

SHORT NOTE

Successful breeding by female-female pairs of flesh-footed shearwaters (*Ardenna carneipes*)

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Flesh-footed shearwaters (*Ardenna carneipes*) (length 40–45 cm; weight 650 g; Marchant & Higgins 1990) currently classified by BirdLife International (2021) as “Near Threatened” and as “At Risk - Relict” under the New Zealand Threat Classification system (Robertson *et al.* 2021) breed on 14 islands around northern New Zealand from the Hauraki Gulf to Cook Strait. There is a small colony of these summer nesting shearwaters on Kauwahaia Island, Bethells Beach (0.7 ha; 36°53' S, 174°26' E). Long-term monitoring of the breeding birds at this site revealed the presence of two eggs in nests on multiple occasions since 2005. Closer examination indicated that rather than re-laying or egg dumping, the eggs were laid by two different females, sometimes in long-term stable partnerships. These same female-female pairs moved together between several different burrows during the study as competition for nests is intense at this site due to the large population (>300 pairs)

of winter breeding grey-faced petrels (*Pterodroma gouldi*) which are present from April to December. This short note reports on the success or otherwise of these same-sex pair bonds and how two females paired together might produce viable eggs.

The flesh-footed shearwater colony at Kauwahaia Island has been monitored annually since 1989 with several short visits made in the Dec–Jan incubation period and again in March or April during chick rearing. I made fewer colony visits after 2014, which reduced the chances of encountering a partner on the nest. No visits were possible in April 2020 and April 2023 due to Covid-19 restrictions and storm damage to the access road and islands. Each bird encountered was banded with a stainless-steel Z-band and records made of presence of eggs or chicks in nests. All accessible eggs were candled by torchlight to determine the state of fertility and extent of embryo development. In addition, in the past seven years (2016–2022) the nests of two female-female pairs were monitored by a trail camera (night setting and short video clips) to observe bird behaviour outside their burrow entrances.

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Amongst a colony of around 20–25 pairs of flesh-footed shearwaters (maximum of 27 pairs in 2016 season), two female-female pairs formed that have remained together for more than a decade. All four birds have been sexed repeatedly at different times by cloacal examination just after laying, presence of an egg in the abdomen or by DNA sexing. These females have had unpaired males available in the colony but seem content to breed together. In most, but not all seasons, there are two eggs laid in their burrows (Tables 1 & 2). When the nest chamber was accessible by using a study hatch, egg fertility was assessed and developing embryos were observed in most seasons in at least one of these eggs (Tables 1 & 2). Often both eggs were warm as the birds tried to maintain incubation of two eggs under their brood patch. This contrasts with the occasional 2-egg nests found in the grey-faced petrel burrows where usually birds were sitting on one warm egg and the other egg was cold or pushed aside. Both females in the flesh-footed shearwater pairs were captured incubating warm eggs in their nest in the same season on 11 occasions. When both eggs were accessible, I discarded the least developed egg or one infertile egg from the nest so that the birds only needed to incubate a single egg. In ten seasons a fully grown chick was encountered in the nest in

April (two other chicks died before April). Trail camera footage in some of these seasons showed the chick was being fed by two different banded flesh-footed shearwaters so both females contributed to rearing the solitary chick. The chicks did not appear to be any different in terms of body mass or wing measurements than other flesh-footed shearwater chicks reared by conventional pairs in the same colony in the same seasons.

The mechanism for successful breeding by two females was finally observed one night on trail camera video footage. A female flesh-footed shearwater emerged from burrow C39 and began calling by her burrow entrance. In the next video clip, a flesh-footed shearwater from a breeding site upslope wandered down, called, and then mounted the female. There was a short act of copulation, then the female returned into her burrow and the helpful male wandered off. No pair bonding or mutual preening behaviour was observed. Extra-pair paternity is seldom recorded in seabirds (Quillfeldt *et al.* 2012) so this is an example where the behaviour is advantageous to both participants.

There is very little evidence from the literature that female-female pairs form in burrowing or cavity-nesting seabirds (Bried *et al.* 2009, Lorentsen *et al.* 2000) and long-term successful relationships

Table 1. Annual activity by a female-female pair of flesh-footed shearwaters (FFS) (*Ardenia carneipes*) at Kauwahaia Island. This pair apparently stayed together from 2007 to 2022. M67 is only 1 m from M54, which had a grey-faced petrel (*Pterodroma gouldi*) chick in 2022.

Year	Burrow	Band A	Band B	Egg status	Chick status
2005	G35	Z-50495	?	1x infertile	No
2006	G35	?	?	Grey-faced petrel chick	-
2007	G35	Z-50495	Z-50496	2x infertile	No
2008	G28	Z-50495	Z-50496	1x infertile, 1x fertile	1x chick
2009	G28	Z-50495	Z-50496	2x fertile	No
2010	G28	Z-50495	Z-50496	1x fertile	No
2011	G28	Z-50495	Z-50496	1x infertile, 1x fertile	1x chick
2012	G28	Z-50495	Z-50496	2x infertile	No
2013	M2	Z-50495	Z-50496	1x infertile, 1x fertile	1x chick
2014	M54	Z-50495	?	1x infertile, 1x fertile	No
2015	M54	Z-50495	?	1 fertile	1x chick
2016	M54	?	Z-50496	1x infertile, 1x fertile	1x chick
2017	M54	?	Z-50496	1x infertile, 1x fertile	1x chick
2018	M54	Z-50495	?	1x infertile, 1x fertile	1x chick
2019	M54	Z-50495	?	1x egg	? (Covid-19)
2020	M54	?	Z-50496	1x infertile, 1x fertile	1x chick
2021	M54	Z-50495	?	1x infertile	No
2022	M67	?	?	FFS x 2 eggs	? (no access - cyclone damage)

Table 2. Annual activity by three different female-female pairs of flesh-footed shearwaters (FFS) (*Ardenna carneipes*) at Kauwahaia Island. The G17 and M7 pairings only lasted one season. The M10/C39 pairing apparently stayed together for 13 years although the nest chamber used was sometimes inaccessible. *cold fertile FFS egg found abandoned in collapsed nest was successfully reared by C39 pair in 2012.

Year	Burrow	Band A	Band B	Egg status	Chick status
2005	G17	Z-35239	Z-35191	2x infertile	No
2006	-				
2007	M7	Z-23893	Z-2827	2x infertile	No
2008	M7	Z-23893	-	1x fertile	No
2009	-				
2010	M10	Z-23893	Z-23404	2x infertile	No
2011	C39	Z-23893	Z-23404	2x infertile	No
2012	C39	Z-23893	Z-23404	2x fresh eggs	1x chick*
2013	C39	?	?	2x eggs	1x chick
2014	C39	Z-23893	?	2x fertile	1x chick
2015	C39	?	?	2x eggs	No
2016	C39	?	?	1x egg	No
2017	C39	?	Z-23404	2x eggs	No
2018	C39	Z-23893	Z-23404	1x egg	1x chick
2019	C39	?	Z-23404	1x infertile, 1x fertile	? (Covid-19)
2020	C39	Z-23893	?	1x fertile	No
2021	C39	Z-23893	?	2x fertile	No
2022	C39	?	?	FFS on 2 eggs	? (no access - cyclone damage)

have not been observed previously. The strong female pair bonds formed at the Kauwahaia Island shearwater colony was most likely created by a shortage of male shearwaters at this site, as has been observed in other seabirds with a skewed sex ratio at the colony (Nisbet & Hatch 1999; Young *et al.* 2008). For example, DNA sexing of a random sample of 98 banded shearwaters caught on the colony across two decades found only 33 males, whereas 65 were females (GT *unpubl. data*).

These two long-term female-female shearwater pairs were successful in staying together across burrow shifts and despite recruiting males observed displaying near their nests. One bird was observed on motion activated trail camera to attract a male to copulate with but then bred with her long-term female partner in their usual burrow. These extra-pair copulations resulted in viable eggs but in most years human intervention was needed to allow a chick to be raised by removal of one of these eggs. On the occasions that both eggs were left in the burrow (due to the eggs being out of reach) the nests were unsuccessful, except in 2013 when a chick was produced in C39 (Table 2). The successful rearing of occasional chicks may have been a factor keeping these female-female pairs together over many years. Whether the pair bonds would have

lasted without any chicks being raised is unknown but elsewhere low breeding success in seabirds does often lead to divorce (Bradley *et al.* 1990). Two other female-female pairings lasted only one season after their nests failed (Table 2) and one of those females (Z-35191) paired with a male the following season. Small population sizes can make birds more willing to adopt mate choices that may not occur on large colonies with plenty of pairing opportunities (Bried *et al.* 2021). Interestingly, on Kauwahaia Island, newly recruiting male flesh-footed shearwaters observed calling at night near the burrows of the female pairs had no success in separating these well-established female pair bonds.

Warham (1990) reported that there was no evidence that any Procellariiformes could successfully rear two chicks in the same breeding season and only one natural nest with two young chicks had ever been observed - a pair of southern giant petrels (*Macronectes giganteus*) on Macquarie Island. Most likely both fertile eggs in these flesh-footed shearwater nests would have failed to hatch without intervention although one chick from a 2-egg clutch was reared once without any human intervention. The fate of the second egg was not determined.

Embryo development was observed in both

eggs of these female-female pairs on multiple occasions, which is surprising as the brood patch of shearwaters is shaped to accommodate only a single egg (Warham 1990). Over time it may become harder for the birds to heat both eggs sufficiently to maintain proper incubation temperatures. These partially incubated eggs were viable however as when the second fertile egg was swapped on several occasions with other flesh-footed shearwater pairs sitting on an infertile egg, those pairs went on to rear the adopted egg and fledge a chick.

Breeding by female-female pairs in burrowing seabirds may be more prevalent than previously realised, especially if colony sex ratios are skewed in favour of females. These findings further challenge the assumption that an unsexed partner will always be part of a male-female pairing in burrowing seabirds.

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