Short Communication

Satellite tracking of flamingos in southern Africa: the importance of small wetlands for management and conservation

Graham McCulloch, Adrian Aebischer and Kenneth Irvine

Abstract The Makgadikgadi Salt Pans in Botswana are one of the most important breeding sites in southern Africa for lesser flamingos *Phoeniconaias minor* and greater flamingos *Phoenicopterus ruber roseus*. Much of flamingo migration behaviour is unknown and there has been speculation on the pattern of flamingo movements to and from Makgadikgadi and their dispersal throughout southern Africa. We carried out the first satellite tracking of flamingos in southern Africa to find out where lesser and greater flamingos go after leaving Makgadikgadi. In July 2001 five lesser and three greater flamingos were tagged. Following migration from the pans, one of the greater flamingos flew west to the coast of Namibia, the other south to a small wetland in South Africa. The lesser flamingos moved south-east from Makgadikgadi to South Africa and Mozambique. Movement by both species was nocturnal. This work shows that flamingos migrate from all over southern Africa to Makgadikgadi to breed. It also shows that, during the non-breeding season, movement is widely dispersed and nomadic among a network of wetlands around the subcontinent. Small wetlands, often unrecognized as important for conservation, provide valuable feeding sites and migration staging posts along flamingo migration routes. This highlights the need for the conservation of the network of small wetlands around southern Africa, which are often under threat from anthropogenic activities, to protect two high profile bird species in decline.

Keywords Flamingos, migration, *Phoeniconaias*, *Phoenicopterus*, satellite tracking, southern Africa, telemetry, wetlands.

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Of the five species of flamingos that occur worldwide two, the greater flamingo *Phoenicopterus ruber roseus* and the lesser flamingo *Phoeniconaias minor*, occur in Africa. The lesser flamingo is categorized on the IUCN Red List as Lower Risk: near threatened across its entire range (Collar *et al*., 1994; IUCN, 2002) and both species are listed in the African Eurasian Waterbird Agreement (AEWA, 2000) as ''populations in decline throughout southern Africa''. Both species are considered Lower Risk: near threatened or Vulnerable throughout southern Africa owing primarily to the lack of breeding sites and the vulnerability of breeding to both natural and anthropogenic disturbance (Brook, 1984; Simmons, 1996; Anderson, 2000a, b). Simmons (1996, 2000) has suggested that a lack of successful breeding at the large wetland sites of Etosha Pan in Namibia and Sua Pan in Botswana may have caused a >20% decline of flamingo numbers over the last two decades. Collectively, small wetlands also provide an important but poorly understood habitat network for flamingos (Breen, 1991; Anderson, 2000c). The conservation of flamingos on small ephemeral pans and some perennial wetlands around southern Africa is of concern owing to the lack of formal, effective protection of the majority of these increasingly threatened sites (Davies & Day, 1986; Allan, 1987; Breen, 1991; Allan *et al.*, 1995; Anderson, 2000c).

The salt pans of the Makgadikgadi depression are a relict of an immense Quaternary palaeolake that once covered much of northern Botswana (Thomas & Shaw, 1991). The remnants of this great lake at Ntwetwe and Sua Pans comprise a flat surface of saline clay that is flooded intermittently with seasonal rainfall. During the rainy season (October–April), the pans are transformed into vast shallow salt lakes that provide excellent feeding conditions for both species of flamingos. The southern section of Sua Pan provides one of the most important breeding sites for both species in southern Africa, with breeding success depending on the extent of seasonal flooding (Hancock, 1990; Simmons, 1996). The pans typically dry out at the end of each season,

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often before breeding is complete, forcing the birds to seek food elsewhere (Hancock, 1990; Simmons, 1996). Controversy surrounds the geographical origin of flamingos that migrate to and from the pans, and while evidence of movements to and from the direction of Makgadikgadi are well documented (Borello *et al.*, 1998; Anderson, 2000c), details of their migration patterns and behaviour are unknown (Simmons, 1996, 2000; Borello *et al.*, 1998). It has been suggested, that because of the very high numbers, up to hundreds of thousands, that occur on Makgadikgadi and Etosha in years of exceptional rainfall (above the average of 400–500 mm) these migrations may link with the East African population (Berry, 1972; Simmons, 1997; Borello *et al.*, 1998).

In July 2001 we began the first satellite tracking of flamingos in southern Africa in an attempt to monitor their movements from Makgadikgadi after an exceptional breeding season. A total of 28 flamingos were caught on Sua Pan using a noosing method similar to that used in East Africa (B. Childress, pers. comm.) and South America (B. Conway, pers. comm.). Using 80 and 30 g PTT satellite telemetry devices, we tagged five lesser and three greater flamingos. The devices were attached using a figure-of-eight style harnessing technique with teflon ribbon (Nagendran *et al.*, 1994). The transmission cycles of each device were set at 8 hours on/158 hours off, for 6 months, switching to a cycle of 8 hours on/44 hours off, for the time estimated to coincide with the 6-month period around breeding and migration. The PTT cycles were offset from the 24-hour orbit cycles of the receiving satellites to avoid possible transmission at a time-window each day with few or no overpasses. 'On' periods, therefore, occurred at different times of the day, alternating between nocturnal and diurnal transmissions. All data were transmitted through the Argos satellite system. Location accuracy varied according to the PTT signal strength and the number of receiving satellites (five in total) during each transmission. The PTTs produced excellent data and we only used location information with accuracies of 150–1,000 m of the real position. The locations of the all sites used by the tracked flamingos are given in Fig. 1 and the Appendix.

Owing to exceptional floods the pans did not dry up in 2001 and the flamingos remained to complete another breeding season. Of the eight birds that were tagged, PTTs on two greater and three lesser flamingo were still transmitting at roughly the same location, to the north-east of Sua Pan (20°22′S, 26°12′E), when the pans finally began to dry out in February 2002. The greater flamingos (GF *a* & GF *b*) left the pans between 18 and 20 February 2002 (Fig. 1). On 20 February GF *a* had moved 170 km west to a small pan on the western edge of the

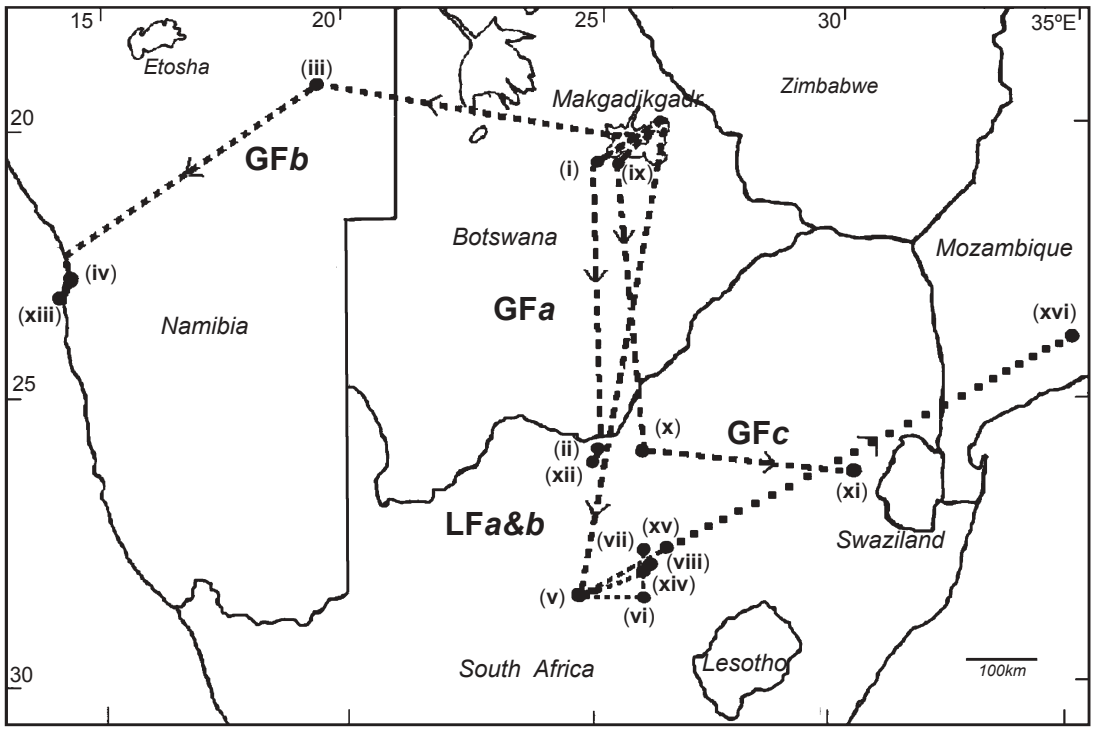

Fig. 1 The migration of two greater flamingos (GF *a* & *b*) and three lesser flamingos (LF *a*, *b* & *c*) from the Makgadikgadi salt pans to their non-breeding destinations around southern Africa. Precise locations of all sites are given in the Appendix.

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Makgadikgadi (site i). On 22 February it was located 580 km south-east on a small lake (site ii), 5 km from Springbok Pan in the western Gauteng Province of South Africa. GF *b* left Makgadikgadi on a westerly course and during the night of 20 February was located 700 km away, flying in the direction of Etosha Pan (site iii), in Bushmanland, north-eastern Namibia. Flamingos have been observed stopping at pans close to this location on numerous occasions and were presumed to be transient flocks, en route between Botswana and Namibia (Hines, 1993; Simmons *et al.*, 1998). Part of this flight (54 km) was tracked continuously for 49 minutes with an estimated average ground speed of 65 km hr^{-1}. At the time, Etosha Pan was dry and therefore unsuitable habitat for flamingos. On 22 February GF *b* was located on the coast of Namibia, 45 km north of Walvis Bay, 1,230 km from Makgadikgadi. On 26 February it had moved south to Walvis Bay (site iv).

On 20 February all three lesser flamingos (LF *a*, *b* & *c*) were still at Makgadikgadi. In the weeks following their departure we observed a highly dispersed movement (Fig. 1). On 23 February LF *a* and *b* were located 930 km south-south-east on Kamfers Dam (site v), an important non-breeding site in the Northern Cape Province of South Africa. Regular observations of large numbers of flamingos have been recorded on this wetland (Anderson, 2000c). On 26 and 28 February LF *a* then moved 130 km east, to Skoppan (site vi) and 60 km north to a small pan (site vii) near Flamingo Pan. On 9 March it flew to another small wetland (site viii) 17 km south. LF *c* made its first stop on a small pan (site ix) 130 km south of Makgadikgadi, before flying to a wetland (site x) near Barbers Pan, where it was located on 4 March. It was then located on the night of 6 March, flying to a wetland in the Lake Chrissie area (site xi), 160 km east. During this flight the bird flew 90 km in 90 minutes at an average ground speed of 60 km hr^{-1}. Despite observations of flamingos occasionally flying over land by day (e.g. Williams, 1993), we recorded migration in progress only during night-time 'on' periods, supporting the theory that flamingos in Africa fly between wetlands at night (Brown *et al.*, 1982). Later in the year some of the flamingos continued nomadic movements to different locations. GF *a* moved 40 km south-south-west to a wetland (site xii) on 31 March, where it remained until the PTT stopped transmitting on 3 May. On 5 May GF *b* flew 45 km south to Sandwich Harbour (site xiii). It returned to Walvis Bay again on 2 June and later that month the bird was found dead (with the transmitter attached) on the edge of a salt works pond 38 km north of Walvis Bay, where it was reportedly scavanged by a jackal. On 21 April LF *a* returned to Kamfers Dam (site v). In June and July it continued its nomadic movements, visiting small wetlands (sites xiv and xv) before returning once again to Kamfers Dam in August. It remained there until the PTT stopped transmitting in mid-September. On 10 May LF *b* had moved 200 km north-east, very close to wetland site xv. The PTT stopped transmitting for a time on 29 June. It began transmitting again on 29 September and LF *b* had then moved to Lake Nanghul (site xvi), a perennial freshwater lake in southern Mozambique.

Flamingo movement from Makgadikgadi was as a result of the disappearance of water, forcing them to leave. Thunderstorms may, however, be linked to their arrival on the pans, as suggested by Simmons *et al.* (1998) (G. McCulloch, pers. obs.). The Tswana name for flamingos in Botswana, meaning thunder and lightning bird, provides some support to this idea. Although none of the tagged birds flew north-east, this study cannot discount the possibilities of migratory connections with East African populations. Mozambique has been suggested as part of a coastal route north for interconnecting populations (Borello *et al.*, 1998). Inspection of the movement of birds suggests that some sites close to Makgadikgadi (i, iii and ix) are transient points on longer migration routes, as previously suggested (Hines, 1993; Simmons *et al.*, 1998), while others are likely to be important feeding sites for non-breeding populations. The results, particularly those of LF *a*, also show that flamingos are highly scattered and movement is nomadic among the many wetlands on which they have been recorded (e.g. Borello *et al.*, 1998; Anderson, 2000c). The majority of sites chosen by the flamingos are located in areas where small, predominantly ephemeral, pans and dams are concentrated (Seaman *et al.*, 1991; Allan *et al*, 1995; Anderson, 2000c). Many small ephemeral wetlands throughout southern Africa are, however, vulnerable to disturbance and degradation from drainage, domestic waste and agricultural pollution (Davies & Day, 1986; Allan, 1987; Breen, 1991; Allan *et al* 1995). Furthermore, most wetlands, including coastal lagoons such as Walvis Bay in Namibia, and many of the dams and other man-made wetlands that often support large flamingo populations, have no or limited protection as conservation sites (Breen, 1991; Allan *et al.*, 1995; Anderson, 2000c). The vulnerability of sites that lack a protected status (Ehrlich & Daily, 1993) is a great concern for flamingo conservation as, collectively, scattered and small sites used by these birds are as equally important in their life-cycle as are the larger sites that afford protection either because of their remoteness (e.g. Sua Pan and Magkadikgadi) or legal status (e.g. Etosha Pan and Kamfers Dam) or both. The results of this work indicate the importance for flamingos of a network of wetland sites across southern Africa and emphasizes the need for a reappraisal of wetland protection in the subcontinent.

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Biographical sketches

Graham McCulloch has recently completed a 3-year research project on the ecology of the Makgadikgadi salt pans and its flamingo population. His other research has included collaborating in regional and pan-African water bird counts, and coordinating and managing small conservation projects for local community schools and overseas volunteer groups.

Kenneth Irvine's research interests include trophic dynamics in lakes, catchment processes and their management, and the impact of anthropogenic disturbance on freshwater ecosystems. He has contributed to the application and development of management and monitoring strategies in England, Ireland and Africa, including research in the Great Lakes, Malawi and Tanganyika, and on the Makgadikgadi saltpans.