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RESEARCH NOTE

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Poultry–carnivore conflict in Chile: Are we advancing toward effective co-existence for small wild carnivore conservation?

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Abstract

Human–carnivore conflicts threaten carnivores worldwide; they are an escalating concern for the conservation of carnivores and the well-being of subsistence farmers. While most of the available information focuses on large carnivores and livestock such as cattle, sheep, and goats, the interaction between mesocarnivores and poultry is a significant challenge that has not received sufficient attention. Chile is no exception; few studies suggest that carnivore predation on poultry threatens small-scale producers and is a nationwide problem. To better assess this conflict, we developed a survey aimed at professionals who work directly with small-scale farmers across the country to examine the current conflict between native, invasive, and domestic carnivores (dogs and cats) and small-scale poultry farmers in rural areas of Chile. A staggering 92.4% of professionals surveyed mentioned that small-scale farmers deal with predation issues, with dogs (with or without owner) being the most frequently mentioned predator (86%), followed by *Lycalopex* foxes, lesser grison (*Galictis cuja*) and American mink (*Neovison vison*). Our results show that confinement, the primary method to prevent predation, could reduce predation event frequency. Despite being illegal, lethal control was mentioned by 36.4% of surveyed professionals as a used method to reduce predation, therefore, representing a potential threat to native carnivores and animal welfare. Addressing poultry predation by native and non-native carnivores (dog and mink) is a crucial step toward advancing human–mesocarnivore coexistence in Chile.

KEYWORDS

Chile, dogs, family poultry, human–carnivore conflict, poultry predation, wild mesocarnivore conservation

1 | INTRODUCTION

Livestock–carnivore conflict, resulting from prey–predator interaction, is one of the main threats to carnivore conservation worldwide. Retaliatory killing of carnivores as a response to livestock predation threatens 30% of carnivore species (Macdonald & Loveridge, 2010; Thirgood et al., 2005; Ugarte et al., 2019; Woodroffe & Frank, 2005). Most studies on livestock–carnivore conflicts focus on interactions between large carnivores and large livestock, and only 11.3% of scientific articles in this area considered carnivores' impact on poultry rearing (Ugarte et al., 2019). Mesocarnivores have received less attention in carnivore–livestock conflict studies than large carnivores (Holmern & Røskaft, 2014; Inskip & Zimmermann, 2009; Moreira-Arce et al., 2018), despite representing 67% of the species associated with this conflict (Ugarte et al., 2019). This disparity may arise from larger home ranges and broader distributions of large carnivores (Ugarte et al., 2019), less understood ecological roles of mesocarnivores (Roemer et al., 2009), and a research bias toward more charismatic large carnivores (Hoffmann & Montgomery, 2022).

Poultry rearing is a fast-growing farming activity, being closely intertwined with human settlements due to poultry's role as waste converters (Steinfeld et al. 2009). Smallholder poultry production units involve one to a few hundred birds and constitute up to 80% of poultry stocks in low-income food-deficit countries (FAO, 2014; Pym et al., 2006). This subsistence farming largely depends on the need for protection against predators (Di Pillo et al., 2019; FAO, 2014; McKellar et al., 2023). Poultry predation can impact the wellbeing and food security of small-scale farmers but also biodiversity conservation (Jaksic et al., 2002; Salom et al., 2021). Retaliatory killing of mesocarnivores after poultry predation is globally threatening their conservation, disrupting food chains, ecosystem functions, and compromising broader biodiversity conservation efforts (Do Linh San, 2024; Marneweck et al., 2022).

Previous studies have identified carnivore–poultry conflict in Chile (Rodriguez et al., 2019.) Poultry predation had the second highest number of reported predation events during 2006–2012 (1073 events according to the Chilean Agriculture and Livestock Service (SAG)), accounting for 19% of events during this period (Rodriguez et al., 2019). Species such as the guigna (*Leopardus guigna*), culpeo (*Lycalopex culpaeus*), and gray chilla (*Lycalopex griseus*) foxes have historically been considered poultry predators (Gálvez et al., 2021; Silva-Rodríguez et al., 2009; Zorondo-Rodríguez et al., 2014, 2020), killed in retaliation (Gálvez et al., 2021; Sanderson et al., 2002), and perceived negatively by local communities (García-Solís et al., 2023; Sacristan et al., 2018).

Anthropogenically introduced carnivores boost this poultry farmer–carnivore conflict. Domestic dogs (*Canis lupus familiaris*) are abundant and widespread in Chile. In rural areas, they have been described as mainly "owned" (Sepúlveda et al., 2014, 2015), but identified as the main cause of small-ruminant loses in small-scale farms (Montecino-Latorre & San Martín, 2018). The American mink (*Neovison vison*) is reported as poultry predator by 84.9% of farmers (Reyes, 2016), causing the loss of 17% of these birds (García-Solís et al., 2023) impacting family poultry livelihoods in this country (Jaksic et al., 2002).

Understanding the interconnections between social consequences and causes of the livestock–carnivore conflict is significant to develop effective conservation strategies (Holmern & Røskaft, 2014). Comprehending management techniques effectiveness, farmers' perceptions, and willingness to prevent poultry predation is one of the first steps toward finding solutions for livestock–carnivore conflicts (Dickman, 2010; Moreira-Arce et al., 2018). This understanding can guide the prioritization of efforts and allocation of resources to conflict hotspots, providing a foundation for integrating socio-economic, ecological, and political factors into successful mitigation strategies (Broekhuis et al., 2017).

In Chile, previous studies have identified carnivore–poultry conflict (Rodriguez et al., 2019), highlighting poultry predation specifically by foxes and, to a lesser extent, by guignas (Gálvez et al., 2021). However, there is a lack of comprehensive documentation at a national scale about poultry predation aspects, such as species involved in poultry losses and their association with farmers' management techniques (preventive or retaliatory). To fill this gap and support a data-driven design of conflict reduction, we explored poultry–carnivore conflicts in Chilean rural areas as perceived by professionals working hand in hand with poultry farmers in this country. Specifically, our aims were: (i) to document conflict-prone species, (ii) to evaluate whether predation occurrence differs with different poultry confinement techniques, (iii) to understand how farmers identify the predator species, and (iv) to assess whether farmers use non-lethal and/or lethal techniques after predation events. Based on our results, we discuss and propose possible measures and strategies to help reduce threats to native carnivores.

2 | METHODS

From October 2019 to March 2020, we conducted an online survey (Table S1) targeting coordinators (hereafter "professionals") of the Agricultural Development Institute (hereafter INDAP) programs; Local Development Program (hereafter PRODESAL), Indigenous Territorial Development Program (hereafter PDTI) and Technical Advisory Service (hereafter SAT). These professionals assist small-scale farms (<12 irrigable hectares; hereafter "farms") organized in local-scale operational units ("OU") to enhance livestock and agricultural production. Professionals visit farms between 7 and 12 times a year and gather information regarding farmers' production and conditions in visitation sheets.

The survey, designed to ascertain the opinions and perceptions of these professionals, was sent through INDAP to 1354 professionals across Chile. Each professional answered one survey representing all the farms in their respective OU. The survey had closed-ended and open-ended questions (Table S1); it was voluntary, and it did not have mandatory questions to maximize the response rate. The survey was approved by the Institute of Ecology and Biodiversity Ethics Committee (N001; Santiago, Chile). Responses were anonymous, and no information was collected that could be used to identify respondents individually. Prior informed consent was obtained from all participants.

The survey included the following sections: (i) OU characteristics and confinement measure used across farms (free-range [no confinement], nocturnal, or total); (ii) predation occurrence (during last 5 years; 2015–2019), frequency (e.g., monthly, several times a year, one per year, one every 2 years), intensity (number of poultry lost per predation event), and main carnivore species involved; (iii) perceived farmers' ability to identify predators, evidence used (e.g., direct observation, location of the bite, number of dead poultry, tracks, or other), post-predation actions, limitations to adopt predation preventive measures, and professional's willingness to receive related training (Table S1).

3 | DATA ANALYSIS

Responses were classified into three major responsible (r) predators reported by professionals and grouped by predator type by performing a hierarchical cluster analysis using the function *hclust* in *R* (R Core Team, 2022). Results were visualized in a dendrogram and cut with *cuttree*.

To analyze the frequency of predation event differences among clusters, we constructed contingency tables-based farm numbers using each confinement type and performed a Pearson's chi-square test, overall and within each predator cluster. The non-parametric Kruskal-Wallis test was employed to analyze differences in predation event intensity between clusters and confinement types. All analyses were computed with R 4.2.0 (R Core Team, 2022).

4 | RESULTS

4.1 | OUs characteristics and management

We obtained 66 answered surveys from 66 OUs (Figure 1a), encompassing 15,902 farms across Chile, of which 11,324 (71.2%) raised poultry, with an average of 148 farms with poultry per OU (range: 1–667; Figure 1b). Only farms with poultry were considered in subsequent analyses. Confinement was a common practice to protect poultry from predators; 57.5% of farms used night confinement (free during the day) and 14.6% applied total confinement (day and night), while 27.8% bred free-ranging poultry.

4.2 | Predation event occurrence and carnivore species involved in poultry predation

The majority of professionals ($n = 61$; 92.4%) reported poultry predation events in the OU over the last 5 years, potentially affecting 10,846 farms (95.6%).

Six native and three invasive carnivores were reported by the professionals as responsible (r) or harmful (h). Unowned (stray or unknown owner) dogs (r: 73.1%; h: 81.8%) and owned (neighbor's) dogs (r: 54.3%; h: 60.6%) were the most mentioned in both categories. Native foxes (r: 64%; h: 53%) and lesser grison (*Galictis cuja*; r: 32.5%; h: 18.2%) were the most common native carnivores in both categories, followed by the introduced American mink (r: 16.3%; h: 12.1%). Professionals also mentioned puma (*Puma concolor*), guigna, and other species such as raptors (*Parabuteo unicinctus*, *Geranoaetus polysoma*, *Milvago chimango*, *Falco sparverius*, *Tyto furcata*, and *Accipiter chilensis*) and snakes (*Philodryas chamissonis* and *Galvarinus chilensis*; Figure 1d).

The dendrogram of predators deemed responsible for poultry killing showed a clustering of the data into four groups (Figure S1): a first cluster (D + I + N) comprising farms in charge of professionals that reported all types of carnivores (domestic, invasive, and native; 60.1% of farms, $n = 38$ OU); a second cluster (D + I) with both domestic and invasive species (17.4% of farms, $n = 14$ OU); a third cluster (N) with only native carnivores (18.1% of farms, $n = 9$ OU); and a fourth cluster of professionals that did not report predation over the past

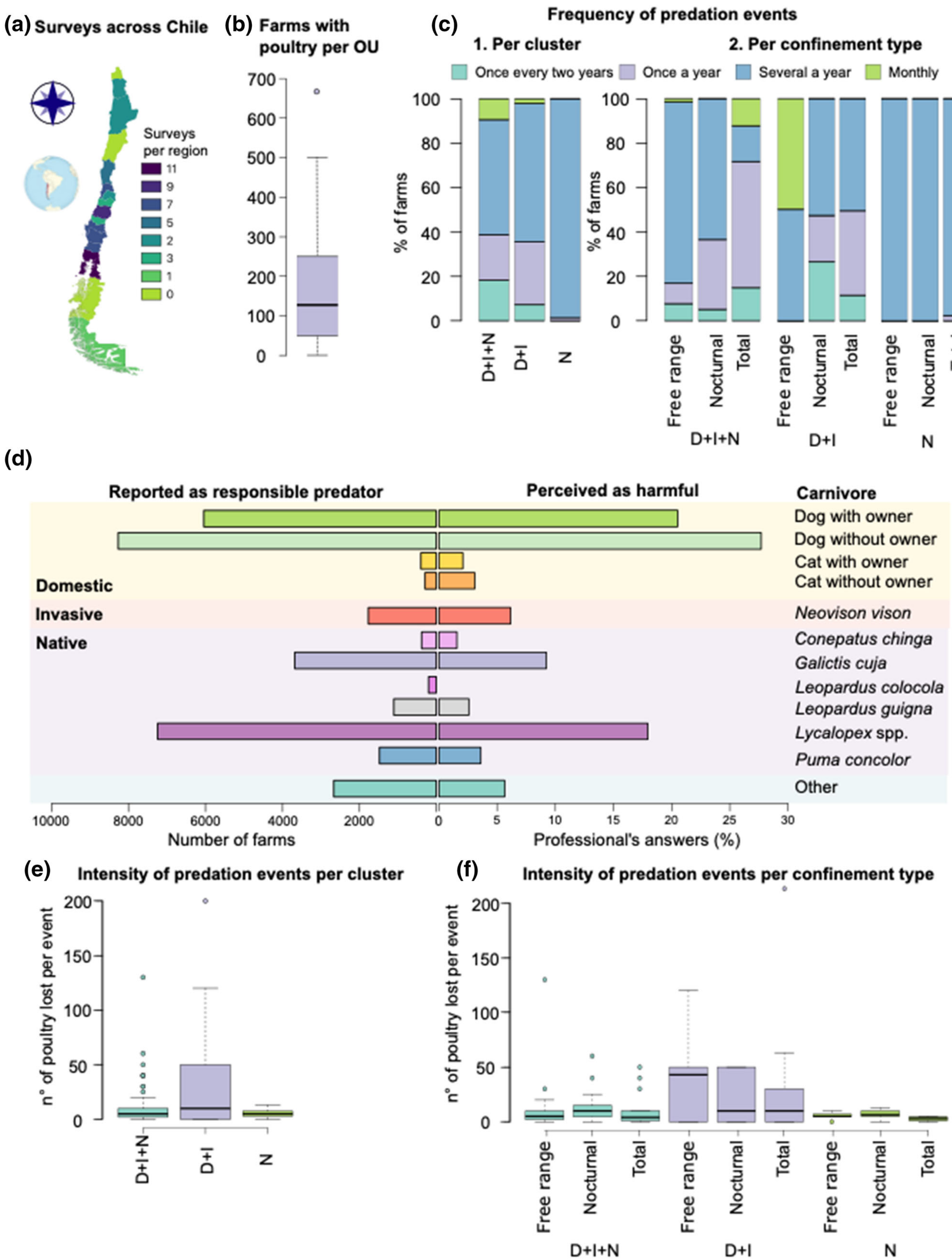

FIGURE 1 Legend on next page.

5 years in the OU (4.2% of farms; $n = 5$ OU; cluster excluded from predation frequency and intensity analyses).

Predation frequency showed a significant association with cluster type ($\chi^2 = 1367.5$, df = 6, $p < .001$). "Several a year" was the dominant response and was associated with all clusters D + I + N, D + I, and N (3,638, 411, and 1997 farms, respectively), as was "Once a year," but in a lower proportion (1668, 165, and 28 farms, respectively; Figure 1c1). Categories "Once every two years" and "Monthly" were only present in clusters D + I + N and D + I (427 and 145 farms; 126 and 75 farms, respectively).

Predation frequency speared by confinement and predator types (clusters; Figure 1c2) showed a significant association indicating dependency among variables for each cluster (D + I + N: $\chi^2 = 1399.1$, df = 6, $p < .001$; D + I: $\chi^2 = 427.77$, df = 6, p < .001; N: $\chi^2 = 46.176$, df = 2, p < .001). The prominent associations were found in the D + I + N cluster, with a higher proportion of "Several a year" under free-range or nocturnal confinement, and a higher proportion of "Once a year" under total confinement. The D + I cluster, particularly under no confinement (free-range), showed the highest frequency of "Monthly" predation events.

Predation intensity was not statistically different by clusters (H (χ^2) = 2.66, df = 2, $p = .26$), but was higher in the D + I cluster compared to D + I + N and N (Figure 1e). Analyzed by confinement type, it showed no statistically significant differences (H [χ^2] = 2.49, df = 2, $p = .28$); however, the predation intensity of cluster D + I showed a tendency to increase under free-range conditions, with a median 4.3 times higher than nocturnal and total confinement (Figure 1f).

4.3 | Professionals' perception of farmers' ability to identify predators and post-predation responses

Most professionals (83.6%; 9747 farms) considered the farmers' ability to identify predators as acceptable, good or very good. A smaller proportion (13.1%; 1366 farms), considered the farmers' ability to be bad or very bad. Professionals in cluster D + I unanimously rated the farmers' identification skills positively (Figure 2a).

Among the farms that reported predation, professionals indicate that 89.3% of farmers ($n = 9689$) do verify the responsible species. From clusters D + I + N and N, direct observation and tracks were the dominant techniques (3695 and 1937 farms, respectively; Figure 2a). For cluster D + I, direct observation and bite location were the most used methods (1937 and 999 farms, respectively; Figure 2a).

Professionals reported the potential use of lethal control by 4279 farms, either by killing the carnivore in a direct encounter inside the coop (25.66% of farms; $n = 2906$) or by chasing it or setting traps (12.12% of farms; $n = 1373$; Figure 2b). From clusters with native carnivores involved (D + I + N and N), professionals indicated that 17.4% of farms reported the predation event to SAG ($n = 2972$) and 5.6% captured the animal and handed it over alive to SAG ($n = 634$; Figure 2b).

Following predation events, professionals reported that 73.8% of farms employed techniques such as enhanced confinement (73.5%) and extended time spent inside the coop (49.6%). Livestock guardian dogs (LGD) and deterrents (lights or sounds) were less prevalent, reported in 12.5% and 0.4% of farms, respectively. The perceived primary limitations to applying preventive measures were limited resources (46.2%), lack of knowledge or training (36.9% and 29.2%), low interest (26.1%), and insufficient technical instruments (23.1%). Only 10.7% of professionals identified predator verification as a barrier to implementing preventive measures. Finally, 95.5% of professionals expressed willingness to be trained to reduce poultry losses within the OUs.

5 | DISCUSSION

Our results indicate that small-scale poultry breeders in Chile face predation by domestic, invasive, and native carnivores, and that they implement lethal control, suggesting an extended problem involving economic losses and illegal retaliatory hunting that threatens native carnivore populations.

Native foxes were perceived as the second most harmful predator (after dogs with and without known owner), supporting previous studies (Gallardo et al., 2020; Gálvez et al., 2021; García-Solís et al., 2023; Rodriguez et al., 2019; Silva-Rodríguez et al., 2009) and the negative

FIGURE 1 (a) Number of surveys conducted across Chile's regions. (b) Distribution of the number of farms with poultry per OU. (c1). Frequency of predation events by cluster (D + I + N, D + I, and N), where D = domestic, I = invasive, and N = native. (c2). Frequency of predation events by cluster and type of confinement. (d) Professional perceived number of farms reporting each carnivore species (domestic, invasive and native) as attackers (left) and percentage of professionals reporting each carnivore species perceived as harmful (right). (e) Intensity of predation events per cluster. (f) Intensity of predation events by cluster and confinement type.

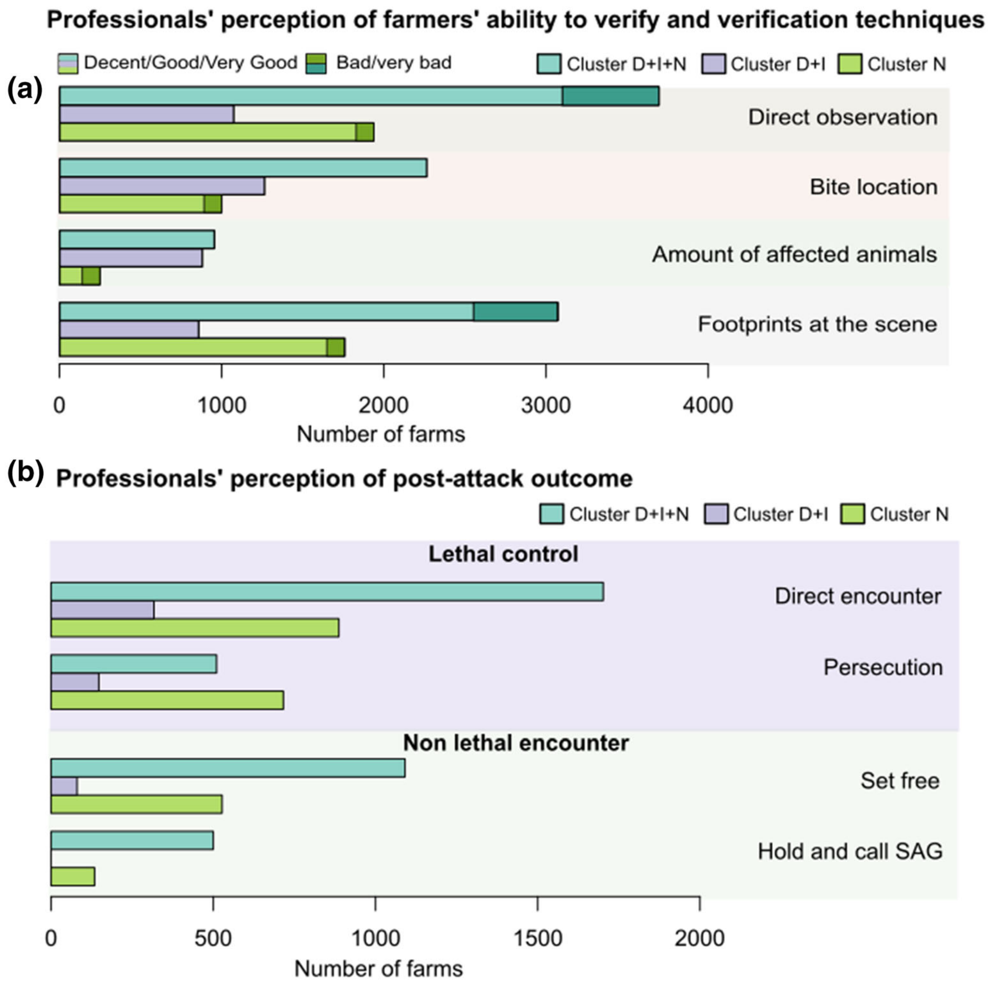

FIGURE 2 (a) Number of farms associated with the professional's perceived farmers' ability to verify the predator species and four verification techniques used to recognize the predator by cluster. (b) Number of farms where professionals report lethal and non-lethal control measures taken following poultry predation events.

attitudes toward foxes as part of the Chilean culture (Díaz et al., 2019; Herrmann et al., 2013; Zorondo-Rodríguez et al., 2020). Foxes must be especially considered as conservation targets for preventive measures, such as coops' improvement or LGD to avoid poultry predation, in order to minimize their persecution.

Despite the guigna's cultural perception as a poultry thief and its killing in retaliation (Herrmann et al., 2013; Sacristan et al., 2018; Sanderson et al., 2002; Zorondo-Rodríguez et al., 2014), habitat configuration and quality are of greater significance for guigna occupancy (Gálvez et al., 2018). A previous study found only 16% of surveyed farmers identified guigna as a poultry predator, contrasting with 50% identifying foxes and 75% hawks (Gálvez et al., 2021). Among other native carnivores, the lesser grison was the second most mentioned species as responsible; however, there is no previous information about this native mustelid in relation to poultry predation in Chile. These findings suggest emerging problems with this carnivore, and therefore require attention and consideration when applying management tools. Alternatively, the lesser grison is probably being confused with the more harmful invasive mink for their similar morphological characteristics.

The majority of professionals reported that farms were experiencing problems with dogs and minks, non-native species with negative effects on domestic and wild species in Chile, due to predation, disease transmission, and habitat segregation (Cabello et al., 2013; Montecino-Latorre & San Martín, 2018; Moreira-Arce et al., 2015; Ortega et al., 2021; Sepúlveda et al., 2011). Dogs, identified as a significant harmful predator to livestock and wildlife worldwide (Contreras-Abarca et al., 2022; Gompper, 2014), were perceived as especially harmful to poultry in our study. Owned dogs represent a significant and complex issue (Montecino-Latorre & San Martín, 2018) that requires a multifaceted approach. Key challenges include owners' reluctance to confine dogs (Zorondo-Rodríguez et al., 2014) and the unclear dog type classification in legislation (Contreras-Abarca et al., 2022). Restricting dogs' movements and enforcing current regulations on responsible tenure could significantly reduce their impact on poultry and wildlife in Chile. Furthermore, the American mink is a problematic invasive species in southern Chile; it has been described as the worst evaluated among poultry breeders and perceived as a non-beneficial species (García-Solís et al., 2023). Our results support this previous finding and suggest that finding social agreement for its control should be easier compared to dogs. Non-native predators must be controlled and considered in the implementation of government strategies and management techniques to protect both small-scale farmers and native species.

Poultry confinement was the predominant preventive method and the primary response to predation events. Confinement is a well-established method for reducing predation risk (Eklund et al., 2017; Moreira-Arce et al., 2018; van Eeden et al., 2017), but it is not effective per se. Fences are effective only when the predator species is successfully targeted, the coops are correctly maintained and fixed (Eklund et al., 2017; Frank & Eklund, 2017), and poultry release is synchronized with human activity (Almuna et al., 2020). We found that complete confinement reduced the frequency of predation in clusters D + I + N and D + I, but showed no effect in the native predators' cluster. We also observed a tendency for the intensity of predation in cluster D + I to increase in free-range conditions. Predator and hunting behavior diversity must be considered in enclosure construction; some fences cannot be properly closed and poultry could be unable to escape (Ahlers et al., 2009), which may explain an increase in predation intensity for cluster N with complete confinement. FAO recommends building fences with correct netting sizes and ground-lodged, preventing predators from entering or passing under them (FAO, 2014).

The most vulnerable poultry to predation are those that graze freely and unsupervised (Rodriguez et al., 2019). Our sample comprised approximately one-third of free-range poultry. Farmers are often reluctant to keep poultry all day inside the enclosure (Almuna et al., 2020). The increase in the necessity for constant maintenance and repair implies work and financial costs. It may be unrealistic to expect that all free-range poultry farmers will adopt confinement, especially considering that respondents mentioned the lack of resources as an important limitation.

Complementing different prevention techniques has been proposed to reduce livestock predation (Moreira-Arce et al., 2018) and may be suitable for poultry production. LGD or deterrent lights or sounds could be effective to dissuade carnivores (Eklund et al., 2017; Miller et al., 2016; Moreira-Arce et al., 2018; Ohrens et al., 2019), representing alternative ways to prevent poultry losses. LGD have been shown to protect poultry without altering chicken behaviors, thus exemplifying a poultry-friendly technique (McKellar et al., 2023). For small-scale poultry farmers, the simplicity and affordability of any of these methods are crucial for their practical implementation.

The farmers' ability to recognize predators was considered positive by professionals in the majority of responses, revealing trust in the farmers correct verification. However, most farmers do not contact SAG to verify the responsible species, despite this being the official and suitable path to follow. Inadequate recognition can result in the incorrect species being blamed, leading to a detrimental misunderstanding for native fauna (Ballejo et al., 2022). Although Chile has a guide for verifying and reporting livestock predation (Guarda et al., 2010), it lacks specific guidance for poultry predation. Developing a comprehensive poultry-specific guide covering both native and exotic predators could greatly enhance predator identification accuracy by farmers and professionals.

Our survey response rate was low (<5%), possibly attributed to the timing of its application with the social unrest in Chile (from October 2019 to March 2020) and the onset of the COVID-19 crisis (Morales Quiroga, 2020). When interpreting our results, we acknowledge the limitations of our dataset due to our limited sample size ($n = 66$). Nevertheless, this study represents the first nationwide survey to comprehensively address the poultry–carnivore conflict, including all types of potential poultry predators, associations with confinement techniques, and outcomes following predation events relevant to mesocarnivores' conservation. This study represents a preliminary step in informing evidence-based strategies to mitigate mesocarnivores' threats.

As a signatory to the Convention on Biological Diversity (CBD), Chile should address the issue of human–wildlife conflict, as outlined in Target 4 of the CBD Post-2022 Global Biodiversity Framework. This requires the effective management of human-wildlife interactions to avoid or reduce human–wildlife conflicts (CBD, 2021). Poultry–carnivore conflict in Chile needs more attention from researchers, governmental involvement, and collaboration from diverse stakeholders to identify win–win strategies. Such an approach would be an advance toward effective evidence-based management and achieving coexistence between local farmers and mesocarnivore conservation.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author, CN, contact constanza.napolitano@ulagos.cl, upon reasonable request.

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