Perceptions of impacts and access to wildlife of domestic carnivores in a sub-Antarctic wilderness area (#17813)

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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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Abstract

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Introduction

In parallel to human population growth, the number of companion animals is constantly increasing as well. Pet and feral dogs (*Canis familiaris*) have reached population estimates of 900 million and cats (*Felis catus*) of 600 million, (O'Brien & Johnson, 2007; Gompper, 2014a) being present on all continents except Antarctica (Hughes et al., 2015). Since their domestication thousands of years ago, domestic dogs have had profound roles in human lives. These include companionship, livestock guarding, rescue, hunting, tourism, service animals, and wildlife management. In consequence, as dogs are part of a diversity of human cultures, their various roles,

human husbandry, and attitudes towards them have different implications for human-dog-wildlife interactions (Miller, Ritchie & Weston, 2014).

The access of wildlife by dogs and cats depend on their husbandry, particularly on their confinement. This ranges from complete restriction of mobility, in leashed or confined owned dogs and cats, to feral domestic carnivores that survive independently of supplemental provisioning from humans (Kays & DeWan, 2004; Vanak & Gompper, 2009). In between these extremes, there exists a range of free-roaming animals that are owned or unowned and are, to some extent, subsidized by humans. As subsidized predators, domestic carnivores can reach higher population densities than wild carnivore populations (Gompper, 2014b), leading to complex socio-ecological consequences.

The impacts of free-roaming subsidized and feral domestic dogs include the loss of livestock (Baker et al., 2008; Echegaray & Vilà, 2010), aggression towards humans (Schalamon et al., 2006), disease transmission (Matter & Daniels, 2010), and wildlife interference (reviewed in Young et al., 2011; Hughes & Macdonald, 2013). Dogs prey on (Butler, du Toit & Bingham, 2004; Manor & Saltz, 2004), compete with (Mitchell & Banks, 2005; Vanak, Thaker & Gompper, 2009), infect (Acosta-Jamett, 2009), and disturb (Silva-Rodríguez, Ortega-Solís & Jiménez, 2010; Silva-Rodríguez & Sieving, 2012) wild animals. Suburban cats are successful small vertebrate predators (Woods, McDonald & Harris, 2003; Loyd et al., 2013). On islands, Medina et al. (2011) reviewed that feral cats were responsible for at least 14% of global bird, mammal, and reptile extinctions (see also Nogales et al., 2013). Both dogs and cats may hybridize with their wild relatives (Randi, 2008).

While the biology of domestic carnivore-wildlife interactions is the focus of research, studies on the human dimensions are still in their infancy (Miller, Ritchie & Weston, 2014). Conflicts between dogs/cats and wildlife could be minimized by a better understanding of how husbandry, attitudes, and behavior of pet owners influence dogs and cats in their access to and interaction with wild prey/carnivores, particularly when close to protected areas. For example, dog owners felt more obliged to leash their dogs when they believed their dog would harm beach-nesting birds or people (Williams et al., 2009). Recent studies have shown that the more adequate the diet that owners feed their dogs and cats, the less they prey on wild animals (Silva-Rodríguez & Sieving 2012, Sepúlveda et al., 2014). Sepúlveda et al. (2014) also reported that the roles dogs play in rural households affected their interactions with wildlife. Dog owners encouraged the

harassment of wild carnivores to protect their livestock, but disapproved the hunting of prey such as endangered southern pudus (*Pudu pudu*).

Here, we focus on understanding the access to wildlife by a population of free-roaming dogs and cats in a sensitive conservation area of southern Chile using questionnaires applied to owners and non-owners. Our objectives were (1) to identify attitudes towards and experiences and perceptions of impacts of free-roaming/feral cats and dogs, and (2) to examine predictors of access to wildlife of owned village/rural dogs regarding dog confinement, care, and consciousness of the dog-wildlife conflict. The survey also provided demographic pet information relevant for future dog and cat management in one of the last wilderness areas of the globe.

Materials & Methods

Ethics statement

Prior informed consent was obtained from each participant by reading a printed statement explaining the aims of the project, the benefits and the absence of risks of participating, the possibility to omit questions, information about use and access to the results, and that the interview is anonymous and voluntary. The participants agreed to participate by signing and kept a copy of the informed consent. Paper and digital questionnaires were stored anonymously. The Scientific Ethical Committee of the University of Magallanes, Chile, certified ethical approval of the instrument.

Study area

The study was carried out on Navarino Island (2.528 km^2), Chile, located at the extreme southern tip of South America (Fig. 1). The island is part of the Cape Horn Biosphere Reserve, which belongs to the Magellanic Sub-Antarctic forest ecoregion, one of the remaining 24 wilderness areas of the world (Mittermeier et al., 2003). The dominant habitats within this ecoregion are unfragmented evergreen and deciduous forests of southern beeches (*Nothofagus* spp.) and Winter's bark (*Drimys winteri*), Magellanic peat bogs (mainly *Sphagnum* spp.), high-Andean habitats, and glaciers (Pisano, 1977). The human population on Navarino Island is of mixed cultural and ethnic origin (Yaghan indigenous people, Chilean Navy members, fishermen, and Chilean and foreign short- and long-term settlers) and is concentrated in the town of Puerto

Williams (2,800 inhabitants), the only town in the ecoregion and the capital city of the Chilean Antarctic Province. There are only seven farmer settlements in the northern rural zone of the island. A small fishing village, Puerto Toro, exists on the eastern coast. The principal economic activities on Navarino Island are fishing, tourism, and small-scale livestock farming. The infrastructure is limited to a dirt road along the northern coast of the island.

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

[please insert Figure 1 here]

Survey

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

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

at different times in a face-to-face interview approach at the participant's home and took 10 to 30 minutes. Two different interviewers conducted the interviews in Spanish (n=72 by ES and n=150 by LS).

We collected information on dog and cat demographics, care (e.g., type of food, degree of confinement), attitudes towards owned dogs and perceptions on free-ranging dogs, personal experiences regarding the pet's interaction with other animals, sightings of feral dogs, observation of problematic situations in and out of town, perceptions of possible impacts of free-ranging dogs and cats, suggestions for reducing the number of free-ranging dogs, and personal data (age, sex, education, residence time). For farm owners, we added questions on their experience in losing domestic animals such as cattle or sheep due to dog attacks. For participants without pets non-relevant questions were not asked (see complete questionnaire as Supplementary Material S1).

Statistics

We used generalized linear models (GLMs) to examine predictors of owned village/rural dogs' access to wildlife, defined here as any wild mammal or bird. We designed three candidate models based on different response variables (Table 1). In Model set M1 we predicted that the less the owner cared for and provided space for the dog (indoors or in backyards) the more a dog would be part of the free-roaming population. We also included the size of the dog and the owner´s attitude towards confinement as predictors for dog restriction, because cultural aspects clearly affect dog-keeping practices (Hsu, Severinghaus & Serpell, 2003; Jackman & Rowan, 2007). In Model set M2 we hypothesized that the more adequately a dog was fed (Silva-Rodríguez & Sieving, 2011), the less wild prey it would bring home. Sex was used as a covariate in this model as there might be sex-related trends (e.g., dispersal was higher for males, Pal, Ghosh & Roy, 1998; male collared dogs ranged over larger areas than females, Sparkes et al., 2014). We also included rural dogs as a predictor variable, as their access to wildlife was expected to be more immediate than for village dogs. As the dog's size was a significant predictor in M1, we used this covariate in M2 also. Finally, in Model set M3 we assessed what factors determined awareness about the dog-wildlife conflict among owners and non-owners. We predicted that participants who believed that dogs might feed on wildlife and those who had experienced a problematic situation with dogs outside town would be more aware. Response and predictor variables are explained in detail in Supplementary Material S2.

As the response variables of the three models were binomial, we fitted generalized linear models (GLMs) with binomial error structure and logit link. The models were parameterized with all possible covariate combinations, but interactions were not included to prevent overparameterization. Prior to analysis, we explored the data following Zuur et al. (2010). Collinearity between covariates was assessed with Spearman correlation coefficients (no coefficients were >|0.4|) and variance inflation factors (VIF, all were < 1.29). The independence of categorical variables was tested using contingency tables (Chi-square and Fisher's exact tests), removing OPERATED from M2 for being significantly associated with LOCATION. For model selection, we used Akaike's Information Criterion corrected for small sample size (AIC_c). We tested whether there was an effect of the interviewer by including interviewer as a random-effect into the models (generalized linear mixed models, GLMMs), but did not detect any (AIC GLMMs >AIC GLMs of the global models, respectively). We accounted for model selection uncertainty (model weights ω_i were < 0.9) using full-model averaging (Symonds & Moussalli, 2011). To rank the predictor variables in terms of importance we summed the Akaike weights for each model in which the variable under consideration appeared (Burnham & Anderson, 2002). The direction of predictor impacts on the response variable was explored by calculating log odds ratios of the averaged estimates with 95% confidence intervals. Statistical modelling was conducted in R (R Core Team, 2016); the VIF function was assessed from Zuur et al. (2009).

[Please insert Table 1 here]

Results

We conducted 215 interviews in Puerto Williams and seven in rural households (n=7). Only five people in Puerto Williams refused to participate. Of the 222 participants, 61.1% were female, the mean participant's age was 40.2 years (SD 11.8, range 18-76 years) with a mean residence time on the island of 12.5 years (SD 14.6, range one month-66 years).

The participants of Puerto Williams owned 121 dogs and 36 cats; both served predominantly as company. Rural households owned 30 dogs and 15 cats, mainly kept as working dogs and for rodent control, respectively. Reproductive control was moderate to high in Puerto Williams (41.7% of dogs and 19.4% of cats not sterilized), but almost absent in the rural zone (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

all village and rural cats (n=26) brought prey home (birds to 56.3% of prey items). Birds were also the most commonly hunted prey group by 18 cats (70.8%). The 222 participants mentioned diverse food items they thought feral dogs would eat (Figure 3). Domestic livestock was the most important group mentioned (42.1%), whereas native birds and guanacos were less perceived (13.9 and 2.4%, respectively).

[Please insert Figure 3 here]

More than half of the participants (55.9%, n=222) had directly experienced problems associated with dogs in the town of Puerto Williams during the last five years (83.9% thereof occurred during the last year), whereas 41 participants (18.5%) reported problems outside the town (61.4% during 2014/2015). Predominant problems in town were direct conflicts with people (among them 24.1% concerned children) and free-ranging domestic animals in town, mostly foals (73.6%) (Fig. 4). In the rural area, people had experienced conflicts between dogs and domestic animals, particularly involving cattle (70.6%), whereas only two people saw dogs feeding on wildfowl eggs. Beyond personal experiences, most participants associated problems to free-ranging dogs in and outside the town (91.9 and 89.2%, respectively). In town, suspected problems mainly involved people, while outside of town concerns involved domestic animals and people (Fig. 4). Dog-wildlife conflicts (e.g., involving guanacos) were only mentioned 19 times (9.4% of 202 problems). However, when asking directly whether feral dogs could have negative impacts on wildlife, most participants said yes (82.0%, n=222) with reference to birds (67.0% of 336 problems). Guanacos figured only 16 times here (5.1%).

With regard to cats, only one third of the participants (31.7% of 218) associated problems with cats outside the town, particularly with cats hunting and eating wild birds and their eggs (55.7% of 70 problems).

[Please insert Figure 4 here]

Three models best explained dog confinement (Model set M1, Table 3). The most important variables with the highest summed Akaike weights ω (upper limit = 1.0) were SIZE (ω=0.97), BACKYARD (ω=0.97), and HOUSE (ω=0.93). Based on the average model estimates

(Fig. 5A), the probability of dog restriction was higher in smaller dogs, where backyards had been modified for dogs and among dog owners that allowed their dogs in any place of the house. A high level of dog care (CARE, ω=0.34), as well as an attitude of "free dogs" (FREEDOM, ω=0.64), did not play an important role in the owner's decision to restrict their dog's movement (Fig. 5A). Two variables best explained whether dogs would bring prey home (Model set M2, Table 3), accounting together for 50% of the model weight: SIZE (ω=1.0), and LOCATION (ω=0.97). The averaged estimates indicated that larger dogs and dogs in rural areas were more likely to bring prey home (Fig. 5B), whereas sex (ω=0.29) and an adequate diet (FOOD, ω=0.28) had little influence. Finally, the participants suspecting that feral dogs feed on wildlife was the most influential factor (FEED, ω=0.86) to explain awareness of dog-wildlife impacts (Model set M3, Table 3), whereas dog ownership (OWNER, ω=0.26) and having experienced a problematic situation caused by dogs outside the town (PROBLEM, ω=0.35) were poor predictors (Fig. 5C).

[Please insert Table 3 here]

[Please insert Figure 5 here]

Discussion

This survey provides an understanding into the perceptions of free-roaming dogs and cats and their impacts in a sub-Antarctic protected area by a representative sample of the local population. We found that free-roaming dog packs were frequently observed (69% of participants) in natural areas of Navarino Island. These might be owned dogs (31% of village dogs and 47% of rural dogs were free-roaming at day and/or at night) as travel distances of free-roaming owned rural dogs may reach up to 4 km (Sepúlveda et al., 2015) or even more (8-30 km, Meek, 1999). However, such large foray distances are an exception. Finding a village dog at a distance >1 km from its home had a 10% chance in a study of dogs scavenging sea-turtle nests (Ruiz-Izaguirre et al., 2014) and most rural dogs even stayed 95% of their time within <200 m from their households (Sepúlveda et al., 2015). But there is also evidence of a feral population of dogs, as the participants reported sightings of unaccompanied dog packs in remote parts of the island (up to 19.4 km away from the northern settled coast, Fig. 2). Moreover, the participants declared 52% of the 171 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

local plant species. On the other hand, the absence of dog-wildlife interactions in the participants' minds might indicate that dogs are mainly perceived as domestic animals that act in a human-dominated context and not as carnivores in a natural ecosystem. This perception might be attributed to the historical attachment bonding between the dog-human dyad believed to be similar to a child-parent relationship (review in Payne, Bennett & McGreevy, 2015).

For cats, awareness of cat-bird problems was higher (18% of the participants). On the one hand, these problems might be more visible, at least for cat owners, whose cats brought birds home (35% of the cats in this study). Twenty-three percent of prey items were returned to households by urban cats in the United States, a number that significantly underestimates true capture rates as Loyd et al. (2013) could show with animal-borne video cameras. On the other hand, Arahori et al. (2017) showed that owners' views of their cats and dogs differed, for example cat owners had a weaker tendency to regard their pets as family members than dog owners. This perception might also influence their view on how cats behave outside their homes. Further investigation is needed on how owners' perceptions might bias their evaluation on their pets' behavior itself (Arahori et al., 2017).

With generalized linear models, we showed that dog confinement had consequences on their access to wildlife. Larger dogs and dogs with owners denying them access to their house or not modifying their yard for them had higher probabilities of roaming freely (Model set M1). There is evidence that dog size affects dog confinement: larger dogs in smaller yards show more problematic behaviors than medium-sized to small dogs (Kobelt et al., 2003) and therefore, might be preferentially kept free-roaming. In-house/backyard confinement also largely depends on the cultural settings (Jackman & Rowan, 2007). In the United States and other industrialized nations, the majority of dogs have one individual owner and are allowed in the house, while in many countries of Africa, Asia, and South America the amount of free-roaming "neighborhood" or "community" dogs is high (Reece, 2005). These dogs have the main function of protecting properties (Jackman & Rowan, 2007). In Chile, the percentage of free-roaming dogs in rural settings is also high (67%, Acosta-Jamett et al., 2010; 84-91% Silva-Rodríguez & Sieving, 2012; 92% Sepúlveda et al., 2014), and national legislation regulating the presence of free-roaming dogs is considered far from sufficient (Bonacic & Abarca, 2014).

Large dog size and rural provenience played a significant role as predictors for dogs bringing wildlife prey home (Model set M2). On the one hand, larger dogs were those with less

restriction by their owners (results M1), which means they also have more access to wildlife. On the other hand, larger dogs are probably more successful hunters with regard to the available mammal and bird prey species on Navarino Island (amphibians and reptiles are absent, Anderson et al., 2006). For successful hunting of larger prey, cooperative group behavior is needed (Butler, du Toit & Bingham, 2004; Packer & Ruttan, 1988), but we did not assess this in the present study.

Rural dogs should have a more direct and faster access to wildlife than village dogs, as most were working or security dogs (94%) and hence had more freedom of movement and familiarity with their surroundings. Different from other studies, an inadequate food supply (i.e., higher percentage of leftovers) was not associated with dogs preying on wildlife. This might be due to methodological differences. Silva-Rodríguez & Sieving (2011) and Ruiz-Izaguirre et al. (2014) considered the body condition score and metabolic energy intake, respectively, while we only relied on the participants' statements. To some extent, the social desirability bias (where the participants wish to appear socially or morally worthy, Maccoby & Maccoby, 1954) might underlie these differences by raising the claims that dogs are fed a commercial food diet. Moreover, 34% of the interviewees reported to feed dogs other than their own on a regular basis, contributing to a reliable alternative food supply in calories. This was also one of the reasons given by Butler, du Toit & Bingham (2004) to explain the inefficiency of dogs as predators in rural Zimbabwe. Finally, we did not include whether dogs were sterilized into Model set M2, as this variable was significantly associated with rural provenience (low spaying/neutering rates among rural dogs, Fisher's exact test, $p < 0.05$). Thus, an intact reproductive state could also explain the fact that rural dogs had a higher probability to bring wildlife prey home. Operated dogs were described to show lower rates of escaping from home and less roaming behavior (Neilson, Eckstein & Hart, 1997; Spain, Scarlett & Houpt, 2004, but see Garde et al., 2015) which might lower their access to wildlife.

Conclusions

Unconfined dogs and cats in the Cape Horn Biosphere Reserve interact with wildlife, particularly birds, although this passes almost unperceived by the local community. To guarantee the future intactness of this wilderness area, it is essential to put the possible impacts of free-ranging pet carnivores on wildlife in perspective. In fact, awareness of dog-wildlife conflicts was higher in participants who thought that feral dogs actually feed on wildlife (Model set M3). Dog

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

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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.

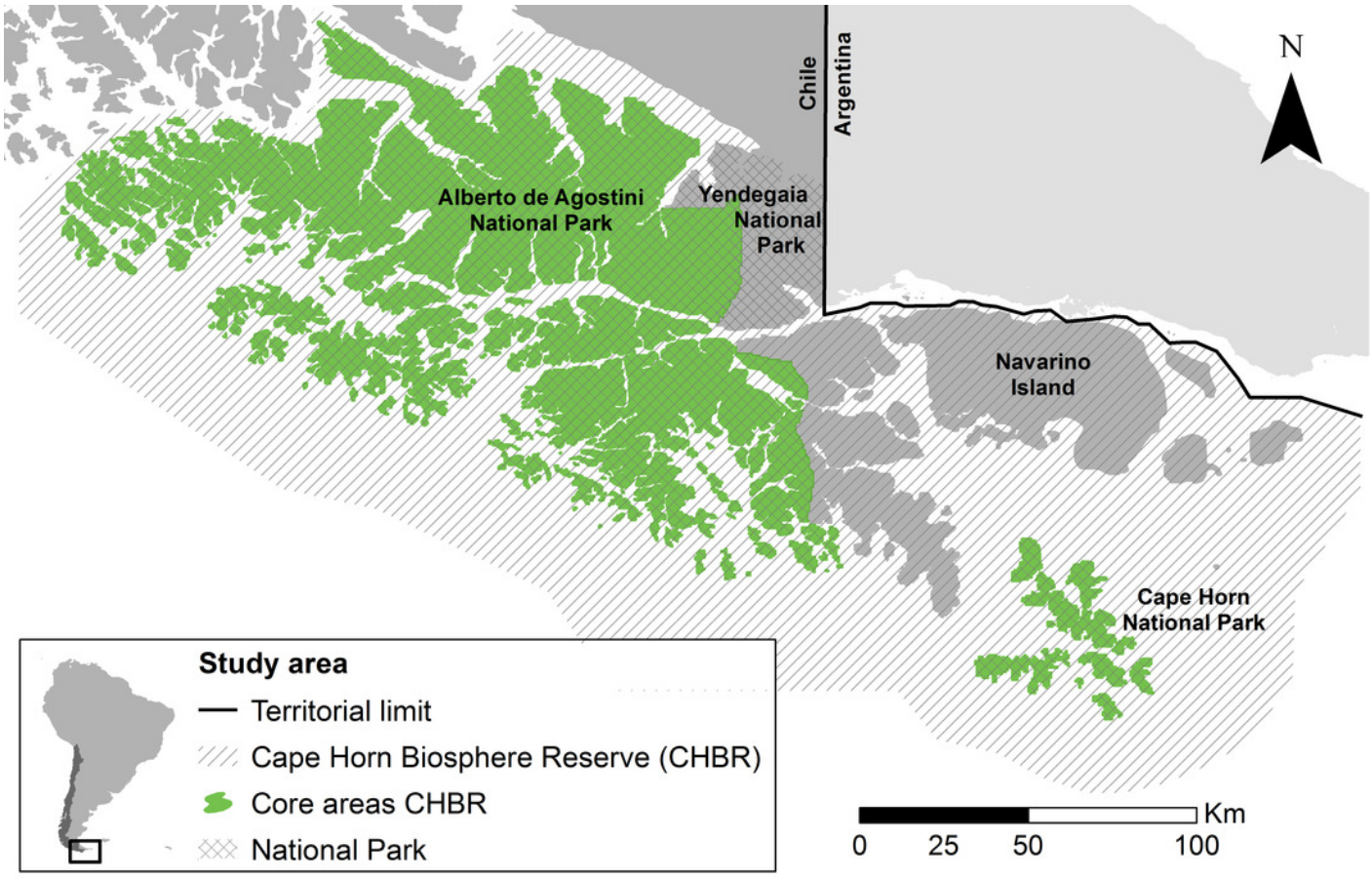

Figure 2

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.

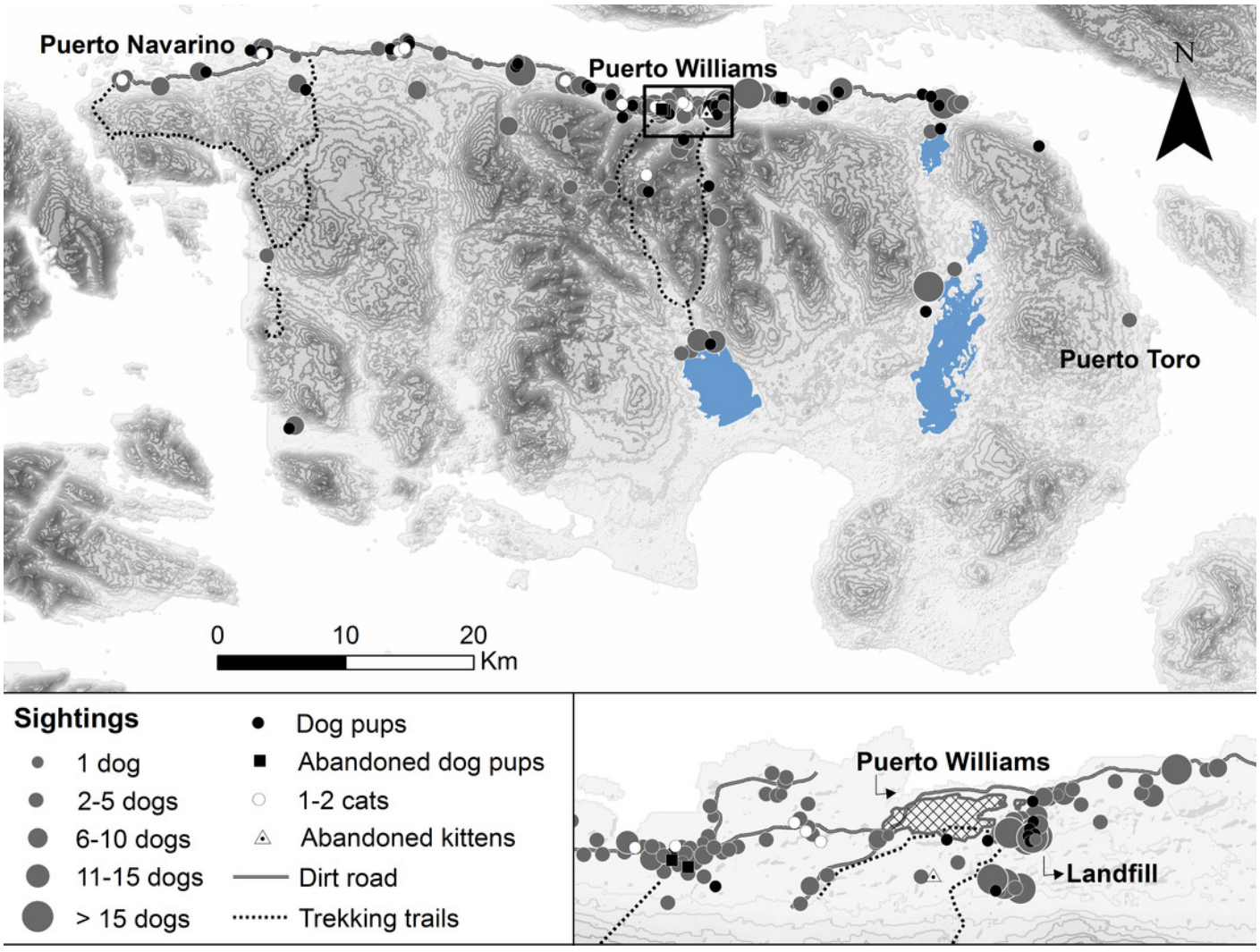

Figure 3

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.*

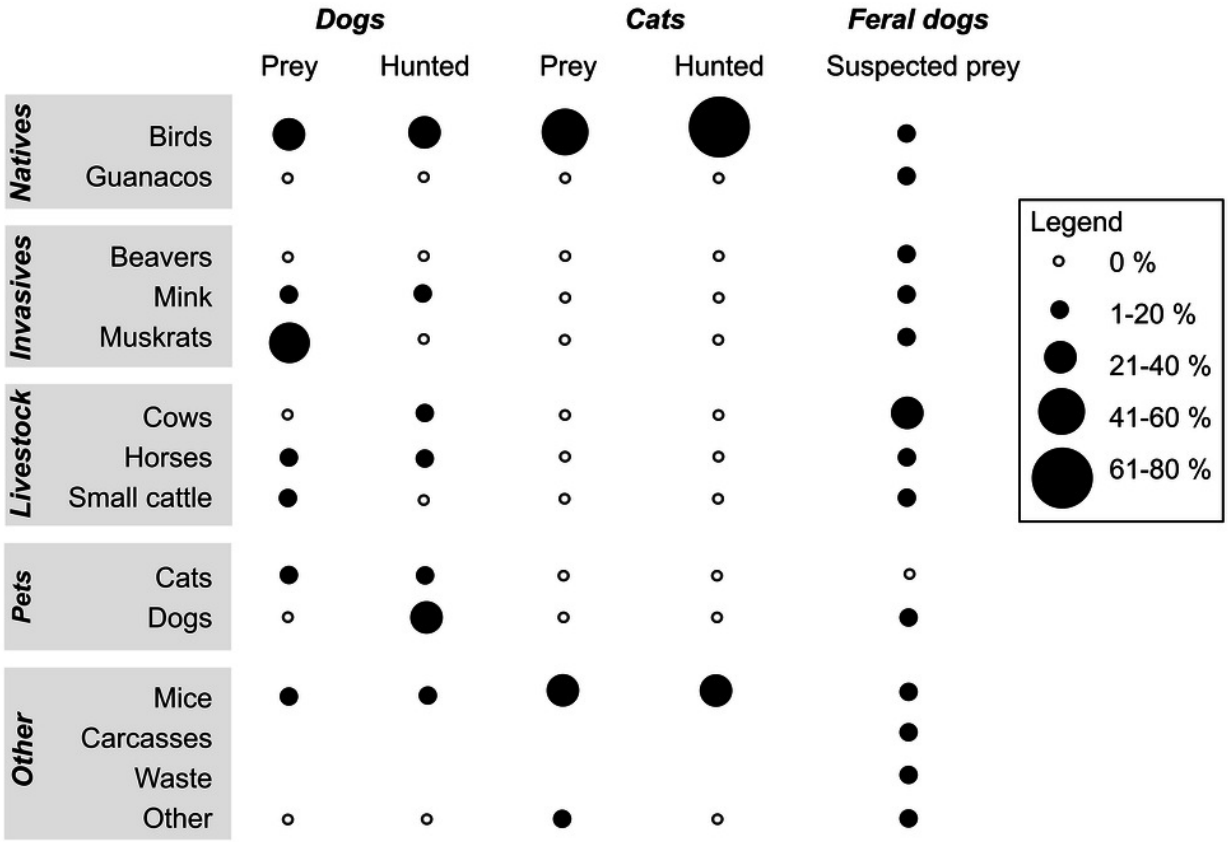

Figure 4

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.

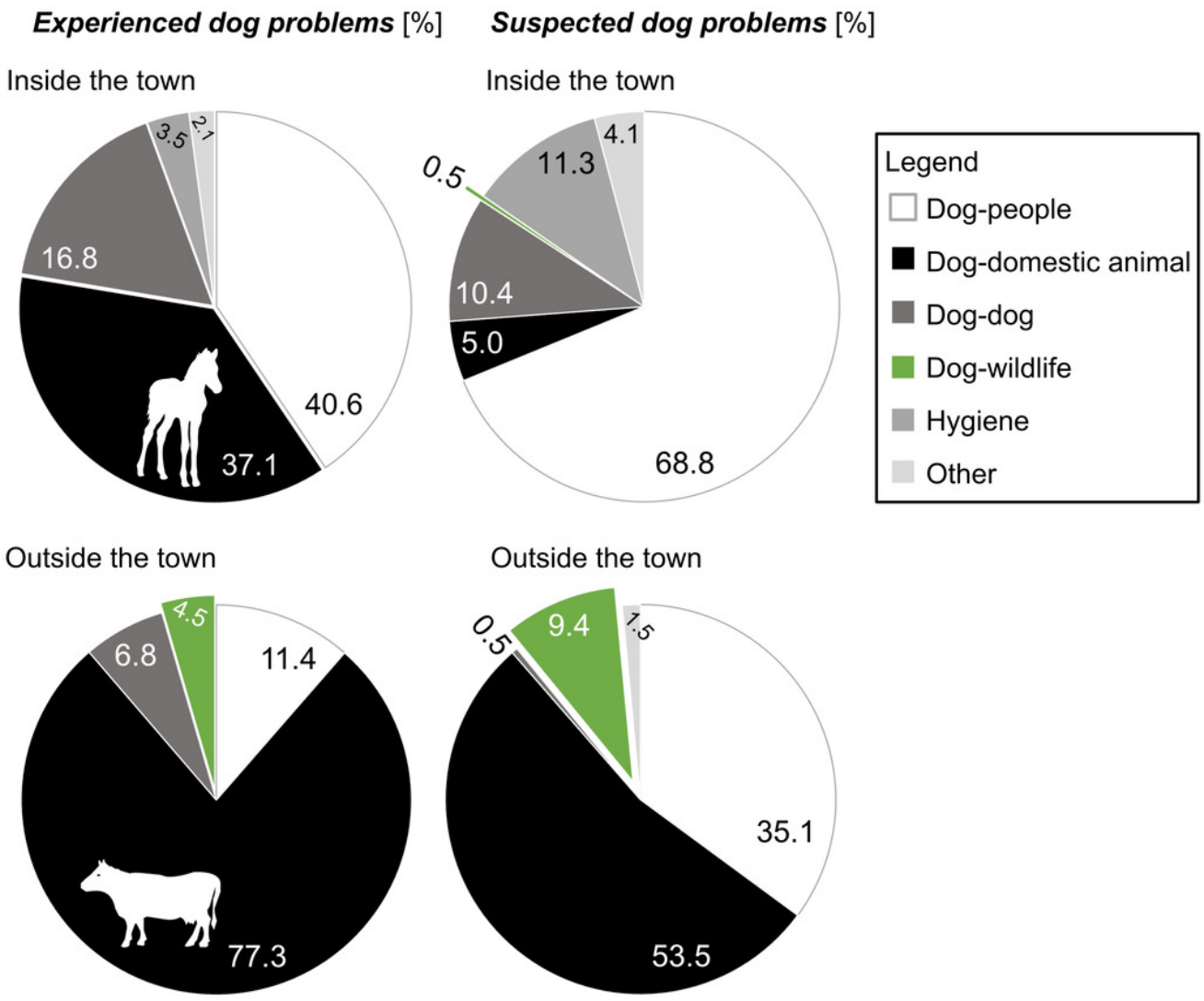
Experienced dog problems [%]
Suspected dog problems [%]
Inside the town
Inside the town
2.1
3.5
16.8
40.6
37.1
0.5
4.1
11.3
10.4
5.0
68.8
Legend
Dog-people
Dog-domestic animal
Dog-dog
Dog-wildlife
Hygiene
Other
Outside the town
Outside the town
4.5
6.8
11.4
77.3
0.5
9.4
1.5
35.1
53.5

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.

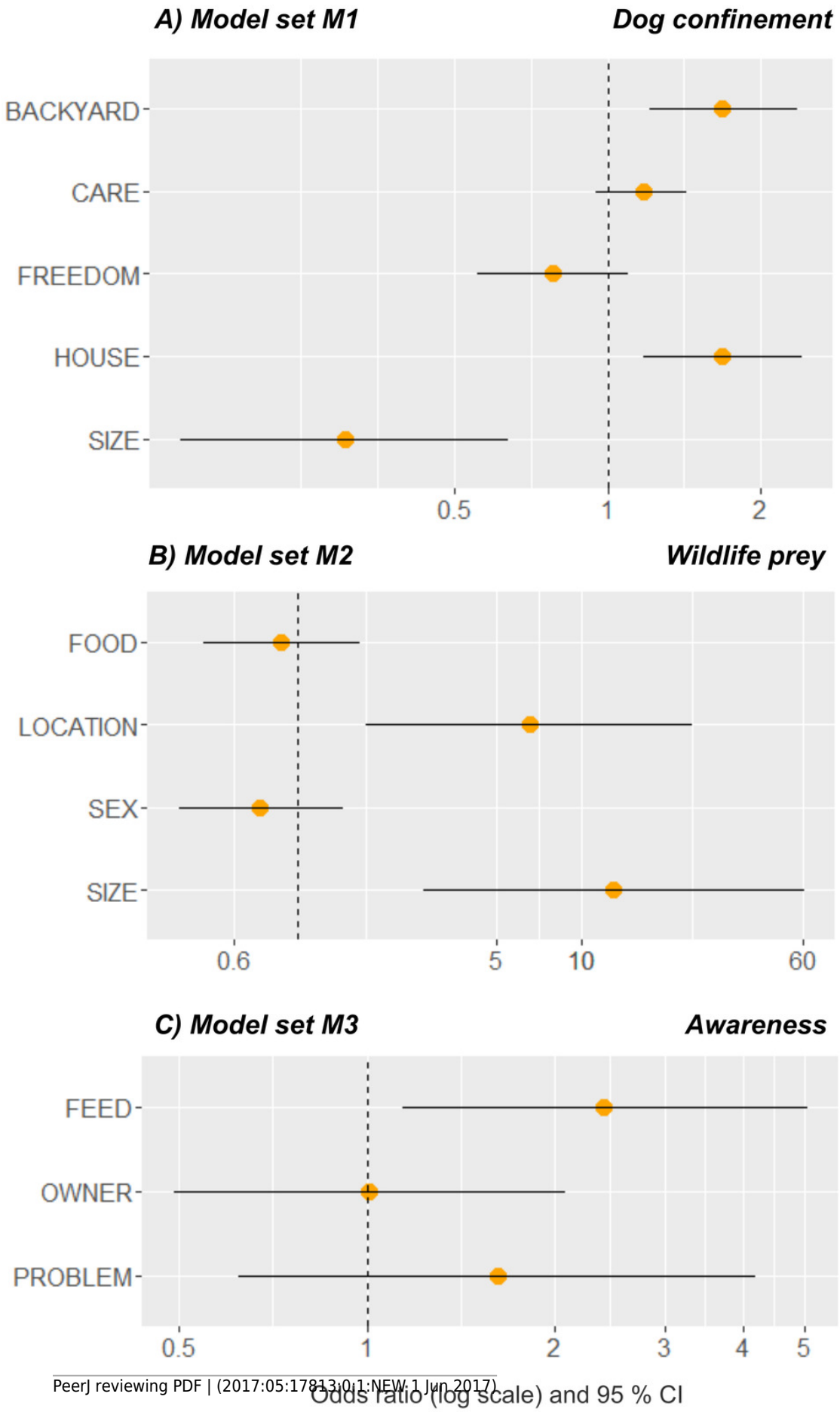
A) Model set M1
Dog confinement
BACKYARD
CARE
FREEDOM
HOUSE
SIZE
0.5
1
2
B) Model set M2
Wildlife prey
FOOD
LOCATION
SEX
SIZE
0.6
5
10
60
C) Model set M3
Awareness
FEED
OWNER
PROBLEM
0.5
1
2
3
4
5
Odds ratio (log scale) and 95 % CI

Table 1(on next page)

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%)

2

3

Table 2 (on next page)

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	-

* n=120

Table 3(on next page)

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

1

2