Vala (n = 4 pairs) agreement was also poor with a weighted kappa of $\kappa = -0.04$.

Table 6: Data for comparing bear counts derived from camera trap data (columns named CT with white background colour) and count data from high stands (columns named Count with grey background) for six counting nights between 6 pm – midnight at n = 9 feeding sites.

	CT	Count	CT	Count	CT	Count
Feeding site	**20.05.2016**		**19.08.2016**		**14.10.2016**	
Bezgovice		4	**1**	**4**	**0**	**2**
Hrib	**1**	**1**	**11**	**4**		0
Janezova koča	0	0	**0**	**2**	**0**	**0**
Lesna gorica	2				0	
Peči		0		0	0	0
Podlesje	**0**	**0**		0		0
Predale		0	**2**	**4**	**1**	**1**
Skalčna pot		0		1		0
Šenberg	**0**	**0**	**0**	**1**		0
Vala	**3**	**2**	**3**	**5**		2
	5.05.2017		**4.08.2017**		**3.11.2017**	
Bezgovice	**2**	**1**	**0**	**3**		3
Hrib	**6**	**4**	**1**	**1**		4
Janezova koča	**4**	**3**	**1**	**1**	**3**	**2**
Lesna gorica	**0**	**3**		6	**3**	**4**
Peči		1				2
Podlesje		1		4		3
Predale		2	**3**	**4**		4
Skalčna pot	**2**	**1**		6		1
Šenberg		0				
Vala	**1**	**3**	**0**	**4**		3

4 Discussion

In general, bear presence tended to be higher at carrion feeding sites and feeding site use increased in the year 2017. However, the best model for predicting bear presence at feeding sites included the positive interaction between food type carrion and the year 2017, which means that the preference for carrion can be mainly attributed to the higher bear presence at carrion feeding sites in the year 2017. Feeding site use peaked during the summer months, while on a daily basis, bears visited feeding sites preferably between 9 pm and 10 pm in the evening. Females with cubs behaved similar to other bears and used carrion feeding sites increasingly in the year 2017, with the effect being even more pronounced for this social unit. Splitting up females with cubs of different age classes revealed a difference in monthly feeding site use, where females with cubs in their first year of life used feeding sites less during spring time, while females with cubs in their second year of life used feeding site increasingly during spring but less during summer. The comparison of camera trapping data for counting bear visits at feeding sites and data from yearly visual counts from high stands showed a moderate agreement based on Cohen's kappa values calculated for the two datasets, while agreement for individual feeding sites ranged from poor to good.

4.1 Preference for carrion in the year 2017

It has been suggested that artificial food, which is superior to natural foods, might be used more by bears, especially in years when natural foods are scarce (Kavčič et al. 2015, Garshelis et al. 2017). A striking difference between the years 2016 and 2017 concerned the availability of natural foods to bears; therefore, the difference in feed use during the two years are likely to be attributed to differences in natural food availability. The year 2016 was not only a mast year with an overabundance of beechnuts, there was also good availability of other natural foods such as berries and insects (K. Jerina, pers. comm.). In contrast, the year 2017 was a poor year with low food availability of both plant- and animal-based natural food sources due to dry weather conditions. This could mean that bears had a higher need for protein-rich food sources in 2017 and, thus, increasingly used carrion feeding sides during that year. Feeding site use in 2016 may have been more opportunistic regarding both feed types due to the high availability of natural foods. Feeding site use and preference for carrion may therefore be largely connected to the availability of natural foods within each year. In turn, this may indicate that bears forage on natural foods when available and, contrary to popular belief, do not become fully

conditioned on artificial food. A shortcoming of our study is that it was difficult to determine what feed type was actually consumed at carrion feeding sites, where both carrion and maize were supplied. For this reason, we did not include the variable in our analyses but rather assume that if carrion was available, bears also consumed it. The higher visitation rates of carrion feeding sites in 2017 support this assumption.

4.2 Use of feeding sites

Bears are primarily nocturnal, with activity peaks during dusk and dawn (Kaczensky et al. 2006, Kavčič 2016). Thus, the increased use of feeding sites between 9 pm and 10 pm corresponds to their first activity peak during dusk. While bears typically show another activity peak during dawn, we did not observe such a peak in our data. This can likely be attributed to food depletion at feeding sites throughout the night, making feeding site visitations during dawn unfavourable. During the beginning and end of the year, bear presence at feeding sites was lower than during the summer. This may result from the fact that some bears were still/already be denning during that time, and/or the avoidance of feeding sites during the hunting season, which typically lasts from beginning of October to end of April. In line with this, females with cubs, which are protected from hunting, used feeding sites also increasingly during spring and autumn. Here, feeding site use of females with cubs in their first year of life and cubs in their second year of life was markedly different; Females with cubs in their first year of life avoided feeding sites during spring, likely because at this time cubs are small and particularly vulnerable to infanticide (Dahle & Swenson 2003). Moreover, these females used feeding sites also increasingly during autumn, after the onset of the hunting season. Reasons for this may be that cubs are larger at this time of the year and infanticide is less likely to occur outside of the spring mating season (Swenson et al. 2001), or that females with cubs do not face hunting pressure and have an increased energy need during autumn hyperphagia. For the same reasons, females with cubs in their second year of life may have used feeding sites also to a larger extent during early spring. Kavčič et al. 2015 showed that the proportion of artificial food in bear scats is highest during spring, while we did not observe a higher bear presence at feeding sites during this time of the year. However, the lower availability of natural foods during spring is likely to account for this result.

4.3 Comparison of bear count data

In the comparison between bear counts from camera trap data and visual counts from high stands, inconsistencies may arise from different observer angles, i.e. camera traps often covered the area of a feeding site only partly, and consequently, the perception of whether the same individual was present for a longer time, or different bears were visiting the feeding sites. Based on literature suggestions (e.g. Rovero & Zimmermann 2016), we used a difference of 30 min between consecutive bear pictures for counting separate individuals for camera trap data. While in some cases this may have been reasonable, in other cases this may have caused an overestimation of the number bears present. Bear numbers from camera trap data at feeding sites, where visitation rates are high, may not be seen as absolute numbers, but are useful for estimating relative population trends. In this case, the above mentioned error is negligible as camera trap pictures are treated equally.

4.4 Conclusion and outlook

The strong public notion that carrion feeding sites are generally more attractive to bears is only partly supported by our results. While bear presence at carrion feeding sites tended to be higher, feed type use seems to be strongly connected to the availability of natural food sources within a year. This means that years with low natural food availability, such as the year 2017, can trigger a higher use of carrion feeding sites. The effectiveness of artificial feeding and its impact on the ecosystem are still poorly understood and we would like to discourage unconditional feeding. Thus, artificial feeding should only be practised with the goal of minimizing undesirable effects (e.g. habituation to humans) and increasing desirable effects such as diverting bears from human settlements, monitoring and baiting for hunting. Recycling road kill and game offal enriches the ecosystem since carrion is an important food source for a number of scavenging species. Wildlife carrion may therefore be provided in particular during years when natural foods are scarce, when it is readily available (e.g. during the hunting season, road kills) and transport costs to feeding sites are low. Our findings suggest that future research investigating the potential of artificial feeding should also take natural food availability into account.

5 Acknowledgements

First and foremost, we would like to thank all the hunters from the Slovenia Forest Service and the Slovenian Hunting Association for their willingness to cooperate in this study and their substantial help with the field work. Many thanks also to all the students that carefully analysed the camera trap photos (Ana, Beatriz, Frowin, Gregor, Lan, László-Benjamin, Lovro, Marta, Miha and Robi). Special thanks to M. Mohorović and M. Krofel for their help in establishing the monitoring program and coordinating the activities of camera trapping and D. Borkovič and Z. Polnar for deploying the equipment on the field. Lastly, thanks to A. Žagar for the initial database maintenance and R. Luštrik for help with extracting metadata in R.

6 References

Burnham, K. P. & Anderson, D. R. (2003). Model selection and multimodel inference: a practical information-theoretic approach. Springer Science & Business Media.

Cohen, J. (1960). A coefficient of agreement for nominal scales. *Educational and Psychological Measurement*, *20*(1), 37-46.

Dahle, B. & Swenson, J. E. (2003). Seasonal range size in relation to reproductive strategies in brown bears Ursus arctos. *Journal of Animal Ecology*, *72*(4), 660-667.

Garshelis, D. L., Baruch-Mordo, S., Bryant, A., Gunther, K. A. & Jerina, K. (2017). Is diversionary feeding an effective tool for reducing human–bear conflicts? Case studies from North America and Europe. *Ursus*, *28*(1), 31-55.

Jerina, K., Krofel, M., Stergar, M. & Videmšek, U. (2012). Factors affecting brown bear habituation to humans: a GPS telemetry study. *Final report—summary for users. University of Ljubljana, Biotechnical Faculty, Ljubljana*.

Jerina, K., Jonozovič, M., Krofel, M. & Skrbinšek, T. (2013). Range and local population densities of brown bear Ursus arctos in Slovenia. *European Journal of Wildlife Research*, *59*(4), 459-467.

Kaczensky, P., Huber, D., Knauer, F., Roth, H., Wagner, A. & Kusak, J. (2006). Activity patterns of brown bears (Ursus arctos) in Slovenia and Croatia. *Journal of Zoology*, *269*(4), 474-485.

Kavčič, I., Adamič, M., Kaczensky, P., Krofel, M. & Jerina, K. (2013). Supplemental feeding with carrion is not reducing brown bear depredations on sheep in Slovenia. *Ursus*, *24*(2), 111-119.

Kavčič, I., Adamič, M., Kaczensky, P., Krofel, M., Kobal, M. & Jerina, K. (2015). Fast food bears: brown bear diet in a human-dominated landscape with intensive supplemental feeding. *Wildlife biology*, *21*(1), 1-8.

Kavčič, I. (2016). Impacts of supplemental feeding and other anthropogenic food sources on the brown bear (Ursus arctos) activity. *PhD Thesis. University of Ljubljana*: pp. 110

Marenče, M. & Jerina, K. (2007). Spremljanje rjavega medveda na stalnih števnih mestih. *Lovec : glasilo Lovske zveze Slovenije*, *90* (5), 246-251.

Mohorović, M., Krofel, M., Jonozovič, M., Stergar, M., Hafner, M., Pokorny, B., Jerina, K. (2015). Prostorska in časovna razpoložljivost mrhovine prostoživečih parkljarjev kot vir hrane za medvede v Sloveniji, prepared within the A5 action of LIFE DINALP BEAR Project (LIFE13 NAT/SI/0005): 34 pp.

Rovero, F., & Zimmermann, F. (Eds.). (2016). Camera trapping for wildlife research. Pelagic Publishing Ltd.

Swenson, J., Dahle, B., & Sandegren, F. (2001). Intraspecific predation in Scandinavian brown bears older than cubs-of-the-year. Ursus, 12, 81-91.

7 Appendices

Appendix. Summary tables for camera trap data

Table A.1. Total number of images taken at all feeding sites (n = 22). The shown numbers include all raw data, e.g. duplicates and in a few cases, data from malfunctioning camera traps which took pictures every 30 seconds instead of every 5 minutes. This data was later filtered to remove duplicates and pictures which were taken within shorter periods than the programmed 5 minutes. In addition, due to the large amount of data, a subsample containing only every third image per feeding site was used for analysis.

	Number of images		
Feeding site	*2016*	*2017*	*Total*
Mošenik	17653	14384	32037
Lesna gorica	4154	4518	8672
Kuzlina ravan	4872	14418	19290
Zagabrnice	1470	1461	2931
Svinjski žleb	6526	3290	9816
Borovnica	13308	16238	29546
Jelovci	6481	5880	12361
Jelovci carrion	4357	/	4357
Skalčna pot	6434	4334	10768
Kujavič	2377	2605	4982
Miklerji	3198	7887	11085
Predale	6155	5068	11223
Predale carrion	/	4060	4060
Bezgovice	13676	6515	20191
Šenberg	3739	/	3739
Hrib	4631	11726	16357
Pogoreli vrh	12781	9532	22313
Janezova koča	5918	9343	15261
Rjavi pesek	8149	5326	13475
Vala	3745	4635	8380
Kalič	10557	5622	16179
Podlesje	8237	6872	15109
Peči	6000	1369	7369
Belica	4807	7445	12252
Total	**159225**	**152528**	**311753**

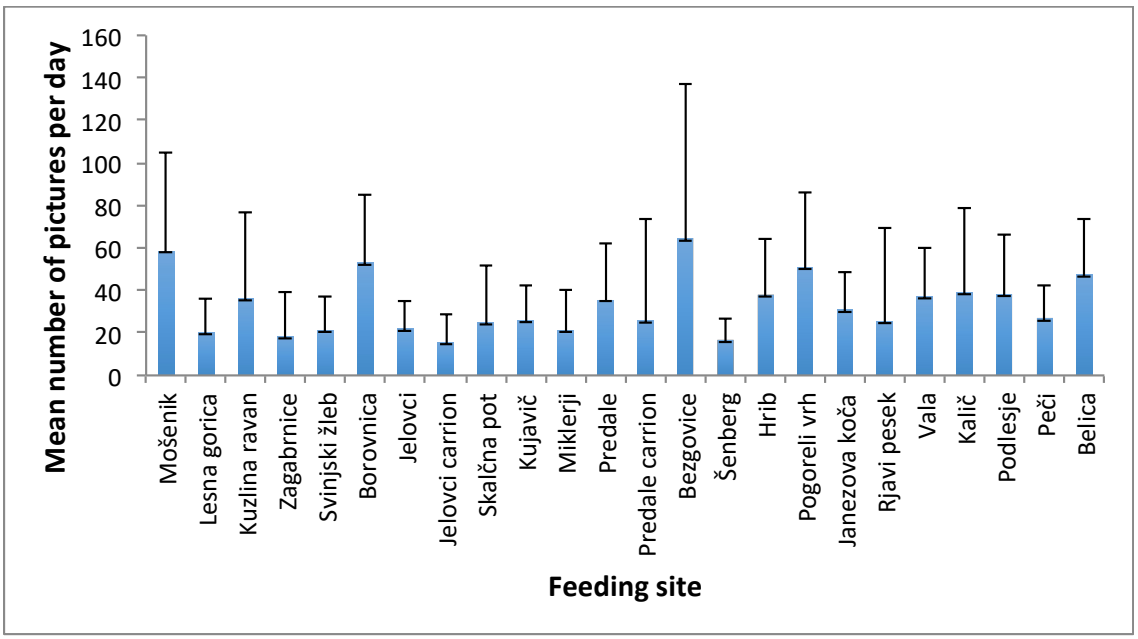

Figure A.1. Mean number of pictures per day for all feeding sites during both years.