UPDATED DISTRIBUTION AND POPULATION DYNAMICS OF MAGELLANIC PENGUIN *SPHENISCUS MAGELLANICUS* COLONIES IN THE STRAIT OF MAGELLAN, CHILE

MANUEL OCHOA-SÁNCHEZ[1*,2,3], JORGE ACEVEDO[2*], CLAUDIO MORAGA[2], KATHERINE GAETE[2], PEDRO VALENZUELA[2], VALERIA SOUZA[1,2] & ELIANA PAOLA ACUÑA GOMEZ[2]

*[1]Instituto de Ecología, Universidad Nacional Autónoma de México, Mexico City, Mexico *(manuel.ochoa@iecologia.unam.mx)*
*[2]Centro de Estudios del Cuaternario de Fuego - Patagonia y Antártica (CEQUA), Punta Arenas, Chile *(jorge.acevedo@cequa.cl)*
[3]Posgrado en Ciencias Biológicas, Universidad Nacional Autónoma de México, Mexico

Received 15 January 2024, accepted 09 May 2024

ABSTRACT

OCHOA-SÁNCHEZ, M., ACEVEDO, J., MORAGA, C., GAETE, K., VALENZUELA, P., SOUZA, V. & ACUÑA GOMEZ, E.P. 2024. Updated distribution and population dynamics of Magellanic Penguin *Spheniscus magellanicus* colonies in the Strait of Magellan, Chile. *Marine Ornithology* 52: 277–282.

The Magellanic Penguin *Spheniscus magellanicus* exhibits a broad latitudinal distribution in southern South America. However, the locations of many breeding colonies remain poorly known on the Pacific side, particularly in the southernmost region. Here, we provide information for six Magellanic Penguin colonies in the Strait of Magellan and adjacent waters that have been known by the local community for years but were unknown in the scientific literature until now: Rupert Islet, Tuckers Islet 1, Tuckers Islet 2, James Island 1, James Island 2, and Monmouth Island. These locations differ in population size and in vegetation coverage: most colonies are characterized by mosses, grasses, and bushes, but a dense forest cover characterizes Tuckers Islet 2. These records update our knowledge of the distribution of Magellanic Penguin colonies on the southernmost tip of South America.

Key words: environmental refugee, seabird distribution, behavioral plasticity, subantarctic penguin colonies

INTRODUCTION

Penguin species differ in several natural history traits, such as breeding strategy. Some penguins dig burrows to rear and protect their chicks (e.g., *Spheniscus* spp.), others build nests in slight cavities on the surface (e.g., *Pygoscelis* spp.), and a few rear their chicks in the open (e.g., *Aptenodytes* spp.; Borboroglu & Boersma 2013). In the case of the Magellanic Penguin *Spheniscus magellanicus*, nest-site selection varies across its distribution. Most Magellanic Penguins breed in burrows dug in bare soil or under bushes, while others build nests in burrows dug under dead trees (Stokes & Boersma 1991, 1998; Miranda *et al.* 2009). Interestingly, birds breeding at higher latitudes can nest successfully in open scrapes (Boersma *et al.* 2013). A potential driver of this nest-site variability could be the interaction between climate conditions, vegetation cover, and predator pressure. Nests covered by vegetation (e.g., bushes, grasses) or soil (i.e., burrows) improve chicks' survival probabilities (Frere *et al.* 1992, 1998; Stokes & Boersma 1998) in two important ways: predation avoidance from aerial predators (e.g., skuas *Stercorarius* spp.) and environmental protection from winds, rain, and heat loss (Gandini *et al.* 1997, 1999). Chicks under three weeks of age are particularly vulnerable to heat loss, since their metabolic rate is low and their feather coat is not thick enough to provide insulation (Taylor 1985, Duchamp *et al.* 2002).

The Magellanic Penguin inhabits the coasts of South America (Boersma *et al.* 2013), breeding in a range that spans more than 15° of latitude. On the Atlantic coast, the northernmost colony is on Islote Redondo (Redondo Islet, 41°26′S) in Argentina. In contrast, the northernmost colony on the Pacific coast is on Isla Cachagua (Cachagua Island, 32°35′S) in Chile (Boersma *et al.* 2013). The breeding range extends slightly beyond the southernmost tip of the continent, to Chile's Diego Ramirez Islands (56°31'S), and Magellanic Penguin nests have also been reported on Islas Malvinas (Falkland Islands; Schlatter & Riveros 1997, Barroso *et al.* 2020) and Isla de los Estados (Staten Island; Raya Rey *et al.* 2022). Magellanic Penguin breeding colonies have been predominantly studied in Argentina (Boersma *et al.* 2013), but the distribution of their colonies remains much less explored on the Pacific coast, especially in the Magallanes region of Chile, where Magellanic Penguins are common seabirds.

Historically, Magdalena Island is the most well-known Magellanic Penguin colony in the Strait of Magellan and was named "Monumento Natural Los Pingüinos" by Chile's Corporación Nacional Forestal in 1982 (Bingham & Herrmann 2008). Other efforts to update the distribution of breeding colonies in the area (Fig. 1) reported sites at Rupert Island (Soto 1990, Acevedo *et al.* 2007, Miranda *et al.* 2009, Acevedo *et al*. 2014), Contramaestre Island (Bingham & Herrmann 2008, CEQUA 2018), Offing Island (Legoupil *et al.* 2011), and Recalada Island (Oehler *et al.* 2007). However, there are likely unknown colonies throughout the Magallanes region, with several colonies probably associated with concentrations of individuals observed foraging at several places in the Strait. As well, the penguins were a common natural resource for Indigenous peoples in some of these localities (Legoupil *et al.* 2011). Thus, the locals knew where the colonies were located.

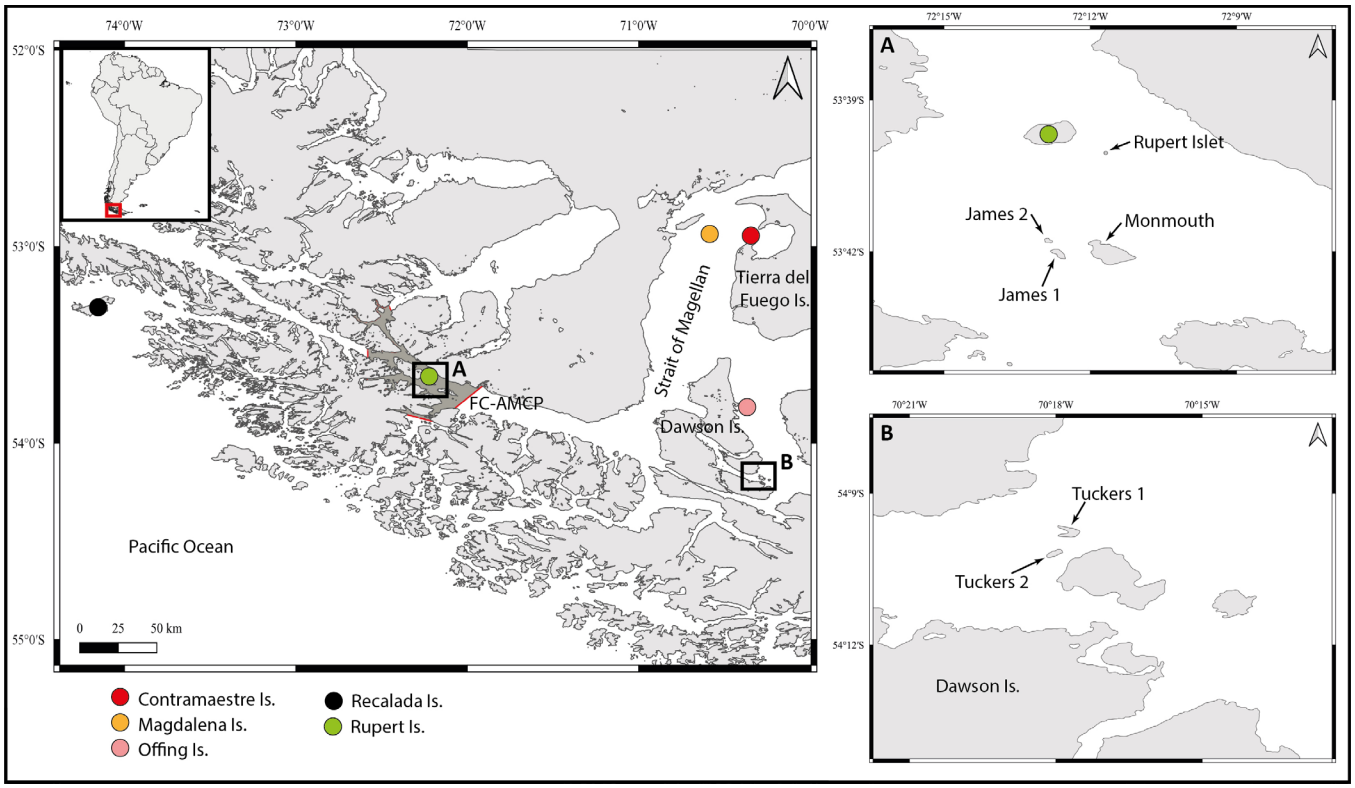

Fig. 1. Location of known and new Magellanic Penguin *Spheniscus magellanicus* colonies in the Strait of Magellan and adjacent waters in southern Chile. Previously known colonies are depicted by circles and new colonies are indicated with arrows. Inset A) shows the colonies in the Francisco Coloane Marine and Coastal Protected Area in the northwestern section of the Strait of Magellan. Inset B) shows the southern end of Dawson Island, where the Tuckers 1 and Tuckers 2 colonies are located. The location of FC-AMCP is shown in a grey shaded polygon.

Here, we report new Magellanic Penguin colonies in the Strait of Magellan and adjacent waters that have been known for years by members of the local communities but were not documented in the literature, including previously unpublished census information collected by one of the authors (JA). All these colonies were visited while conducting sampling for the ongoing project *Microbiome of the external surface of keystone species of ecological and economic importance in the Magellanes region and the Chilean Antarctic* (see Ochoa-Sánchez *et al.* 2023a for a description of the project).

MATERIALS AND METHODS

In 2007, Magellanic Penguin breeding colonies in the Francisco Coloane Marine and Coastal Protected Area (FC-AMCP, northern and southern boundaries are 53°43′S, 071°52′W and 53°17′S, 072°26′W, respectively) were censused as part of the project *Diagnóstico de flora, fauna terrestre y aves marinas en el Área Marina Costera Protegida Francisco Coloane* (Acevedo *et al.* 2007) at the beginning of the chick-rearing period. In 2013, another census was conducted as part of the project *Diagnóstico de relación predadores – presas del Área Marina Costera Protegida Francisco Coloane* (Acevedo *et al.* 2014), this time during the incubation period. Both surveys were carried out by researchers with experience in penguin censuses and covered the known breeding colony of Rupert Island, and the new breeding colonies: two colonies on separate landmasses in the James Islands and a single colony on Monmouth Island (Fig. 1).

In both 2007 and 2013, the population size of each colony was estimated (Acevedo *et al.* 2007, 2014) using circular plots of 100 m^2 (see Borboroglu *et al.* 2002 for a detailed description of survey methods). Briefly, the first plot was placed at a random point and the remainder were placed in a ~35-m zigzag path through the colony area. Within each circular plot, the total number of burrows was counted, and each burrow was categorized as active or inactive. A nesting burrow was considered active when it contained adults, eggs, or chicks; it was considered inactive if it had none of these. The breeding-area boundaries of each colony were estimated from georeferenced points using a handheld GPS unit (Garmin e-Trex H; Olathe, USA), with the data subsequently plotted on a satellite image using the ArcView program (Environmental Systems Research Institute; Redlands, USA). These georeferenced points were then used to define the area occupied by the penguins, resulting in a polygon of the nesting boundaries. To estimate a raw population size ($\hat{N}$), Acevedo *et al.* (2007, 2014) utilized the formula $\hat{N} = d \times A$, where d is the average burrow density per square meter and A is the nesting area in square meters (m^2). To obtain 95% confidence intervals and the corrected mean, they explored the spatial pattern distribution of the data following the methods of Krebs (1999) and performed a U-Statistic goodness-of-fit test to confirm whether the distribution of the data was further supported.

During 2022 and 2023, breeding colonies in the Strait of Magellan were revisited, from the known breeding colony at Contramaestre Island (52°56′35″S, 070°21′29″W) to Rupert Island at FC-AMCP

(53°39′40″S, 072°12′43″W), including the new colonies on Tuckers Islets (54°09′59″S, 070°17′48″W; Acevedo *et al*. 2024) (Fig. 1). The breeding colonies were revisited between October and January/February as part of the project *Microbiome of the external surface of keystone species of ecological and economic importance in the Magallanes region and the Chilean Antarctic: Microbes as bioindicators of the aquatic ecosystem health in a global warming scenario* (see Ochoa-Sánchez *et al*. 2023a for a description of the project and Ochoa-Sánchez *et al*. 2023b, 2024 for sampling details and findings about penguin body microbiota). This allowed us to update the presence/absence of the locally known and new breeding colonies and to describe each colony's vegetation habitat.

RESULTS AND DISCUSSION

Unreported breeding colonies were found on six islands/islets in the study region (Fig. 1). These landmasses varied considerably in their topography and vegetation cover, highlighting the phenotypic plasticity exhibited by Magellanic Penguins in their choice of nesting habitat (Fig. 2). We describe each of the six colonies below.

Tuckers islets colonies

Penguins were found nesting at two separate colonies at Tuckers Islets, which comprise two islets situated near the southwestern coast of Dawson Island in Whiteside Channel, Tierra del Fuego Island, Chile (Fig. 1B). There was one colony on each islet. The northern islet (Tuckers 1) is 9.55 ha (0.0955 km^2) and is shaped like a U that opens to the west. It has a heterogeneous vegetation cover, dominated by tall grasses (family: Poaceae), shrubs (Fig. 2A), and the remains of desiccated dead trees (likely the remains of *Nothofagus* spp.), under which penguin burrows were found (Fig. 2F). In higher-altitude areas of the islet, the colony was dominated mainly by bare soil; in some areas, it was dominated by *Sphagnum* spp. mosses. Burrows were primarily associated with tall grasses and shrubs, though smaller numbers of nests were observed where the ground was bare, in the roots of dead trees, and sparingly in the *Sphagnum* area. A recent survey of Tuckers 1 resulted in an estimate of 2218 breeding pairs (95% confidence interval (CI) 1593–2840; Acevedo *et al.* 2024). In contrast, the southern islet (Tuckers 2) is 7.2 ha and oval-shaped. Its vegetation cover is a homogenous, dense forest dominated by *Nothofagus* spp. (Fig. 2B), and penguins nest both in holes inside fallen trees (Fig. 2G) and

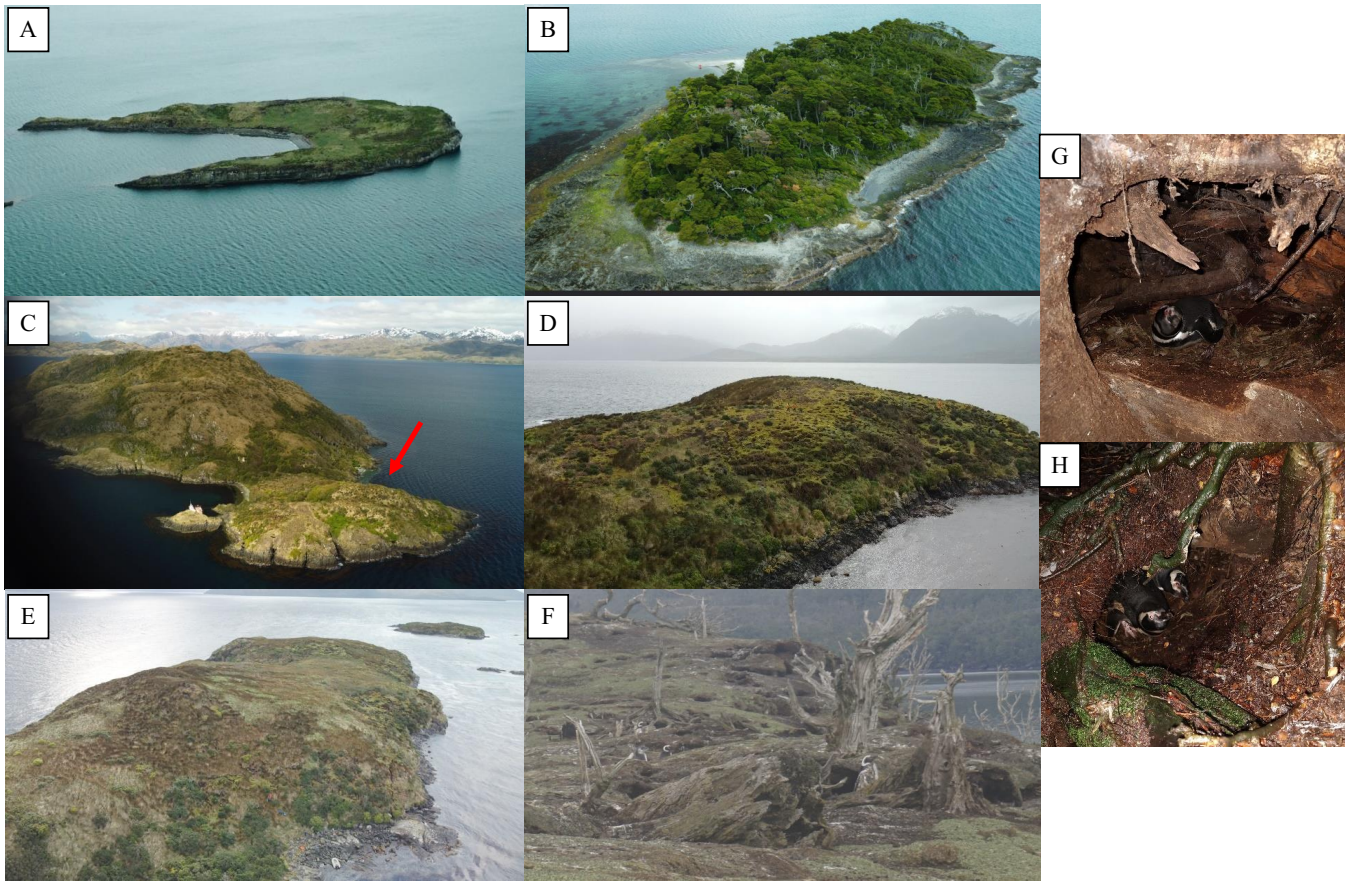

Fig 2. Environmental characteristics of the six newly identified Magellanic Penguin *Spheniscus magellanicus* colonies in the Strait of Magellan in southern Chile. Images (A–E) show the overall vegetation on the islet or island, while F–H show examples of nesting sites. A) Tuckers 1 is characterized by heterogeneous vegetation with tree remnants, bushes, grasses, and mosses. B) Tuckers 2 is characterized by dense forest cover. C) Monmouth Island is characterized by heterogeneous vegetation with bushes, mosses, and forest. The specific location where penguin burrows were located are indicated with a red arrow. Rupert Islet (D) and the James Islands (James 1 and 2; E) are characterized by heterogeneous vegetation including bushes and mosses. F) Penguins on Tuckers 1 nest below the remnants of dead trees. On Tuckers 2, penguins nest inside a hollow of a fallen tree (G) and between the roots of living trees (H). Photo credits: A–B) Pedro Valenzuela, January 2022; C–E) Pedro Valenzuela, December 2023; F–H) Manuel Ochoa-Sánchez, January 2022.

below the roots of living trees (Fig. 2H). No census was carried out during our visits to this second islet due to the density of the forest.

FC-AMCP

Colonies at Monmouth Island, the James Islands, and Rupert Islet are located in the FC-AMCP (Fig. 1A). All these colonies have been locally known since at least 2006 (Acevedo *et al.* 2007).

Monmouth Island, with a surface approximate of 45.8 ha, is situated to the south of the known breeding colony of Rupert Island. However, the breeding colony occurs only in a small area (0.79 ha) on the northern coast of the island. The nesting area is characterized by heterogeneous vegetation, with tall grasses (family: Poaceae) and shrubs (*Gaultheria mucronata* and *Hebe elliptica*) alternating with *Nothofagus betuloides* and *Drimys winteri* forest (Fig. 2C). The penguin burrows are located under shrubs and in areas without vegetation. Penguins were also seen in the *D. winteri* forest, but we did not explore that habitat further; transiting the island was challenging due to the harsh meteorological conditions. We believe that penguins would likely nest under living trees, as they do at the Tuckers 2 colony, but further surveys are required to confirm this. A census conducted in 2007 estimated a population of 316 breeding pairs (Acevedo *et al.* 2007), which declined to 42 (95% CI 22–61) pairs in 2013 (Acevedo *et al.* 2014). No census was conducted during our short visits in October 2022 and October–November 2023, but the colony may continue to have a low number of pairs due to the large proportion of empty nests found throughout the surveys.

James Islands comprise two small islands located northwest of Monmouth Island (Fig. 1A). There was one colony on each island. James Island 1 (James 1) is 2.05 ha and James Island 2 (James 2) is 1.59 ha. Both are characterized by a homogenous cover of bushes (*G. mucronota*; Fig. 2D) with nests distributed throughout. In 2007, there were an estimated 2052 breeding pairs on James 1 and 1536 on James 2 (Acevedo *et al.* 2007). This trend changed six years later: in 2013, there were an estimated 384 (95% CI 183–468) and 373 (95% CI 139–571) breeding pairs on James 1 and 2, respectively (Acevedo *et al.* 2014). No census was conducted during our short visits in October–November 2022, but we suspect that the colony could continue to have a low number of pairs, again, in line with the large proportion of unoccupied nests found throughout our short survey.

Rupert Islet (2.54 ha) is located to the south of Rupert Island and to the northeast of Monmouth Island. It is characterized by a heterogeneous cover of grasses (family: Poaceae), shrubs (*G. mucronata* and *H. elliptica*), and *Sphagnum* spp. mosses (Fig. 2D). Nests occur mostly in the upper part of the islet. No population census has been conducted.

These six colonies are new for the scientific literature and their inclusion here expands the knowledge of penguin breeding-colony distribution on the southernmost tip of South America. We also increase our knowledge about the Magellanic Penguin population size and its associated changes, particularly in the FC-AMCP. In that area, the low number of breeding pairs on Monmouth and James islands in 2013 coincides with a 28.4% increase in the number of breeding pairs on Rupert Island (Acevedo *et al.* 2014). However, the total population estimate in FC-AMCP (combining Rupert Island, Monmouth Island, and James 1 and 2) has remained relatively stable between 2007 (n = 9692) and 2013 (n = 8892). Therefore, these sites may constitute a "meta-colony" with interacting parts.

Similarly, it appears that penguins from Tuckers 1 are moving to Tuckers 2. This is indicated by the low burrow occupancy coupled with increased erosion on Tuckers 1 (Acevedo *et al.* 2024), which was not observed on Tuckers 2. Erosion may be a consequence of penguin burrowing, as has been reported on Punta Entrada (50°08′S, 068°21′W, 460 km northeast) at the mouth of the Santa Cruz River estuary (Ercolano *et al.* 2016) and Martillo Island (54°54′S, 067°22′W, 200 km southeast) in Beagle Channel (Quiroga *et al.* 2020). Further monitoring and tracking of penguins at Tuckers 1 and 2 are required to better understand these dynamics. Magellanic Penguins nesting in the forest could influence erosion and ecological succession. In the long term, penguins nesting on Tuckers 2 could enhance erosion by causing extensive damage to roots, as appears to be the case on Rupert Island (Miranda *et al.* 2009) and Tuckers 1. Whether the trend of Magellanic Penguins establishing colonies on forest islands continues in this region is an open yet relevant question. Overall, Magellanic Penguins could be considered "ecosystem engineers" that enhance diversity and ecological succession, including the enrichment of soil by nitrogen from their feces (Pisano & Schlatter 1981). This might lead to vegetative succession involving plant species that thrive in high concentrations of nitrogen (e.g., some grass species). Additionally, other animals could use abandoned nests as refuges, especially arthropods. Together these aspects could enhance diversity, but more work is needed to prove this hypothesis.

Recently, Magellanic Penguin colonies in northern latitudes have decreased in numbers due to extreme heatwaves and increased mortality of females (Boersma & Rebstock 2014, Holt & Boersma 2022). This trend is likely to continue since the frequency and intensity of weather anomalies linked to climate change are going to increase in the mid-latitudes of South America, whereas warming in southern latitudes may be less (Feron *et al.* 2019). Because the southernmost region of South America could become a more suitable place for the establishment and persistence of Magellanic Penguin colonies, the specific locations of colonies are valuable information for monitoring the status of this species and its effect on its habitat.

ACKNOWLEDGMENTS

We thank Captain Hugo Cárdenas and the crews of the *MaryPaz II* and *Huracan* for our safe trips and for logistical support and transportation during the surveys. We acknowledge the support of Edy Cadin, Oscar Mancilla, and Alex Marin for their help during fieldwork. The 2022–2023 surveys were framed within the ongoing project *Microbiome of the external surface of keystone species of ecological and economic importance in the Magallanes region and the Chilean Antarctic: Microbes as bioindicators of the aquatic ecosystem health in a global warming scenario* by the Agencia Nacional de Investigación y Desarrollo de Chile (ANID; Strengthening of the Scientific Development of Regional Centers, project number R20F0009). Andrea Raya Rey provided valuable comments to improve our paper.

REFERENCES

ACEVEDO, J., AGUAYO-LOBO, A., DOORN, M.A., ET AL. 2007. *Diagnóstico de flora, fauna terrestre y aves marinas en el Área Marina Costera Protegida Francisco Coloane.* Final Report for Project BIP N°30061426-0. Punta Arenas, Chile: Fundación Centro de Estudios del Cuaternario Fuego- Patagonia y Antártica.

ACEVEDO, J., AGUAYO-LOBO, A., HARO, D., ET AL. 2014. *Diagnóstico de relación predadores-presas del Área Marina Costera Protegida Francisco Coloane*. Final Report for Project ID 612543-3-LE13. Punta Arenas, Chile: Fundación Centro de Estudios del Cuaternario Fuego y Patagonia Antártica.

ACEVEDO J., MORAGA, C.A., GAETE, K., ET AL. 2024. First abundance estimates of Magellanic Penguin (*Spheniscus magellanicus*) colony at Tucker Islets. *Polar Biology* 47: 157–162. doi:10.1007/s00300-023-03215-8

BARROSO, O., CREGO, R.D., MELLA, J., ET AL. 2020. Colaboración científica con la Armada de Chile en estudios ornitológicos a largo plazo en el archipiélago Diego Ramírez: Primer monitoreo del ciclo anual del ensamble de aves en la isla Gonzalo. *Anales del Instituto de la Patagonia* 48(3): 149–168. doi:10.4067/S0718-686X2020000300149

BINGHAM, M. & HERRMANN, T.M. 2008. Magellanic Penguin (Spheniscidae) monitoring results for Magdalena Island (Chile), 2000–2008. *Anales del Instituto de la Patagonia* 36(2): 19–32. doi:10.4067/S0718-686X2008000200003

BOERSMA, P.D., FRERE, E., KANE, O., ET AL. 2013. Magellanic Penguin. In: BORBOROGLU, P.G. & BOERSMA, P.D. (Eds.) *Penguins: Natural History and Conservation*. Seattle, USA: University of Washington Press.

BOERSMA, P.D. & REBSTOCK, G.A. 2014. Climate change increases reproductive failure in Magellanic Penguins. *PLoS One* 9: e85602. doi:10.1371/journal.pone.0085602

BORBOROGLU, P.G. & BOERSMA, P.D. 2013. *Penguins: Natural History and Conservation*. Seattle, USA: University of Washington Press.

BORBOROGLU, P.G., YORIO, P., BOERSMA, P.D., DEL VALLE, H., & BERTELLOTTI, M. 2002. Habitat use and breeding distribution of Magellanic Penguins in northern San Jorge Gulf, Patagonia, Argentina. *The Auk* 119: 233-239.

CEQUA (FUNDACIÓN CENTRO DE ESTUDIOS DEL CUATERNARIO DE FUEGO PATAGONIA Y ANTÁRTICA). 2018. *El Pingüino como Especie Carismática: Herramientas para Desarrollar y Potenciar una Ruta Turística en el Estrecho de Magallanes y Tierra Del Fuego*. Final Report Proyecto Innova CORFO 15BPCR-48591. Punta Arenas, Chile: CEQUA.

DUCHAMP, C., ROUANET, J.-L., & BARRÉ, H. 2002. Ontogeny of thermoregulatory mechanisms in King Penguin chicks (*Aptenodytes patagonicus*). *Comparative Biochemistry and Physiology A* 131: 765–773. doi:10.1016/s1095-6433(02)00014-4

ERCOLANO, B., CRUZ, I. & MARDERWALD, G. 2016. Impacto de los pingüinos patagónicos (*Spheniscus magellanicus*) en la dinámica geomorfológica de Punta Entrada (Patagonia austral, Argentina). *Cuaternario y Geomorfología* 30: 29–47. doi:10.17735/cyg.v30i3-4.51463

FERON, S., CORDERO, R. R., DAMIANI, A., ET AL. 2019. Observations and projections of heat waves in South America. *Scientific Reports* 9: 8173. doi:10.1038/s41598-019-44614-4

FRERE, E., GANDINI, P. & BOERSMA, D. 1992. Effects of nest type and location on reproductive success of the Magellanic Penguin *Spheniscus magellanicus. Marine Ornithology* 20: 1–6.

FRERE, E., GANDINI, P., & BOERSMA, D. 1998. The breeding ecology of Magellanic Penguins at Cabo Vírgenes, Argentina: What factors determine reproductive success? *Colonial Waterbirds* 21: 205–210. doi:10.2307/1521907

GANDINI, P., FRERE, E. & BOERSMA, D. 1997. Efectos de la calidad de hábitat sobre el éxito reproductivo del pingüino de magellanes (*Spheniscus magellanicus*) en Cabo Virgenes Santa Cruz, Argentina. *Ornitología Neotropical* 8: 37–48.

GANDINI, P., FRERE, E. & BOERSMA, D. 1999. Nest concealment and its relationship to predation and reproductive success in the Magellanic Penguin at its southern-most continental colony. *Ornitología Neotropical* 10: 145–150.

HOLT, K.A. & BOERSMA, P.D. 2022. Unprecedented heat mortality of Magellanic Penguins. *Ornithological Applications* 124: duab052. doi:10.1093/ornithapp/duab052

KREBS, C.J. 1999. *Ecological Methodology, 2nd Edition.* Menlo Park, USA: Addison-Wesley Educational Publication.

LEGOUPIL, D., BÉAREZ, P., LEFÈVRE, C., SAN ROMÁN, M., & TORRES, Y.J. 2011. Estrategias de subsistencia de cazadores recolectores de Isla Dawson (Estrecho de Magallanes) durante la segunda mitad del Holoceno: Primeras aproximaciones. *Magallania* 39: 153–164. doi:10.4067/S0718-22442011000200011

MIRANDA, M., GIBBONS, J., CÁRCAMO, J., & VILINA, Y.A. 2009. Hábitat reproductivo y estimación del tamaño poblacional del pingüino de magallanes (*Spheniscus magellanicus*) en Isla Rupert, Parque Marino Francisco Coloane, Estrecho de Magallanes. *Anales del Instituto de la Patagonia* 37(1): 103–111. doi:10.4067/S0718-686X2009000100010

OCHOA-SÁNCHEZ, M., ACUÑA GÓMEZ, E.P., MORAGA, C.A., ET AL. 2024. The ephemeral microbiota: Ecological context and environmental variability drive the body surface microbiota composition of Magellanic Penguins across subantarctic breeding colonies. *Molecular Ecology* 33: e17472. doi:10.1111/mec.1747

OCHOA-SÁNCHEZ, M., ACUÑA GOMEZ, E.P., MORENO, L., ET AL. 2023a. Body site microbiota of Magellanic and King penguins inhabiting the Strait of Magellan follow species-specific patterns. *PeerJ* 11: e16290. doi:10.7717/peerj.16290

OCHOA-SÁNCHEZ, M., ACUÑA GOMEZ, E.P., RAMÍREZ-FENÁNDEZ, L., EGUIARTE, L.E., & SOUZA, V. 2023b. Current knowledge of the Southern Hemisphere marine microbiome in eukaryotic hosts and the Strait of Magellan surface microbiome project. *PeerJ* 11: e15978. doi:10.7717/peerj.15978

OEHLER, D.A., FRY, W.R., WEAKLEY, L.A., & MARIN, M. 2007. Rockhopper and Macaroni Penguin colonies absent from Isla Recalada, Chile. *The Wilson Journal of Ornithology* 119: 502–506. doi:10.1676/06-096.1

PISANO, E. & SCHLATTER, R.P. 1981. Vegetación y flora de las islas Diego Ramírez (Chile). II. Comunidades vegetales vasculares. *Anales del Instituto de la Patagonia* 12: 195–204.

QUIROGA, D.R.A., CORONATO, A., SCIOSCIA, G., ET AL. 2020. Erosive features caused by a Magellanic Penguin (*Spheniscus magellanicus*) colony on Martillo Island, Beagle Channel, Argentina. *Cuadernos de Investigación Geográfica* 46: 477–496. doi:10.18172/cig.4337

RAYA REY, A., BALZA, U., DOMATO, I. & ZUNINO, F. 2022. New Magellanic Penguin *Spheniscus magellanicus* colony in a subantarctic island. *Polar Biology* 45: 1553–1558. doi:10.1007/s00300-022-03093-6

SCHLATTER, R.P. & RIVEROS, G.M. 1997. Historia natural del Archipiélago Diego Ramírez, Chile. *Serie Científica – Instituto Antártico Chileno* 47: 87–112.

SOTO, N. 1990. *Proyecto de protección y manejo de las colonias de pingüinos presentes en Isla Rupert e Isla Recalada, Reserva Nacional Alacalufes. Informe de temporada 1989–1990*. Punta Arenas, Chile: Corporacion Nacional Forestal de Chile.

STOKES D.L. & BOERSMA, P.D. 1991. Effects of substrate on the distribution of Magellanic Penguins (*Spheniscus magellanicus*). *The Auk* 108: 923–933. doi:10.1093/auk/108.4.923

STOKES, D.L. & BOERSMA, P.D. 1998. Nest-site characteristics and reproductive success in Magellanic Penguins (*Spheniscus magellanicus*). *The Auk* 115: 34–49. doi:10.2307/4089109

TAYLOR, J.R.E. 1985. Ontogeny of thermoregulation and energy metabolism in pygoscelid penguin chicks. *Journal of Comparative Physiology B* 155: 615–627. doi:10.1007/BF00694453