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1    **Scavenging in the realm of senses: smell and vision drive recruitment**  
2    **at carcasses in Neotropical ecosystems**

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## 24 **Abstract**

25 Social information, acquired through the observation of other individuals, is especially relevant  
26 among species belonging to the same guild. The unpredictable and ephemeral nature of carrion  
27 implies that social mechanisms may be selected among scavenger species to facilitate carcass  
28 location and consumption. Here, we apply a survival-modelling strategy to data obtained  
29 through the placement and monitoring of carcasses in the field to analyse possible information  
30 transmission cascades within a Neotropical scavenger community. Our study highlights how the  
31 use of different senses (smell and sight) within this guild facilitates carcass location through the  
32 transmission of social information between species with different carrion foraging efficiencies.  
33 Vultures with a highly developed sense of smell play a key role in this process, as they are the  
34 first to arrive at the carcasses and their presence seems to serve as a visual cue for other species  
35 to locate the resource. Our study supports the local enhancement hypothesis within scavengers,  
36 whereby individuals locate carcasses by following foraging heterospecifics, also suggesting the  
37 importance of the sense of smell in the maintenance of the community structure.

## 38 **Keywords**

39 Foraging behaviour; intra-guild interactions; interspecific communication; public information  
40 transmission; scavenging assemblages; species networks

## 41 **Introduction**

42 Social information refers to the acquisition of cues by monitoring how other individuals interact  
43 with the environment [1]. The use of this kind of information is increasingly recognized as a  
44 widespread phenomenon in biology [2,3]. Social information transmission is known to influence  
45 animal movement [4], foraging patterns [5], habitat selection and reproduction [6].

46 Traditionally, social information was understood to occur between individuals belonging to the  
47 same species (i.e., conspecifics) since they share their ecological needs [7]. Later on,  
48 information transmission processes have also become evident between individuals of different  
49 species (i.e., heterospecifics) that share and compete for a resource [8,9]. While most studies

50 have focused on information exchanges among conspecifics, fewer have analysed social  
51 facilitation between species from the same guild, where a strong influence in guild structure is  
52 expected because this information transmission may reduce competition costs [8–11].

53 Carrion is an unpredictable and ephemeral resource that can be exploited by many species, even  
54 at the same time [12]. Thus social mechanisms to facilitate carrion location and consumption  
55 may be selected among scavenger species, since individual foraging would be very costly  
56 [13,14]. Social information can pass through individuals unintentionally as cues, e.g., vultures  
57 flying in circles and descending to the ground attract other vultures and carnivores [15–17]; or  
58 intentionally as signals to obtain something in return, e.g. corvids attract raptors or mammalian  
59 carnivores to carcasses to tear the skin and access the meat, as they do not have the capacity to  
60 do so [1,18].

61 Many studies have mentioned the facilitation between scavenger species in locating carrion, but  
62 very few have described and analysed this process in detail [15,19,20]. For obligate scavengers  
63 (i.e., vultures), it is not exactly known how social transmission occurs when vultures locate  
64 carcasses, but there are two hypotheses about it. On the one hand, the “local enhancement”  
65 hypothesis, whereby individuals locate carcasses by seeing conspecifics feeding at a point  
66 [20,21]. On the other hand, the "vulture chains" hypothesis states that vultures establish visual  
67 chains while they are flying to the carcass, that are used for carrion signalling [13]. In either  
68 case, there is a positive influence of the number of vultures arriving at a carcass and a decrease  
69 in the time needed for the arrival of new individuals [13,21]. So far, these two assumptions have  
70 been established and tested intraspecifically for a single vulture species, even if different vulture  
71 species can feed together in a carcass at the same time [22–24].

72 As described for other guilds, there may be interspecific differences in the scavenger  
73 information transmission cascades [3]. Some species may "initiate" or "lead" the information  
74 transmission process, being important for the maintenance of these cascades and thus for the  
75 carrion consumption process [25,26]. In particular, it has been suggested that information  
76 transmission mechanisms (i.e., capacity to generate and use information provided by others)

77 may be more deeply rooted in specialist (e.g., vultures) than in generalist species (e.g.,  
78 facultative species) [2,19]. Also, the generation and use of social information can depend on  
79 species competitive ability (e.g., due to differences in size) and foraging efficiency (e.g., use of  
80 different senses) [3,27]. Thus, the likelihood of individuals to join, follow or stay feeding at a  
81 carcass can depend on the presence of other species with particular traits (e.g., largest beak,  
82 ability to smell), translating into characteristic patterns of arrival of the species to the carcass  
83 [15]. The analysis of temporal data on species occurrence combined with species traits may  
84 indicate what benefits may be sought by some species following others [3,28].

85 Experimental work is still critically needed to determine what social information is used and  
86 how it is used in different natural scenarios. Therefore, in this study we aim to combine data  
87 obtained through the monitoring of carcasses in the field and the realization of models in which  
88 we analyse possible information transmission cascades within a Neotropical scavenger  
89 community. This guild has been less studied, even though some vulture species have a  
90 developed sense of smell. Therefore, we identify and rank the scavenger species that influence  
91 the process of locating and recruitment at carcasses according to different species traits (e.g.,  
92 morphological or behavioural attributes) that define their roles within the assemblage [10,11].  
93 We tested (1) if scavengers use social information to find carcasses, in particular, if species with  
94 higher foraging efficiency (i.e., developed sense of smell) arrive first, discovering carcasses and  
95 serving as cues for others, (2) if the information transmission occurs immediately through local  
96 enhancement or if the time-scale at which the transmission takes place is longer, (3) how the  
97 presence and abundance of species with different competitive capacities influence the  
98 information transmission within the assemblage, and thus the order of arrival of species to a  
99 carcass, and (4) which species traits are most influential in the generation of information and its  
100 social transmission.

## 101 **Methods**

### 102 **Study area and scavenger community**

103 The fieldwork was carried out in the *Cerrado* savanna, Piauí state, North-eastern Brazil. This  
104 biome has a tropical climate with two seasons, the dry season (i.e., from April to September)  
105 and the wet season (i.e., from October to March). The vegetation is very diverse, ranging from  
106 grasslands to closed forest canopy [29,30]. This area holds four species of American vultures  
107 (Cathartidae): turkey (*Cathartes aura*), lesser yellow-headed (*Cathartes burrovianus*),  
108 American black (*Coragyps atratus*) and king (*Sarcoramphus papa*) vultures. Also, facultative  
109 scavengers are present, including five species of other raptors, such as southern caracaras  
110 (*Caracara plancus*) and yellow-headed caracaras (*Milvago chimachima*), as well as mammals  
111 (5 species), reptiles (3) and other facultative birds (2) (further details in Table S1) [31].

## 112 **Study design and variables**

113 During November 2018, we placed 55 carcasses differentiated into two sizes: large carcasses (n  
114 = 10), between 20 – 40 kg, corresponding to goat carcasses; and small carcasses (n= 45), in  
115 which we grouped chicken pieces and whole chickens, between 0.075 – 2 kg. We monitored  
116 each carcass until its complete consumption ( $48.41 \pm 14.41$  hours for large carcasses and  $13.55$   
117  $\pm 19.56$  hours for small carcasses) [31] using two automatic cameras (Browning Strike Force  
118 pro HD), one set up to take images and the other to take videos (see [31] for more details). The  
119 camera was automatically activated by the animal when it was detected. We placed carcasses  
120 separating the larger ones by a minimum of 1.5 km and the smaller ones by a minimum of 150  
121 m, considering them as independent replicates (see [31] for more details of the location of the  
122 carcasses). Carcasses were placed during the day, both in the morning (before 12:00, n = 31)  
123 and in the afternoon (up to sunset, n = 24). We worked mainly with the images, but we used the  
124 videos (henceforth both called ‘archives’) when we did not have any image due to camera  
125 failure. We obtained a total of 27,092 archives (i.e., 24,624 for goat carcasses and 2,468 for  
126 chicken carcasses). For each one, we determined 1) the carcass to which it belongs (i.e., carcass  
127 ID), 2) the date and time when the archive was taken, 3) the time between carcass placement  
128 and the archive (‘time since carcass placement’), 4) the species present in the archive  
129 (‘presence’), and 5) their abundances, i.e., the numbers of individuals of each species

130 ('abundance'). We further quantified, for each carcass, the percentage of shrub and tree cover in  
131 a 5-meter radius around the point where we placed the carcass ('vegetation cover'). Vegetation  
132 cover could affect information transmission, so that a higher cover would make it more difficult  
133 for a species to receive visual cues [11,32].

#### 134 **Statistical analysis**

135 Because differences in community structure and consumption patterns were found between the  
136 two carcass sizes [31], we analysed the data for large and small carcasses separately. The use of  
137 camera-trap data to model multi-species time-series dynamics is complicated because the  
138 images are not taken at regular intervals, but only when a species is present. Thus, the absence  
139 of a species is indicated by the absence of images from it, but this should be considered as data  
140 (on species absence), not as missing data. To resolve this, we converted the irregular camera-  
141 trap data into regular interval data. We denoted the time interval by  $\Delta t$ , and used  $\Delta t = 10$  min  
142 in our main analyses (see Supporting information for sensitivity analyses where we use either  
143  $\Delta t = 1$  minute or  $\Delta t = 1$  hour instead). We denoted by  $y_{ijt}$  the maximum count of individuals  
144 of species  $j$  in carcass  $i$  from any image taken during time interval  $t$ . We indexed time so that  
145  $t = 1$  corresponds to the interval starting when the carcass was placed into the field.

146 Our main focus was to ask how the first arrival time of each focal species depends on the  
147 previous presence of heterospecifics. We included as 'focal species' those species that had  
148 appeared in at least 5 carcasses and used the first occurrence (i.e., first arrival) in each of the  
149 carcasses as the response variable (see Table S1). To account for possible confounding effects  
150 (not related to species interactions) that we thought could be influencing species arrival, we first  
151 established a baseline model in which we modelled 'focal species' abundance  $y_{ijt}$  with a  
152 Poisson regression, where we used as predictors (i) 'vegetation cover', (ii) 'time of the day', and  
153 (iii) 'time since carcass placement'. We included 'vegetation cover' as a continuous covariate  
154 ranging from 0 to 1. We included 'time of the day' through linear combination of the periodic  
155 functions  $\sin(2\pi h/24)$  and  $\cos(2\pi h/24)$ , where  $h \in [0,24]$  is the hour of the day when the  
156 image or video was taken. We included both first and second order effects of 'time since carcass

157 placement' to account for the species abundances peaking at intermediate times since carcass  
158 placement. We note that the influence of 'time since carcass placement' can be either due to  
159 confounding factors (e.g., the stage of decay of the carcass) or due to species interactions (e.g.,  
160 the late arrival of the species being explained by the focal species using other species as a cue).  
161 As these two cannot be conclusively separated from observational data, we performed a  
162 sensitivity analysis where 'time since carcass placement' was either included or excluded in the  
163 baseline model (see Supporting information). We denoted the linear predictor of the fitted  
164 baseline model by  $L_{ijt}$ . We note that this linear predictor summarizes the effects of all  
165 confounding effects into a single variable.

166 To ask how the first arrival times of the species depend on the presence of heterospecifics, we  
167 followed a survival-modelling strategy. We denoted by  $p_{ijt}$  the presence ( $p_{ijt} = 1$   
168 corresponding to  $y_{ijt} > 0$ ) or absence ( $p_{ijt} = 0$  corresponding to  $y_{ijt} = 0$ ) of species  $j$  in  
169 carcass  $i$  from any image taken during time interval  $t$ . We considered, for each carcass and each  
170 'focal species', the data only until the first arrival of each of the species, so that the sequence of  
171 the data  $p_{ijt}$  (i.e., response variable) over time intervals  $t$  is of the form of a series of zeros  
172 (absences) followed by one (presence). We modelled these data with logistic regression, where  
173 the predictors (i.e., explanatory variables) were the linear predictor  $L_{ijt}$  from the baseline model  
174 (to account for confounding effects and avoid overloading the model with covariates due to our  
175 small sample size), and the presence of other species in earlier times  $h_{ijt}$ . To consider the  
176 possibility of a species arriving at the carcass regardless of whether another species has been  
177 there previously, we consider the model that only includes the linear predictor  $L_{ijt}$  (i.e., without  
178 including the previous presence of another species) as a null model. In particular, the first and  
179 second order effects of 'time since carcass placement' model the baseline probability of when  
180 the focal species typically appears to the carcass. If the prior presence of some other species  
181 turns out to have e.g., a positive effect, it means that, the focal species is likely to appear earlier  
182 than predicted by the null model if prior presence of other species was recorded in the carcass,



183 whereas it is likely to appear later than predicted by the null model if prior presence of other  
184 species was not recorded in the carcass.

185 We considered several alternatives to define the presence of other species in earlier times ( $h_{ijt}$ )  
186 to evaluate different hypotheses for the transmission of information between species. We varied  
187 the following axes: (A) who the influencer is (i.e., the species or set of species that arrive in the  
188 carcass prior to the focal species and that may be influencing its appearance); (B) at what time-  
189 scale the influence takes place (i.e., how long does the visual cue of the presence of other  
190 species last); (C) is it the presence or abundance of the influencer that matters? Concerning (A),  
191 we either considered (A1) all the species other than the focal species irrespective of their  
192 identity; (A2) those avian species that can smell, i.e., *Cathartes* species, with an olfactory bulb  
193 up to four times larger than other sympatric vultures (e.g., black vultures) [33–35]; (A3) each  
194 individual species, however restricting the analyses to only those species detected occurring  
195 before the focal species at least five times. Concerning (B), we considered the data for the  
196 influencer either (B1) during the previous 10 minutes; (B2) during the previous 30 minutes;  
197 (B3) during the previous hour, following the methodology established by Orr et al. (2019); or  
198 (B4) during the previous 4 hours; to detect whether information cascades were occurring on a  
199 larger time scale, as would occur in the vulture chain hypothesis. Concerning (C), we  
200 considered (C1) the presence-absence of the influencer, (C2) the proportion of time-intervals  
201 during which the influencer was present; or (C3) the maximum abundance of the influencer  
202 during the focal time period (i.e., values determined in the alternatives of hypothesis B). Some  
203 of these predictors are correlated, and thus they are not independent alternatives, but comparison  
204 about their relative fits to the data may, however, yield valuable suggestions on the likely  
205 drivers of the heterospecific interactions.

206 All analyses were conducted in the R programming environment [36] using generalized linear  
207 models (GLMs) with a Poisson distribution (log link function) or a Bernoulli distribution (logit  
208 link function). For GLMs we used the *glm* function in the *lme4* package [37]. We selected the  
209 best models based on Akaike's information criteria for small samples (AICc) from all potential

210 models (including null model) using the *AICc* function in the *MuMIn* package [38], and we  
211 choose only those with an  $\Delta AICc < 2$  (i.e., top-ranking models) [39]. Finally, we calculated the  
212 goodness of fit for the top-ranking models through the percentage of deviance explained ( $D^2$ )  
213 [39]:

$$214 \quad D^2 = \frac{\text{null deviance} - \text{residual deviance}}{\text{null deviance}} \times 100$$

## 215 **Results**

216 Some species in the community were recorded commonly as the first to reach the carcass (e.g.,  
217 *Cathartes* species, with a first arrival time of  $25.61 \pm 17.82$  hours), while we never observed  
218 some other species to arrive as the first ones (Fig. 1). The arrival of the species to large  
219 carcasses was more predictable than their arrival to small carcasses, as for small carcasses there  
220 was a greater variability in the times it took for species to reach the carcass (Fig. 1, see Table S2  
221 for further details).

222 We observed a several cases where species influenced each other's arrival positively, but not  
223 any case of a negative influence (Fig. 2). In particular, the king vulture and the southern  
224 caracara were positively influenced by the previous occurrences of the other species. This result  
225 was highly robust, as we observed such a positive influence almost independently on how we  
226 constructed the biotic predictor, i.e., whether we considered as the influencer all species or only  
227 some of them, whether we considered the *presence* or *abundance* of the influencer, or whether  
228 we considered the *presence* of the influencer over short or long time-intervals (the  
229 predominance of green squares in Fig. 2 for these species). Furthermore, these results held  
230 whether we discretized the data to  $\Delta t=1$  min,  $\Delta t=10$  min or  $\Delta t=1$  hour interval, and whether we  
231 included or excluded the *time since carcass placement* in the baseline model (see Supporting  
232 Information). Interestingly, for both the king vulture and the southern caracara, at large  
233 carcasses we observed the strongest influence of the *abundances of all other species*, whereas at  
234 small carcasses the *presence* of influencers *with olfaction* (especially the turkey vulture; with a  
235 first arrival time to small carcasses of  $29.14 \pm 17.00$  hours, Table S2) had the highest effect,

236 being included in the top-ranking models (green squares marked with thick borders in Fig. 2).  
237 Also at small carcasses, the lesser yellow-headed vulture ( $19.60 \pm 18.43$  hours, Table S2) was  
238 influenced by the previous *presence of all other species*, especially by the proportion of time  
239 that the other species were present shortly before the focal time (i.e., alternatives of B; Fig. 2).  
240 Our results were not conclusive on whether the American black vulture was or was not  
241 influenced by the previous *presence* of heterospecifics, as in some of the model variants we did  
242 record a significant effect while in other model variants we did not do so (see Supporting  
243 Information). We did not obtain any influence of heterospecifics on their arrival for turkey  
244 vultures, hoary foxes ( $19.13 \pm 10.46$  hours) and the black-and-white tegu ( $31.45 \pm 18.51$  hours),  
245 either because there were not enough previous occurrences of other species to fit the models, or  
246 because their influences were not significant (Fig. 2). As expected, the linear baseline predictor  
247  $L_{ijt}$  had a positive effect for all species, even if the effect was not significant for some cases  
248 (Fig. 2).

## 249 **Discussion**

250 Disentangling the use of social information between species that share a resource and exhibit  
251 different foraging capabilities is fundamental to understand the interspecific interactions and  
252 how a guild is structured [40]. Our results show how the use of different senses (smell and  
253 vision) to find carrion allows for facilitation processes through the transmission of information  
254 between scavengers in a Brazilian *cerrado* community. American vulture species with high  
255 olfactory ability are the first to arrive at the carcasses and initiate visual information cascades  
256 that will indicate species with a lower foraging efficiency (e.g., limited olfactory ability) the  
257 presence of the carcasses. In general, signal reception and subsequent response seem to take  
258 place in short times, which supports the “local enhancement” hypothesis, so that when any  
259 individual sees a heterospecific feeding at a location, it may approach and locate the carcass  
260 [13,41]. Furthermore, these patterns of information transmission appear to be strongly  
261 influenced by the size of the resource, being fundamental in the location of small carcasses.

262 Our findings support that scavenger species in this Neotropical guild rely on olfactory (e.g.,  
263 *Cathartes* vultures, mammals) and visual cues (e.g., most avian scavengers) to locate carcasses.  
264 This result contrasts with the foraging behaviour of scavenger guilds in Eurasia and Africa, in  
265 which only mammals have a highly developed sense of smell, whereas vultures rely only on  
266 visual cues to locate carrion [35,42]. In our system, vulture species with a developed sense of  
267 smell seem to have a clear advantage over those lacking this ability, since they are the first ones  
268 that arrive to most carcasses [24,43]. This dominance of vultures at large and small carcasses in  
269 Neotropical ecosystems contrasts with the dominant role of meso-carnivores and raptors at  
270 small carcasses in other biomes [44].

271 We highlight the role of the turkey vulture, as it is consistently the first one locating large  
272 carcasses and it does not depend on any species to locate the smaller ones [24,35,45]. On the  
273 contrary, our models show that the first occurrence of the lesser yellow-headed vulture depends  
274 on the previous presence of other species, despite they had short arrival times and a highly  
275 developed sense of smell [34,42,46]. Therefore, our findings could be due to differences in these  
276 species' relative abundance in the study area (authors, unpublished data).

277 Foraging behaviour refers to both the acquisition of resources and the way in which information  
278 about those resources is acquired (i.e., personal experience and social information) [47].

279 Although our data are correlational, our results show the existence of temporal associations  
280 between species, suggesting a facilitation process locating carrion (i.e., increase in foraging  
281 efficiency), since the presence of heterospecifics at the carcasses positively influences the  
282 appearance of new species [5,48]. This agrees with social information taking a fundamental role  
283 when resources are unpredictable, as happens with carrion [49]. Previous research has shown  
284 that species using different foraging behaviour (e.g., different senses) act as initiators of mixed-  
285 species feeding aggregations in multiple systems [50,51]. Our results show that vulture species  
286 with developed sense of smell generate this information, since their presence serves as a visual  
287 cue for other species to locate the carcasses. Our findings also show that, once a species with  
288 olfactory capacity arrives at the carcass, the rest of the species may join independently of the

289 identity of the species, creating information cascades but without following a specific order of  
290 arrival. Through the reception of social information, individuals with lower foraging capacity  
291 may visually follow the ones with higher capacity (e.g., developed olfaction) that have  
292 previously arrived to the carrion following olfactory cues [18]. However, the decision to join a  
293 group of individuals from other species must involve a balance between the potential benefits  
294 (e.g., access to the resource) and costs (e.g., aggressive interactions) [2]. Similarly, the  
295 individual who generates the initial cue (e.g., turkey vultures) will benefit from arriving in first  
296 place but is not expected to profit from the arrival of other species, since there is a possibility of  
297 being displaced by new individuals who arrive at the carcass (e.g., larger species like king  
298 vultures). This has been seen for turkey vultures, which used to be displaced after the arrival of  
299 other species [24,27,45].

300 Furthermore, facilitation processes through social information cascades seem to be influenced  
301 by carcass size and the temporal scale. On the one hand, our results show how the presence of  
302 species with a developed olfactory capacity (i.e., turkey and yellow-headed vultures) especially  
303 influences the arrival of other species at small carcasses. This may be because small carcasses  
304 are more difficult to locate, i.e., the intensity of the visual cue is stronger at large carcasses due  
305 to their larger size. Although it is also possible that the olfactory cue may be stronger at large  
306 carcasses (i.e., more rotting biomass). Therefore, having a developed sense of smell may be a  
307 fundamental advantage for reaching small carcasses first, since the difficulty of finding them is  
308 higher. In addition, at small carcasses the mere presence of an individual from another species  
309 would serve as a visual signal, while at large carcasses the maximum abundance is more  
310 important. This could be because the number of individuals consuming a carcass is larger at the  
311 large ones, generating a stronger visual signal [31]. On the other hand, cues were perceived on a  
312 different time scale by the different species, since some of them arrived at the carcass  
313 immediately upon perception of the cue (e.g., 10 minutes) and others required longer periods of  
314 time (e.g., up to 4 hours). This could be because not all species respond to the presence of other  
315 species equally, probably due to differences in foraging efficiency, abundance and competitive

316 abilities among them [52,53]. We found that most species responded quickly to the previous  
317 presence of heterospecifics, which supports the “local enhancement” hypothesis against the  
318 hypothesis of a wider chain of information (e.g., “vulture chains” hypothesis) [41].

319 Interestingly, mammals and reptiles do not seem to be influenced by the previous presence of  
320 other species. This contradicts what happens in other systems where birds influence the arrival  
321 (i.e., recruitment) of carnivores, or vice versa [15,17]. Both mammals and reptiles have a  
322 developed sense of smell and chemoreception, respectively, which would allow them to locate  
323 carrion without depending on vulture species. This lack of use of social information may be also  
324 due to the quick consumption of small carcasses (i.e., the only ones that are consumed by most  
325 facultative scavengers), as the first individual to locate the carcass is the one consuming it  
326 completely in most cases [31].

327 Our study highlights how the use of different senses (i.e., smell and sight) within a Neotropical  
328 scavenger guild gives rise to facilitation processes in locating carcasses using heterospecific  
329 social information. Species with a higher efficiency in finding carcasses (e.g., highly developed  
330 smell) play a key role in this process, as they seem to serve as visual cue for the rest of the  
331 species. The use and transmission of social information is subject to strong selection pressures  
332 and can influence since the individuals from the same or different species to the community  
333 structure [9,10]. This makes essential to continue investigating how senses influence the  
334 processes of social information transmission and its relative importance depending on different  
335 factors, considering both heterospecific and conspecific information, and including all the  
336 species of the scavenging community.

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#### 347 **Data accessibility**

348 All the raw data and analysis code used during the current study are available in the Figshare  
349 Digital Repository [54]

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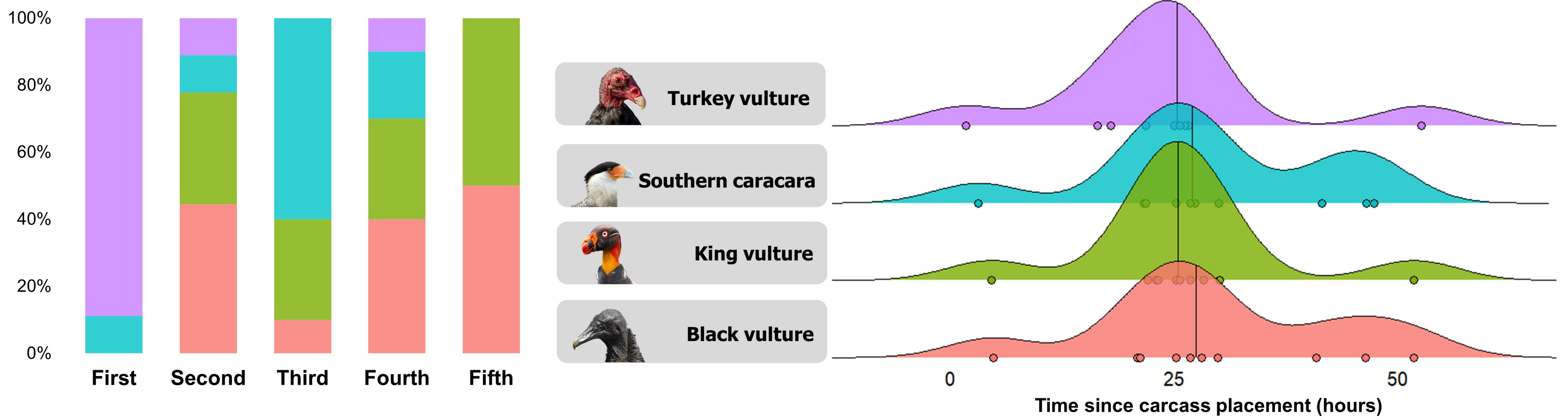
489 **Figure legends**

490 **Figure 1.** The succession of arrival (bar plots) and arrival time since carcass placement  
491 (smoothed plot) of different species to large carcasses and small carcasses. The photographs  
492 exemplify consumption patterns, numbers in each image refer to the chronological arrival of a  
493 new species and the colour of the number refers to the species. Bar plots represent the  
494 percentage of times that each of the focal species (i.e., different colours) reached the carcasses  
495 in the different positions (i.e., x-axis; from the first position to the fifth one). The smoothed  
496 plots show, for each of the focal species (i.e., y-axis), their frequency with which they arrived at  
497 different times since carcass placement (i.e., x-axis in hours). The vertical line in the frequency  
498 curves represents the median value of the arrival time for each species. See Table S2 for further  
499 details.

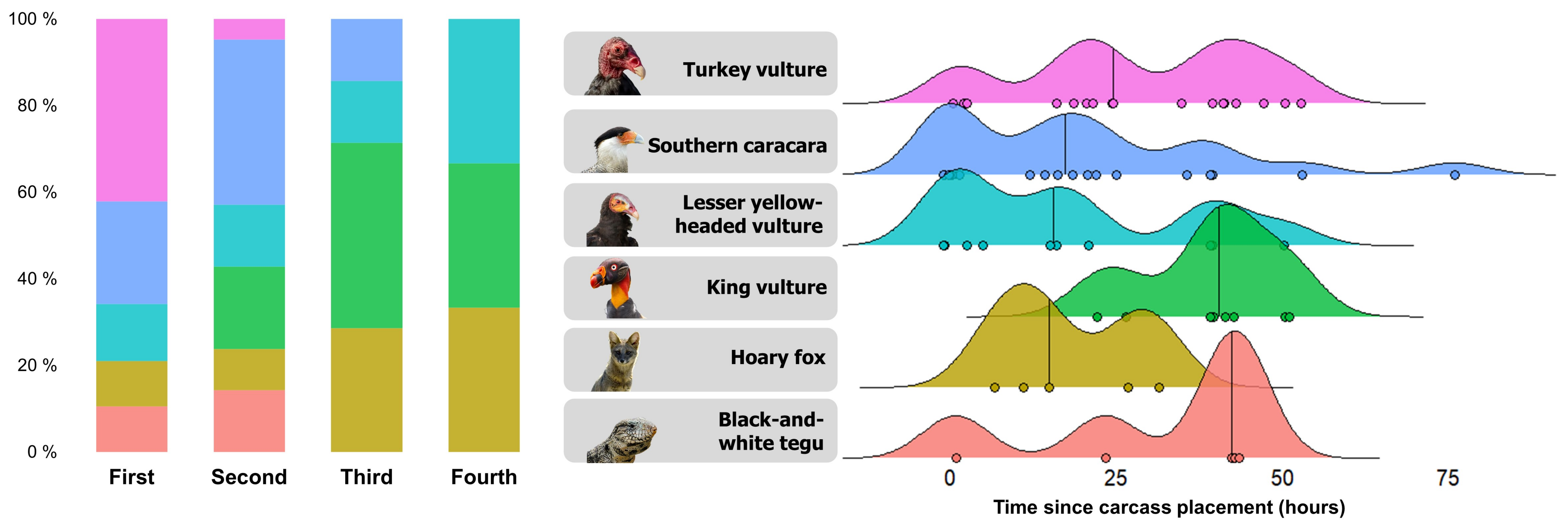
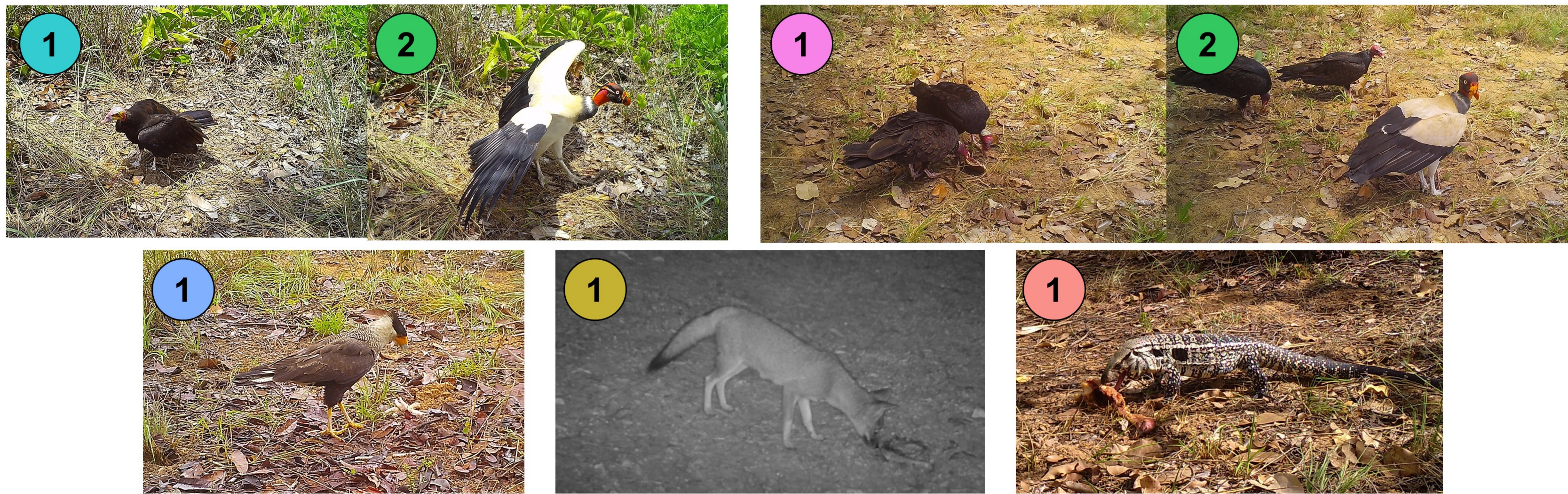
500 **Figure 2.** Results of the logistic regression on heterospecific influence on first arrival times,  
501 shown separately for large and small carcasses. Circles refer to the influence of the baseline  
502 predictor  $L_{ijt}$ , and the squares to the heterospecific influence. Positive and significant ( $p < 0.05$ )  
503 influence on the occurrence (i.e., first appearance) of each focal species is indicated in green;  
504 non-significant effects are indicated in grey and model combinations not considered are shown  
505 in white. The absence of squares indicates that there is no model for that focal species. The  
506 different combinations for B1-B4 (i.e., importance of the presence or abundance of the  
507 influencer) and C1-C3 (i.e., previous time considered) assumptions are represented in the mini-  
508 squares. See Tables S3 and S4 for further details. The results are shown here for the data  
509 discretized to time resolution of  $\Delta t = 10$  min, and for the case where the time since carcass  
510 placement was included in the baseline model. See Supporting Information for corresponding  
511 results for data discretized to time resolution of  $\Delta t = 1$  min or  $\Delta t = 1$  hour, and the case where the  
512 time since carcass placement was excluded in the baseline model.



# LARGE CARCASSES



# SMALL CARCASSES





# INFLUENCERS



Baseline predictor  
*Lijt*



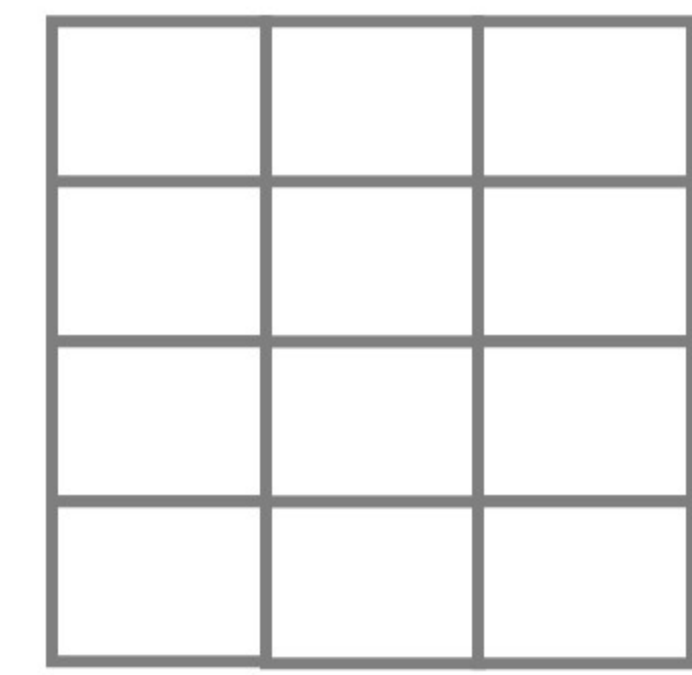
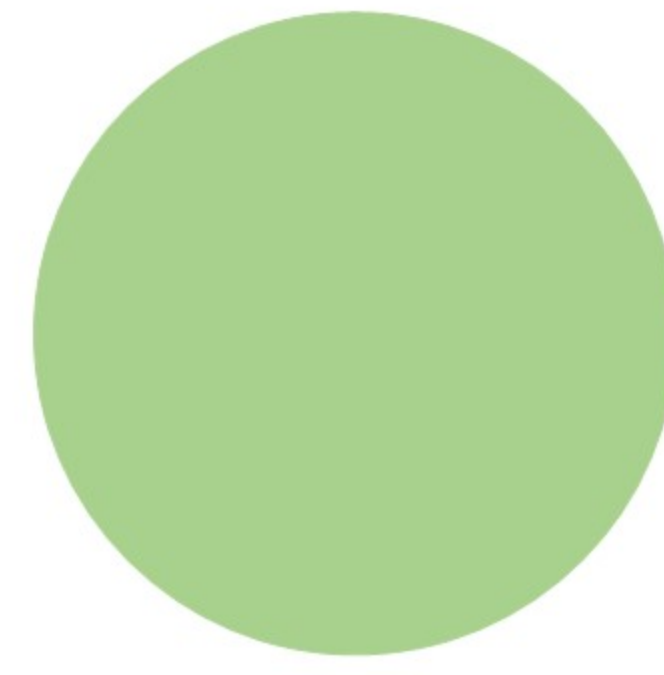
Baseline predictor  
*Lijt*



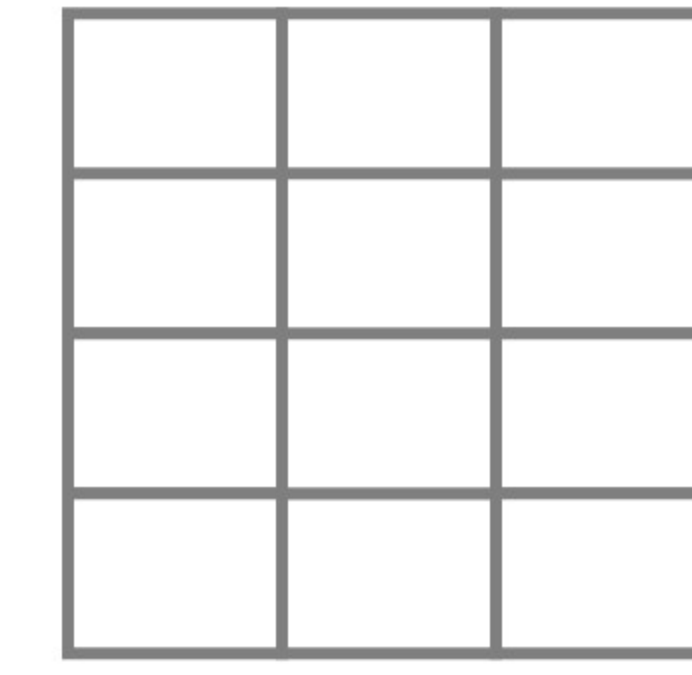
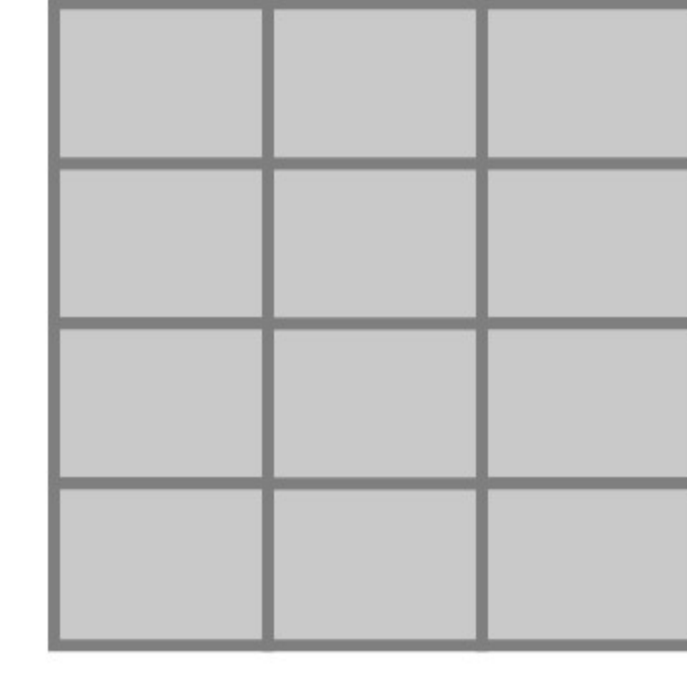
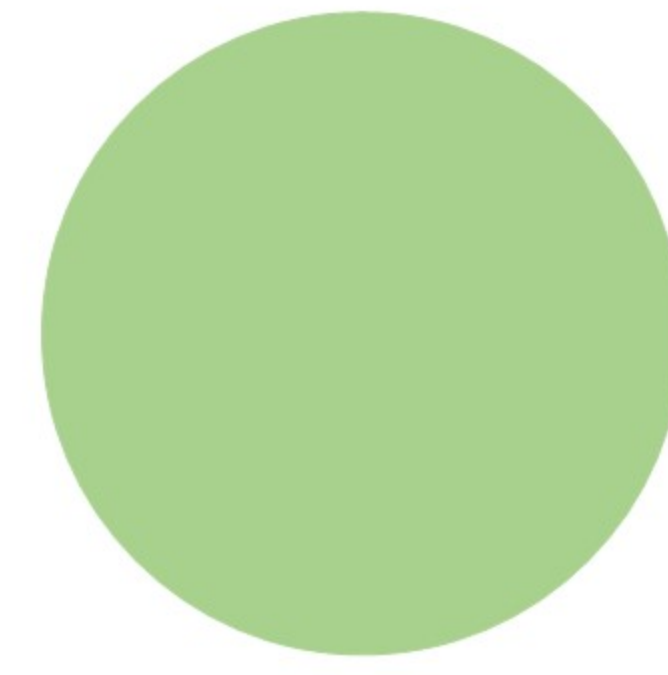
# FOCAL SPECIES



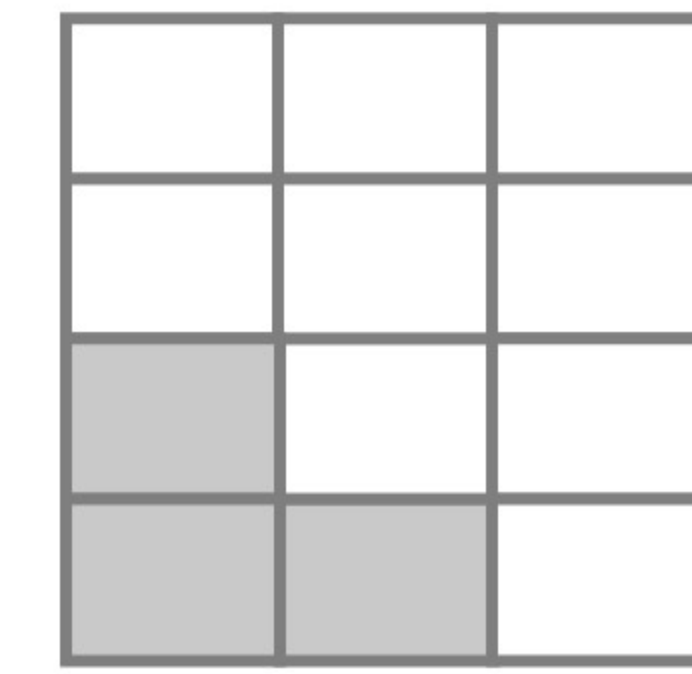
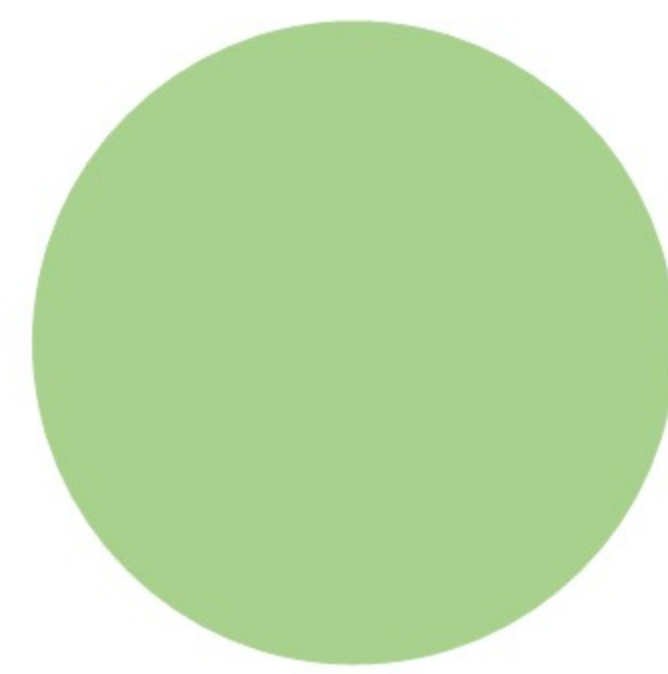
Turkey vulture



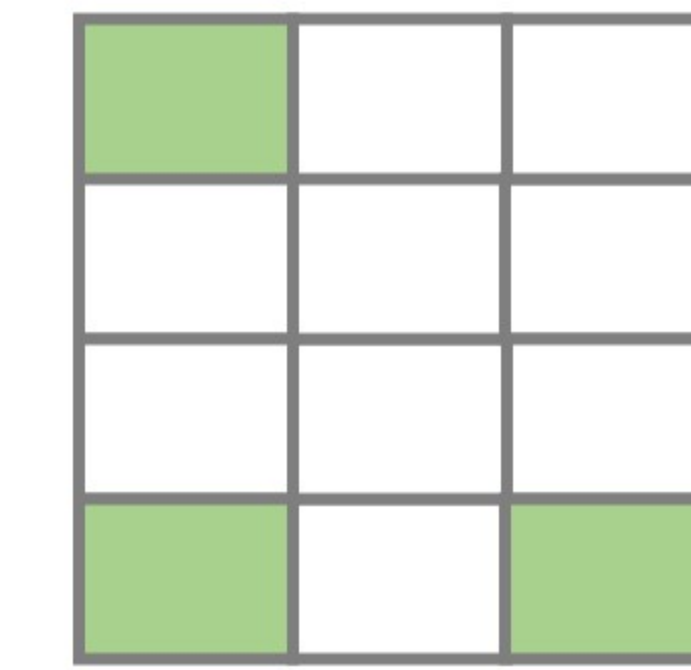
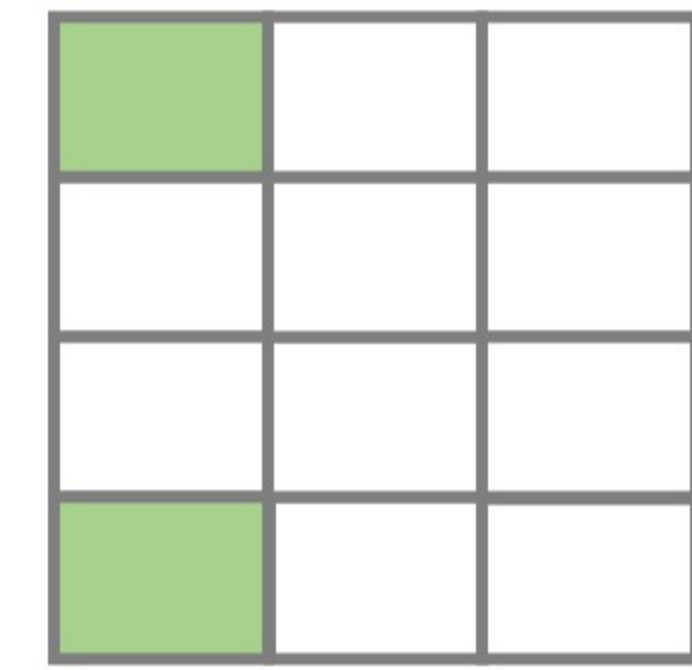
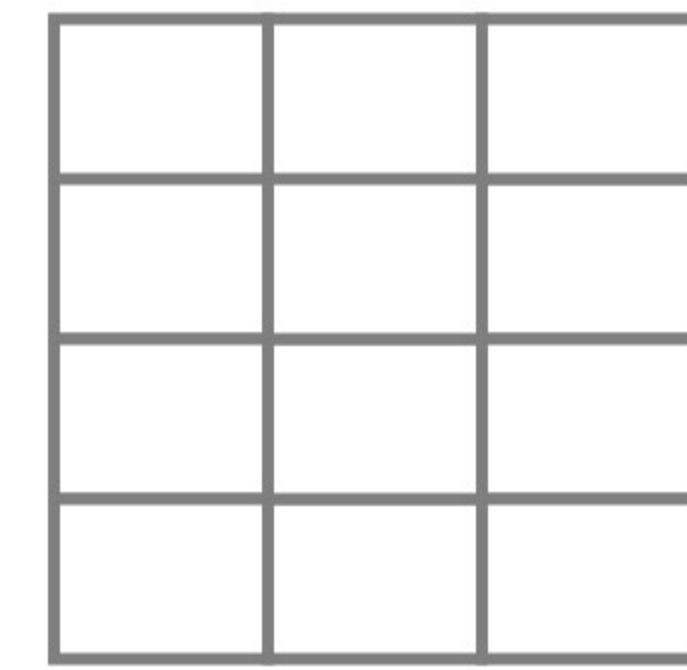
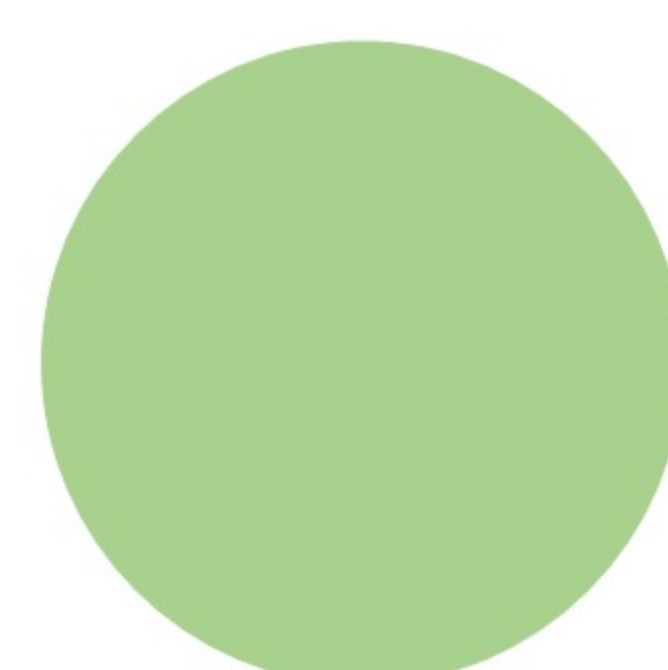
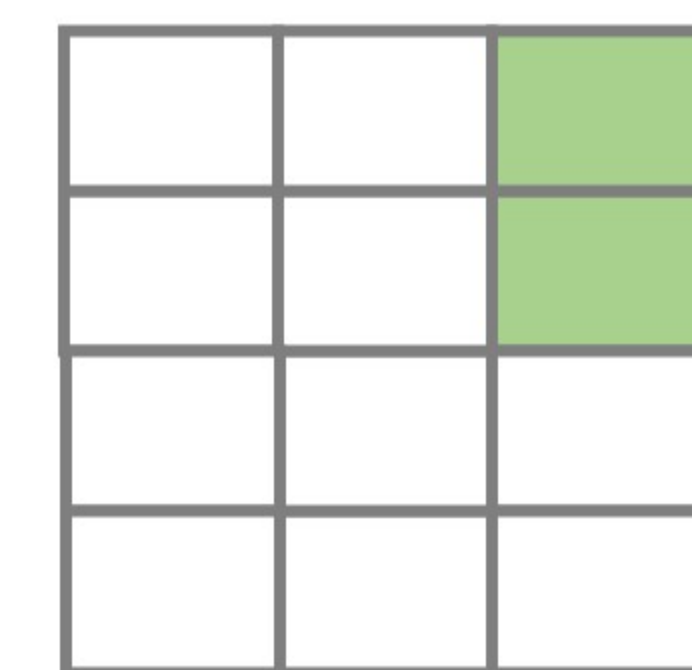
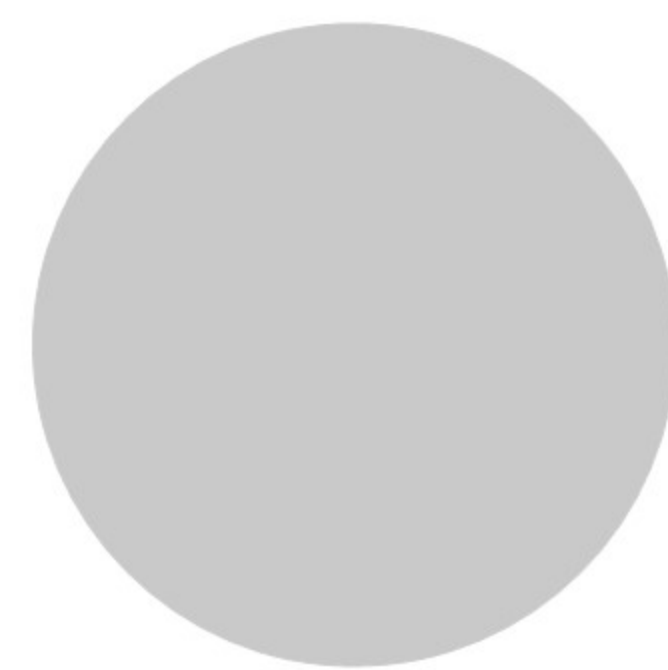
Lesser yellow-headed vulture



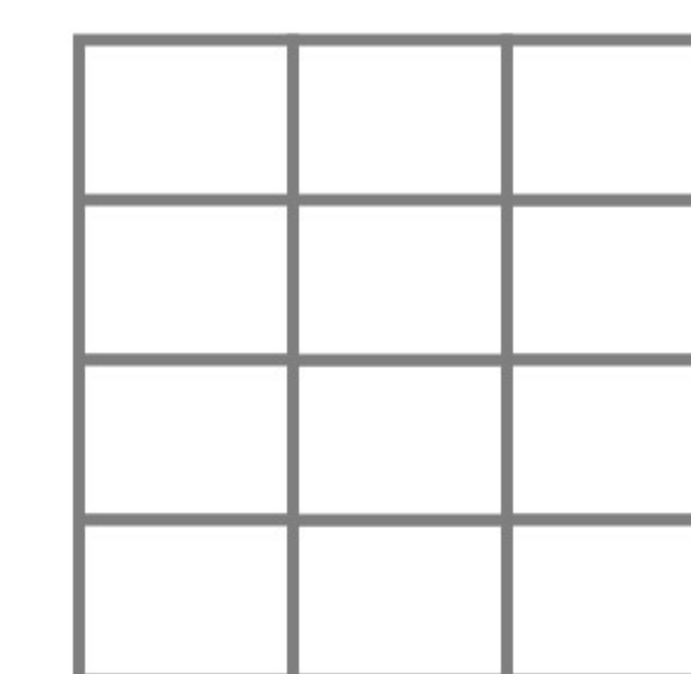
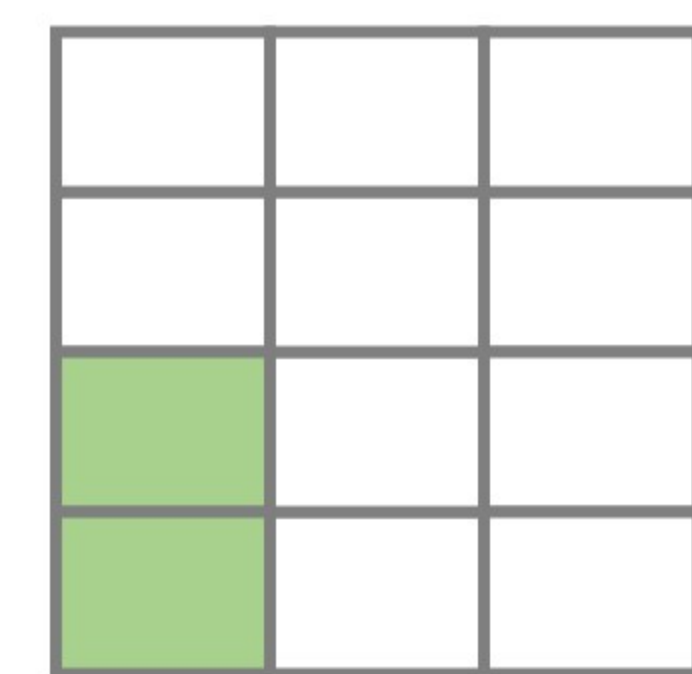
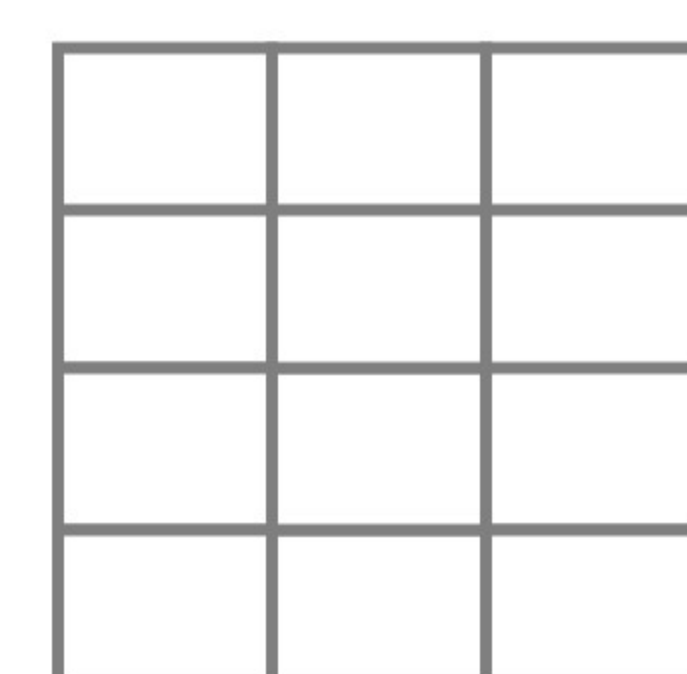
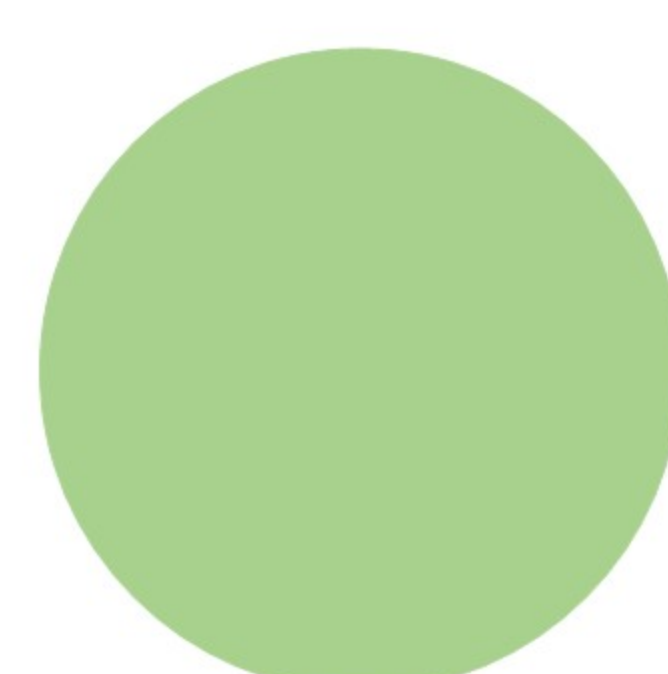
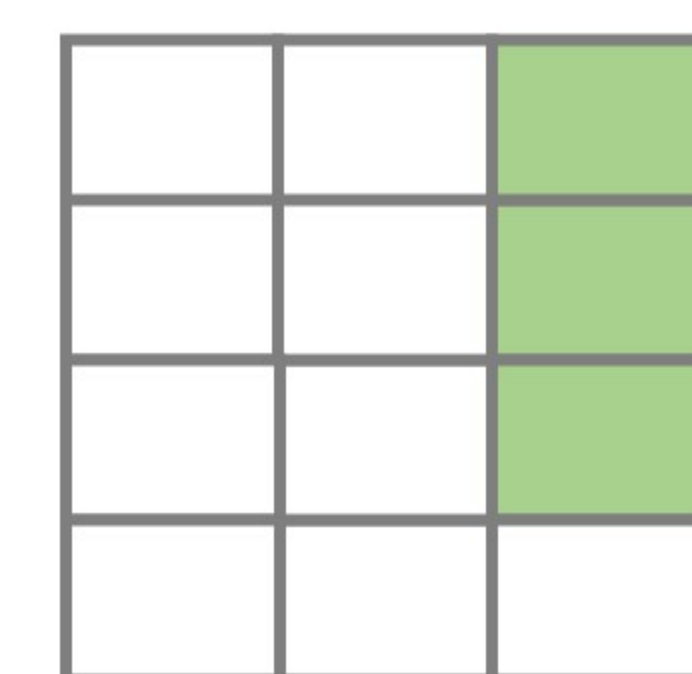
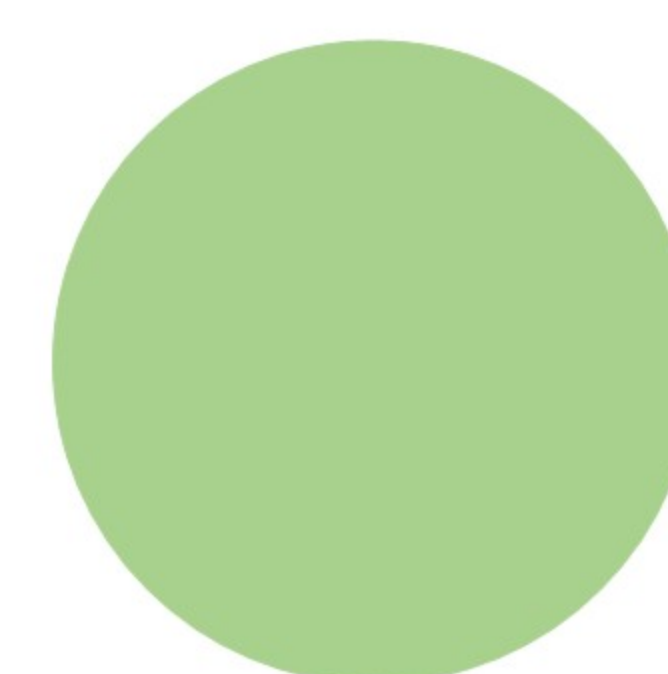
Black vulture



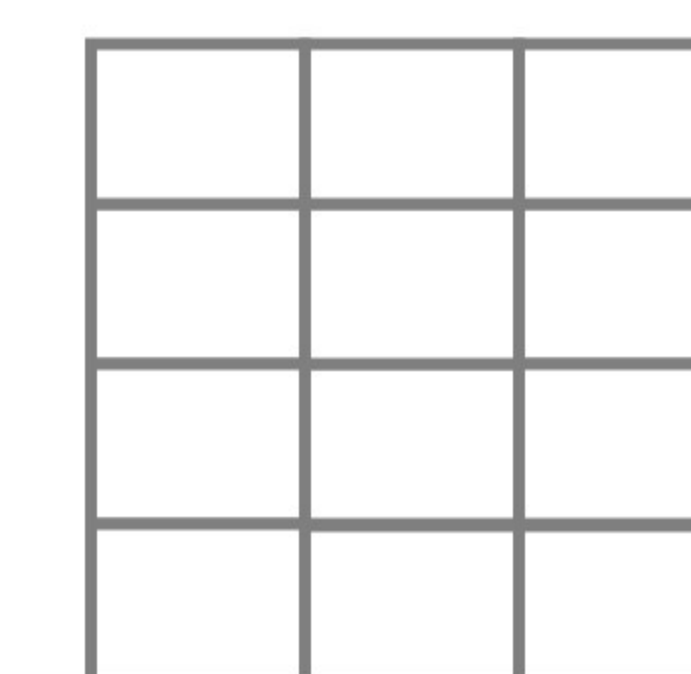
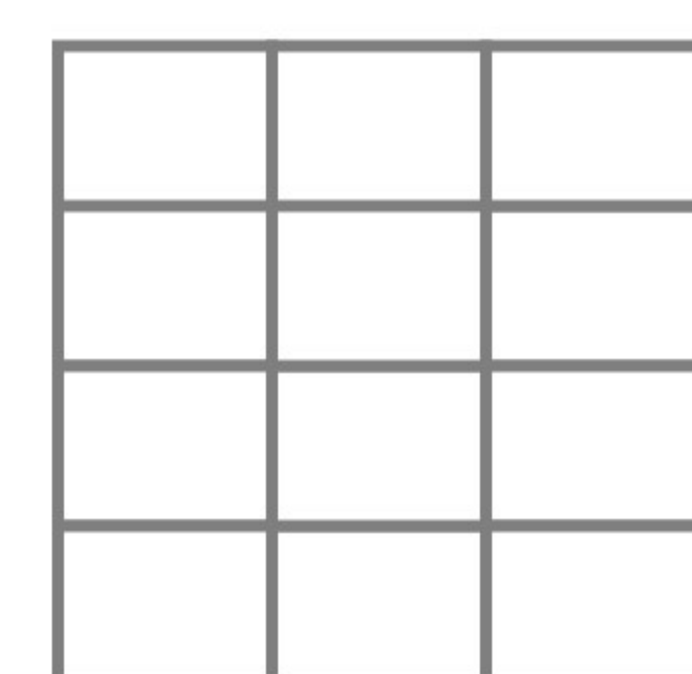
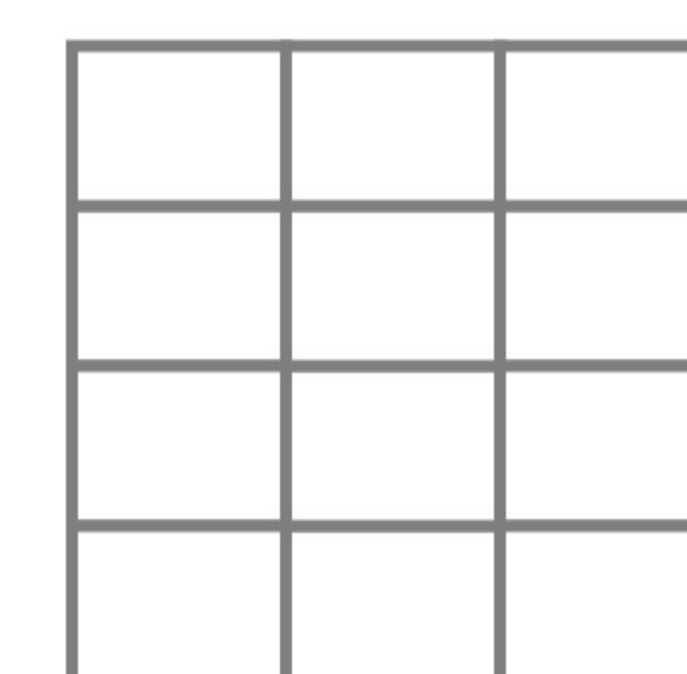
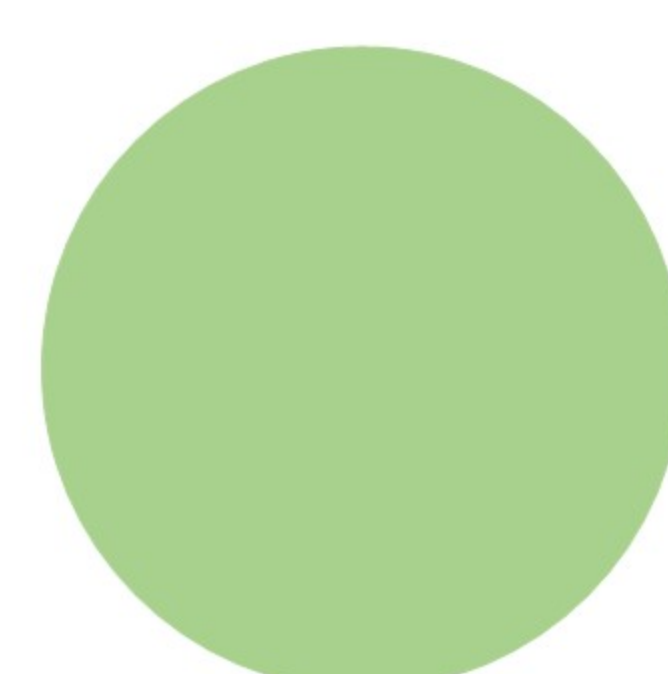
King vulture



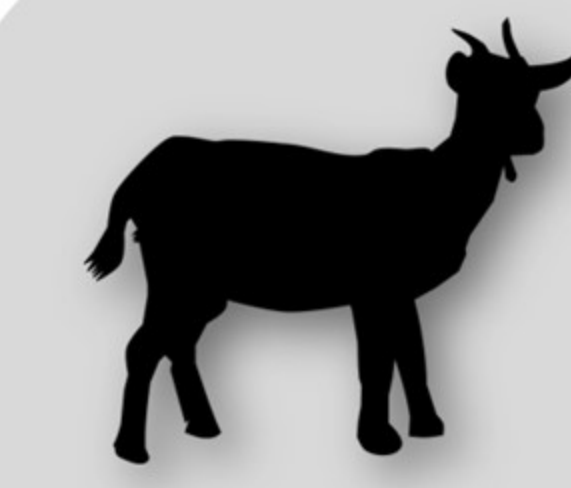
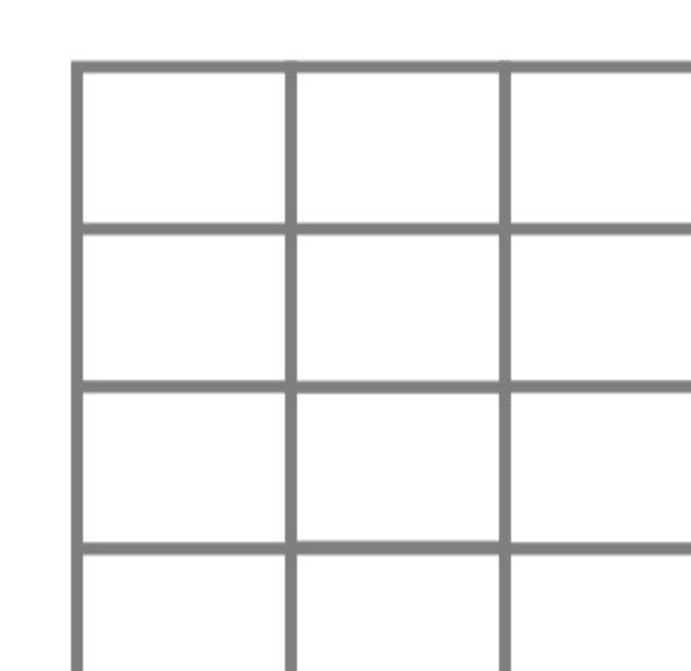
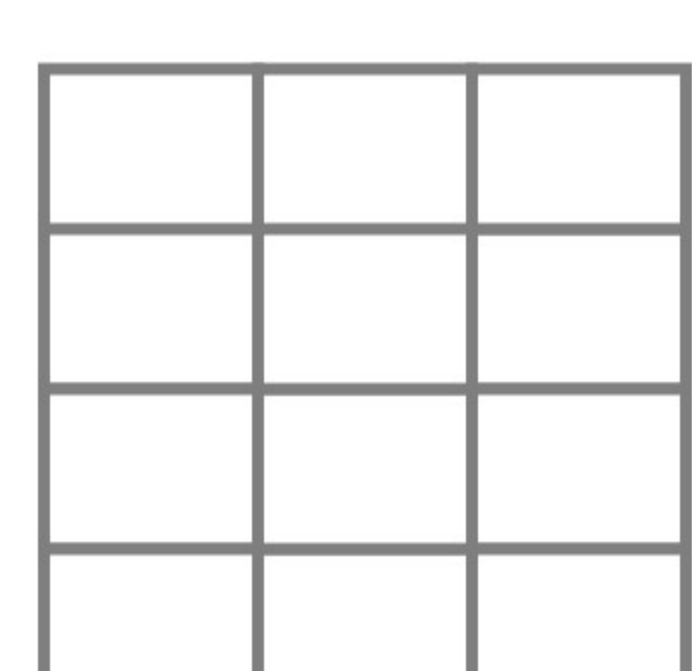
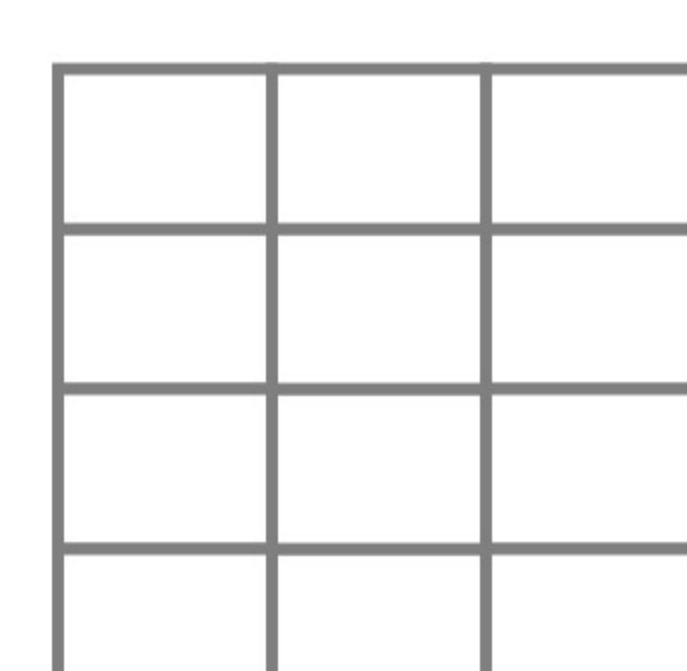
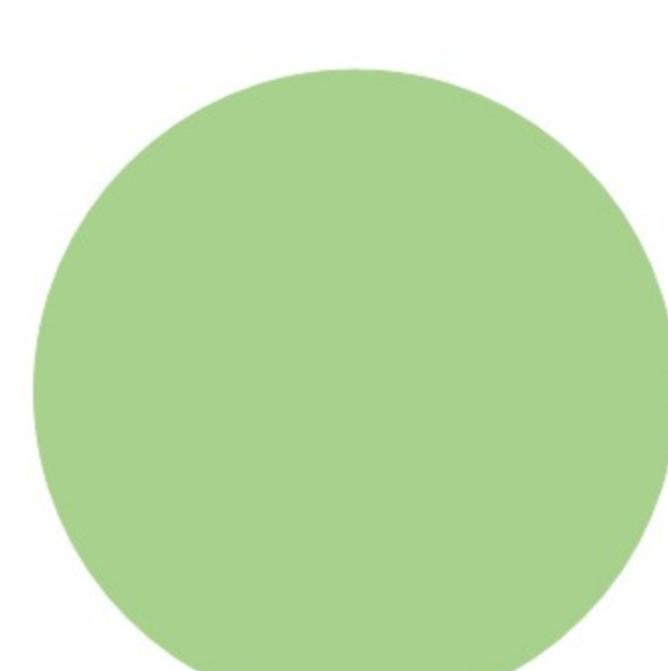
Southern caracara



Hoary fox



Black-and-white tegu



Large carcasses



Small carcasses



Significant positive effect



Significant negative effect



Not significant effect



Not included

## Time-scale of the influence

Previous 10 min

Previous 30 min

Previous 1 hour

Previous 4 hours


Presence

Proportion of time present

Abundance

Influencer