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1 **Sharing your snack: unusual observation of a chick-chick feeding**
2 **occurrence in colonial king penguin (*Aptenodytes patagonicus*)**

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26 **Abstract**

27 King penguins (*Aptenodytes patagonicus*) are colonial seabirds presenting an extraordinary
28 breeding cycle. Parents take over 14-mo to raise a single chick to independence, upon which
29 fledglings depart at sea for more than a year. Juveniles often return to the colony within the
30 three austral summers following departure, and before the age of first reproduction (around ca.
31 5-6 years old.), possibly to acquire the essential skills involved in breeding. Little to nothing is
32 known on the acquisition of parental behavior. Here, we report an anecdotal, yet highly
33 unusual, observation of chick-chick feeding behavior in this species. The behavior is highly
34 unusual in that two non-sibling chicks, not yet independent, and hatched at different times
35 (early and late) of the same breeding season were observed, the older chick feeding the younger
36 one. Whereas alloparental feeding is known to occur in this species, this is the first reported
37 observation of a chick-chick feeding event. This unusual behavior raises the question of
38 whether the early social environment plays a role in the acquisition of essential parenting skills
39 in this species.

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41

42 **Keywords:** Allofeeding, chick feeding, food sharing, learning, parental care, penguin,
43 seabird

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46 **1. Introduction**

47 Allofeeding, the act of feeding another individual, is common in many bird species
48 (Silver, Andrews, & Ball, 1985). Between adults, it often occurs in the context of reproduction,
49 where food sharing between partners is suggested as a strategy allowing to strengthen the pair
50 bond (Lack, 1940; Smith, 1980; Mori et al., 2010), reduce the nutritional stress of the recipient
51 (often the female) during critical periods such as egg-laying (Jing et al., 2009; Halley, Holmes,
52 & Robinson, 2015), or allow social integration within flocks by reducing aggression in highly
53 sociable species (e.g. Eurasian Siskins, *Carduelis spinus*; Senar, 1984). Allofeeding also occurs
54 in the context of parental care, where individuals might feed offspring belonging to a parent,
55 sibling, or unrelated conspecific (Stamps et al., 1985; Carlisle & Zahavi, 1986; Jouventin,
56 Barbraud, & Rubin, 1995; Waite & Strickland, 1997; Kalishov, Zahavi, & Zahavi, 2005;
57 Lecomte et al., 2006; Jing et al., 2009; Roulin et al., 2016; Ducouret et al., 2020; Ogino,
58 Maldonado-Chaparro, & Farine, 2021). Such behavior may be selected because of the direct
59 and indirect fitness benefits accrued to both (often, but not always, related) recipients and
60 donors (Hatchwell, 2009; Lloyd et al., 2009; Meade et al., 2010; Ogino, Maldonado-Chaparro,
61 & Farine, 2021).

62 In this short note, we report a singular observation of chick-chick feeding in a colonial
63 seabird species, the king penguin (*Aptenodytes patagonicus*). King penguins are long-lived
64 seabirds that breed in vast colonies of several thousand of pairs on small subantarctic islands
65 during the Austral summer (Barbraud et al., 2020). Their breeding cycle is long and complex,
66 as parents take over 14-mo to raise a single chick (Stonehouse, 1960; Weimerskirch, Stahl, &
67 Jouventin, 1992). Because reproduction extends for over a year, successfully breeding adults
68 in one year are constrained to breed later in the subsequent season. Thus, breeding occurs in
69 two waves: early breeding is initiated in November, whereas late breeding is initiated around
70 January-February, and it is rare that late breeders succeed (Weimerskirch, Stahl, & Jouventin,

71 1992; Stier et al., 2014). In early November, after the molt, early breeders gather in colonies
72 for a period of courtship and mate choice of roughly 11 days, before copulation occurs and the
73 female lays a single egg. The egg is rapidly passed to the male, which starts incubating it on its
74 feet, against a specialized warm skin fold devoid of feathers, called the brood pouch. During
75 this period, the female leaves for a 300-500 km foraging trip at sea (Bost et al., 1997) during
76 which they target myctophid fish usually clustered around marine areas of high productivity
77 such as the polar front (Guinet et al., 1997). Male and female parents will keep alternating
78 incubation duties, until the egg hatches some 53 days later, usually by early January. This is
79 about the time when late breeding birds start laying their single egg that will hatch round late
80 March (Viblanco et al., 2014). After hatching, parents then alternate chick feeding duties at a
81 high frequency until the start of the Austral winter in June. Adult penguins possess the unusual
82 ability to conserve undigested, unspoiled food within their stomach, allowing to feed the chick
83 when it hatches, or should the partner be delayed at sea (Gauthier-Clerc et al., 2000). During
84 the Austral winter (June to September), chicks are then left to themselves as their parents move
85 to more distant foraging grounds (Bost et al., 2004). During the winter, chicks cluster into
86 groups called “crèches” which afford them some protection against predation by giant petrels
87 (*Macronectes spp.*) (Le Bohec, Gauthier-Clerc, & Le Maho, 2005) and adverse weather
88 conditions (Eichhorn et al., 2011). They are intermittently fed by their parents, and rely almost
89 exclusively on body reserves during prolonged fasting periods to last throughout the winter
90 (Cherel, Stahl, & Maho, 1987; Saraux et al., 2012). Chick feeding by the parents resume in
91 September-October, the subsequent spring, where chicks fatten for an extra 2-3 months before
92 molting and finally departing for their first journey at sea (Stonehouse, 1960; Weimerskirch,
93 Stahl, & Jouventin, 1992).

94

95 **2. Study site and subjects**

96 **2.1. Study site**

97 The animals in this report were observed in the French Southern Territories (Southern Indian
98 Ocean), on Possession Island, in the Crozet Archipelago (46°26'S, 51°52'E). Birds were
99 monitored in the “Baie du Marin” colony, home to over 23,000 breeding pairs (Barbraud et al.,
100 2020), and located close to a permanent research station.

101

102 **2.2. Animals observed**

103 During the 2019-20 breeding season, as part of various studies conducted in the framework of
104 a long-term monitoring program on the behavior and ecophysiology of king penguin
105 (ECONERGY 119 program of the French Polar Institute), regular behavioral scans were
106 carried out each week between early December and early May 2020. Scan sampling was
107 performed over 40-min periods, sampling the behavior of birds every minute, totaling over
108 16800 min, or 280 h, of observation. The behavioral repertoire of king penguins is described
109 in detail elsewhere (Stonehouse, 1960; Côté, 2000; Viblanc et al., 2011; Jouventin & Dobson,
110 2018). Briefly, the typical behavior of adults on-land includes: sleeping and resting behavior,
111 comfort behavior (stretching, preening, shaking, etc.), vocalizing, territorial aggression, and
112 egg-chick care (includes turning the egg, feeding and preening the chick). In chicks, similar
113 comfort, sleeping and resting, and vigilance behavior is observed. Vocalizing is directed mostly
114 to the parent and consists in soliciting food. Chick behavior also includes aggressive behavior,
115 mainly threats.

116

117 **3. Observation and discussion**

118 On the 16th of March 2020, we observed (and filmed) a chick-chick feeding event in king
119 penguins (see Online Supplementary Materials). What was singular about this observation was
120 that an older chick hatched earlier in the breeding season (around January) was observed

121 feeding a younger chick hatched later in the same breeding season (around March), shortly
122 before the Austral winter. King penguins raise a single chick per reproductive attempt, so the
123 two chicks were not siblings. During the entire observation, one adult king penguin was present
124 in close proximity (contact with the chicks), though we had no information on whether this
125 adult was the parent of either chick. However, following the observation, the older chick moved
126 further away, and the adult took charge of the younger chick (AC, personal observation). The
127 brooding pouch of the adult was markedly visible (video 0:10, 0:17, 0:25) suggesting it might
128 indeed have been the parent of the smaller, not yet thermally independent, chick. The older
129 chick displayed all of the typical behaviors displayed by breeding adults. Specifically, the older
130 chick was seen (1) feeding the younger chick (video 0:00-0:07; Online Supplementary
131 Material; Fig 1A); (2) behaving aggressively and territorially towards neighbors (video 0:15-
132 0:18; Fig 1B); and (3) attempting to guide the younger chick on top of its feet, the typical
133 breeding position of adults (video 0:26-0:33; 0:50-1:06; Fig 1C). Although older chicks are
134 known to behave aggressively towards one another (Stonehouse 1960; Le Bohec et al. 2005),
135 there is to our knowledge no published record of chicks behaving parentally towards other
136 chicks in this species. It is quite possible that the feeding attempt was a successful one: both
137 the young and older chick showed several swallowing movements following the feeding event,
138 which is usually observed following a successful feeding attempt (video 0:04-0:07; Online
139 Supplementary Material; Fig 2). In addition, it is interesting to note that the older chick
140 attempted to guide the younger chick on top of its feet after the breeding adult had done so just
141 before.

142 In penguins, allofeeding is rare but found across species. Anecdotal accounts have been
143 reported between mates in chinstrap penguins (*Pygoscelis antarctica*; Mori et al., 2010), Adélie
144 penguins (*Pygoscelis adeliae*; Yoda & Ropert-Coudert, 2002) and jackass penguins
145 (*Spheniscus demersus*; Broni, 1983). In king penguins, allofeeding from adults to chicks is

146 relatively common (25% of cases over 280 adult feeders observed; Lecomte et al., 2006) and
147 is mostly attributed to failed breeders who preferentially feed chicks raised by close neighbors
148 at during the time of brooding.

149 To our knowledge, allofeeding between offspring in birds has so far only been
150 documented in between related offspring of the same clutch (Stamps et al., 1985; Roulin et al.,
151 2016; Ducouret et al., 2020). Most king penguins only raise a single chick every two years at
152 best, and given that the two chicks in our observations were from the same breeding season, it
153 seems unlikely they were closely related, though we cannot know for certain. Higher-than-
154 expected relatedness has been observed between neighboring breeders in king penguin
155 colonies, though this relatedness remains weak and restricted to particular areas of the colonies
156 such as the colony centre (Cristofari et al., 2015). Nevertheless, the fact that chick-chick
157 feeding behavior has been observed in species with ecologies and life histories as contrasted
158 as budgerigars (*Melopsittacus undulatus*; Stamps et al., 1985), owls (*Tyto alba*; Roulin et al.,
159 2016; Ducouret et al., 2020), and penguins (this paper), suggests that (1) this unusual behavior
160 may have evolved several times independently; and (2) relatedness may not be the only factor
161 influencing the evolution of helping behavior in birds.

162 Whether such chick-chick interactions occur frequently or not in king penguins is
163 unknown. We have been working on this species for several decades, spent every year hundreds
164 of hours of scan-sampling observations in the field, and yet have so far never encountered such
165 behavior before. Thus, this behavior is likely rare. Yet, penguin colonies are massive
166 assemblages of thousands of individuals (Barbraud et al., 2020), and our observations were
167 short-lived (seconds). While it is likely that such observations are usually missed, and perhaps
168 more frequent than thought. Regardless, this observation questions the benefits and
169 adaptiveness of such behavior. If indeed food was transferred from the older to younger chick,
170 this behavior might appear maladaptive since any energy loss for offspring before the Austral

171 winter is risky in the face of the strong energy constraints faced by chicks during prolonged
172 (up to 5 months) fasting (Cherel, Stahl, & Maho, 1987). This would be especially the case if
173 the donor was in poor body condition itself, since the marginal value of obtaining food depends
174 on individual needs and/or condition. Unfortunately, we did not have information on chick
175 body mass. However, our observation (see Online Supplementary Materials) did not suggest
176 that the donor was in poor condition, at least visually (*i.e.*, the donor chick did not appear to be
177 particularly lean or emaciated). Thus, an alternative explanation may be that imitating parental
178 behavior from a young age primes offspring for future reproduction when sexual maturity is
179 reached. This might be especially advantageous for chicks in good condition that can afford
180 trading-off a small surplus of food for the acquisition of a behavior critical for future life-
181 history stages. Some indication that social learning might be important in king penguins comes
182 from data on the time spent in attendance of juvenile king penguins to their natal colonies
183 before their first breeding attempt. After having fledged, juvenile king penguin will remain at
184 sea for at least a full year, travelling large extents of the Southern Ocean (Orgeret et al., 2019),
185 before returning to their natal colony (most birds return after two years; Saraux et al., 2011).
186 Juveniles return to their natal colonies in part for molting, however, the time they spend on-
187 land exceeds that necessary for molting only (Saraux et al., 2011). Since first reproductive
188 attempts are thought to occur at 3 or 4 years old at the earliest (Barrat, 1976) and more generally
189 around 6 years old (Weimerskirch, Stahl, & Jouventin, 1992), it is unclear why these animals
190 remain on-land. One suggestion is that juveniles use this time to learn the complex ritualized
191 displays of courtship, perhaps through observation/imitation, prior to engaging into active
192 breeding themselves (Saraux et al., 2011). This would entail that those activities related to
193 breeding (including courtship and potential care of the egg or offspring) could partly be under
194 the influence of social learning in penguins.

195 Nonetheless, given the lack of other observations of this nature so far, it is not possible to
196 currently conclude on the adaptive nature of this behavior. It could well be maladaptive since
197 maladaptive behaviors should be counter selected, explaining their rare occurrence in nature.
198 Thus, future studies will be needed to bridge the gap between anecdote and data, allowing us
199 to determine whether this unusual observation has any role to play (or not) in the acquisition
200 of essential parental skills in king penguins, and more generally, in seabirds.

201

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207

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313

314

315 **Figures**



316

317 **Fig 1.** Early-born king penguin (*Aptenodytes patagonicus*) chick observed: (A) feeding a late-
318 born king penguin chick on the 16th of March 2020; (B) displaying the typical territorial
319 behavior of a breeding adult. The extend open bill towards neighbors is accompanied by a
320 vocalization and is a territorial threat known as bill gapping (Côté, 2000; Viera et al., 2011);
321 (C) attempting to guide the younger chick on top of its feet, the typical breeding position of
322 adults, which brood young chicks on their feet in a specialized bare and highly vascularized
323 skin flap called the brood pouch (Stonehouse, 1960).

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328 **Fig 2.** Swallowing sequence observed in the early-born king penguin chick, suggestive of a
329 successful feeding attempt (see text).