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SHORT COMMUNICATION

Swimming by pumas (*Puma concolor*) in Patagonia: rethinking barriers to puma movement

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Observations of pumas (*Puma concolor*) swimming across large bodies of water remain anecdotal in the scientific literature. Here we report long-distance swimming by a foraging male puma in Chilean Patagonia, as revealed by Argos and GPS technology. Our observation raises the question as to what might constitute a barrier to puma movements and gene flow in southern South America. Pumas are a flagship species used in identifying wildlife corridors and in landscape-scale conservation efforts in North America, and we feel a better understanding of puma metapopulation dynamics in South America is essential to both future conservation of the species and landscape-scale conservation efforts in southern South America as well.

Keywords: barriers; Chile; connectivity; Lago Cochrane; Patagonia; puma; swimming

Introduction

Wide-ranging species are at particular risk due to anthropogenic habitat loss and fragmentation (e.g., Berger 2004). Such species, including pumas (*Puma concolor*), often rely on metapopulation dynamics to remain viable (Hansson 1991; Sweanor et al. 2000). In North America, puma research has focused on anthropogenic effects on connectivity between populations (Beier 1993; Sweanor et al. 2000; Ernest et al. 2003). However, natural barriers (such as large open bodies of water) are also believed to impede population connectivity in large carnivores. For example, DNA data suggest that pumas in Argentina and Brazil appear bounded by the Rios Negro and Paraná (Culver et al. 2000).

Pumas in southern South America suffer continued persecution (Franklin et al. 1999; Elbroch et al. 2009), which almost certainly increases their risk of population fragmentation. Thus an understanding of what constitutes barriers to puma movements in southern South America, including an understanding of the permeability of large bodies of water, would be useful to better manage and conserve southern South America's largest carnivore.

There are a few published anecdotes recording that pumas swim or cross large bodies of water. Holt (1932) reported a puma climbing into a boat along the Orinoco River, in Brazil, in a spot where the river was at least "a mile wide." Terborgh et al. (1997) reported seeing pumas swimming to and from islands in the 3919 km^2 Lago Guri in Venezuela. Alvarez (1993) reported a puma swimming in the Everglades, USA, and in Arizona, USA. E. York (personal communication) reported that a marked puma crossed the Colorado River from the south to north rim of the Grand Canyon National Park.

Here we present quantitative evidence (based on satellite telemetry) that pumas are capable swimmers, gathered during our ongoing study of the feeding ecology of pumas in the presence of endangered huemul deer (*Hippocamelus bisulcus*).

Materials and methods

Study area

Our study of Patagonian pumas is located in the Aysen District, Chilean Patagonia (Figure 1). The study area covers approximately 120,000 ha, and includes the Lago Cochrane National Reserve (6925 ha) on the northwest shore of Lago Cochrane, the privately owned Estancia Valle Chacabuco (69,000 ha) and the southern portions of the Jeinimeni National Reserve (161,100 ha); the study area is also the southern portion of the future Patagonia National Park, currently under construction. The habitat is characteristic of rugged Patagonia mountains, and includes southern beech (*Nothofagus* spp.) forests, Patagonia steppe, grasslands, riparian areas and wetlands.

Lago Cochrane straddles the border with Argentina, where it is called Lago Pueyrredón. Geller (1992) reported that the surface of Lago Cochrane/Pueyrredón was at 109 m a.s.l. and its surface area

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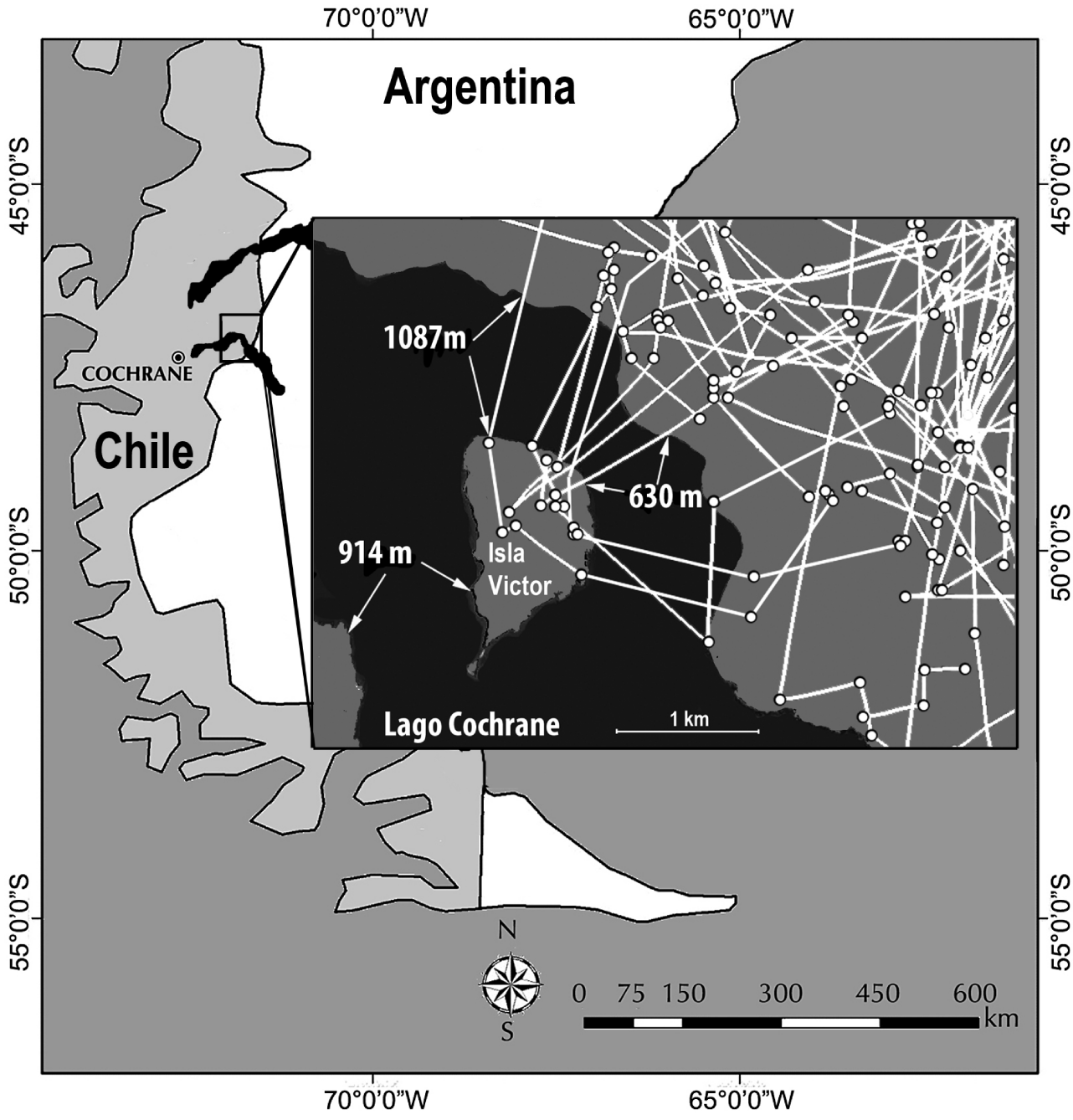

Figure 1. The study site in southern Chile. The inset illustrates the movements of Puma 8, on and around Isla Victor. Projected swimming distances were measured from shoreline to shoreline and attempted to include only the distance covered in the water. Several distances, including that from the island to the south shore, have been identified with arrows.

was 320 km^2. The maximum recorded depth of the lake was 378 m, as determined by an echo-sounder, and surface and bottom temperatures in February 1990, were recorded at 11.7 and 7.3°C, respectively (Geller 1992). The summer of 2009–2010 was cooler than normal and we thus would expect the surface temperature at the time of these observations to be cooler than previously reported.

Field methods

We captured pumas from March to September 2008 and 2009, when locating pumas was facilitated by snow on the ground. We traveled on horseback until we saw fresh puma tracks, and then hounds were used to force pumas to retreat to safety habitat (either a tree or rocky outcrop) where we could safely approach the animal. Pumas were anesthetized with a

Ketamine/Zalopine mixture administered with a dart gun. Anesthetized pumas were lowered to the ground where age (Laundré et al. 2000), sex, weight and body measurements of the animals were recorded. Animals were then fitted with an Argos-GPS collar. Once the animal was completely processed, the effects of the capture drugs were reversed with Atipamezole. During the reversal, pumas were monitored from a safe distance until they walked away on their own accord. All capture procedures were approved by an independent Institutional Animal Care and Use Committee at the University of California, Davis (Protocol No. 13252).

We programmed Argos-GPS collars to collect location data at two-hour intervals. Location data were downloaded via the internet at two–four-day intervals depending upon programming. Movements were displayed and distances between consecutive locations were calculated upon retrieval in ArcGIS 9.1.

Results

Puma 8, a 67 kg male estimated to be 6 years old, was captured and fitted with an Argos-GPS collar in June 2009. After 10 months of continuous tracking, Puma 8 was first recorded swimming a long distance. GPS data showed that he had made two trips on 10 and 12 March to Isla Victor in Lago Cochrane. An immediate site investigation confirmed that Puma 8 had successfully hunted, killed and partially eaten four domestic sheep during his initial two visits, and had returned to the mainland between his foraging bouts on the island. Puma 8 subsequently moved as far as 21.86 km from Isla Victor into another part of his range. On 19 and 20 March, Puma 8 returned to the island, and again for a final visit on the 24 March. Puma 8 never remained during daylight hours on the island during any trip, and consistently traveled to and returned from the island within a single night. The distances swum by Puma 8 to Isla Victor depended upon the angle of approach (see Figure 1), but ranged from 549 to 1087 m ($n = 10$, mean 809.6 $\pm$ 215.7 SD).

Discussion

Puma dispersal maintains genetic diversity across the landscape and is essential in revitalizing small populations and recolonizing habitats in which local populations have become extinct (i.e., source–sink dynamics) (e.g., Beier 1995; Robinson et al. 2008). Fragmentation can also result in a decrease in genetic diversity within a metapopulation, which in turn can reduce the evolutionary potential of a species to adapt to changing environments (Lande & Barrowclough 1987) or decrease the defensibility of a species against disease (Wildt et al. 1987).

Our data as well as commentary by other authors (Seton 1925; Holt 1932), however, suggest that large bodies of water are not a barrier to pumas as previously assumed (Culver 2010). While Puma 8 did not cross Lago Cochrane, the island to which he repeatedly swam is exactly in the middle of the lake. Thus, it would require an identical effort to continue south from Isla Victor and to cross Lago Cochrane completely (a distance of 914 m from the island to the south shore), as it would to return to the northern shore. Therefore, we conclude that pumas can cross Lago Cochrane using islands as stepping-stones, and that such crossings are a potential dispersal route that could result in genetic mixing and/or subsidize a declining population.

Elbroch et al. (2009) suggested that hostile matrices in southern South America dominated by sheep farms may hinder or prevent the dispersal of pumas. The mortality of a puma in a hostile matrix reported in Elbroch et al. (2009), combined with the swimming of Puma 8 reported here, challenge us to reassess probable barriers to puma movements in South America, a complex landscape that includes massive lakes, large rivers, expansive ice fields, fjords and hostile matrices where livestock owners hunt predators. As the largest predator in southern South America, pumas have the potential to be both a flagship species for identifying and protecting wildlife corridors and an umbrella species in large-scale conservation efforts in future conservation strategies in South America.

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