FIRST GROUND VISIT TO THE EMPEROR PENGUIN *APTENODYTES FORSTERI* COLONY AT JASON PENINSULA, LARSEN C ICE SHELF, WEDDELL SEA, ANTARCTICA

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ABSTRACT

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The growth of ecotourism leads tour operators to develop means of exploration that facilitate access to remote and difficult-to-reach areas. For instance, new ice-class expedition ships can now bring visitors to isolated places in Antarctica that have never before been visited. In November 2021, a first ground visit was made to the Emperor Penguin *Aptenodytes forsteri* colony at the Jason Peninsula. The result is the first census of the population that has been conducted *in situ*. This example illustrates that reaching extremely isolated places through ecotourism is an opportunity to develop citizen science and collect useful data.

La croissance de l'écotourisme a conduit les tours opérateurs à développer des moyens d'exploration qui facilitent l'accès à des régions lointaines même pour les chercheurs. Par exemple, de nouveaux navires polaires peuvent maintenant rejoindre des lieux isolés qui n'ont jamais été visité en Antarctique. En novembre 2021 eut lieu pour la première fois la visite d'une colonie de Manchot Empereur *Aptenodytes forsteri* à la péninsule de Jason et pour la première fois un recensement de la population a été conduit *in situ*. C'est une opportunité de développer la science citoyenne pour recueillir des données au sujet de la faune sauvage.

Key words: ecotourism, citizen science, Emperor Penguin, Larsen C Ice Shelf, Jason Peninsula, population census

INTRODUCTION

The travel and tourism industry is growing quickly (Sofronov 2018). One branch of tourism that is currently in development is ecotourism (Masberg & Morales 1999). It is meant to be an enlightening nature travel experience that contributes to the conservation of the ecosystem, while simultaneously respecting the integrity of the host communities. The motivations of ecotourists are to appreciate natural and cultural features and to preserve these features while gaining knowledge and understanding (Wight 1996, Khanra *et al.* 2021).

Among eco-destinations, Antarctica has been attracting more and more visitors in recent decades. Totals have increased from 10 000 summer tourists in the first years of the 21st century to 40 000 at the end of the first decade to 55 000 during the austral summer of 2019/20. Around 100 000 visitors are expected for the 2022/23 season (Cruise Industry News 2021). Even though the consequences of Antarctic ecotourism thus far have been regarded as negative (Geffroy *et al.* 2017, Shannon *et al.* 2017), the regular and increasing access to remote destinations should also be considered as a unique and positive opportunity for collecting data that would be difficult, or even impossible, to collect otherwise.

In this context, citizen science programs have become increasingly popular (Silvertown 2009). For instance, the following projects are currently being conducted aboard expedition ships visiting Antarctica: Happywhale, FjordPhyto, Globe Clouds, Penguin Watch, PolarTag, Seabird Surveys, and Secchi Disk (IAATO 2022). Citizen science projects enlist members of the public to record useful observations, which, when pooled together, can create an enormous dataset covering a vast geographic and/or time scale that could not be achieved otherwise. In return, such projects aim to increase participants' connections to science and conservation, while supporting science literacy and environmental stewardship (Dickinson *et al.* 2012).

In Antarctica, the Emperor Penguin *Aptenodytes forsteri* (hereafter penguin) is an iconic species (Jenouvrier *et al.* 2021) that generally forms colonies on fast ice connected to the shore, although colonies can be found on land and ice shelves in a couple of locations (Fretwell *et al.* 2014, 2021). The species is classified as "Near Threatened" by the International Union for Conservation of Nature owing to its use of fast ice for breeding, to its use of pack ice for foraging and moulting, and to the projection by climate models for sea ice to shrink as climate change progresses (Rackow *et al.* 2022). The very nature of this isolated habitat makes information and data collection in real time difficult, due to the logistical challenges to reach it (Ancel *et al.* 2017). Otherwise, colony size and trends on an Antarctic-wide basis have been assessed only remotely (Fretwell *et al.* 2012). Ecotourism in Antarctica and citizen science may help fill this gap opportunistically. Here, I provide a concrete example demonstrating how ecotourism could be used to collect data on species living in a remote environment.

METHODS AND RESULTS

The increasing interest of people in polar regions has encouraged tour operators to build new ships, not only to satisfy an increasing demand but also to help improve the standard of navigation in icy polar waters. Among these new builds, the passenger vessel *Le Commandant Charcot* is among the more innovative ships. Designed to meet the international Polar Class 2 standard (meaning that it can operate year-round in polar waters through sea ice up to three meters thick), the vessel's ice capability competes with only a very few governmental icebreakers, such as the nuclear-powered ones in Russia (Cruise Industry News 2021). This new feature unlocks destinations that were previously inaccessible. During her first Antarctic season, *Le Commandant Charcot* started navigating southbound in the Weddell Sea at the end of November 2021, which is early for an Antarctic cruise. The voyage was called "Larsen C", and the goal was to reach the ice shelf of its namesake.

An excellent weather window and a wide stretch of open water that appeared after a severe storm created an opportunity to proceed towards the Jason Peninsula (Fig. 1). We passed east of Snow Hill Island, where the fast ice closest to the southwestern nunatak of the island is home to the northernmost Emperor Penguin colony (described by Todd *et al.* 2004). During navigation on 23–24 November 2021, the ship's speed was kept low, around 3–4 knots (5.5–7.4 km/h). The vessel was constantly changing course to avoid glacial ice trapped within the sea ice. Once we reached a lead (an opening in the ice, Fig. 1), the ship was able to increase speed to 7 knots in uncharted waters. There were no significant irregularities in the seabed that required a slower speed; continuous depth soundings remained around 200 m. On the evening of 24 November, once we were 25 nautical miles (46.3 km) off the coast of Cape Framnes (65°57′42.17″S, 060°32′15.54″W), we made a reconnaissance flight via the vessel's helicopter.

As expedition leader, my preparatory research revealed that a new Emperor Penguin colony had been discovered in the target region in 2012 using satellite imagery (Fretwell *et al.* 2014). Of the four Emperor Penguin colonies breeding on ice shelves, this one was located on the northern part of the Larsen C Ice Shelf, just south of Cape Framnes on the Jason Peninsula. Based on satellite pictures, the first analyses estimated the population to be around 3800 adults (Fretwell *et al.* 2014). Our objective was to locate this new colony, check the sea ice conditions (if present), plan the ship's route for the safest and most environmentally friendly approach, obtain a census of the population, and collect any other interesting information.

Following Antarctic Treaty Secretariat recommendations (ATCM 2004), we flew at an altitude of 750 m over the ice and found the colony, which was spread out in four subgroups of various sizes at the location detected by Fretwell *et al.* (2014). We located the two largest subgroups on the ice shelf at 66°05′22.12″S, 060°39′58.90″W. There was a band of sea ice from the water's edge

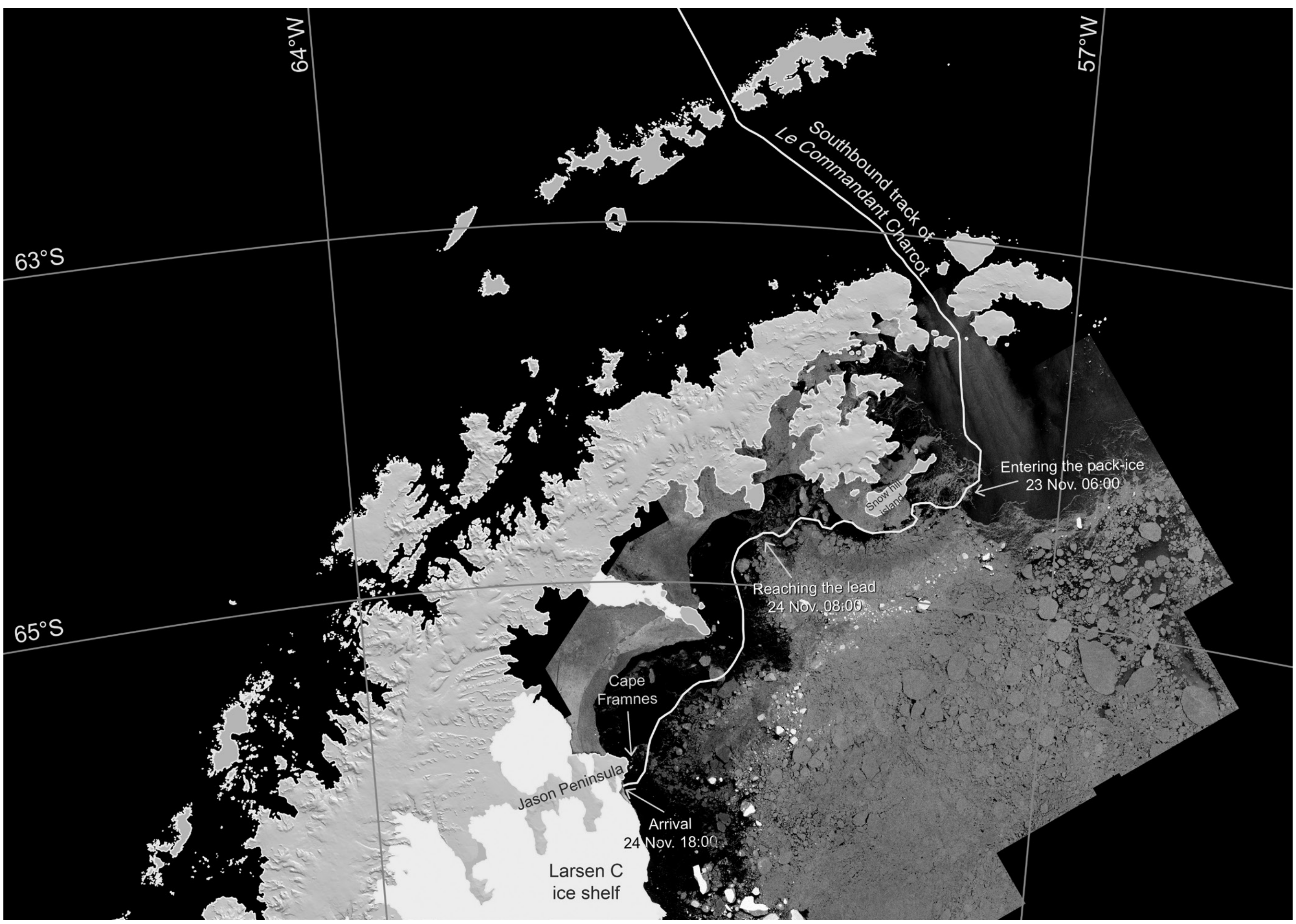

Fig. 1. Assembly of pictures from Sentinel1, a constellation of two satellites taking year-round pictures of the Earth's surface, showing the southbound GPS track of *Le Commandant Charcot* through the pack ice. These images were taken on 25 November 2022 above the Jason Peninsula, Antarctica. Photo credit: Polarview

to the ice shelf. We did not land; we only took pictures from above and flew back to the ship.

The same evening (24 November), we berthed the ship with the bow in the edge of the fast ice at 66°05.648′S, 060°36.043′W, holding a stable and safe position. The stern of the vessel remained in open water, ensuring that no cracks were made in the sea ice (Fig. 2). I organized a reconnaissance walk until midnight with the team of guides. Our group consisted of fewer than 20 people, and since the sun sets just before midnight at this latitude, we had very good light conditions during the evening. I decided that we would make a clear and unique track in the snow by walking in a single line to minimize our impact. First, we walked 1.5 km on the sea ice. The consistency of the sea ice was smooth, very hard, about 1.10 m thick, and covered by 10 cm of fresh snow. We found a place where we could reach the ice shelf safely without disturbing the penguins' access point. We identified a ramp for us to access the ice shelf. At the time of our inspection, this ramp was the least used by penguins compared to the two other ones we observed visually in the area. We then walked 1.8 km to reach the two larger subgroups, leaving the other two subgroups unobserved. Upon arrival, we stopped 50 m away from the edge of the colony (as measured with a laser range finder), which was clearly defined by the position of the chicks. We remained there for roughly an hour to record observations. This was to be the location where we would bring our groups of visitors the following day.

On 25 November, guides and passengers departed the ship at 07h00. As a precaution, we transported our safety equipment by pulling them on two pulkas disinfected using the biocide Virkon, which is recommended by the International Association of Antarctica Tour Operators (IAATO 2021). One pulka was left at the halfway point and the second pulka was left on the ice shelf, one kilometer away from the colony. One snowmobile was stationed on the sea ice close to the ship's gangway, ready to be used in the event of an emergency. We broke into small groups consisting of two guides per 20 or fewer passengers, separating the groups by fitness level, as not everyone was able to hike the full distance (6.6 km). For the shorter option, the group would walk the same route but stop before the halfway point and observe the adult Emperor Penguins coming and going to their colony. We staggered the departure of the 101 passengers and 53 crew members, ensuring a smooth rotation of groups so that no more than 100 people were ashore at any given time. Everyone followed the track we made the previous day and took care to ensure that no one kneeled in the vicinity of wildlife. This was to minimize contact with the ground and therefore the potential spread of local disease via animal feces (i.e., penguins, seals, flying birds) on clothing, and to limit the introduction of human germs to the local environment (IAATO 2021). The last group was back aboard by 13h00. The ship departed at 13h00, leaving only a line of footprints in the snow and the imprint of the ship's hull in the edge of the fast ice (Figs. 2, 3).

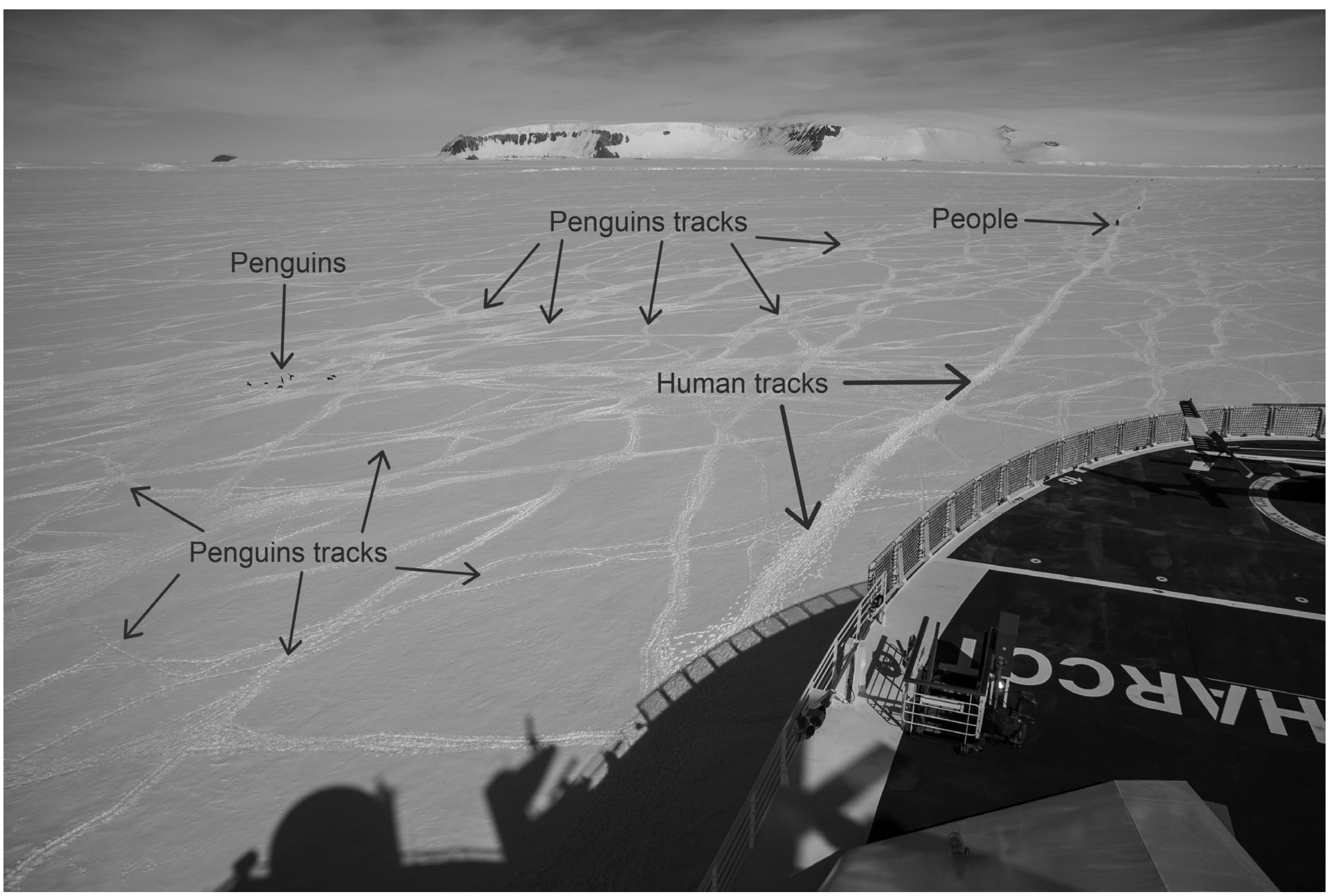

Fig. 2. The passenger ship *Le Commandant Charcot* berthed in the edge of the sea ice at the Jason Peninsula, just southeast of Cape Framnes, Antarctica (66°05.648′S, 060°36.043′W). We note the single line of footprints made by the passengers as well as the many Emperor Penguin *Aptenodytes forsteri* tracks. Photo credit: Jonathan Zaccaria

Fig. 3. Imprint left in the sea ice edge by the ship *Le Commandant Charcot* after departure from the Jason Peninsula, Antarctica. Photo credit: Étienne Garcia

The four subgroups of Emperor Penguins were located on the ice shelf. This area is the northernmost boundary of the Larsen C ice shelf, which extends for many miles further south. The thickness of the ice shelf at this location is much thinner than it is to the south, reaching a thickness of ~1.5 m over the sea ice and rising gently towards the west.

We identified different access points that the Emperor Penguins used to reach the ice shelf from the fast ice. These consisted mostly of snow bridges between the sea ice and the ice shelf. Due to tidal movement and the melting snow in summer, the snow bridges were mostly open (i.e., structurally weakened with evidence of fractures), 30–50 cm wide, and present all along the sea ice/ice shelf connection. There were very few places in which a snow bridge would remain sufficiently intact to allow penguins access to the ice shelf. Occasionally, wind and waves would cause some pieces of sea ice to attach higher onto the ice shelf, forming a natural ramp (Fig. 4). Many penguin tracks were observed, and the tracks were spread all over the sea ice, suggesting that this population of penguins did not have a preferred route to go from open water to the colony. However, as the number of ramps providing access from the sea ice to the ice shelf were limited, the penguins tended to gather around these ramps before spreading out again on the other side.

Penguins could climb onto the ice shelf, thanks to the presence of sea ice and the fact that the ice shelf was thinnest at this location. During our reconnaissance flight, we observed that there was very little sea ice left at the outermost tip of the ice shelf. However, Cape Framnes appeared to prevent the sea ice from drifting away under the influence of the elements (Weddell Gyre, storms, tidal currents, etc.), which in turn allowed Emperor Penguins to access the ice shelf and complete their breeding cycle.

One subgroup of Emperor Penguins was further south than the other three, close to a rocky area; they were named group A (Figs. 5, 6). Two subgroups were very close to each other in a more central position (groups B and C), and the fourth was further north, closer to De Urquiza cliff (group D; Fig. 7). We could easily distinguish the chicks from the adults on the aerial pictures, which were taken with a 70–400 mm tele-zoom lens and a 45 megapixel image sensor. Using Adobe Photoshop and taking care to allow for no overlap between pictures, I marked each chick on the photograph with a coloured marker, changing colours after every 50 chicks. The population census was as follows: Subgroup A had 953 chicks (Fig. 6), subgroup B had 521 (Figs. 8, 9), subgroup C had 1097 (Figs. 8, 10), and subgroup D had 1250 (Fig. 11), for a total of 3821 chicks. All subgroups were composed mainly of

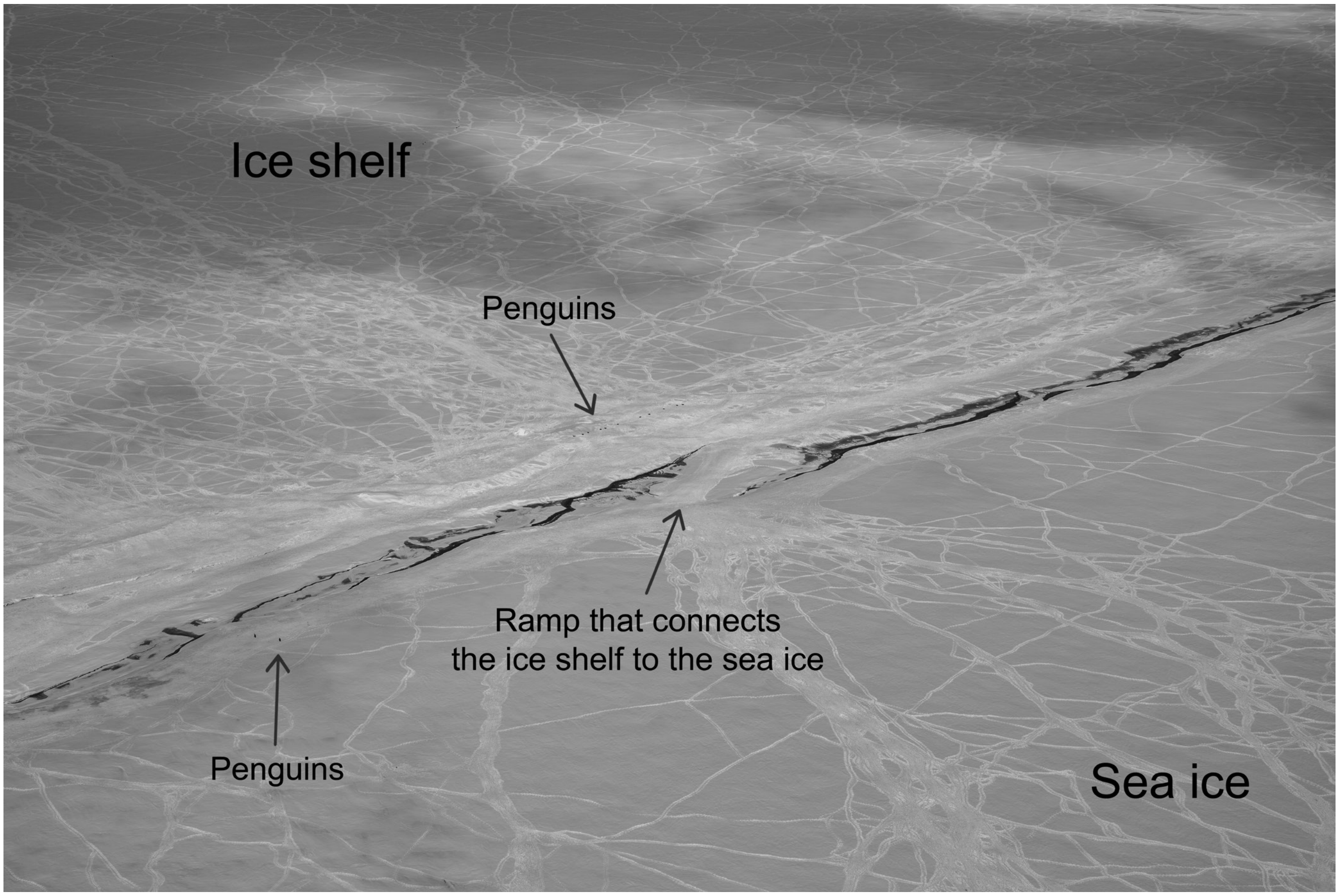

Fig. 4. Aerial view of the connection between the sea ice and the ice shelf. Emperor Penguins *Aptenodytes forsteri* are indicated to give a sense of scale. Numerous penguin tracks can be seen on both sides of the connection. Photo credit: Olivier Blaud (Studio Ponant)

Fig. 5. Aerial view of Emperor Penguin *Aptenodytes forsteri* subgroup A on the Jason Peninsula, Antarctica; this subgroup is further south than the rest of the colony members. Subgroup B, C, and D are on the right of the picture in the background. Photo credit: Olivier Blaud (Studio Ponant)

Fig. 6. Aerial photograph of Emperor Penguin *Aptenodytes forsteri* subgroup A on the Jason Peninsula, Antarctica. This picture was used to census the chick population in this subgroup (n = 953 chicks). Photo credit: Olivier Blaud (Studio Ponant)

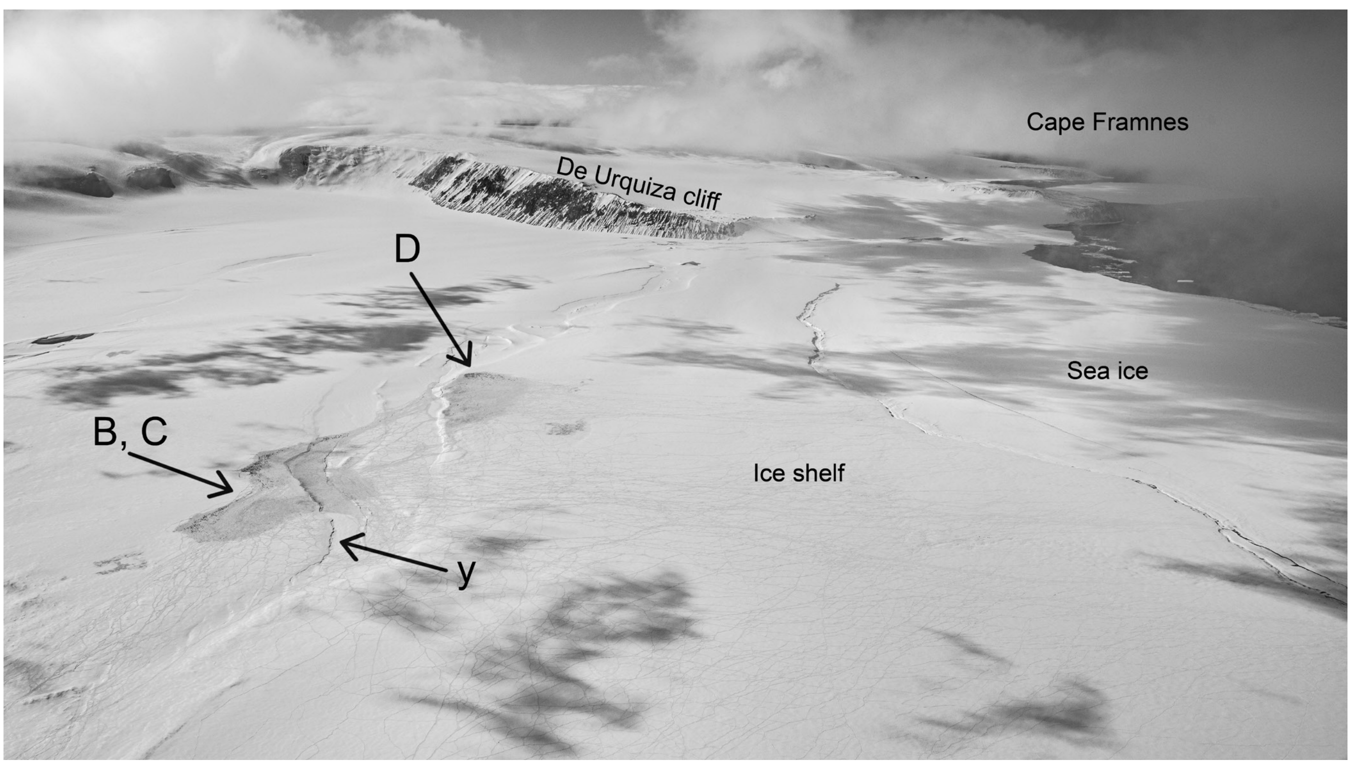

Fig. 7. Aerial picture of Cape Framnes, Antarctica, on 24 November 2022, viewed towards the north. On the far right, the sea ice is fastened to the ice shelf. On the left, there is a crack within the ice shelf (y arrow), probably due to tidal forces. Emperor Penguin *Aptenodytes forsteri* subgroups B & C were located close together, while subgroup D was further north. Subgroup A, located further south, is not visible. Photo credit: Olivier Blaud (Studio Ponant)

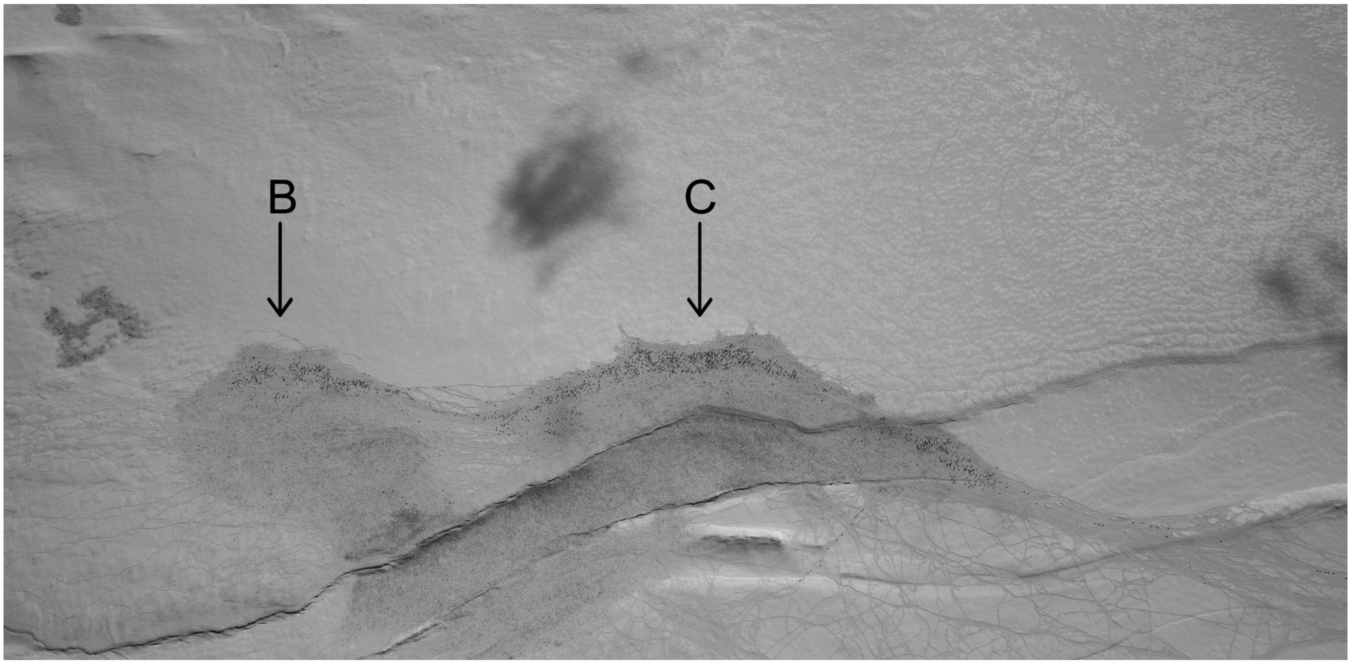

Fig. 8. Aerial photograph of Emperor Penguin *Aptenodytes forsteri* subgroups B and C on the Jason Peninsula, Antarctica. This picture does not accurately differentiate the chicks from the adults. Photo credit: Olivier Blaud (Studio Ponant)

Fig. 9. Aerial photograph of Emperor Penguin *Aptenodytes forsteri* subgroup B on the Jason Peninsula, Antarctica. This picture was used to census the chick population in this subgroup (n = 521 chicks). Photo credit: Olivier Blaud (Studio Ponant)

downy chicks without their parents, as expected for this time of year. Many chicks had already started their moulting process, and no dead chicks could be observed in the periphery of the two subgroups we visited.

Unfortunately, the picture for censusing subgroup C (Fig. 10) did not cover the whole group of penguins. Another picture was taken of the same area using a smaller focal length (Fig. 8), but it was not possible to distinguish the adults from the chicks in that photograph. Based on the density of chicks on that image, I conservatively estimated that at least another 200 chicks were missing from the photograph. Therefore, the likely total number of chicks was around 4000.

The breeding success of Emperor Penguins can change dramatically from one year to another depending on the weather and ice conditions. For example, in other known colonies, breeding success can range from 18% to 96% with averages around 50% to 67%

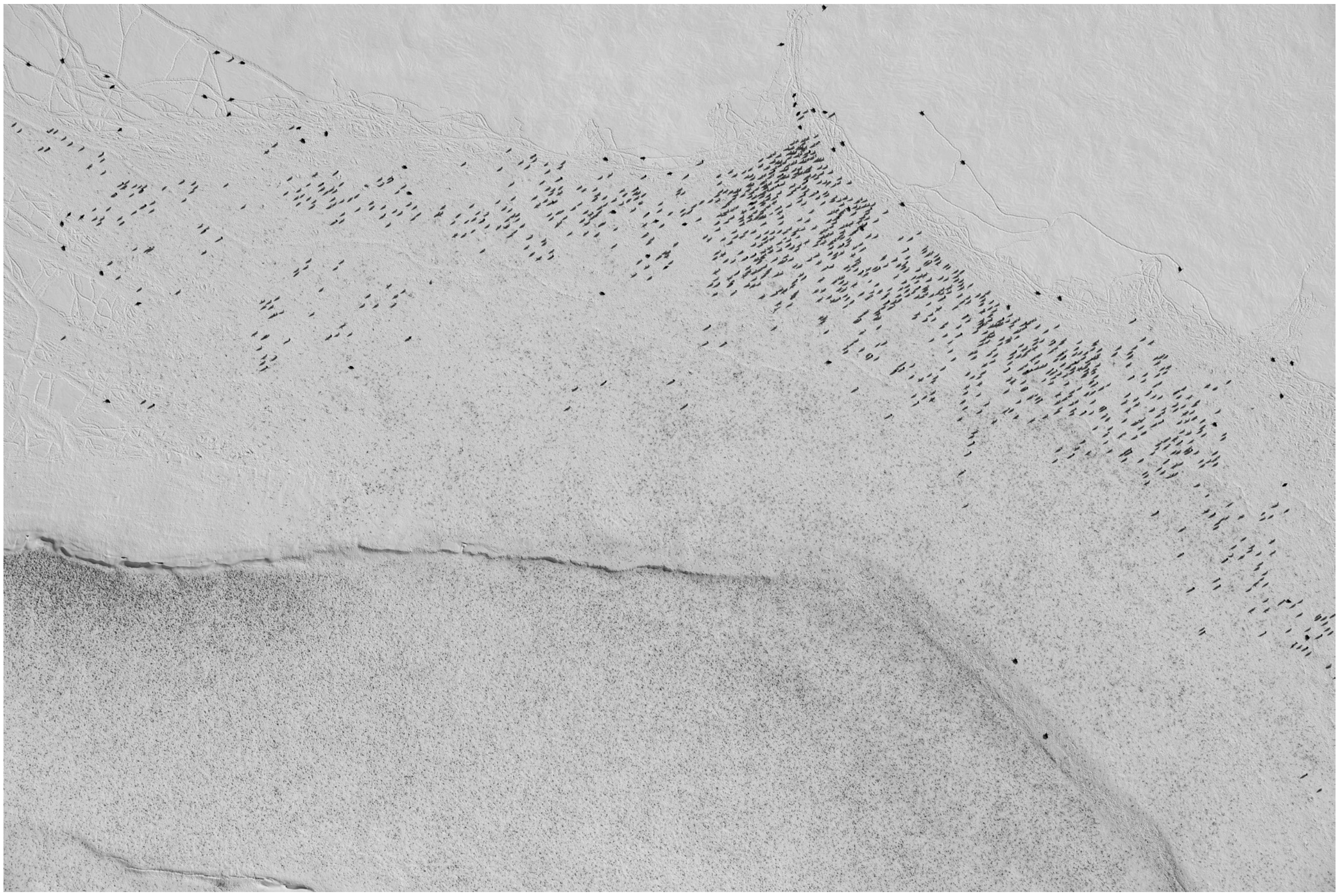

Fig. 10. Aerial photograph of Emperor Penguin *Aptenodytes forsteri* subgroup C on the Jason Peninsula, Antarctica. This picture was used to census the chick population in this subgroup (n = 1097 chicks). The size of this subgroup is cropped on the bottom right. Fig. 8 offers a better understanding of the size of the whole group. The missing part on the left side is covered by Fig. 9 with no overlap. Photo credit: Olivier Blaud (Studio Ponant)

(Jenouvrier 2009, Robertson 2014). Making the conservative assumption that the breeding success was very high (around 90%) for the Emperor Penguins at the Jason Peninsula in 2021, this brings the total estimation of breeding pairs from 4000 to 4444. That is more than double the estimate made by satellite a decade earlier (Fretwell *et al.* 2014).

In the field, we did not observe any Southern Giant Petrels *Macronectes giganteus*, but we did observe other predatory birds: South Polar Skuas *Stercorarius maccormicki*, Brown Skuas *Stercorarius antarcticus*, and Kelp Gulls *Larus dominicanus*. Moreover, during our navigation to the colony after we left Snow Hill Island, we did not see any whale blows for a full day despite observing Humpback Whales *Megaptera novaeangliae* and Orcas *Orcinus orca* outside of that one day. Only very few Crabeater Seals *Lobodon carcinophaga* were observed close to the Emperor Penguin colony.

DISCUSSION

Here, the *in-situ* observations of a new colony of Emperor Penguins was made possible thanks to a tourist trip aboard an ice-breaking cruise ship. This trip provided valuable information about the way Emperor Penguins of the Jason Peninsula reach the Larsen C ice shelf from the sea. Indeed, this colony appears to depend on the state of the sea ice, the way it is connected to the ice shelf, and the solidity of the snow bridges.

Surprisingly, there were very few predatory birds on site and in the region around the Jason Peninsula. This absence of flying predators around the colony may be because this colony is so isolated: the closest known dense colonies of penguins are located at least 180 km away, on the western side of the peninsula around Cape Tuxen. On the Weddell Sea side, the closest penguin colonies are those at Snow Hill Island (220 km to the north) and Dolleman (500 km to the south; Fretwell *et al.* 2012, Oceanites 2023). This absence of birds may also be because food resources are scarce and used solely by the Emperor Penguins, or due to the lack of snow-free areas to build nests in this region. Perhaps accordingly, no whales were observed in the vicinity of the colony or during the inbound transit after we passed the ice belt south of Snow Hill. It may be that, because this area is usually so densely packed with sea ice and glacial ice, whales do not have many opportunities to breathe and therefore avoid the area.

Project One Health, whose aim is to analyse the microbiological impact of human presence on Antarctic ice, showed that there had not been any human microbiological contamination by walking on the sea during our voyage (P.Y. Lévy of POCRAMÉ, IHU Méditerranée Infection, pers. comm.).

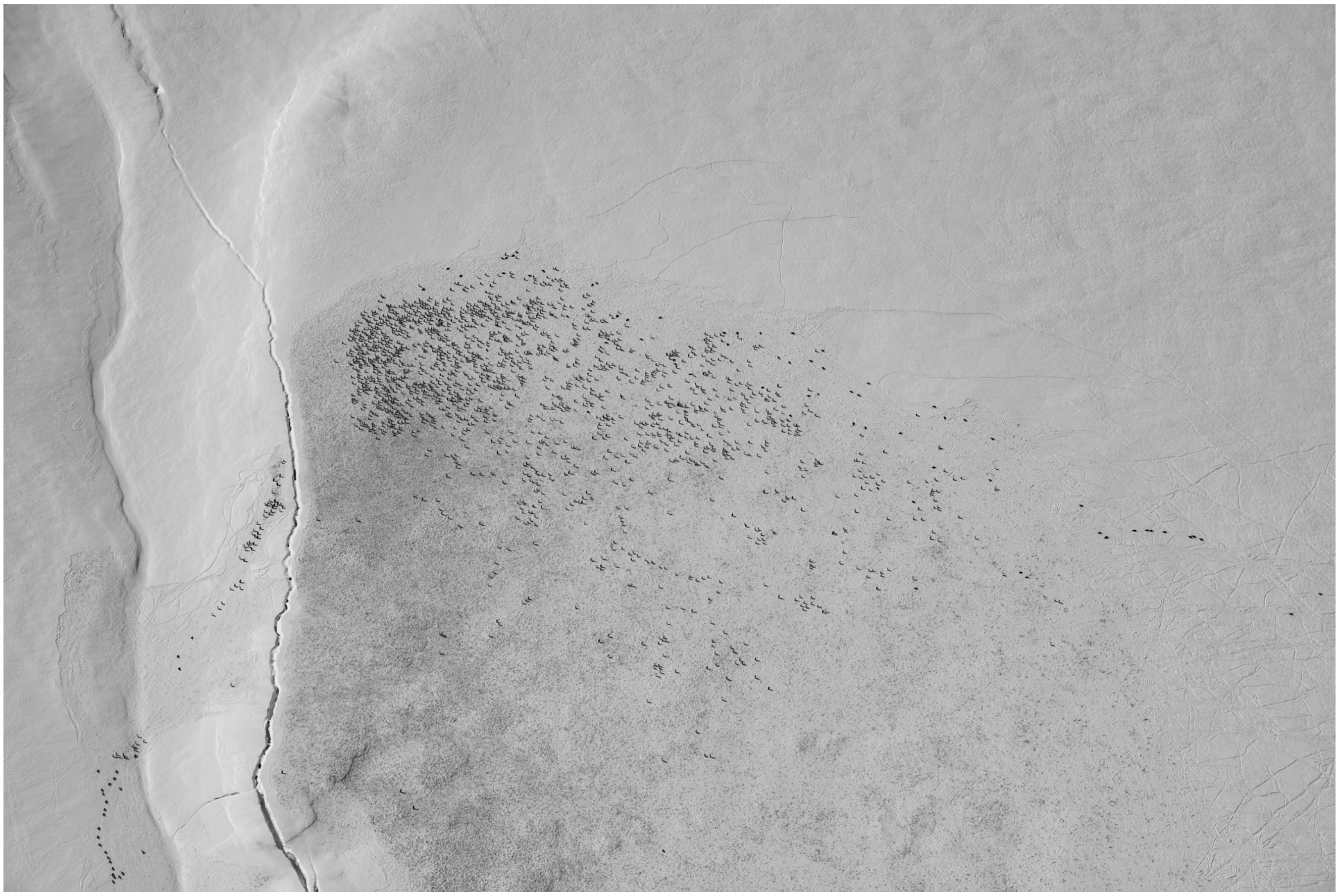

Fig. 11. Aerial photograph of Emperor Penguin *Aptenodytes forsteri* subgroup D on the Jason Peninsula, Antarctica. This picture was used to census the chick population in this subgroup (n = 1250 chicks). Photo credit: Olivier Blaud (Studio Ponant)

However, counting penguins from pictures taken at specific points in time has its problems. Based on well-studied colonies, a count late in November will consist of older chicks that survived the periods of greatest mortality: egg loss and chick mortality soon after hatching. Finding the incubation area, if possible, should be of high priority. Researchers should keep in mind that the count is dependent on the timing of the breeding cycle. For most counts of opportunity, such as during tourist cruises, the count will be taken during a time of great variation in adult presence, and the count will consist mainly of chicks because most adults are away foraging to feed the chicks. Ideally, the ground count should occur when the satellite imagery is taken to help confirm accuracy of the satellite estimates. Also, in the aerial picture taken by Fretwell *et al.* (2014), we observed that a penguin subgroup was located on the fast ice, while the main group was on the ice shelf. Therefore, I hypothesise that the incubation takes place on the fast ice, where the penguins stay as long as the fast ice conditions hold. When summer approaches and the fast ice breaks up, the penguins move to a more stable area on the ice shelf to complete their breeding cycle; this may be why no signs of chick mortality were observed. It would be interesting to follow up on satellite imagery at the Jason Peninsula to confirm both this hypothesis and the census within the next year or two.

In closing, I highly encourage more collaboration between science and tourism to collect data on a large scale. I also encourage citizen science programs and their repeated visits to sites that are difficult to access for researchers.

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