Perceptions of impacts and access to wildlife of domestic carnivores in a sub-Antarctic wilderness area

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Background. Hundreds of millions of domestic carnivores worldwide have diverse positive affiliations with humans, but can provoke serious socio-ecological impacts when free-roaming. In protected areas, unconfined dogs and cats interact with wildlife as predators, competitors, and disease-transmitters while their access to wildlife depends on husbandry, attitudes, and the behavior of pet owners.

Methods. We used questionnaires (n=222) to understand perceptions of impacts of free-roaming dogs and cats, and predictors of access to wildlife of owned dogs in one of the last wilderness areas of the world, the Cape Horn Biosphere Reserve, located in southern Chile.

Results. We found that free-roaming dog packs can be frequently observed (69% of participants) in nature with evidence of a feral population of dogs on the island. However, dog-wildlife conflicts passed almost unperceived (<9% of experienced and suspected problems). Only 18% of the participants thought that cats might impact birds. Generalized linear models showed that free-roaming dogs were larger dogs and those of dog owners not willing to share their house with them or to modify their backyard for them. The probability that dogs brought prey to owners' homes was higher in larger and rural dogs. Awareness of dog-wildlife impacts was higher in participants who considered that wildlife (besides cattle, horses, waste) could be part of feral dogs' prey.

Discussion. We conclude that the context in which free-roaming dogs are perceived to interact is predominantly anthropogenic. Hence, environmental education is needed to draw attention to the possibility of unconfined pet interaction with wildlife in the southernmost protected area of the globe.

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19   **Abstract**

20   **Background.** Hundreds of millions of domestic carnivores worldwide have diverse positive

21   affiliations with humans, but can provoke serious socio-ecological impacts when free-roaming. In

22   protected areas, unconfined dogs and cats interact with wildlife as predators, competitors, and

23   disease-transmitters while their access to wildlife depends on husbandry, attitudes, and the

24   behavior of pet owners.

25   **Methods.** We used questionnaires (n=222) to understand perceptions of impacts of free-roaming

26   dogs and cats, and predictors of access to wildlife of owned dogs in one of the last wilderness areas

27   of the world, the Cape Horn Biosphere Reserve, located in southern Chile.

28   **Results.** We found that free-roaming dog packs can be frequently observed (69% of participants)

29   in nature with evidence of a feral population of dogs on the island. However, dog-wildlife conflicts

30   passed almost unperceived (<9% of experienced and suspected problems). Only 18% of the

31   participants thought that cats might impact birds. Generalized linear models showed that free-

32   roaming dogs were larger dogs and those of dog owners not willing to share their house with them

33   or to modify their backyard for them. The probability that dogs brought prey to owners' homes

34   was higher in larger and rural dogs. Awareness of dog-wildlife impacts was higher in participants

35   who considered that wildlife (besides cattle, horses, waste) could be part of feral dogs' prey.

36   **Discussion.** We conclude that the context in which free-roaming dogs are perceived to interact is

37   predominantly anthropogenic. Hence, environmental education is needed to draw attention to the

38   possibility of unconfined pet interaction with wildlife in the southernmost protected area of the

39   globe.

40

41   **Introduction**

42   In parallel to human population growth, the number of companion animals is constantly

43   increasing as well. Pet and feral dogs (*Canis familiaris*) have reached population estimates of 900

44   million and cats (*Felis catus*) of 600 million, (O'Brien & Johnson, 2007; Gompper, 2014a) being

45   present on all continents except Antarctica (Hughes et al., 2015). Since their domestication

46   thousands of years ago, domestic dogs have had profound roles in human lives. These include

47   companionship, livestock guarding, rescue, hunting, tourism, service animals, and wildlife

48   management. In consequence, as dogs are part of a diversity of human cultures, their various roles,

49 human husbandry, and attitudes towards them have different implications for human-dog-wildlife

50 interactions (Miller, Ritchie & Weston, 2014).

51 The access of wildlife by dogs and cats depend on their husbandry, particularly on their

52 confinement. This ranges from complete restriction of mobility, in leashed or confined owned dogs

53 and cats, to feral domestic carnivores that survive independently of supplemental provisioning

54 from humans (Kays & DeWan, 2004; Vanak & Gompper, 2009). In between these extremes, there

55 exists a range of free-roaming animals that are owned or unowned and are, to some extent,

56 subsidized by humans. As subsidized predators, domestic carnivores can reach higher population

57 densities than wild carnivore populations (Gompper, 2014b), leading to complex socio-ecological

58 consequences.

59 The impacts of free-roaming subsidized and feral domestic dogs include the loss of

60 livestock (Baker et al., 2008; Echegaray & Vilà, 2010), aggression towards humans (Schalamon

61 et al., 2006), disease transmission (Matter & Daniels, 2010), and wildlife interference (reviewed

62 in Young et al., 2011; Hughes & Macdonald, 2013). Dogs prey on (Butler, du Toit & Bingham,

63 2004; Manor & Saltz, 2004), compete with (Mitchell & Banks, 2005; Vanak, Thaker & Gompper,

64 2009), infect (Acosta-Jamett, 2009), and disturb (Silva-Rodríguez, Ortega-Solís & Jiménez, 2010;

65 Silva-Rodríguez & Sieving, 2012) wild animals. Suburban cats are successful small vertebrate

66 predators (Woods, McDonald & Harris, 2003; Loyd et al., 2013). On islands, Medina et al. (2011)

67 reviewed that feral cats were responsible for at least 14% of global bird, mammal, and reptile

68 extinctions (see also Nogales et al., 2013). Both dogs and cats may hybridize with their wild

69 relatives (Randi, 2008).

70 While the biology of domestic carnivore-wildlife interactions is the focus of research,

71 studies on the human dimensions are still in their infancy (Miller, Ritchie & Weston, 2014).

72 Conflicts between dogs/cats and wildlife could be minimized by a better understanding of how

73 husbandry, attitudes, and behavior of pet owners influence dogs and cats in their access to and

74 interaction with wild prey/carnivores, particularly when close to protected areas. For example, dog

75 owners felt more obliged to leash their dogs when they believed their dog would harm beach-

76 nesting birds or people (Williams et al., 2009). Recent studies have shown that the more adequate

77 the diet that owners feed their dogs and cats, the less they prey on wild animals (Silva-Rodríguez

78 & Sieving 2012, Sepúlveda et al., 2014). Sepúlveda et al. (2014) also reported that the roles dogs

79 play in rural households affected their interactions with wildlife. Dog owners encouraged the

80 harassment of wild carnivores to protect their livestock, but disapproved the hunting of prey such

81 as endangered southern pudus (*Pudu pudu*).

82   Here, we focus on understanding the access to wildlife by a population of free-roaming

83 dogs and cats in a sensitive conservation area of southern Chile using questionnaires applied to pet

84 owners and non-owners. Our objectives were (1) to identify attitudes towards and experiences and

85 perceptions of impacts of free-roaming/feral cats and dogs, and (2) to examine predictors of access

86 to wildlife of owned village/rural dogs regarding dog confinement, care, and consciousness of the

87 dog-wildlife conflict. The survey also provided demographic pet information relevant for future

88 dog and cat management in one of the last wilderness areas of the globe.

89

90 **Materials & Methods**

91

92 **Ethics statement**

93   Prior informed consent was obtained from each participant by reading a printed statement

94 explaining the aims of the project, the benefits and the absence of risks of participating, the

95 possibility to omit questions, information about use and access to the results, and that the interview

96 is anonymous and voluntary. The participants agreed to participate by signing and kept a copy of

97 the informed consent. Paper and digital questionnaires were stored anonymously. The Scientific

98 Ethical Committee of the University of Magallanes, Chile, certified ethical approval of the

99 instrument.

100

101 **Study area**

102   The study was carried out on Navarino Island (2.528 km^2), Chile, located at the extreme

103 southern tip of South America (Fig. 1). The island is part of the Cape Horn Biosphere Reserve,

104 which belongs to the Magellanic Sub-Antarctic forest ecoregion, one of the remaining 24

105 wilderness areas of the world (Mittermeier et al., 2003). The dominant habitats within this

106 ecoregion are unfragmented evergreen and deciduous forests of southern beeches (*Nothofagus*

107 spp.) and Winter's bark (*Drimys winteri*), Magellanic peat bogs (mainly *Sphagnum* spp.), high-

108 Andean habitats, and glaciers (Pisano, 1977). The human population on Navarino Island is of

109 mixed cultural and ethnic origin (Yaghan indigenous people, Chilean Navy members, fishermen,

110 and Chilean and foreign short- and long-term settlers) and is concentrated in the town of Puerto

111 Williams (2.800 inhabitants), the only town in the ecoregion and the capital city of the Chilean
112 Antarctic Province. There are only seven farmer settlements in the northern rural zone of the island.
113 A small fishing village, Puerto Toro, exists on the eastern coast. The principal economic activities
114 on Navarino Island are fishing, tourism, and small-scale livestock farming. The infrastructure is
115 limited to a dirt road along the northern coast of the island.

116 Until the present day, the only major human impacts in the Cape Horn Biosphere Reserve
117 are biological invasions, particularly of wild and domestic exotic mammals that outnumber their
118 native counterparts (Anderson et al., 2006). Feral dogs and cats have been recorded on pristine
119 islands in the reserve (Anderson et al., 2006). Although on Navarino Island, free-roaming and feral
120 dogs are commonly sighted, few observations of their impacts exist. Dogs have been reported to
121 depredate on the southernmost population of guanacos (*Lama guanicoe*), which is virtually
122 unstudied and considered in danger of local extinction (Cunazza, 1991; Gónzalez, 2005). There is
123 also scientific evidence of dogs preying on nests of solitary nesting waterfowl, such as the flightless
124 steamer duck (*Tachyeres pteneres*), a species endemic to Patagonia, and nesting colonies of the
125 South American tern (*Sterna hirundinacea*) (Schüttler et al., 2009). There are no accounts of the
126 impacts of local cats.

127

128 [please insert Figure 1 here]

129

130 **Survey**

131 From May 2015 to April 2016, we interviewed 215 households in Puerto Williams and the
132 seven existing farm owners in the rural area of Navarino Island. To test the questionnaire design
133 and adapt the questions, we conducted a pilot study with four trial informants that were later not
134 included in the sample.

135 For Puerto Williams, using a confidence interval of 5% and applying the finite population
136 correction for smaller populations (Bernard, 2006: 183), we calculated a representative sample
137 size of 215 interviewees based on a census of households applied by the first author in May 2015
138 (490 houses). We randomly chose 280 households from a map of numbered houses in town (adding
139 30% to the sample size of 215 to correct for non-responses). When we did not find an adult person
140 at home, we left a message explaining the motivation for our visit and our contact details. We
141 visited each household up to three times before it was replaced. The questionnaires were applied

142 at different times in a face-to-face interview approach at the participant's home and took 10 to 30

143 minutes. Two different interviewers conducted the interviews in Spanish (n=72 by ES and n=150

144 by LS).

145   We collected information on dog and cat demographics, care (e.g., type of food, degree of

146 confinement), attitudes towards owned dogs and perceptions on free-ranging dogs, personal

147 experiences regarding the pet's interaction with other animals, sightings of feral dogs, observation

148 of problematic situations in and out of town, perceptions of possible impacts of free-ranging dogs

149 and cats, suggestions for reducing the number of free-ranging dogs, and personal data (age, sex,

150 education, residence time). For farm owners, we added questions on their experience in losing

151 domestic animals such as cattle or sheep due to dog attacks. For participants without pets non-

152 relevant questions were not asked (see complete questionnaire as Supplementary Material S1).

153

154 **Statistics**

155   We used generalized linear models (GLMs) to examine predictors of owned village/rural

156 dogs' access to wildlife, defined here as any wild mammal or bird. We designed three candidate

157 models based on different response variables (Table 1). In Model set M1 we predicted that the less

158 the owner cared for and provided space for the dog (indoors or in backyards) the more a dog would

159 be part of the free-roaming population. We also included the size of the dog and the owner's

160 attitude towards confinement as predictors for dog restriction, because cultural aspects clearly

161 affect dog-keeping practices (Hsu, Severinghaus & Serpell, 2003; Jackman & Rowan, 2007). In

162 Model set M2 we hypothesized that the more adequately a dog was fed (Silva-Rodríguez &

163 Sieving, 2011), the less wild prey it would bring home. Sex was used as a covariate in this model

164 as there might be sex-related trends (e.g., dispersal was higher for males, Pal, Ghosh & Roy, 1998;

165 male collared dogs ranged over larger areas than females, Sparkes et al., 2014). We also included

166 rural dogs as a predictor variable, as their access to wildlife was expected to be more immediate

167 than for village dogs. As the dog's size was a significant predictor in M1, we used this covariate

168 in M2 also. Finally, in Model set M3 we assessed what factors determined awareness about the

169 dog-wildlife conflict among owners and non-owners. We predicted that participants who believed

170 that dogs might feed on wildlife and those who had experienced a problematic situation with dogs

171 outside town would be more aware. Response and predictor variables are explained in detail in

172 Supplementary Material S2.

173   As the response variables of the three models were binomial, we fitted generalized linear

174   models (GLMs) with binomial error structure and logit link. The models were parameterized with

175   all possible covariate combinations, but interactions were not included to prevent

176   overparameterization. Prior to analysis, we explored the data following Zuur et al. (2010).

177   Collinearity between covariates was assessed with Spearman correlation coefficients (no

178   coefficients were $>|0.4|$) and variance inflation factors (VIF, all were < 1.29). The independence

179   of categorical variables was tested using contingency tables (Chi-square and Fisher's exact tests),

180   removing OPERATED from M2 for being significantly associated with LOCATION. For model

181   selection, we used Akaike's Information Criterion corrected for small sample size (AIC_c). We

182   tested whether there was an effect of the interviewer by including interviewer as a random-effect

183   into the models (generalized linear mixed models, GLMMs), but did not detect any (AIC GLMMs

184   >AIC GLMs of the global models, respectively). We accounted for model selection uncertainty

185   (model weights ω_i were < 0.9) using full-model averaging (Symonds & Moussalli, 2011). To rank

186   the predictor variables in terms of importance we summed the Akaike weights for each model in

187   which the variable under consideration appeared (Burnham & Anderson, 2002). The direction of

188   predictor impacts on the response variable was explored by calculating log odds ratios of the

189   averaged estimates with 95% confidence intervals. Statistical modelling was conducted in R (R

190   Core Team, 2016); the VIF function was assessed from Zuur et al. (2009).

191

192   [Please insert Table 1 here]

193

194   **Results**

195   We conducted 215 interviews in Puerto Williams and seven in rural households (n=7). Only

196   five people in Puerto Williams refused to participate. Of the 222 participants, 61.1% were female,

197   the mean participant's age was 40.2 years (SD 11.8, range 18-76 years) with a mean residence

198   time on the island of 12.5 years (SD 14.6, range one month-66 years).

199   The participants of Puerto Williams owned 121 dogs and 36 cats; both served

200   predominantly as company. Rural households owned 30 dogs and 15 cats, mainly kept as working

201   dogs and for rodent control, respectively. Reproductive control was moderate to high in Puerto

202   Williams (41.7% of dogs and 19.4% of cats not sterilized), but almost absent in the rural zone

203   (83.3% dogs, 93.3% cats) (Table 2). Rural pet owners did not vaccinate against rabies, but

204   treatment for parasites was more frequent among village and rural pets (36.1-100%). Pets in Puerto

205   Williams and rural dogs were provided mainly with commercial food and/or meat (>77.7%).

206   However, 35 village dogs (28.9%) were fed in others than the owner's household and 74

207   interviewees in town (34.4%) reported to feed other dogs than their own on a regular basis (71.8%

208   at least once a week), mostly with leftovers (73.5% of 83 mentioned food items).

209   The most common method of dog restriction (69.4% in town, 53.3% rural) was keeping

210   dogs in the house (60.8% of 112 responses), fewer were kept free in the backyard (19.6%) or

211   leashed (19.6%). The reasons mentioned for allowing unrestricted movement of dogs in town and

212   rural environments were the owner's unwillingness to leash, as this might turn dogs aggressive,

213   the owner claiming a concept of freedom ("it is a free animal"), unsuitable facilities, and the dog

214   being accustomed to free-roaming (60.0% of 50 explanations). Twenty dogs (13.2%) had gone

215   missing during 12-24 hours during the last year, among which 13 dogs had even disappeared for a

216   period of up to one week before returning home. Cats disappeared more frequently (17 cats,

217   33.3%); 13 cats for 2 to 7 days. Over the last ten years, interviewees reported the missing of 35

218   pets, while 10 of 23 dogs and 8 of 12 cats had definitely gone lost during the last 5 years.

219

220   [Please insert Table 2 here]

221

222   Free-roaming dogs not accompanied by people can be frequently observed (68.5% of

223   participants) outside the town, whereas cat sightings in natural environments were almost absent

224   (5.4%, Figure 2). Dogs were mostly observed in packs, with a mean pack size of seven dogs (SD

225   7.5, range 2-60, n=171 sightings), while only 8.3% of the sightings were single dogs. Dog pups

226   (abandoned or feral) outside Puerto Williams were sighted by 52 participants (23.4%) with a mean

227   litter size of 4.0 (SD 2.3, range 1-12). Four participants observed dog and cat pups (n=17 in total)

228   having been abandoned in cardboard boxes outside the town.

229

230   [Please insert Figure 2 here]

231

232   Twenty-three village and rural dogs (15.2%) brought prey home, mainly invasive muskrats

233   (*Ondatra zibethicus*, 54.2%) and birds (25.0%, Figure 3). One third of all dogs (n=49) were

234   observed to hunt other animals, particularly birds (35.2%) and other dogs (24.1%). Over half of

235   all village and rural cats (n=26) brought prey home (birds to 56.3% of prey items). Birds were also

236   the most commonly hunted prey group by 18 cats (70.8%). The 222 participants mentioned diverse

237   food items they thought feral dogs would eat (Figure 3). Domestic livestock was the most

238   important group mentioned (42.1%), whereas native birds and guanacos were less perceived (13.9

239   and 2.4%, respectively).

240

241   [Please insert Figure 3 here]

242

243   More than half of the participants (55.9%, n=222) had directly experienced problems

244   associated with dogs in the town of Puerto Williams during the last five years (83.9% thereof

245   occurred during the last year), whereas 41 participants (18.5%) reported problems outside the town

246   (61.4% during 2014/2015). Predominant problems in town were direct conflicts with people

247   (among them 24.1% concerned children) and free-ranging domestic animals in town, mostly foals

248   (73.6%) (Fig. 4). In the rural area, people had experienced conflicts between dogs and domestic

249   animals, particularly involving cattle (70.6%), whereas only two people saw dogs feeding on

250   wildfowl eggs. Beyond personal experiences, most participants associated problems to free-

251   ranging dogs in and outside the town (91.9 and 89.2%, respectively). In town, suspected problems

252   mainly involved people, while outside of town concerns involved domestic animals and people

253   (Fig. 4). Dog-wildlife conflicts (e.g., involving guanacos) were only mentioned 19 times (9.4% of

254   202 problems). However, when asking directly whether feral dogs could have negative impacts on

255   wildlife, most participants said yes (82.0%, n=222) with reference to birds (67.0% of 336

256   problems). Guanacos figured only 16 times here (5.1%).

257   With regard to cats, only one third of the participants (31.7% of 218) associated problems

258   with cats outside the town, particularly with cats hunting and eating wild birds and their eggs

259   (55.7% of 70 problems).

260

261   [Please insert Figure 4 here]

262

263   Three models best explained dog confinement (Model set M1, Table 3). The most

264   important variables with the highest summed Akaike weights ω (upper limit = 1.0) were SIZE

265   (ω=0.97), BACKYARD (ω=0.97), and HOUSE (ω=0.93). Based on the average model estimates

266   (Fig. 5A), the probability of dog restriction was higher in smaller dogs, where backyards had been

267   modified for dogs and among dog owners that allowed their dogs in any place of the house. A high

268   level of dog care (CARE, ω=0.34), as well as an attitude of "free dogs" (FREEDOM, ω=0.64), did

269   not play an important role in the owner's decision to restrict their dog's movement (Fig. 5A). Two

270   variables best explained whether dogs would bring prey home (Model set M2, Table 3), accounting

271   together for 50% of the model weight: SIZE (ω=1.0), and LOCATION (ω=0.97). The averaged

272   estimates indicated that larger dogs and dogs in rural areas were more likely to bring prey home

273   (Fig. 5B), whereas sex (ω=0.29) and an adequate diet (FOOD, ω=0.28) had little influence. Finally,

274   the participants suspecting that feral dogs feed on wildlife was the most influential factor (FEED,

275   ω=0.86) to explain awareness of dog-wildlife impacts (Model set M3, Table 3), whereas dog

276   ownership (OWNER, ω=0.26) and having experienced a problematic situation caused by dogs

277   outside the town (PROBLEM, ω=0.35) were poor predictors (Fig. 5C).

278

279   [Please insert Table 3 here]

280

281   [Please insert Figure 5 here]

282

283   **Discussion**

284   This survey provides an understanding into the perceptions of free-roaming dogs and cats

285   and their impacts in a sub-Antarctic protected area by a representative sample of the local

286   population. We found that free-roaming dog packs were frequently observed (69% of participants)

287   in natural areas of Navarino Island. These might be owned dogs (31% of village dogs and 47% of

288   rural dogs were free-roaming at day and/or at night) as travel distances of free-roaming owned

289   rural dogs may reach up to 4 km (Sepúlveda et al., 2015) or even more (8-30 km, Meek, 1999).

290   However, such large foray distances are an exception. Finding a village dog at a distance >1 km

291   from its home had a 10% chance in a study of dogs scavenging sea-turtle nests (Ruiz-Izaguirre et

292   al., 2014) and most rural dogs even stayed 95% of their time within <200 m from their households

293   (Sepúlveda et al., 2015). But there is also evidence of a feral population of dogs, as the participants

294   reported sightings of unaccompanied dog packs in remote parts of the island (up to 19.4 km away

295   from the northern settled coast, Fig. 2). Moreover, the participants declared 52% of the 171

296   sightings as feral dogs. However, it is not clear whether this population has achieved long-term

297 human independence, as in the case of dogs eradicated from Isabela Island, Galápagos (Reponen
298 et al., 2014). The reported population of abandoned dog pups and dogs that had gone lost
299 indefinitely might have been recruited to packs of feral dogs. For cats, the few sightings (5% of
300 participants) in natural areas were along the northern settled coast except for one cat sighted at 5.2
301 km south from the coast. Further phenotypical, genetic and ecological research is needed to better
302 understand the feral dog and possible feral cat population of Navarino Island.

303 Although there were 171 dog sightings during the last year, dog-wildlife conflicts of free-
304 roaming dogs passed almost unperceived (4.5% of 44 observed problems). The direct observation
305 of dog-wildlife interactions is probably a rare situation in the case of mammals as the mammalian
306 community on Navarino island is small (Anderson et al., 2006). There exist only five terrestrial
307 native species: two species each of bats and mice, and the vulnerable guanaco. Among exotic
308 mammals, there are three elusive wild species (North American beaver, American mink *Neovison*
309 *vison*, and muskrat) and free-ranging domestic mammals such as cows, horses, sheep, and pigs.
310 Guanacos have not been sighted along the northern coast for many years (González, Zapata &
311 Marín, 2002) and their densities were as low as 0.14 individuals/km^2 for the northeastern coast of
312 Navarino island (González, 2005). Thus, it is almost impossible to see predation or harassment of
313 guanacos by dogs (one piece of photographic evidence was taken by Denis Chevallay in 2002).
314 However, individual dog attacks on rare species may impact their persistence significantly (e.g.,
315 pudus, Silva-Rodríguez & Sieving, 2012; mountain gazelles *Gazella gazella*, Manor & Saltz,
316 2004). This is why future studies on dog impacts on the southernmost isolated population of
317 guanacos are an urgent need.

318 The chances of interactions among dogs and birds should be much higher, since birds,
319 among them many sea birds, are the most diverse and abundant group among vertebrates in the
320 Cape Horn Biosphere Reserve (Rozzi et al., 2006). Indeed, six dogs brought bird prey home and
321 19 dogs were observed by their owners to harass birds (Fig. 3). However, these experiences were
322 not translated into the context of a possible "dog-wildlife" conflict: only 9% of the 202 suspected
323 dog problems outside the town were dog-wildlife problems, while most were dog-domestic animal
324 (54%) or dog-people conflicts (35%). On the one hand, this might be due to a lack of knowledge
325 of the local fauna by short-term residents and because of missing Cape Horn biocultural identity
326 in the schoolrooms. Rozzi et al. (2008) reported an absence of native fauna in the imaginaries of
327 local short-term residents who primarily mentioned exotic, cosmopolitan roses and apple trees as

328   local plant species. On the other hand, the absence of dog-wildlife interactions in the participants'

329   minds might indicate that dogs are mainly perceived as domestic animals that act in a human-

330   dominated context and not as carnivores in a natural ecosystem. This perception might be

331   attributed to the historical attachment bonding between the dog-human dyad believed to be similar

332   to a child-parent relationship (review in Payne, Bennett & McGreevy, 2015).

333   For cats, awareness of cat-bird problems was higher (18% of the participants). On the one

334   hand, these problems might be more visible, at least for cat owners, whose cats brought birds home

335   (35% of the cats in this study). Twenty-three percent of prey items were returned to households by

336   urban cats in the United States, a number that significantly underestimates true capture rates as

337   Loyd et al. (2013) could show with animal-borne video cameras. On the other hand, Arahori et al.

338   (2017) showed that owners' views of their cats and dogs differed, for example cat owners had a

339   weaker tendency to regard their pets as family members than dog owners. This perception might

340   also influence their view on how cats behave outside their homes. Further investigation is needed

341   on how owners' perceptions might bias their evaluation on their pets' behavior itself (Arahori et

342   al. 2017).

343   With generalized linear models, we showed that dog confinement had consequences on

344   their access to wildlife. Larger dogs and dogs with owners denying them access to their house or

345   not modifying their yard for them had higher probabilities of roaming freely (Model set M1). There

346   is evidence that dog size affects dog confinement: larger dogs in smaller yards show more

347   problematic behaviors than medium-sized to small dogs (Kobelt et al., 2003) and therefore, might

348   be preferentially kept free-roaming. In-house/backyard confinement also largely depends on the

349   cultural settings (Jackman & Rowan, 2007). In the United States and other industrialized nations,

350   the majority of dogs have one individual owner and are allowed in the house, while in many

351   countries of Africa, Asia, and South America the amount of free-roaming "neighborhood" or

352   "community" dogs is high (Reece, 2005). These dogs have the main function of protecting

353   properties (Jackman & Rowan, 2007). In Chile, the percentage of free-roaming dogs in rural

354   settings is also high (67%, Acosta-Jamett et al., 2010; 84-91% Silva-Rodríguez & Sieving, 2012;

355   92% Sepúlveda et al., 2014), and national legislation regulating the presence of free-roaming dogs

356   is considered far from sufficient (Bonacic & Abarca, 2014).

357   Large dog size and rural provenience played a significant role as predictors for dogs

358   bringing wildlife prey home (Model set M2). On the one hand, larger dogs were those with less

359   restriction by their owners (results M1), which means they also have more access to wildlife. On

360   the other hand, larger dogs are probably more successful hunters with regard to the available

361   mammal and bird prey species on Navarino Island (amphibians and reptiles are absent, Anderson

362   et al., 2006). For successful hunting of larger prey, cooperative group behavior is needed (Butler,

363   du Toit & Bingham, 2004; Packer & Ruttan, 1988), but we did not assess this in the present study.

364   Rural dogs should have a more direct and faster access to wildlife than village dogs, as

365   most were working or security dogs (94%) and hence had more freedom of movement and

366   familiarity with their surroundings. Different from other studies, an inadequate food supply (i.e.,

367   higher percentage of leftovers) was not associated with dogs preying on wildlife. This might be

368   due to methodological differences. Silva-Rodríguez & Sieving (2011) and Ruiz-Izaguirre et al.

369   (2014) considered the body condition score and metabolic energy intake, respectively, while we

370   only relied on the participants' statements. To some extent, the social desirability bias (where the

371   participants wish to appear socially or morally worthy, Maccoby & Maccoby, 1954) might underlie

372   these differences by raising the claims that dogs are fed a commercial food diet. Moreover, 34%

373   of the interviewees reported to feed dogs other than their own on a regular basis, contributing to a

374   reliable alternative food supply in calories. This was also one of the reasons given by Butler, du

375   Toit & Bingham (2004) to explain the inefficiency of dogs as predators in rural Zimbabwe. Finally,

376   we did not include whether dogs were sterilized into Model set M2, as this variable was

377   significantly associated with rural provenience (low spaying/neutering rates among rural dogs,

378   Fisher's exact test, $p < 0.05$). Thus, an intact reproductive state could also explain the fact that rural

379   dogs had a higher probability to bring wildlife prey home. Operated dogs were described to show

380   lower rates of escaping from home and less roaming behavior (Neilson, Eckstein & Hart, 1997;

381   Spain, Scarlett & Houpt, 2004, but see Garde et al., 2015) which might lower their access to

382   wildlife.

383

384   **Conclusions**

385   Unconfined dogs and cats in the Cape Horn Biosphere Reserve interact with wildlife,

386   particularly birds, although this passes almost unperceived by the local community. To guarantee

387   the future intactness of this wilderness area, it is essential to put the possible impacts of free-

388   ranging pet carnivores on wildlife in perspective. In fact, awareness of dog-wildlife conflicts was

389   higher in participants who thought that feral dogs actually feed on wildlife (Model set M3). Dog

390 characteristics (large in size and rural provenience) and care (unwillingness of indoor/courtyard
391 confinement) clearly influenced their access to wildlife. To improve pet management for the
392 benefit of wildlife, social change can be created through communication, education, and changing
393 of cultural norms (examples in Miller, Ritchie & Weston, 2014). This should be done using an
394 integrative approach that respects the many dimensions of pet carnivores in their beneficial and
395 problematic interactions with their human, conspecific, and natural environment.

396

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405

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Figure 1

Map of Navarino Island, southern Chile.

Navarino Island is within the pristine Cape Horn Biosphere Reserve, with the Alberto de Agostini and Cape Horn National Parks as core areas and Yendegaia as a recently created national park.

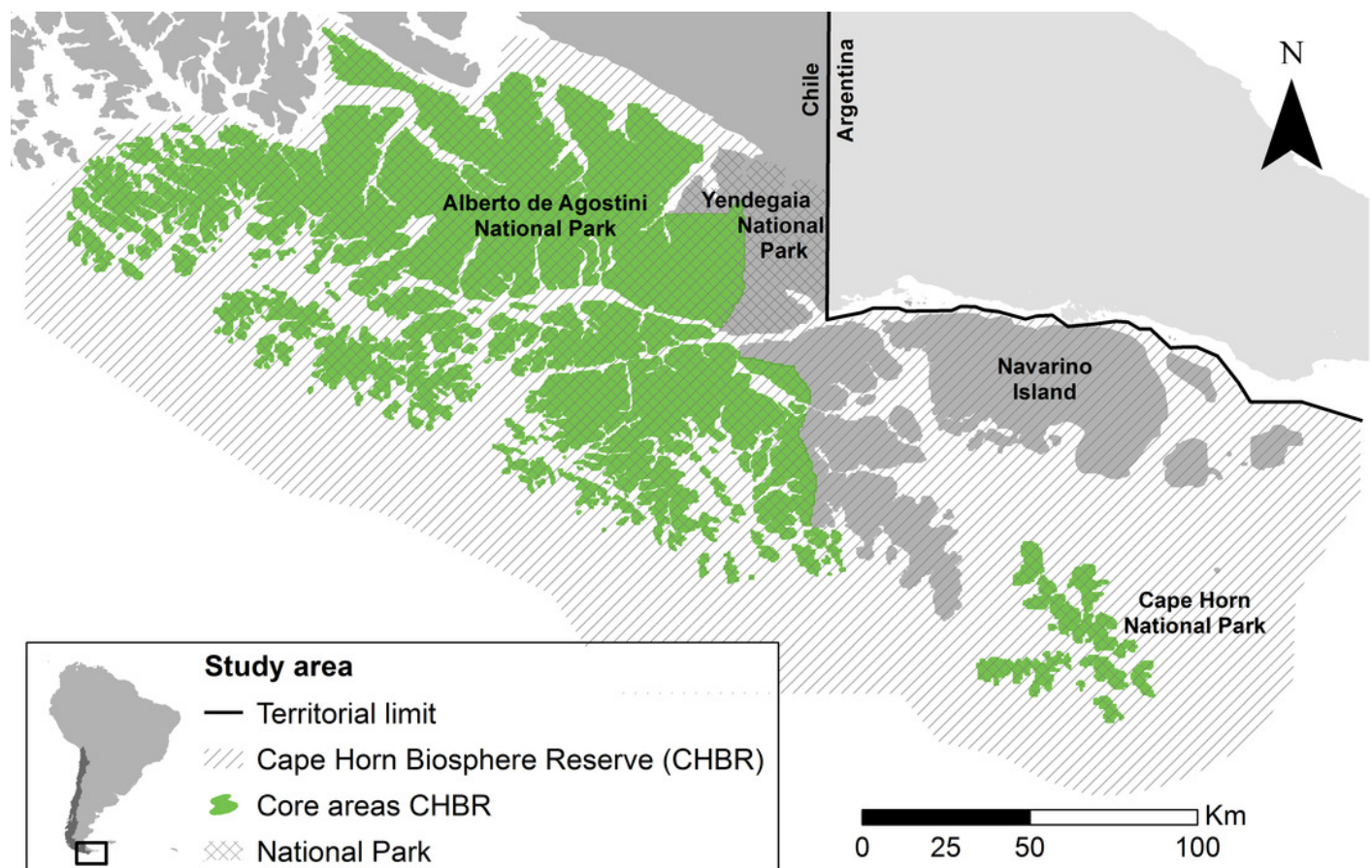



Figure 2

Free-ranging dog and cat sightings on Navarino Island.

Approximate sighting locations of unaccompanied adult dogs and cats, dog pups (abandoned or feral) and kitten (abandoned) from n=225 sightings by 141 participants during the last year. Dog sightings are shown in different classes of pack size.

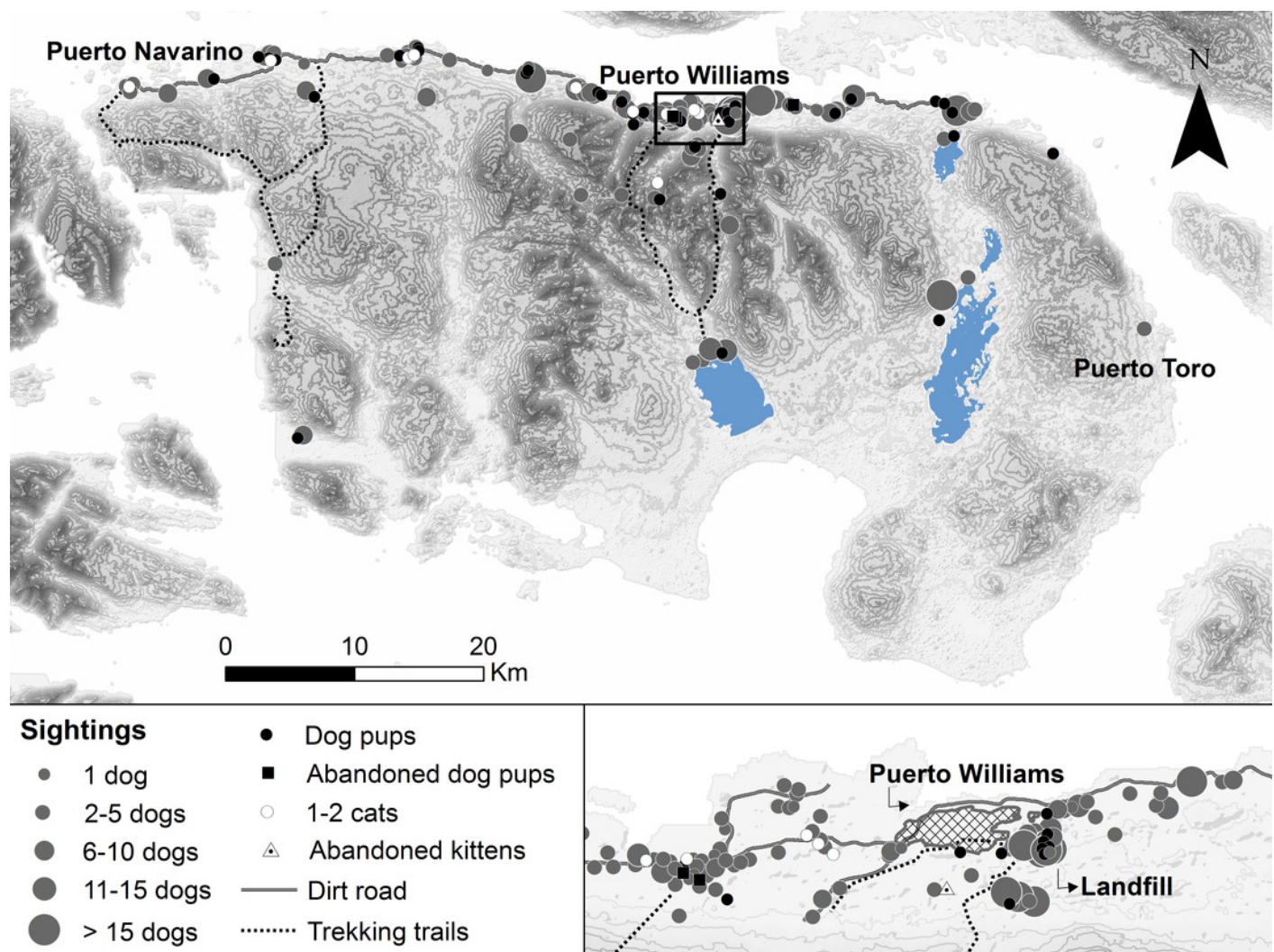



Figure 3

Preyed/hunted animals by dogs and cats, and suspected feral dog prey.

Prey brought to owners by 23 of 151 dogs (n=24 mentioned items), animals observed to be hunted by 49 dogs (n=54 items), prey brought to owners by 26 of 50 cats (n=32 items), animals observed to be hunted by 18 cats (n=24 items), and suspected feral dog prey (n=454 items) by 222 participants. "Other" includes bats (preyed on by cats), horse feces, vegetable material, and rabbits (not present on Navarino Island), among the suspected feral dog prey.

Note: Auto Gamma Correction was used for the image. This only affects the reviewing manuscript. See original source image if needed for review.

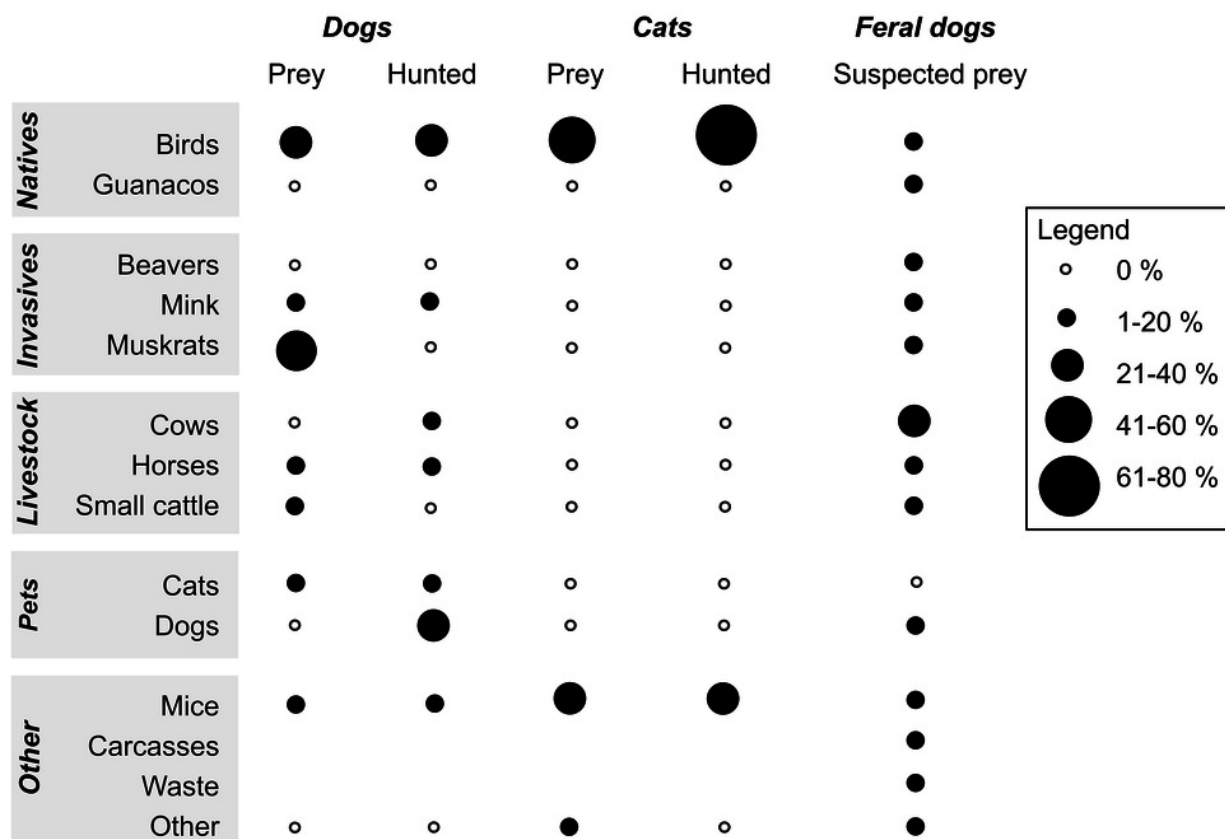



Figure 4

Experienced and suspected problems with dogs.

Problematic experiences during the last five years inside (n=143) and outside of Puerto Williams (n=44) and suspected dog problems (first problem mentioned) inside (n=221) and outside the town (n=202). Conflicts between dogs and people included biting, attacking, frightening, disease transmission, and accidents. Dog-domestic animal problems referred to killing, attacking, or feeding on free-ranging domestic animals such as cows, horses, sheep, pigs, and cats. Conflicts with wildlife included killing wild animals such as birds, North American beavers (*Castor canadensis*), and guanacos or harming ecosystems. Dog-dog conflicts were fights among dog packs (which were also perceived as a danger for humans) and disease transmission. Dog feces and waste dispersing were considered as hygienic problems. "Other" includes cases such as dog overpopulation, bad image for tourists, and barking.

Experienced dog problems [%]   **_Suspected dog problems_ [%]**

Inside the town

Inside the town

Legend
- ☐ Dog-people
- ■ Dog-domestic animal
- ▦ Dog-dog
- ▮ Dog-wildlife
- ▩ Hygiene
- ▢ Other

Outside the town

Outside the town

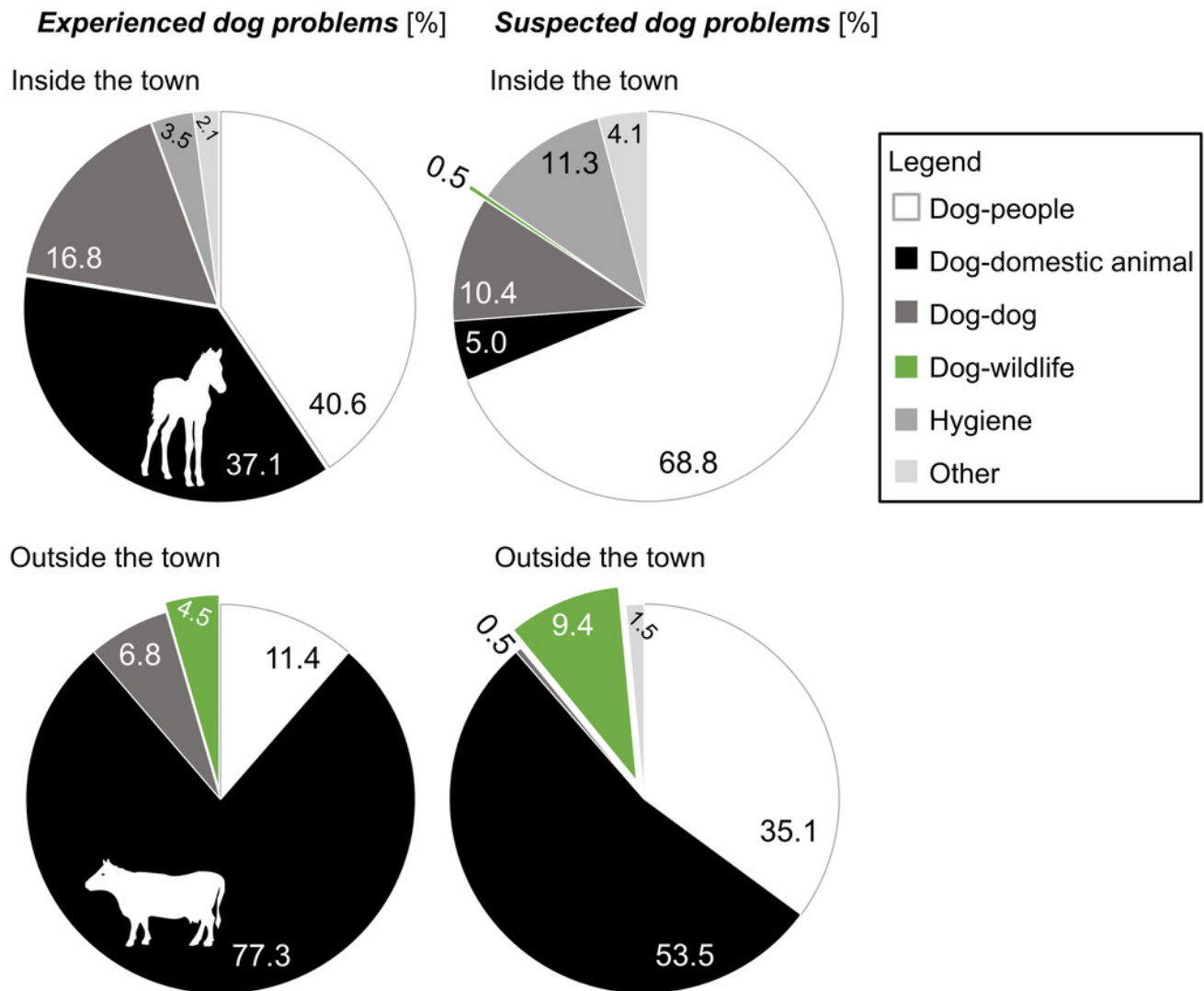



Figure 5

Model averaged odds ratios for model sets predicting dog access to wildlife.

Plots show the model averaged parameter estimates as odds ratios on a log scale with 95% confidence intervals (CI) for A) Model set M1, where the variables BACKYARD, HOUSE, and SIZE best predicted dog confinement, B) Model set M2, where the variables LOCATION and SIZE best predicted whether dogs brought wildlife prey home, and C) Model set M3, where the variable FEED best predicted awareness of dog-wildlife impacts. The other variables had confidence intervals that overlapped the dashed line at 1, which implies that there is no direction of the parameter estimate. Estimates with odds ratios <1 indicate a negative association with the response variable, whereas those >1 indicate a positive association.

A) Model set M1 **Dog confinement**

BACKYARD

CARE

FREEDOM

HOUSE

SIZE

0.5   1   2

B) Model set M2 **Wildlife prey**

FOOD

LOCATION

SEX

SIZE

0.6   5 10   60

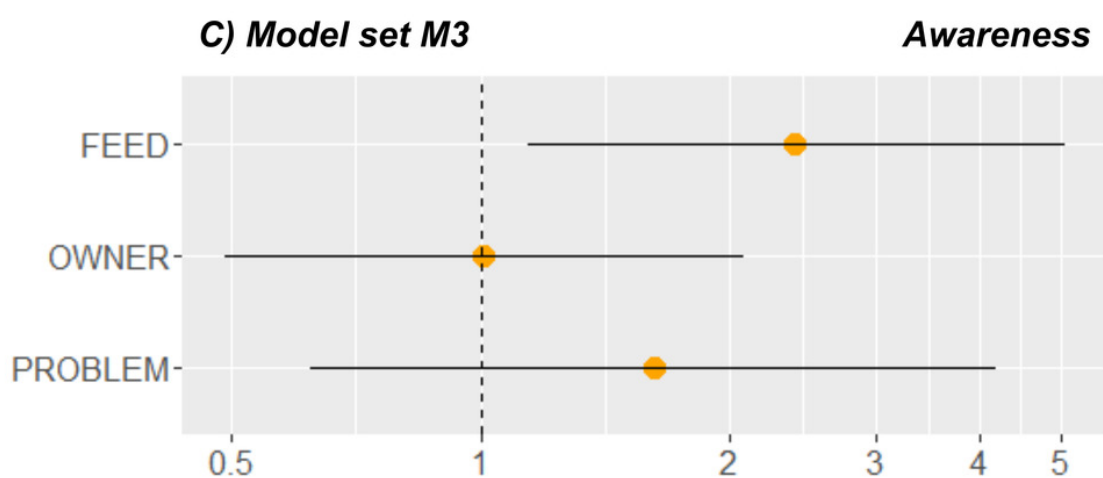
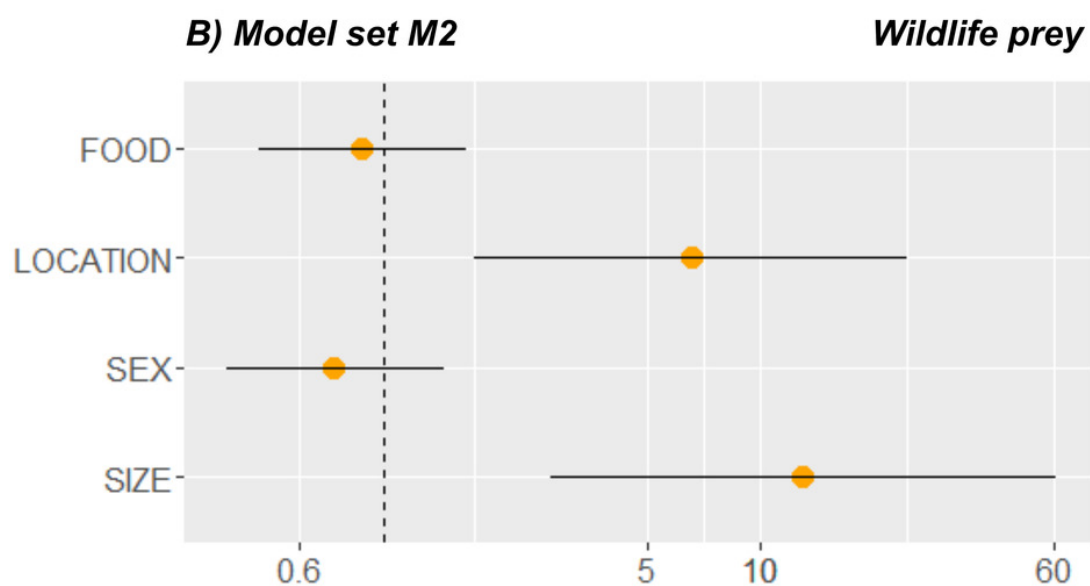
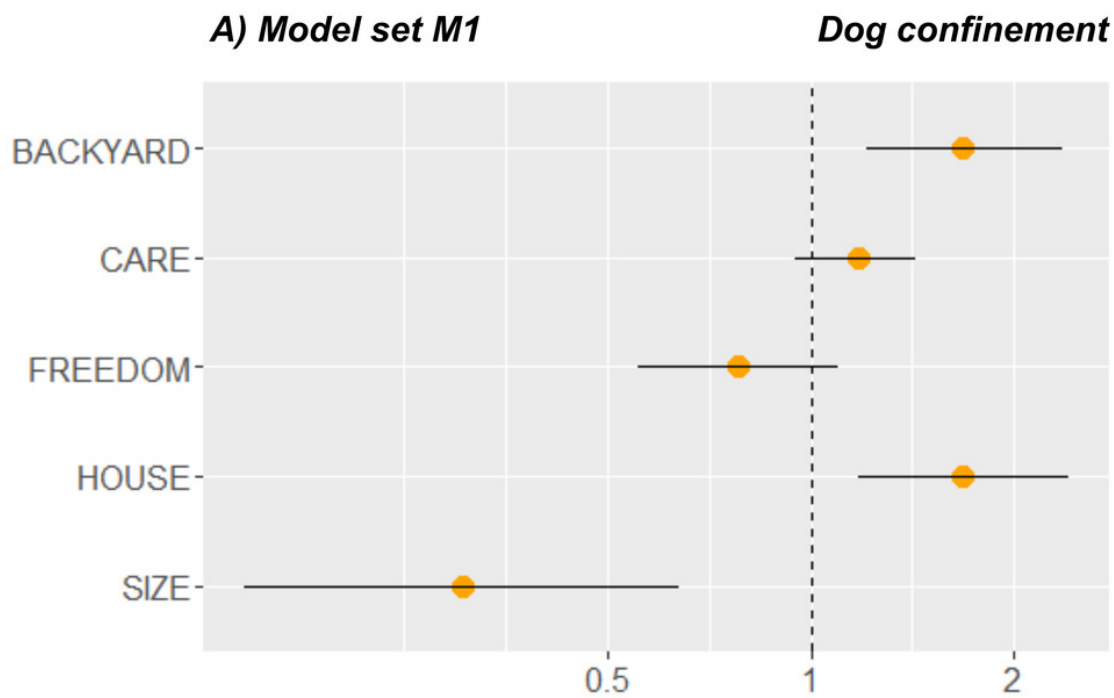
C) Model set M3 **Awareness**

FEED

OWNER

PROBLEM

0.5   1   2   3   4   5

Odds ratio (log scale) and 95 % CI

Candidate models for predicting dog access to wildlife.

A detailed parameter description is provided in Supplementary Material S2. Response variables refer to questions Q18 (M1), Q25 (M2), and Q35 (M3) of the questionnaire (see Supplementary Material S1).

Candidate model sets	Response variable	Parameters included	Data set	n*
M1	Dog is confined day and night (yes/no)	CARE+BACKYARD+FREEDOM +HOUSE+SIZE	Dogs in Puerto Williams	114
M2	Dog brought wildlife prey to home (yes/no)	FOOD+LOCATION+SEX+SIZE	Dogs in Puerto Williams and rural households	146
M3	Participant is aware of dog-wildlife impact (yes/no)	FEED+OWNER+PROBLEM	All participants in Puerto Williams and rural households	209

1   * We deleted 7 NAs from Model 1 (5.8%), 5 from Model 2 (3.3%), and 13 from Model 3 (5.9%)

Demographic cat and dog data, and husbandry results.

The data was obtained on the owed dog and cat population through questionnaires from 215 households in the town of Puerto Williams and from the seven accessible rural households along the northern coast.

	Town households		Rural households	
	Dogs	Cats	Dogs	Cats
Demographic data				
Households with pet ownership (%)	85 (39.5)	30 (14.0)	6 (85.7)	6 (85.7)
Mean pet number per household (SD)	1.4 (0.9)	1.2 (0.6)	5 (3.3)	2.5 (2.51)
Total pet number	121	36	30	15
Male: female ratio	1.3:1	0.7:1	2:1	0.3:1
Mean pet age (SD)	3.7 (3.8)	4.8 (4.1)	3.8 (4.6)	3.0 (3.0)
Number of pups in previous year	16	0	21	7
Local origin (Navarino Island) (%)	66.1	66.7	96.7	100
Reproductive control				
Females spayed; males neutered (%)	66.7; 52.2*	71.4; 93.3	10.0; 20.0	8.3; 0.0
Health				
Vaccinated against rabies (%)	55.4	33.3	0.0	0.0
Treated for parasites (%)	60.3	36.1	100.0	40.0
Food provisioning				
Commercial food and/or meat (%)	77.7	94.4	86.7	20.0
Leftovers (%)	12.4	0.0	13.3	33.3
Mix of above (%)	9.9	5.6	0.0	46.7
Dog confinement				
Free-roaming during day or night (%)	30.6	-	46.7	-
24 hours free-roaming (%)	19.0	-	30.0	-

1 * n=120

Best-ranked generalized linear models for predicting dog access to wildlife.

Summary of model selection for models with ΔAIC_c <2. K indicates the number of parameters per model, ΔAIC_c the distance from the lowest AIC_c, and ω_i the model weight.

Model set	Competing models	k	AIC_c	ΔAIC_c	ω_i
M1	BACKYARD+CARE+FREEDOM+HOUSE +SIZE	6	113.57	0.00	0.32
	BACKYARD+HOUSE+SIZE	4	113.67	0.11	0.31
	BACKYARD+FREEDOM+HOUSE+SIZE	5	113.67	0.11	0.30
M2	LOCATION+SIZE	3	103.43	0.00	0.50
	LOCATION+SEX+SIZE	4	105.23	1.80	0.20
	FOOD+LOCATION+SIZE	4	105.38	1.95	0.19
M3	FEED	2	199.48	0.00	0.40
	FEED+PROBLEM	3	200.54	1.06	0.23