

Mother's voice recognition by seal pups

Newborns need to learn their mother's call before she can take off on a fishing trip.

In gregarious mammals, mother and pup need to be able to recognize each other's voices in order to be reunited in a crowd¹, a skill that has only been studied in domesticated species where mother and young stay together during the rearing period². In otariids, females have to leave their newborn to feed at sea, but offspring nevertheless develop long-term recognition of their mother's voice³. Here we show that pups of the subantarctic fur seal (*Arctocephalus tropicalis*) can acquire this ability when they are just 2–5 days old, and that the mother times her departure accordingly.

On Amsterdam Island in the Indian Ocean, fur seals are born from late November to early January⁴. The rearing period lasts for an average of 10 months and consists of foraging trips at sea that last for 2–3 weeks at a time, interspersed with suckling periods ashore lasting for 3–4 days⁵. After parturition, mothers usually stay with their young for about a week before leaving the colony on their first feeding trip⁵. When she returns, a female must relocate her own pup among the many similar ones in the rookery⁶. This

reunion depends mainly on vocalizations (Fig. 1) because pups respond specifically to their mother's voice⁷.

We investigated the age at which this specific response develops in pups. By using playback experiments for several days after birth, we assessed the evolution of pups' behavioural responses to their own mother's calls and to those of strange females. As the pup needs to be able to recognize its mother when she comes back from foraging at sea, its response to her voice should have developed before her first departure, which is presumably delayed by the mother until her pup can recognize her.

Responses to playback tests revealed that pups ($n=9$) react vocally to any female's calls a few hours after birth, but after 2–5 days they can respond specifically to their mother's voice. This response was always established before the female's departure, which occurred 2–10 days after parturition. Moreover, the departure date depends on the timing of this voice recognition by the pup ($n=9$; regression analysis, reciprocal- X model: departure date is 10.9–11.9/specific-response date (days after birth); $P<0.05$).

To test the efficiency of the pups' learning, we measured the time taken by pups to find their mother after her return from her first sea trip. Of the monitored mother–pup pairs ($n=15$), 66% met up within 7 min, and the remaining pairs were united within 11 min (regression analysis, double-reciprocal model: percentage of successful meetings calculated as $1/(-0.000356 + 6.45/\text{time required})$; $P<0.01$).

In colonial mammals, the ability of pups to recognize their mother's voice is

crucial for their survival as, in most species, females only feed their own offspring⁸. Mother–young recognition must therefore develop as soon as it is needed, before the first separation. In several bird species, vocal identification between parents and young generally coincides with offspring mobility⁹. In *A. tropicalis*, factors other than call recognition may be involved¹⁰ — for instance, females may leave the shore when pups stop suckling¹¹. Our results show that, in spite of the variable duration of ontogeny, the mother's departure date is linked to the pup's ability to recognize her voice. This supports the idea that recognition of a mother's call by her pup is an important factor in allowing her to go to sea.

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Figure 1 A subantarctic fur seal (*Arctocephalus tropicalis*) mother on her return from a foraging sea trip. The mother starts calling soon after arriving ashore and her pup calls in reply to indicate its position within the colony. As they approach one another, they continue to emit vocalizations until they are reunited.

Palaeontology

The beaks of ostrich dinosaurs

Primitive ornithomimids, a ubiquitous group of specialized Cretaceous dinosaurs nested within a clade of predominantly carnivorous theropods, are known to have had teeth, whereas derived ornithomimids had an edentulous beak, which has prompted speculation about their dietary habits¹. Here we describe two new ornithomimid specimens in which soft-tissue structures of the beak have been preserved. These creatures probably used their beaks to strain food sediment in an aqueous environment, rather than for

predation on large animals.

Specimen RTMP (Royal Tyrrell Museum of Palaeontology) 95.110.1 is an almost complete skeleton of the Campanian ornithomimid *Ornithomimus edmontonicus*² from Dinosaur Provincial Park, Alberta, Canada (Fig. 1a). This specimen preserves traces of the keratinous covering (rhamphotheca) on the beak on the tips of the right premaxilla and dentary. As preserved, the soft tissue extends up to 3.5 mm from the rostral and mandibular margins, and fills a gap left by the anterior divergence of the premaxilla and dentary. The rhamphotheca on each jaw tapers posteriorly and terminates just behind the midpoint of the right naris. The upper rhamphotheca extends about 1 mm farther

posteriorly than the lower, and is also slightly longer anteriorly. The surfaces of the dentary and the premaxilla are densely pitted next to the preserved soft tissue, indicating extensive neurovascularization in the region of the ramphotheca.

The other specimen, IGM (Institute of Geology, Mongolia) 100/1133, is a sub-adult of *Gallimimus bullatus*³ from Tsaagan Khushu, Nemegt Basin, Mongolia (Fig. 1b). Although slightly crushed, the skull is remarkably complete. The interior surface of the ramphotheca is preserved on both the right premaxilla and dentary. Small, separate columnar structures extend sub-perpendicularly to the buccal margin of the rostrum. These structures, which are remnants of the lingual surface of the beak, project up to 5.6 mm, as preserved, at the tip of the premaxilla, but are shorter posteriorly. They are tightly packed and evenly spaced (about 0.5 mm from centre to centre). Presumably, these columnar structures would have been at least partially covered laterally by an outer ramphotheca, as in TMP 95.110.1 and extant anseriforms.

These specimens demonstrate the pres-

ence of a beak, presumably keratinous, in ornithomimids (Fig. 2). The *Gallimimus* specimen shows structures (Fig. 1c) that are reminiscent of the lamellae on the beaks of anseriforms⁴. Most anseriforms feed by manipulating food and by straining sediment with their beaks. The lamellae help in segregating food articles from other material, which is expelled from the side of the beak during feeding, and they also aid in cutting plant material during grazing.

In an analysis of 17 diverse modern anseriform species, some straining was observed in all species except the piscivorous merganser⁵, which has large, tooth-like lammellae. The *Gallimimus* condition closely resembles that of the shoveller *Anas clypeata*, an extreme filter-feeding strainer with a diet of plants, freshwater molluscs, ostracods and foraminiferans⁵. Other features of the ornithomimid skeleton have been used as grounds to suggest that they were not carnivorous⁶.

Ornithomimids with numerous small gastroliths have been reported from deposits in China⁷. Although gastroliths are patchily distributed in Dinosauria, they



Figure 2 Artist's rendition of a feeding ornithomimid, showing the sediment-straining method probably used by these dinosaurs.

are most often associated with herbivorous (*Psittacosaurus mongoliensis* and sauropods) or putatively herbivorous (*Caudipteryx zhoui*) groups. Although there is not enough evidence to indicate that these ornithomimids behaved similarly to anseriforms, it is unlikely that these delicate features were used for predation on large animals. Furthermore, ornithomimids are abundant in mesic environments (such as Nemegt⁸, Iren Dabasu⁹ and Dinosaur Park Formations¹⁰), but are rarer in more arid environments (such as Djadokhta^{8,11}). This suggests that ornithomimids may be ecologically tied to food supplies in wetter, more mesic environments, which would be consistent with their beak morphology.

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Figure 1 Two ornithomimid specimens, showing preservation of soft-tissue structures of the beak. **a**, The anterior end of the rostrum of *Ornithomimus edmontonicus* (RTMP 95.110.1) in lateral view (reversed). Red arrow indicates preserved soft tissue. Scale bar, 1 cm. **b**, *Gallimimus bullatus* (IGM 100/1133) in right lateral view. Scale bar, 2 cm. **c**, Detail of red box in **b**, showing soft-tissue lamellae along the rostral margin. Scale bar, 3 mm.