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REVIEW

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The California Quail (*Callipepla californica*) in Chile and Argentina: introduction history, current distribution, and biological features

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Abstract

Background Little is known about the California Quail (*Callipepla californica*) as an invader in Chile and Argentina. Our goal was to review the history of its introduction and to provide updated information on its spread and current geographic distribution in those two neighboring countries, together with information on its body measurements (weight, wing length, and tail length), diet (granivory, frugivory), parasitism (endo and ecto), and other interspecific interactions (competition and predation), including hunting by humans.

Methods and result We conducted a selective review of the history of introduction, distributional records, and biological features of *C. californica*, as recorded in mainstream journals, landmark monographs and books, and internet sources. We also measured specimens collected in central Chile and analyzed their stomach contents. We report that the California Quail was first introduced to Chile in 1864, and it now spans ca. 2,800 km in the country. From stocks in Chile, this bird was back-introduced to California (USA), and also introduced to Argentina in the 1920s, now spanning ca. 1,400 km in the country. It is currently abundant and legally hunted in both countries. In Chile, its non-breeding diet is strongly granivorous. In Argentina it feeds similarly. In Chile, endoparasites are three species of nematodes, one of cestodes, and two of coccidian protozoans; ectoparasites are three species of hard ticks, one of mites, and two of chewing lice. No such data are available from Argentina. In Chile, combining autumn and winter samples we obtained mean weights of 194.4 (± 9.0 SD) g for 21 adult males and of 183.9 (± 14.3 SD) g for 10 adult females, figures similar to those reported for *C. c. brunnescens* in California (USA), which we suspect is the subspecies now spread over in Chile and Argentina.

Discussion We propose that interesting scientific opportunities are being missed regarding the population genetics of a species with introductions and back-introductions that may have left founding effects and genetic bottlenecks in Chile and Argentina, and perhaps some peculiar "Chilean" genetic markers among California (USA) populations. We also raise the question whether this introduced species may be deemed invasive, calling for research to determine its impact in its new environment.

Keywords *Callipepla californica brunnescens*, Competition, Diet, Hunting, Invader, Measurement, Nothoprocta perdicaria, Parasitism, Predation, Rubus ulmifolius

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Background

The introduction of the California Quail (*Callipepla californica*), a native of western North America [35, 37], to Chile is particularly curious, because the originators of the two earliest quail introductions are identified, together with the quail approximate number, year,

and release location [30]. And also because quails from Chile were later back-introduced to California, USA [63], but no follow-up has been conducted [30]. Since their original introduction to central Chile in the 1860-1880s, quails have expanded their distribution toward the north and south, were introduced eastward to neighboring Argentina in the 1920s, and have become so abundant that hunting is permitted and even promoted in both countries. Still, basic aspects of their introduction history, spread, current distribution, and biology are little known in their invaded South American ranges. Here, we synthesize all information available on California Quail in Chile and Argentina, thus partly remedying that situation.

Methods

Literature review

We back-tracked references from current to older sources, using mainstream journals, monographs, and books, and relevant grey literature. Some new sources emerged when engine-searching the internet without time or language constraints for key words such as California quail, Valley quail, Codorniz californiana, Codorniz, *Lophortyx californica, Callipepla californica*) and they are referenced by URL as needed. The search for California Quail in the diet of vertebrate predators (mammalian carnivores and avian raptors) was especially challenging, because it required screening prey lists from many reports on different predators from all over the country. Fortunately, two recent books provided detailed references to the extensive literature on the quantitative diets of Chilean hawks and owls [28] and that of Chilean carnivores [26]. No such summaries are available from Argentina. We specifically discarded work on the systematics of *Callipepla* (=*Lophortyx*) *californica*, unless it provided natural history observations, distinguishing between first-hand information and secondary use of literature sources.

Distributional map construction

We accessed the eBird database [73] (provided by ROC (Red de Observadores de Aves de Chile, https://www.redobservadores.cl/) for all the occurrence records of California Quail in both Chile and Argentina, without discriminating by date, observation protocol, or number of birds recorded. That information was loaded into QGis (version 3.22.12) using WGS84 coordinates. The shapefiles of both countries and of South America were downloaded from the web: For Chile, from the website of the Library of National Congress (https://www.bcn.cl/siit/mapas_vectoriales/index_html); for Argentina, from https://datos.gob.ar/dataset/jgm-servicio-normalizacion-datos-geograficos/archivo/jgm_8.26; and for South America https://www.efrainmaps.es/descargas-gratuitas/am%C3%A9rica/. Next, we created a grid (based on hexagons) which extent was calculated on the basis of the occurrence data layer. We used the "count points in a polygon" vector analysis tool, to generate another layer of polygons sorted on the basis of the number of points per polygon. We classified this layer into two classes: polygons that had less than 1 record (which were excluded from the map) and polygons that contained at least 1 record (light brown color in Fig. 1). Finally, we intersected the South American layer with the count-of-points by polygons layer, to exclude from the map the parts of the hexagons that extended beyond the shoreline (only for aesthetic reasons).

Dietary analysis

We collected 13 specimens of California Quail during May (autumn) and 18 during August (winter) of 2022, shot with a 0.22 caliber air rifle in Chicureo (33°26′12″S, 70°61′85″W, Chacabuco Province, Metropolitan Region, Chile). We followed stipulations in Law N° 19473 (Hunting Law and its regulations, 2018). We assessed the quantitative composition in the diet based on food content in crops and stomachs of 11 of the 13 quail captured during May. The content was washed with water and filtered using a sieve (0.25 mm), then allowed to dry at 30 °C for 24 h in a drying oven. The identification of all dietary contents was carried out using a stereoscopic magnifying glass (× 90 and × 150) (Wild Heerbrugg Switzerland M5-86456). The animal component of the diet was identified based on morphological characteristics (shape, color, size) using an insect identification guide [37]. The plant component was also identified by morphological characteristics (shape, color, size) following the taxonomic classification of [55]. The seeds were identified based on field matches with seeding adult plants and in comparison to field guides of [23] and [52]. Each dietary element was quantified based on its occurrence over all birds (O% = [number of birds with *i* food item/total birds] × 100) and by biomass (B% = [weight of *i* food item/total food weight] × 100).

Bird measurements

Freshly killed birds and their gut contents were weighed using an analytical balance (Allfine model XY1000-2C) rounding up to the nearest 0.1 g. Standard ornithological linear measurements of folded wing length (=wing chord length) and tail length were taken after [10], using a ruler graduated in mm. To determine possible differences in measurements between sexes and to compare weight and length with values reported in the literature, Student's t-tests for one sample were applied. We had to do this because data from the literature were expressed only as means without standard deviation. Therefore, the

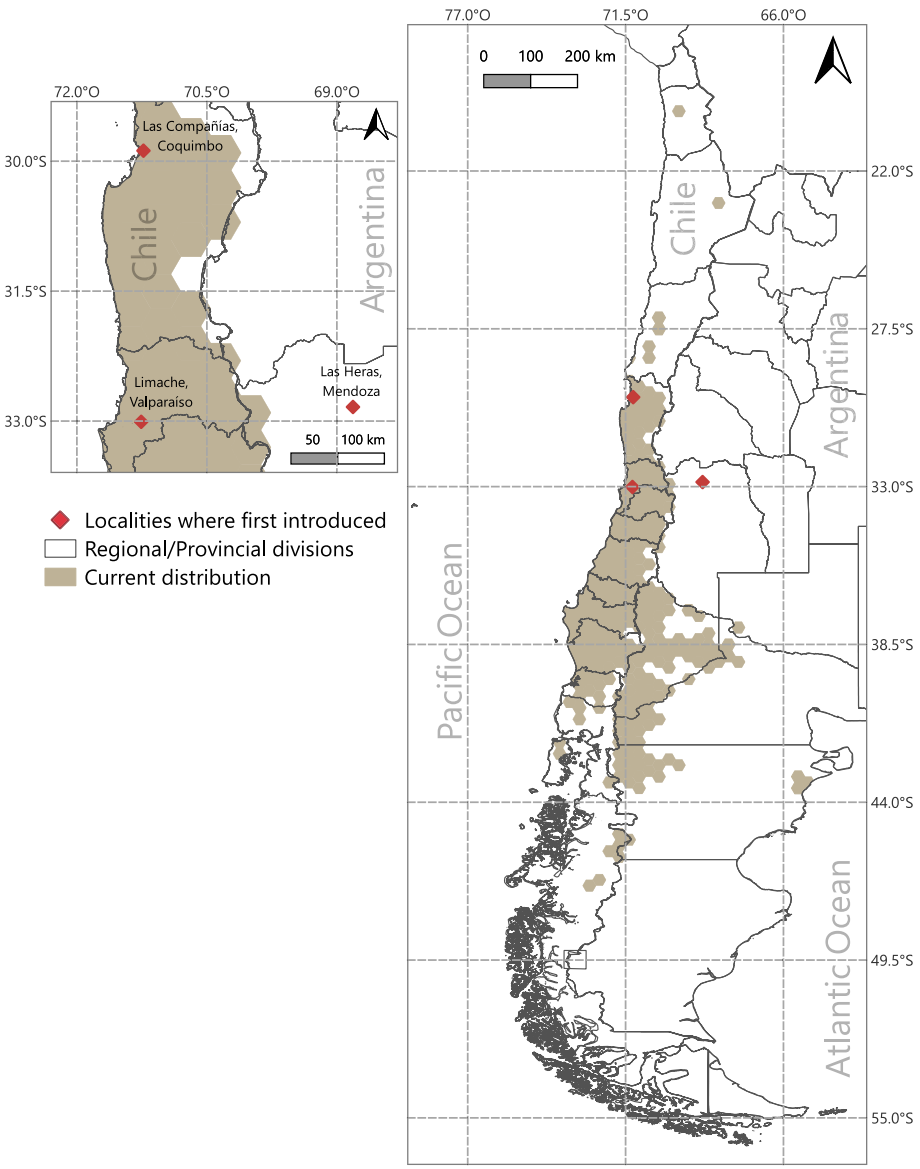

Fig. 1 Map of occurrence of California Quail in Regions of Chile and Provinces of Argentina, depicted in light brown

mean reported by other authors was tested against the 95% confidence interval of the corresponding mean calculated from our own samples, which were normally distributed (Anderson–Darling test). All statistical analyses were performed with Minitab software (version 2019).

Results and discussion

Introduction, spread, and current distribution

According to [63] the first introduction of California Quail to Chile was by the Dutch citizen William Groves, who emigrated from San Jose (California, USA) and brought with him a dozen quails in 1864, which he kept caged in his farm in Limache town (Valparaíso Province, now Region, Chile). The quails escaped and became established in the wild. A separate introduction was carried out by the US citizen C. J. Lambert in the vicinity of Las Compañías, a town just north of La Serena city (Coquimbo Province, now Region, Chile). Lambert imported quails from San Francisco (California, USA) and released them in Las Compañías in either 1881 or 1882. Later, US citizen F. E. Booth, who came to Santiago city (Santiago Province, now Metropolitan Region, Chile) from San Francisco (California, USA), made an unusual back-introduction: He bought quails in Santiago city's central market, sent them to California by ship, and so a first batch of 134 quails was duly recorded as arriving

at San Francisco's port (California, USA) during the first half of January 1927, for release into coverts on a game preserve in Sonoma County (California, USA). Because Swarth's paper [63] was submitted for publication on 9 February 1927, it is possible that later batches of "Chilean" quails may have been shipped to California, USA.

According to [46], the California Quail was introduced to Chile later (in 1870), but apparently he did not have access to the paper by [63]. Phillips [46] reported that quails were sold in Valparaíso city´s market dead and alive, and that they were game birds. He also stated that some were taken by captain Wakelborn to the two largest Juan Fernández Islands (off the coast of Valparaíso Region) in 1912 or 1913 and that a few years later they were thriving in both (Más Afuera and Más a Tierra, now called Alejandro Selkirk and Robinson Crusoe, respectively). And finally, that some quails were translocated to the surroundings of Curicó city in 1914 and that they thrived and colonized further. Barros [1] was cited to that effect, and indeed this author reported that he and his brother Jorge Barros released quails brought from Santiago city to Nilahue valley near Curicó city (Talca Province, now part of Maule Region) in 1913. Barros [2] stated that by 1917–1921 quails were common in the Blanco River basin (Valparaíso Province, now Region), up to 1,650 m elevation during summer and migrating downward during winter. Simberloff and von Holle ([61]:293) found that quails introduced in 1912 or 1913 to the Juan Fernández Islands were already naturalized. Hahn et al. ([22]:423–424) followed [46] and not [63] in reporting 1870 as the date of introduction of quails in continental Chile, and indicated that they ranged from the Coquimbo to Talca Provinces, that they were found in large numbers, that they were introduced to Juan Fernández Islands in 1912 or 1913 by captain Wahlbom (notice the different spelling), and that they thrived on Alejandro Selkirk but not on Robinson Crusoe Island. Chapman [5] also mentioned the presence of introduced quails in the two largest Juan Fernández Islands. Housse ([24]:96–99) extended their southern range from Talca (now Maule Region) to Concepción Province (now Bio Bío Region) and to Santa María Island off the coast of Coronel city (Bio Bío Region). Goodall et al. ([20]:191–192) continued to report 1870 as the introduction date of California Quail, and added that Carlos Haverbeck released quails further south during the 1940s in Valdivia Province (now Los Ríos Region), and that on account of excessive rainfall they all migrated northward to Malleco and Bio Bío Provinces. They also declared that quails were abundant between Coquimbo Province (now Region) and the Bio Bío River. Johnson and Goodall ([36]:278–279) added to their previous work [20] that four pairs of quails released by W. (Guillermo) R. Millie at Vallenar city in Atacama Province (now Region) at an unknown date and that they were still present at the upper Huasco River valley in the 1960s.

Bird census reports by [7, 8] and [12] indicated that California Quail had relatively high density in mediterranean shrubland habitats of central Chile. Macdonald et al. [40] reported that they were found in the relatively pristine La Campana National Park, in Valparaíso Region. Vuilleumier [66] reported that quails were found in continental Chile from Atacama to Los Lagos Regions (spanning ca. 1,500 km) and commented that this species appeared to be exported annually from Chile to Argentina and Brazil, citing [25]. He also reported its presence on Robinson Crusoe Island. Mann [41] visited in 1968 and 1970 the two larger Juan Fernández Islands and found no quails in either. Torres and Aguayo [64] also visited the archipelago in 1970 and did not observe quails. Perplexingly, [59] reported them as present in the two islands, and it is unclear if he visited them or when. Torres-Mura et al. [65] went to Robinson Crusoe Island in 1998 and declared the California Quail as extirpated there, and [21] stated the same for the Alejandro Selkirk's population.

The latest scientific reports on the status of the California Quail in Chile [27, 31, 32] provide no fresh information on this species. Interestingly, [56] reported that the California Quail is currently found in General Carrera Lake basin and north of Cochrane city (Aysén Region). Indeed, Eduardo Pavez (personal communication) saw quails in the Mañihuales River basin as early as in 2007. Up north, Jaime E. Jiménez (personal communication) recently saw quails in Ñielol Hill, Temuco city (Araucanía Region) and Juan Carlos Torres-Mura (personal communication) indicates that the California Quail's northernmost reach in continental Chile now stands at Antofagasta Region, with extant populations in Chuquicamata mine (released during the 1900s by employees of Anaconda Copper Company), San Pedro de Atacama, and Paposo. Thus, the California Quail in Chile currently encompasses ca. 2,800 km in a beeline from its northernmost location around Chuquicamata mine to its southernmost around Cochrane city. See Fig. 1.

According to [44], the first introduction to Argentina was by the Chilean citizen Carlos S. Reed, who released 25 pairs collected in Valparaíso (Chile) into Las Heras (surroundings of Mendoza city, Mendoza Province) in 1920; in 1922 he again released ca. 4,000 more. Reed [47] and [48] reported that these birds acclimated well, and [57] listed the species as present by then, but the last known wild individual was collected in Mendoza in 1956 and currently no California Quail exist in the whole Mendoza Province. By the same token, [9] reported the introduction of this species to San Luis Province, but they no

longer exist there [44]. Another introduction of Chilean quails was effected in Neuquén Province in 1943, when 10 pairs were released in Estancia (=ranch or farm) La Primavera on the banks of Traful River; these birds acclimated well and spread all over the southern part of the Province, occupying the Limay River and Caleufu River valleys, overspilling to the southeast of Negro River and to the Nahuel Huapi Lake basin (Río Negro Province). It should be noted that [45] reported the birds of that Province (then officially called Gobernación de Río Negro), and saw no California Quail then, nor any other alien bird such as Rock Pigeon or House Sparrow or European Starling. Proceeding southwards from Río Negro Province, the quails eventually reached northwest Chubut Province [58], aided by an introduction to the east of Chubut during the 1990s [6]. They also spread northwards within Neuquén Province, assisted by new introductions occurring during 1968–1971 [42–44].

According to an Argentine governmental web site (https://sib.gob.ar/especies/callipepla-californica), the California Quail is currently distributed from Córdoba and San Juan Provinces in the north, southwards to Neuquén and Rio Negro Provinces, highlighting its presence in the Nahuel Huapi National Park (spread across Neuquén and Rio Negro Provinces bordering Chile), and Lanín National Park (Neuquén Province, also bordering Chile). Quite recently, [56] reported the southernmost quail detection in El Portezuelo, north of Esquel city in northwest Santa Cruz Province. Thus, the California Quail in Argentina currently encompasses ca. 1,400 km in a beeline from its northernmost location around Córdoba city to its southernmost near Esquel city. See Fig. 1).

Our own distributional map (Fig. 1) shows all the above published records on California Quail in Chile and Argentina, plus those registered by citizen science in the eBird web site (http://www.ebird.org). It should be reminded that the polygons and ensuing area depict a "flat" view of geographical distribution: a single observation of a single quail individual weighs the same as numerous records of several quail flocks. That is, the map does not reflect quail abundance, only presence or absence. It should also be noted that first, old, recent, or today's records are not discriminated. Thus, it is possible that old observations may not represent current presence. That is, the quail was but it is not now present at a given locality. A case in point, although California Quail was introduced and recorded in Las Heras (Mendoza Province, Argentina) in 1920 and 1922, the last observation of its presence was in 1956, and it has not been seen since. It general, it appears that California Quail has been expanding unaided in two directions: southwards and eastwards. In the near future, we may expect new records from Magallanes Region (Chile) and Santa Cruz Province (Argentina); see [56].

Body weight, wing length, and tail length

From our study site in central Chile we measured mean autumn weights of 197.0 (±8.3 SD) g for 6 adult males and 181.3 (±14.9 SD) g for 7 adult females, and mean winter weights of 193.3 (±9.3 SD) g for 15 adult males and 189.8 (±13.3 SD) g for 3 adult females. Combining autumn and winter samples we obtained the pooled results reported in Table 1. For *C. californica californica* in California, USA, [11] reported mean winter weights but without providing dispersion statistics (Table 1). For *C. californica brunnescens* in California, USA, [62] also reported combined autumn and winter mean weights; without dispersion statistics (Table 1). Leopold ([38]:10) reported mean weights of both *C. c. californica* and *C. c. brunnescens*, not discriminating by sex and not providing

Table 1 Weight (g) of California Quail *Callipepla californica* according to sex and origin reported here from Metropolitan Region of Chile (unknown subspecies) and from California counties (USA) on *C. c. californica* and *C. c. brunnescens*

Subspecies	Sex and locality	n	Weight (mean ± SD)	Reference
C. californica ssp.	Males (Metropolitan Region)	21	194.4 ± 9.0	This paper
	Females (Metropolitan Region)	10	183.9 ± 14.3	This paper
	Both (Metropolitan Region)	31	191.0 ± 11.8	This paper
C. c. californica	Males (County unreported)	39	179	[11]
	Females (County unreported)	25	171	[11]
	Both (Yolo County)	64	175.6	([38]:10)
	Both (San Luis Obispo County)	227	177	([38]:10)
	Both (Los Angeles County)	29	157.3	([38]:10)
C. c. brunnescens	Males (County unreported)	25	187.4	[62]
	Females (County unreported)	11	182	[62]
	Both (Contra Costa County)	321	187.8	([38]:10)
	Both (San Mateo County)	652	189.5	([38]:10)

dispersion statistics (Table 1). Examining all these data (Table 1), *C. c. brunnescens* appears to be heavier than *C. c. californica*. Our measurements from Chile are not significantly different from those reported for the large subspecies *C. c. brunnescens* in California ($P=0.493$), and are significantly heavier ($P<0.001$) than those for *C. c. californica*. No data on quail body weight are available from Argentina.

At our study site in central Chile we obtained wing length and tail length data of California Quail (Table 2), which can be compared to data reported by [20] for central Chile (the same data were used by [36]). Thus, Goodall et al.'s quails from several localities [20] were significantly short-winged and short-tailed in comparison to ours from a single locality ($P<0.001$ in both cases). In California, USA, [51] reported data for *C. c. californica* (the same data were used by [4]); see Table 2. Certainly, the Chilean specimens of both sexes have longer wing and tail than those of *C. c. californica* in California, USA ($P<0.001$ for wing length in both sexes, $P=0.001$ for female tail length, $P=0.081$ for male tail length). Unfortunately, no such data are available from *C. c. brunnescens* in California, USA, but on account of this subspecies being heavier it could be expected to also have longer wing and tail. No data on quail wing or tail length are available from Argentina.

Putative subspecific origin

There is no absolute clarity as to which subspecies of California Quail was introduced to Chile (*Callipepla californica californica* or *C. californica brunnescens*), but ([66]:336) noted that"Hellmayr (1932) also stated that 'Chilean specimens agree with the brown-backed, dark-flanked race of the humid coast region of California, which Grinnell […] has shown to be entitled to the name of *L. californica brunnescens*' (p. 424)." Given the Chilean origin of California Quail in Argentina, the same origin should apply. Our weight data for Chile reported above are close to, and even higher than, those reported for the relatively large *C. californica brunnescens* in California, USA. And our wing and tail length data are larger than those of the smaller *C. californica californica* in California, USA. Genetic analyses in the manner of [67] and [68], or more sophisticated, are called for to definitely resolve this systematic issue, which currently leans toward attributing California Quail in both Chile and Argentina to the subspecies *C. californica brunnescens.*

Table 2 Measurements (mm) of wing chord length (WCL) and tail length (TL) of California Quail *Callipepla californica* according to sex and origin for Metropolitan Region of Chile (unknown subspecies) and from California counties (USA) on *C. c. californica*

Subspecies	Sex	n	WCL (mean ± SD)	TL (mean ± SD)	Reference
C. californica ssp.	Males	17	115.9 ± 2.0	91.6 ± 3.9	This paper
	Females	7	115.0 ± 1.8	88.7 ± 2.0	This paper
	Both	24	115.7 ± 2.0	90.3 ± 3.5	This paper
	Both	16	112.7	82.3	[20]
C. c. californica	Males	35	110.6	89.2	([4]; 51)
	Females	13	107.8	83.8	([4]; 51)

Endo and ectoparasitism

In reviewing the parasitological literature for California Quail in Chile, regarding endoparasitism, [15] reported three species of nematodes, one of cestodes, and two of coccidian protozoans (*Dispharynx nasuta, Heterakis gallinarum, Capillaria cf. caudinflata, Anonchotaenia globata, Eimeria tenella,* and *Eimeria okanaganensis*, respectively) among 114 fresh quail specimens from southcentral Chile. From the same batch, but regarding ectoparasitism, [16] reported on the quail's skin and plumage the presence of two species of chewing lice, three of hard ticks, and one of mites (*Epicolinus elipticus, Zlotozyckella stefani, Megninia glynglimura, Pseudolichus* sp., *Amblyomma tigrinum*, and a Trombiculidae, respectively). More specifically, [17] documented that the hard tick *A. tigrinum* was found to be shared with the Chilean Tinamou (*Nothoprocta perdicaria*). No data on quail parasitism are available from Argentina.

Food habits and interspecific interactions

Housse ([24]:97) reported that California Quail in evergreen shrublands of central Chile were chiefly granivorous, eating varied seeds and cereals, especially wheat and grape seeds, which they smashed against the ground similarly as the Chilean Tinamou (*Nothoprocta perdicaria*); secondarily they ate fruits and vegetables; and lastly insects, including beetles, grasshoppers, caterpillars, and grubs (no taxonomic identification was provided). He reported that during wintertime 68% of the diet was made up of weed seeds, alfalfa and clover leaves, the remainder being invertebrates. In semiarid shrublands of north-central Chile, [69–71] reported that quails and tinamous were sympatric and granivorous, but did not report their dietary details; still, the former were not attracted to commercial seeds offered in experimental feeders, while the later were but did not behave aggressively against other granivorous birds at the feeders [71]. Jaksic [29, 30] discussed that the California Quail was suspected of competing with the Chilean Tinamou, with which it shares the same habitat preferences for shrubby areas and likely food (meaning seeds), but that no hard evidence existed on their possible interactions. This was somewhat remedied by [18, 19], wherein the two species

were shown to be strongly granivorous, with insects representing well below 1% of their diet by both frequency and volume. When comparing the composition of the quail diet with that of the tinamou, 18 species of herb seeds out of 47 were found in common as well as one species of insect. In both bird species, seeds of Poaceae constituted the core of their diet by both frequency and volume, with Fabaceae being the second most abundant item in the quail diet, and Polygonaceae in the case of the tinamou. Although these two species share some of their food in common, up to now there is no confirmation of a competitive interaction, which could have led to a decrease of the species being outcompeted (i.e., the tinamou). Indeed, for the Chilean Tinamou, [3] reported that "Numbers have been much reduced in recent years, especially in the north of its range, where it is now scarce. It is the most prized game-bird in Chile and is hunted with guns and dogs, as well as being trapped illegally." Although not stated, competition by the California Quail seems not to be involved in such tinamou population decrease.

At our study site in central Chile, during autumn of 2022 (Table 3), the food item with the highest occurrence in the diet was the alien invasive blackberry (*Rubus ulmifolius*, a Rosacea) either as seed (100% of 11 crops and stomachs), fruit (64%), or vegetative tissue (55%), followed by the Rosacea *Quillaja saponaria* (seeds in 82% of 11 crops and stomachs, but not as fruits or tissue); insects occurred in only 9% of the crops and stomachs. The food items with the highest frequency in the diet were *R. ulmifolius* seeds (65% of items), *Q. saponaria* seeds (6%), and unidentified seeds (12%). The food items with the highest biomass in the diet were *R. ulmifolius* fruits (57% of total biomass consumed), *R. ulmifolius* seeds (22%), and *Q. saponaria* seeds (8%). The animal component of the diet was negligible by biomass, represented by two beetles (Coleoptera) and one unidentified insect species. More than a strict granivore, quails from central Chile behaved as granivores/frugivores, at least during autumn, with blackberry fruits and seeds contributing over 80% of the biomass in their diet. Interestingly, [49] analyzed the interactions of avian frugivores and plants in a neighboring shrubland, but failed to mention the California Quail as a fruit eater. The ecological consequences of this alien bird feeding on the invading blackberries and perhaps dispersing their viable seeds is worth investigating, because it fits the scenario called "invasional meltdown," wherein nonindigenous species benefit from their positive interactions [60]. Indeed, in central Chile, California Quail often takes shelter under blackberry bushes. Navas [44] reported for this bird in Argentina a mixed diet with berries, fruits, and seeds (but not their proportions or taxonomic identification), and a few unidentified insects and arachnids. According to him, the California Quail has found an "empty niche" there, thus discarding competition with

Table 3 California Quail diet in central Chile during autumn 2022 based on numerical frequency of occurrence over 11 stomachs and by total biomass

Diet items	Family/Order	Species	Occurrence (%)	Biomass (%)
Seeds	Rosaceae	*Rubus ulmifolius*	100.0	21.4
	Rosaceae	*Quillaja saponaria*	81.8	7.5
	Fabaceae	*Acacia caven*	36.4	2.4
	Fabaceae	Unidentified sp.	36.4	0.4
	Anacardiaceae	*Lithraea caustica*	27.3	0.9
	Celastraceae	*Maytenus boaria*	36.4	1.3
	Loranthaceae	*Tristerix tetrandrus*	9.1	1.1
	Unidentified	Unidentified sp.	63.6	0.7
Fruits	Rosaceae	*Rubus ulmifolius*	63.6	56.3
	Loranthaceae	*Tristerix tetrandrus*	9.1	0.2
	Unidentified	Unidentified sp.	18.2	2.7
Leaves	Rosaceae	*Rubus ulmifolius*	54.5	0.4
	Celastraceae	*Maytenus boaria*	9.1	0.0
	Unidentified	Unidentified	27.3	4.7
Insects	Coleoptera	Unidentified sp. 1	9.1	0.0
	Coleoptera	Unidentified sp. 2	9.1	0.0
	Unidentified	Unidentified sp.	9.1	0.0
Total stomachs			11	100.0
Total biomass (g)				45.3

sympatric animals. Whether the California Quail competes for food with granivorous/frugivorous birds and small mammals is an open question. Interactions with humans, apart from hunting (see below) and commercial farming have not been reported, but [72] noted that quails are not present in city parks of Santiago.

Only six studies reported predation of California Quail by Chilean raptors. Jiménez and Jaksic [33] and [34] detected two quails in a sample of 311 regurgitated pellets of the Austral Pygmy Owl *Glaucidum nanum* [13]*;* reported three among 68 pellets of the Cinereous Harrier *Circus cinereus*; and [14], citing [24], an unquantified occurrence in the diet of the Chilean Accipiter *Accipiter chilensis*. Rivas-Fuenzalida et al. [53] and [54] reported having once observed a Rufous-tailed Hawk (*Buteo ventralis)* and a White-throated Hawk (*Buteo albigula*) to kill one quail each in southern Chile. It thus seems that California Quail is rarely preyed on by some Chilean raptors, and not at all by Chilean carnivores. The only one observation reported on quail predation in Argentina was of a White-throated Hawk as well [54].

Hunting quotas

The Chilean Hunting Law and Bylaws [39] in Article N° 5 of the bylaws provides for California Quail the following daily bag limits per licensed hunter: 15 individuals (from Arica-Parinacota to Atacama Regions), 25 (from Coquimbo to Maule Regions), 25 (from Bio Bío to Los Lagos Regions), and 10 (from Aysén to Magallanes Regions), between 01 April and 31 August of each year. In Argentina, according to [50], there are no bag limits, and quail hunting is promoted online by several private concerns (e.g., https://www.hookfire.com/Argentina-Uruguay-Wingshooting-Destinations/Tipiliuke-Lodge-Quail-Hunting, https://www.burntpine-travel.com/argentina-quail/).

Conclusion

We have synthesized all data available on California Quail in Chile and Argentina (Fig. 2), noting that more information from the former, but especially from the latter country, is badly needed. As usual with invading species in Chile and Argentina, there has not been much interest in studying them scientifically, and efforts have been chiefly oriented to hunting, controlling, managing, or eradicating them. Interesting scientific opportunities are being missed: For instance, in determining the population genetics of a species such as the California Quail, with introductions and back-introductions that may have left founding effects and genetic bottlenecks in Chile and Argentina, and perhaps some peculiar "Chilean" genetic markers among California (USA) populations. Also, the invasive character of the California Quail deserves further scrutiny. Undeniably, this is a non-native, exotic or alien species, introduced by direct human agency, that has increased its abundance and geographic range within Chile and Argentina. It may thus be labelled as an invader, by any definition [32]. Less clear is its categorization as an invasive species, that is: "(a) exotic species in the process of expansion in a container area; (b) exotic species that inflicts an impact on the environment where it is found" ([32]:4). The California Quail fits part (a) but not necessarily part (b) of that definition. More research is needed to determine the impact of this species in its new environments.

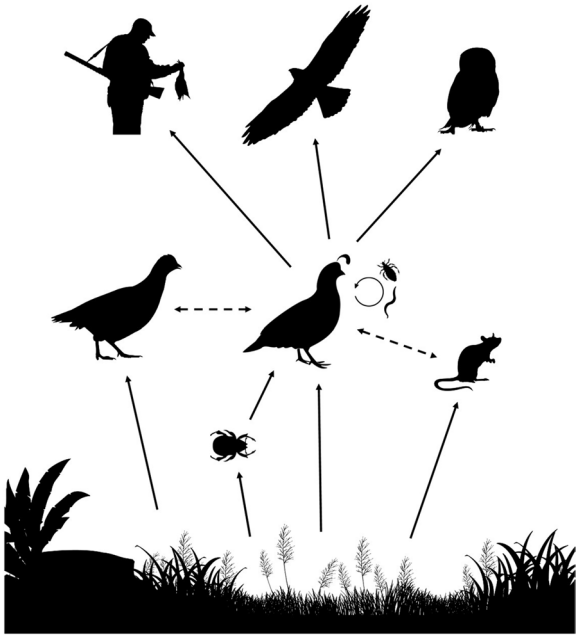

Fig. 2 Idealized food web of California Quail in Chile. Likely links with food plants (leaves, fruits, seeds), potential competitors (tinamous, granivorous/frugivorous rodents), endo and ectoparasites, and predators (hawks and owls)

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Authors' contributions

Conceptualization (FJ); data curation (BA, CZ, FJ); funding acquisition (FJ); investigation (BA, CZ, FJ); writing – original draft (FJ); writing – review and editing (BA, CZ, FJ). The author(s) read and approved the final manuscript.

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Availability of data and materials
Quantitative authors' data that support some of the findings reported in this study are openly available in Research Gate at https://www.researchgate.net/publication/363925762_California_quail_in_Chile_weight_and_length_data.

Declarations

Ethics approval and consent to participate
Not applicable; this is a chiefly a literature review of published sources. With regard to collecting specimens of California Quail, we followed stipulations in Law N° 19473 (Hunting Law and its regulations, see [39]).

Consent for publication
Not applicable; this is a literature review of published sources.

Competing interests
The authors declare no conflict of interest.

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