Winter diet and ingestion of synthetic micro-particles by the Chilean Flamingo *Phoenicopterus chilensis* in Bahía Quinchao, Chiloé, southern Chile

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Abstract

The Chilean Flamingo *Phoenicopterus chilensis* uses several marine wetlands on the Chiloé Archipelago (southern Chile) during winter, yet its trophic ecology and exposure to contaminants in these habitats remain poorly studied. We investigated winter diet and incidental ingestion of synthetic micro-particles at a wintering site located in the Bahía Quinchao marine wetland (42°S). Eleven faecal samples collected in July 2025 were analysed, to identify prey remains and synthetic micro-particles. The diet was dominated by benthic invertebrates – mainly polychaetes (frequency of occurrence (FO) = 100%; relative abundance (RA) = 55.6%) and the foraminiferans *Elphidium williamsoni* (FO = 91%; RA = 22%) and *Ammonia beccarii* (FO = 55%; RA = 11.8%). Other components included small bivalves (FO = 55%) and amphipods of the genera *Monocorophium* and *Parawaldeckia*. Synthetic micro-particles (n = 55) were recorded in 100% of samples. Bahía Quinchao is an important winter foraging habitat for the Chilean Flamingo, supported by abundant infauna associated with intertidal sediments. However, the consistent presence of synthetic micro-particles reveals recurrent exposure to anthropogenic contamination, highlighting the need to integrate this threat into monitoring and conservation programmes for wetlands in southern Chile.

Key words: food items, migratory wading bird, plastic contamination, polychaetes, wintering site.

Flamingos (family: Phoenicopteridae) are highly specialised filter-feeders adapted to exploit microscopic trophic resources through a lamellar bill apparatus and a unique inverted feeding posture (Mascitti & Kravetz 2002; Delfino & Carlos 2024). Their

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strong dependence on shallow wetlands makes them vulnerable to hydrological modification, habitat loss and contamination, threats that explain the unfavourable conservation status of several species at a global scale (Caziani *et al.* 2007; Delfino & Carlos 2024).

The Chilean Flamingo *Phoenicopterus chilensis* has the widest distribution of South America's flamingos, with resident and migratory populations using continental, estuarine and marine wetlands from Peru to Tierra del Fuego, including Argentina, Bolivia, Paraguay and Chile, and with non-breeding records in Brazil, Uruguay and Ecuador (BirdLife International 2018). This species is a benthivorous filter-feeder that exploits small sediment-associated invertebrates – mainly annelids, copepods, ostracods, cladocerans, rotifers and aquatic insects – along with microalgae, cyanobacteria and particulate organic matter (Tobar *et al.* 2017; Polla *et al.* 2018; Aldana-Ardila & Carlos 2021).

In southern Chile, particularly in the Los Lagos Region, the marine and estuarine wetlands of Chiloé and Maullín host a regular wintering presence of the austral population of the Chilean Flamingo (Von Meyer & Espinosa 1998; Cursach *et al.* 2025). These individuals likely breed in the interior wetlands of Argentina and undertake seasonal movements towards the Pacific coast (Von Meyer & Espinosa 1998; Cursach *et al.* 2025). Their winter arrival is associated with the availability of extensive intertidal flats, high benthic productivity and relatively stable conditions during the cold season (Delgado *et al.* 2010). Information on the winter diet of the Chilean Flamingo in these marine wetlands is scarce and comes almost exclusively from Caulín Bay (41°S), in Chiloé. There, Tobar *et al.* (2014) described a winter diet dominated by benthic invertebrates, particularly the foraminiferan *Ammonia beccarii*, copepods *Harpacticus* sp. and polychaete. Later, Tobar *et al.* (2017) documented marked interannual variation, with diets that included both benthic invertebrates and non animal items such as algae and plant fibres, composed of up to 15 prey categories.

In the Chiloé Archipelago, plastic debris and microplastics have accumulated for decades on beaches, seafloors and intertidal flats (Hinojosa & Thiel 2009; Hinojosa *et al.* 2011; Ahrendt *et al.* 2021, 2023). Although microplastic ingestion is globally documented in coastal birds (Provencher *et al.* 2017; Wang *et al.* 2021), recent global reviews indicate a complete lack of data for southern South America (Trapletti Lanti *et al.* 2026), leaving its occurrence in Chilean filter feeding and sediment feeding birds virtually unknown. Because flamingos ingest sediment and filter fine particles, their potential exposure to microplastics may be considerable. Therefore, this study aimed to characterise the diet of the Chilean Flamingo and its exposure to synthetic micro-particles at a wintering site located in an intensively used coastal landscape of the Chiloé Archipelago, southern Chile.

Methods

Study area

The study was conducted in the Bahía Quinchao marine wetland (42°32.87'S, 73°24.69'W), located in the southern sector of Quinchao Island, within the Chiloé

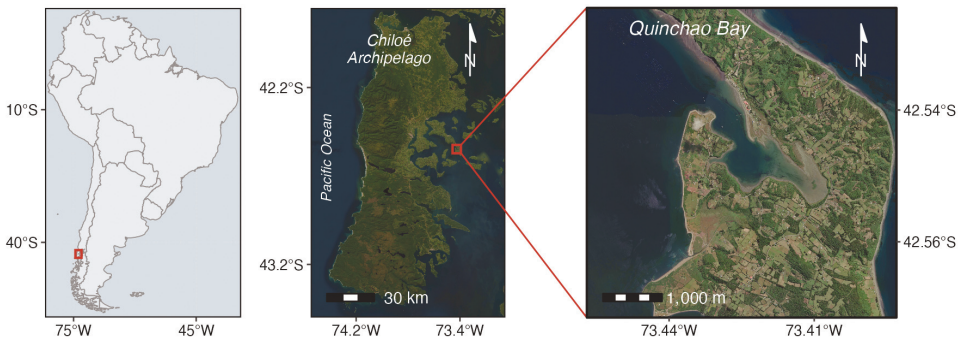


Figure 1. Geographic location of the Quinchao Bay marine wetland, on Quinchao Island, Chiloé Archipelago, southern Chile.

Archipelago. The bay is narrow, elongated and sinuous, with strong tidal influence (Fig. 1). Its shores contain extensive intertidal flats composed of silt and fine sand, while the supratidal zone includes saltmarshes, grasslands, dunes, sandy and gravel beaches, and two small river mouths (FCM 2023). The climate is humid and strongly influenced by the Pacific Ocean, with a mean annual temperature of 12°C and precipitation exceeding 2,000 mm (FCM 2023). Intensive aquaculture activities – mainly salmon and mussel farming – occur in the marine area adjacent to the bay.

Sediments in this marine wetland are dominated by fine sand, medium sand, and a stable proportion of silt, with composition remaining relatively constant throughout the year (Herrera *et al.* 2024). Particle size decreases from the coastal edge toward the interior of the intertidal zone, while the upper intertidal contains a higher proportion of gravel (Herrera *et al.* 2024). Across the upper, middle and lower intertidal levels, the combination of fine sand, medium sand and silt forms a soft substrate that favours the presence and abundance of infauna, particularly polychaete worms (Herrera *et al.* 2024).

Data collection

The diet of the Chilean Flamingo was assessed by analysing 11 faecal samples collected on 15 July 2025. Each sample corresponded to a different adult in the flock, identified by its plumage colouration through a 60× spotting scope while the birds were feeding and subsequently defecating. Samples were collected at low tide after the birds had left the feeding area. Fresh faecal samples were collected using new polyethylene bags turned inside out and worn as gloves to minimise contamination from external fibres (Coughlan *et al.* 2025). The samples were air dried and processed in the laboratory following the methods of Tobar *et al.* (2014, 2017).

Taxonomic identification of prey remains was conducted using a stereomicroscope (10–30×) and a compound optical microscope (400×). Prey were identified using taxonomic guides (Araya & Zúñiga 1985; Goddard & Zúñiga 1995), and microscope photographs of diagnostic

structures were taken using a Sony DSC-HX200V camera mounted on the microscope. Frequency of occurrence (FO) was determined for each prey category. Polychaete individuals were quantified based on paired jaws, as the rest of the body is typically digested; copepods were quantified using cephalothoraxes and amphipods using heads and thoraxes (Tobar *et al.* 2014, 2017).

All suspected synthetic micro-particles present in the samples were separated and classified by colour, following operational criteria commonly used in studies of synthetic micro-particle presence and ingestion (Provencher *et al.* 2017; Wang *et al.* 2021; Coughlan *et al.* 2025). Synthetic micro-particles were not measured individually due to their small size and because the objective of the study was to document their occurrence rather than to describe their morphometric features.

Data analysis

The number of prey remains and synthetic micro-particles was recorded for each faecal sample. From this we calculated frequency of occurrence (FO), defined as the proportion of samples in which each item appeared, and relative abundance (RA), defined as the proportion of total prey remains represented by each item.

Results

Faecal analysis indicated that the diet was composed primarily of benthic invertebrates, with a clear dominance of polychaetes and foraminiferans (Table 1). Polychaetes were the most representative prey item, occurring in all samples (FO = 100%) and totalling 288 diagnostic jaws, accounting for nearly half of all animal items (RA = 55.6%). Amongst foraminifera, *Elphidium williamsoni* appeared in 10 of 11 samples (FO = 91%), with 114 remains (RA = 22%), while *Ammonia beccarii* was detected in six samples (FO = 55%), totalling 61 remains (RA = 11.8%).

Other components of the infauna were present in lower proportions (Table 1). Small bivalves (Veneridae) were detected in six samples (FO = 55%), with 12 diagnostic remains (RA = 2.3%). The amphipods *Monocorophium insidiosum* and *Parawaldeckia kidderi* occurred in seven (FO = 64%) and three samples (FO = 27%), respectively, totalling 25 (RA = 4.8%) and 18 (RA = 3.5%) remains.

Ingestion of synthetic micro-particles was widespread, with fragments detected in 100% of faecal samples (Table 1). A total of 55 fragments were recorded, with a marked dominance of blue colour (32 fragments), followed by red (13), green (7) and white (3). Fragments corresponded to sub-millimetric to few-millimetre particles, mostly rigid and with irregular edges (Fig. 2).

Discussion

The winter diet of the Chilean Flamingo sampled in the Bahía Quinchao was dominated by benthic invertebrates, mainly polychaetes and foraminiferans, confirming the trophic use of muddy intertidal flats as foraging habitat. In addition, the detection of synthetic micro-particles in all faecal samples demonstrates direct exposure to anthropogenic particulate pollution, representing a relevant preliminary record for the species in southern Chile.

Table 1. Number of prey remains and synthetic micro-particles found in 11 Chilean Flamingo faeces collected in July 2025 in the Quinchao Bay marine wetland, Chiloé, southern Chile.

Items	**Faeces**										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Polychaeta	22	62	43	8	30	15	51	17	25	11	4
Elphidium williamsoni	63	3	3	1	0	1	20	7	14	1	1
Ammonia beccarii	3	0	0	0	0	0	18	6	19	4	11
Monocorophium insidiosum	0	0	5	3	0	0	1	6	1	1	8
Parawaldeckia kidderi	0	0	0	0	0	0	0	7	1	0	10
Veneridae	0	0	0	0	1	1	1	0	1	1	7
Total animal remains	**88**	**65**	**51**	**12**	**31**	**17**	**91**	**43**	**61**	**18**	**41**
Blue particles	0	4	5	1	3	3	6	1	4	3	2
Red particles	1	2	0	1	4	2	0	1	0	2	0
Green particles	1	3	0	0	2	0	1	0	0	0	0
White particles	1	0	0	0	1	0	0	1	0	0	0
Total synthetic micro-particles	**3**	**9**	**5**	**2**	**10**	**5**	**7**	**3**	**4**	**5**	**2**

In Bahía Quinchao, benthic infauna is composed of 23 families, with a strong representation of Annelida, Mollusca and Cnidaria, reflecting a diverse assemblage associated with fine-sediment substrates (Herrera *et al.* 2024). Annelida is the most abundant group across all intertidal levels locally, particularly the families Naididae, Nereididae, Maldanidae and Orbiniidae (Herrera *et al.* 2024). Additional taxa include arthropods of the families Cirolanidae and Idotheidae, and cnidarians of the family Actiniidae (Herrera *et al.* 2024). Among molluscs, the families Mytilidae, Mactridae, Psammobiidae, Semelidae, Veneridae, Trochidae and Ranelidae are widely represented, with higher abundances in the upper intertidal zone (Herrera *et al.* 2024). This benthic composition is consistent with the soft-sediment structure of the wetland and with our results, in which the Chilean Flamingo consumed mainly polychaetes and foraminiferans.

The only comparable information on the winter diet of the Chilean Flamingo in marine wetlands of southern Chile comes from Caulín Bay, where Tobar *et al.* (2014, 2017) documented diets dominated by

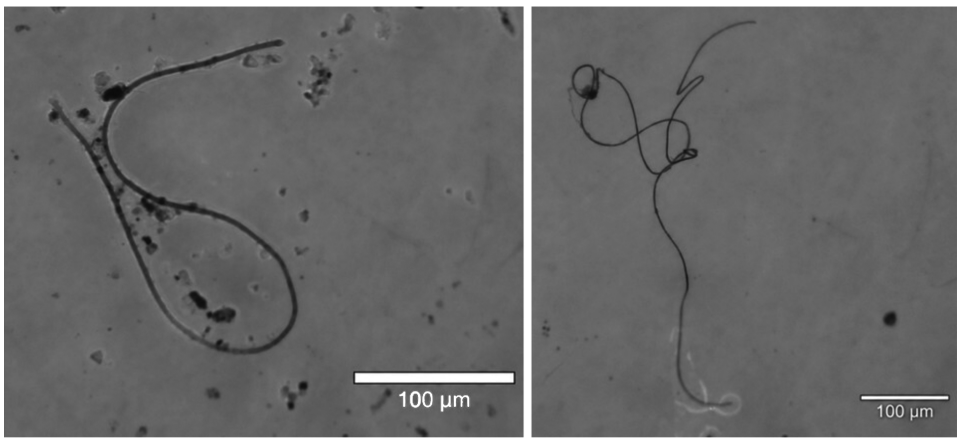


Figure 2. Photographs of some synthetic micro-particles found in 11 Chilean Flamingo faeces collected in July 2025 in the Quinchao Bay marine wetland, Chiloé, southern Chile.

benthic invertebrates, particularly *Ammonia beccarii*, *Harpacticus* sp. and polychaetes, with marked interannual variability. In Quinchao, although sampling was limited to a single winter (2025), the diet was also diverse but showed a much stronger dominance of polychaetes and foraminiferans.

The detection of synthetic micro-particles in all faecal samples represents, to our knowledge, one of the first records of microplastic ingestion by the Chilean Flamingo in marine wetlands of southern Chile. A recent study from Laguna Chaxa, in the Atacama Desert, reported microplastics in faeces of Phoenicopteridae but did not identify the species involved (Hormero 2025). The presence of synthetic micro-particles in all samples suggests recurrent exposure to particulate anthropogenic contamination, consistent with the tendency of microplastics to accumulate in muddy, organic-rich, low-energy sediments (Prajapati *et al.* 2024; Van Daele *et al.* 2024). In Bahía Quinchao, these sediments coincide with the areas used by the Chilean Flamingo for foraging and with the habitat where its main benthic prey are concentrated, potentially facilitating incidental ingestion of synthetic micro-particles during feeding.

Like other benthic foragers, such as fishes and crayfish, which incidentally ingest microplastics while feeding on benthic invertebrates (Coccia *et al.* 2026), the Chilean Flamingo likely takes in synthetic micro-particles through the consumption of polychaetes and foraminiferans associated with muddy sediments. The predominance of blue fragments observed in this study is consistent with findings from both aquatic vertebrates (Coccia *et al.* 2026) and waterfowl in Great Britain and Ireland (Coughlan *et al.* 2025), suggesting that blue-coloured particles are among the most ingested forms of microplastics across a wide range of aquatic consumers.

The presence of synthetic micro-particles in Bahía Quinchao sediments aligns with

contamination patterns described for the inland sea of Chiloé and northern Chilean Patagonia, where numerous studies have documented abundant floating debris and microplastics in surface waters, beaches and seafloor habitats (Hinojosa & Thiel 2009; Hinojosa *et al.* 2011; Ahrendt *et al.* 2021, 2023). Among local sources, mussel and salmon aquaculture stands out as a dominant contributor of fragments, foams and fibres, a pattern consistently reported in fjords and channels of southern Chile (Hinojosa & Thiel 2009; Jorquera *et al.* 2022; Leppes *et al.* 2025). Additionally, the hydrodynamics of the inland sea of Chiloé promote the formation of retention zones and the deposition of particles from remote sources in low-energy muddy substrates, which act as natural sinks for microplastics (Hinojosa *et al.* 2011; Jorquera *et al.* 2022). Nearby aquaculture and fisheries should be considered potential sources of plastic contamination. However, the absence of direct sediment analyses, polymer characterisation, and source tracing prevents attribution of the detected particles to specific origins.

This scenario is particularly relevant given that the Chilean Flamingo is classified as Near Threatened at both global and national levels (BirdLife International 2018; MMA 2026). Its dependence on marine wetlands under anthropogenic pressure, combined with the increasing presence of microplastics in the intertidal sediments of Chiloé (Jorquera *et al.* 2022; Ahrendt *et al.* 2023), may increase its vulnerability. Recurrent ingestion of plastics may affect bird health through obstruction, internal abrasion, reduced feeding capacity and exposure to polymer-associated contaminants, effects widely documented in marine and coastal birds (Provencher *et al.* 2017; Wang *et al.* 2021). The detection of synthetic micro-particles in all samples suggests that Bahía Quinchao is a priority site for monitoring interactions between microplastics and waterbirds in coastal ecosystems of southern Chile.

Our results should be interpreted as preliminary. The small sample size and sampling restricted to a single period prevent assessment of seasonal and interannual variability in diet. It is also unclear whether ingestion of synthetic micro-particles reflects a persistent pattern or a temporary condition of the site. Future studies should incorporate repeated sampling across seasons and years, comparative analyses among wetlands, characterisation of synthetic micro-particles in sediments and prey, and chemical identification of polymers using specialised techniques (*e.g.* Cesarini *et al.* 2025). Such an approach would allow a more robust evaluation of the relationship between food availability, intertidal habitat use, and exposure to plastic contamination, assisting conservation strategies for the Chilean Flamingo and marine wetlands of Chiloé. Together, these findings identify Bahía Quinchao as both an important wintering site and a priority area for monitoring plastic contamination in migratory flamingos.

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Photograph: Chilean Flamingos in Bahía Quinchao, Chiloé, Chile, by Claudio Delgado.