

Migratory movements and winter diving behaviour of Adélie penguins from two East Antarctic colonies

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Winter generally challenges foraging opportunities of endothermic marine predators due to reduced prey availability. This is especially the case for penguins that breed on Antarctic coast, as extending sea-ice cover and short daylight hours further constrain their foraging behaviour during winter. Therefore, successful foraging behaviour would be critical for the survival of penguins during winter non-breeding period. However, winter foraging behaviour has been difficult to study until recently, and the factors influencing penguin behaviours are poorly understood. Here we examine how extrinsic (environmental) and intrinsic (physiological) factors affect the migratory movements and winter diving behaviour of Adélie penguins *Pygoscelis adeliae*, by comparing their movement and behaviour from two East Antarctic colonies. We attached geolocation and depth recorders on Adélie penguins breeding at Hukuro Cove colony, near Syowa station (Syowa: 69.21° S, 39.63° E) in 2011 and 2012, and at Petrel Island colony near Dumont d'Urville station (DDU: 66.67° S, 140.00° E) in 2015. Loggers were recovered during the following breeding season of the birds. We obtained movement and dive data during winter from 5 and 11 penguins from Syowa in 2011 and 2012, and 11 penguins from DDU. Migratory movements showed similar patterns between Syowa and DDU birds, despite being separated by 100° in longitude: most penguins migrated toward northwest direction, ranging up to 1480 km and 1290 km from Syowa and DDU colonies, on average. In late June- early July, Syowa and DDU birds reached the mean westernmost longitude of 9° E and 114° E, respectively. Most birds moved westward even during the molting period, suggesting that penguins drifted with ice. Antarctic coastal current that flows westward along the Antarctic continent appears to play a significant role in shaping the migration patterns of Adélie penguins in East Antarctica. Diving depths were generally greater (up to 120-140 m) during non-breeding than breeding period in penguins from both colonies. Seasonal patterns in diving depths varied between two years at Syowa and between two colonies, likely due to variability in the depth distribution of prey. In contrast, seasonal patterns in diving effort (time spent diving per day) were consistent between Syowa and DDU birds. Penguins showed higher diving effort (up to 6-8 h diving) in late February, April and September-October. These three periods correspond to pre-molt, post-molt and pre-breeding period of penguins, respectively. Metabolic demands related to annual molt and pre-breeding fat accumulation would be an important factor determining the diving effort of penguins.