

Black shag (*Phalacrocorax carbo*): roost counts at Melling, Hutt Valley, and breeding in the Wellington region, New Zealand

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Abstract We counted the black shags (*Phalacrocorax carbo*) frequenting a night roost at Melling, 4.5 km up-river from the Hutt River mouth, Wellington, New Zealand, and studied the timing of breeding at various colonies in the Wellington region. Numbers at the roost were counted from Oct 1993 to Sep 1998: maximum and minimum mean monthly counts were in Feb and Aug, respectively. The main egg-laying period of 3 coastal colonies (0-2 km from the coast) (Mar-May) was c.3 months earlier than at 2 inland (5-33 km) colonies (Jun-Aug). We discuss the possibility that the difference in timing of breeding by shags in colonies at different distances from the coast is related to the different timing of peak prey availability in the 2 habitats (coastal marine, and inland riverine).

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INTRODUCTION

Breeding colonies of the black shag (*Phalacrocorax carbo*) occur from Northland to Southland (Bull *et al.* 1985), and on some offshore islands of New Zealand (Marchant & Higgins 1990). Roost sites and breeding colonies are distributed from the coast to well inland, and both are occupied at night during the non-breeding season. However, although the black shag is widespread and relatively common, the timing of its breeding and the monthly variation in numbers at night roosts have been little studied.

Falla (1932) stated that the species bred twice a year, laying eggs in May and Sep, but did not relate this to particular colonies. Eggs were laid at inland colonies near Lake Wairarapa in Aug-Oct (Sim & Powlesland 1995). By comparison, Gales (1984) found that black shags at the small coastal colony of Stony Creek, Dunedin, laid 2 clutches in May (neither hatched), 2 in Sep, and 1 in Nov. At

the same colony, Lalas (1983) noted that 5 clutches were laid during Sep-Jan; perhaps egg-laying was protracted because "nesting was drastically affected by human disturbance, ... all nestlings as they reached an age of about six weeks leapt out of their nests when disturbed and plummeted over the cliff to their deaths." Eighty-five percent of clutches of black shags breeding at a coastal site near Lake Kohangatera, Wellington, were laid during Apr-May, the remainder being laid in Jun-Sep (Powlesland & Reese 1999). Counts at dusk of shags roosting at this colony over 2 years, and observations of individually colour-banded adults and juveniles, indicated that some shags were absent from the colony during the non-breeding season, but apparently stayed mainly within a 30 km radius (Powlesland & Reese 1999).

In this paper we report the monthly counts of black shags roosting at Melling, near the mouth of the Hutt River, and the timing of breeding at various colonies in the Wellington region. Our aim in studying the roosting and breeding of black

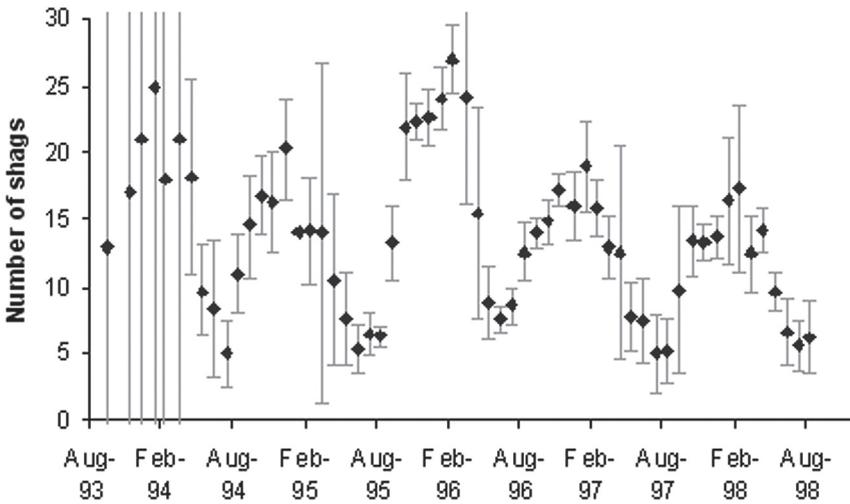


Fig. 1 Mean monthly counts (with 95% confidence intervals) of black shags (*Phalacrocorax carbo*) at the Melling roost, Hutt Valley, New Zealand, Oct 1993 to Sep 1998.

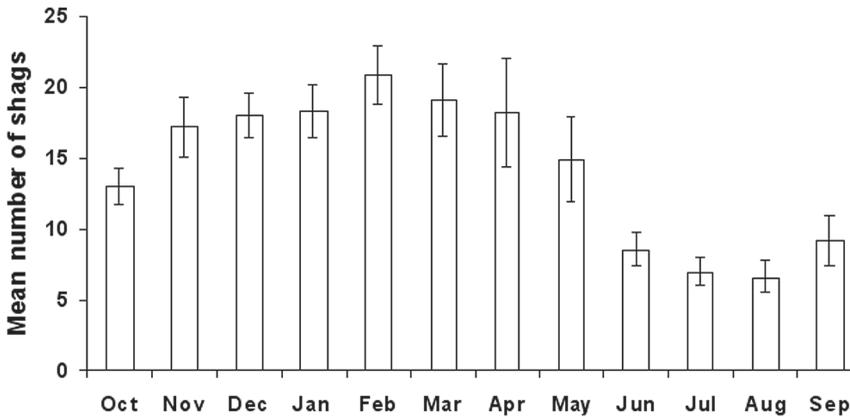


Fig. 2 Mean monthly counts (with 95% confidence intervals) of black shags (*Phalacrocorax carbo*) roosting at Melling, Hutt Valley, New Zealand, during 1993-98

shags in the region was to determine whether black shags bred at different times in coastal and inland colonies.

STUDY SITES AND METHODS

Observations at each of the following 4 sites were made using a 20x telescope, without the use of a hide. Details recorded during each colony visit were the number of roosting shags and occupied nests, and the predominant activity of adult nest occupants (mate attraction; nest-building; incubation; nestling rearing).

The Melling site (41°12'S, 174°55'E), is 4.5 km upstream from the mouth of the Hutt River, and is next to State Highway 2, near the Melling Bridge. A grove of macrocarpa (*Cupressus macrocarpa*) trees was used by shags as a night roost, and once as a breeding site. Roosting shags were counted during the 30 minutes before dark. Although most shags were at the roost before this period, shags occasionally arrived as darkness fell. We attempted

to obtain at least 4 counts each month over 5 years, from Oct 1993 to Sep 1998. In addition, during each count the trees were scanned for any evidence of that shags were nesting.

Black shags were first reported nesting in beech (*Nothofagus* sp.) trees beside the Hutt River opposite the Te Marua golf course (41°06'S, 175°08'E), 21.5 km up-river from the Melling site, in Oct 1994 by Shane Cotter. Te Marua was visited 4 times during the 1995 breeding season to determine when the shags bred.

During 1996 to 2005, at least fortnightly visits were made to the pied shag (*Phalacrocorax varius*) colony at Makara Beach (41°13'S, 174°43'E) on the Wellington west coast. One pair of black shags nested at the colony, on a macrocarpa tree, in 1999.

Sandy Bartle (*pers. comm.*) found black shags nesting at Pipinui Point (41°11'S, 174°45'E) in Oct 1994. In contrast to other sites, where the shags nested exclusively in trees, at Pipinui Point they nested among sparse clumps of flax (*Phormium tenax*)

and tauhinu (*Cassinia leptophylla*) on rock ledges on a steep ridge. The colony was at c. 100 m a.s.l., directly overlooking the shoreline. We visited the site in Mar, Apr, and May 1995, and in Apr 1996.

Wilkinson & Wilkinson (1952) reported 2 black shag colonies on rocky pinnacles on Kapiti Island, where they were rangers from 1924 to 1942 (MacLean 1999), but did not give the locations. These colonies were not seen during a boat survey of nests of coastal breeding bird species on 30 Nov 1996 by Wellington members of the Ornithological Society of New Zealand. However, 1 colony was seen on the north side of Kaiwharawhara Stream (40°52'S, 174°54'E) on the canopy of karaka (*Corynocarpus laevigatus*) trees c. 100 m inland. In 1983/84, this colony extended onto a small spur on the south side of the stream. During the same period, individual pairs nested in coastal rock crevices between Kaiwharawhara and Te Mimiorakopa Streams, and 3 pairs nested at Wharekohu Point and 2 south of Wharekohu Bay, at the southern end of the island (K. Brown & B. Cairns, *pers. comm.*).

The timing of nesting at the other 4 black shag colonies known in the region, where available, was obtained from the literature.

Changes in the numbers of black shags roosting monthly at Melling were compared by plotting means with 95% confidence intervals ($\pm 95\%$ C.I.), noting that although no overlap in confidence intervals indicates a significant difference, overlapping confidence intervals, particularly a small overlap, does not necessarily indicate a non-significant difference.

RESULTS

Melling roost counts

During the 5 years of counts, the mean number of shags roosting month⁻¹ at Melling peaked in Jan in 1994/95, Feb in 1993/94 and 1996/97, and Mar in 1995/96 and 1997/98 (Fig. 1). Peak mean numbers month⁻¹ were highest at 27.0 in 1995/96, and declined in the subsequent two 12-month periods. Mean numbers of shags month⁻¹ declined to a minimum in Jul or Aug each year, with the minimum monthly mean count generally being 5 or 6 birds. The pattern of monthly mean counts for the combined 1993–1998 data (Fig. 2) indicated that maximum mean numbers of roosting shags were seen in Feb and minimum in Aug. Numbers using the roost declined significantly from May to Jun, and increased significantly from Oct to Nov.

At the time of this study, black shag nestlings at the colony near Lake Kohangatera, Pencarrow (41°23'S, 174°52'E), about 2 km inland from the Wellington south coast and 18 km from the Melling roost, were being cohort colour-banded (1990, 1992 and 1993) or individually colour-banded (1994, 1995, 1996) (Powlesland & Reese 1999). Between 1993 and 1998, at least 3 cohort colour-banded and

7 individually colour-banded shags were seen at the Melling roost. Too few observations at the start of the breeding season were made at both sites in close succession to determine accurately when adults stopped using the Melling roost in favour of the Lake Kohangatera colony, but it was probably during Feb–Mar. One observation suggests that black shags can easily fly the 18 km between the two sites. During the evening of 21 Sep 1998, W/M–G/Y was roosting at Melling; 2 days later it was seen at the colony feeding a fledgling, which it probably did every day.

Timing of breeding at Wellington region colonies

The location and timing of egg-laying at black shag colonies in the Wellington region of which we are aware are given in Table 1. Four “coastal” colonies were either (Pipinui Point, Makara Beach, Kapiti Island) on the coast, or (Lake Kohangatera) <2 km from the coast. At 3 of the colonies, most clutches were laid in Mar–May, with the few later clutches laid at the Lake Kohangatera colony being replacements for earlier failed nesting attempts (Powlesland & Reese 1999). The black shag laying season on Kapiti I is not known. Wilkinson & Wilkinson (1952) did not report when nesting occurred at the 2 colonies they observed. However, on 30 Nov 1996, 8 nests were seen at the colony near Kaiwharawhara Stream, of which 2 were vacant and the rest each contained 1 or 2 large downy chicks judged to be about 1 month old. These chicks would have resulted from clutches laid in late Sep or early Oct. We do not know whether the shags had nested there earlier in the year.

Inland, the lake behind the Wainuiomata Dam was drained in about 1991, and, apparently, the shags vacated their colony there soon after (Table 1). We have not been able to find any information about the timing of black shag breeding at this colony. Likewise, we have not visited the Hutt River gorge colony nor found any records that indicate the timing of breeding. Eggs were recorded at the Te Marua colony in Jul–Aug in 1994 and 1995, and at the single nest at Melling in Jun 1994.

DISCUSSION

Peak numbers of black shags at the Melling roost in Jan–Mar (Fig. 2) coincided with the end of successful breeding at the Te Marua site in late Dec–early Jan (egg-laying late Jul–early Aug; incubation c. 29 days (Heather & Robertson 2005); chick-rearing to independence c. 125 days (Powlesland & Reese 1999)). Although some banded black shags from the coastal Lake Kohangatera colony used the Melling roost, numbers at this roost did not decline markedly at the time these birds would probably have left it (Feb–Mar) to roost overnight at the colony, where most clutches were laid in Apr–May (Powlesland & Reese 1999). One explanation for this would be that

Table 1 Locations of colonies and timing of egg-laying by black shags (*Phalacrocorax carbo*) in the Wellington region, North Island, New Zealand. MEP, main egg-laying period. Observations, years in which observations made at that colony.

Location	Observations	Year of nesting	No. of nests	MEP	Source	MEP (summary)
Coastal colonies						
Lake Kohangatera, south coast	1993-98	Each year	21 - 30	Apr - May	Powlesland & Reese (1999)	Apr - May
Pipinui Point, west coast	1995-96	Each year	6 - 10	Mar - Apr	This study	Mar - Apr
Makara Beach, west coast	1997-2005	1999	1	May	This study	May
Kapiti I	1924? 1996	Unknown 1996	Unknown 8	Unknown Sep - Oct	Wilkinson & Wilkinson (1952) This study	
Inland colonies						
Melling, Hutt Valley	1993 - 98	1994	1	June	This study	Jun
Te Marua, Hutt Valley	1994 - 95	Each year	2 - 10	Jul - Aug	This study	Jul - Aug
Wainuiomata Dam	1981-82	Unknown	Unknown	Unknown	Parrish (1984)	
Hutt River gorge downstream of Pakuratahi Forks	Unknown	Unknown	Unknown	Unknown	Stephenson (1977)	

only a minority of shags at Melling originated from coastal colonies, such as Lake Kohangatera. That there was a significant decline in numbers roosting at Melling from May to Jun (means of 14.9 and 8.5, respectively), a few weeks before the start of egg-laying at the inland Te Marua colony suggests that most shags at Melling were from colonies further up the Hutt River. The significant increase in numbers at Melling from Oct to Nov (means 13.1 and 17.2, respectively) occurred a few weeks after completion of nesting at coastal colonies, such as Lake Kohangatera, in Oct.

The main egg-laying period of black shags in the Wellington region at coastal sites is Mar-May (autumn), and at inland sites is apparently Jun-Aug (winter). We do not know why there should be a 3-month difference in the start of egg-laying by black shags at coastal versus inland Wellington colonies. Weather conditions experienced by shags at the two types of colonies in the Wellington region probably differ little, given the small differences in distance from the coast (0-2 km for coastal colonies, 5-33 km for inland colonies), and in altitude (coastal colonies 0-100 m a.s.l.; inland colonies, 40-200 m a.s.l.).

Food availability is an important factor influencing the timing of breeding in most birds (Murton & Westwood 1977; Perrins & Birkhead 1983; Ford 1989). Birds must time their breeding such that the peak in their food requirements coincides with when prey is most readily available. Egg production in the black shag, and in the Phalacrocoracidae in general, is not particularly demanding given that they lay small eggs relative to female body size; (2.5%, 2.1-4.7%, respectively; Table 24 in Johnsgard 1993). Food demand peaks for black shags during the 2nd half of chick-rearing, and in early post-fledging when adults must find sufficient prey for 1-3 large young as well as for themselves. Also, given that there is high mortality of Phalacrocoracidae in the first few months of independence (Johnsgard 1993), it would be important for adults to fledge young when prey is readily available so that young shags can catch sufficient prey to survive while their foraging skills are still developing. Thus, the main reason for the difference in timing of breeding by black shags at Wellington coastal versus inland colonies may be that the timing of peak prey availability differs.

In marine habitats, black shags generally forage in shallow waters (1-3 m; Stonehouse 1967), with an average maximum of 6.1 m (Nelson 2005) along coasts and in estuaries and harbours. They avoid deep water and rarely forage far offshore (Snow & Perrins 1998). This habitat selection is reflected in the fish species black shags brought to the coastal Lake Kohangatera colony during the breeding season (Apr-Oct). The main prey

species were mostly bottom-dwelling: in order of importance (% of 420 prey items in 119 pellets) they were spotty (*Notolabrus celidotus*), rock cod (*Lotella phycis*), yellow-eyed mullet (*Aldrichetta forsteri*), sole (Pleuronectiforms), red cod (*Pseudophycis* spp.), and mackerel (*Trachurus* spp.) (McKinnon *et al.* 2004). Similarly, the main prey species of black shags at the coastal Otago colony at Stony Creek during Oct 1979-Jan 1980 was the yellow-eyed mullet (58% of 62 pellets), while thornfish (*Bovichtus variegatus*), red cod, wrasse (*Pseudolabrus* spp.), and rock cod occurred in 10 - 32% of pellets (Lalas 1983). Some of these species (spotty, red cod, yellow-eyed mullet, mackerel, common sole) spawn from winter into summer, and their juveniles start to settle from the larval planktonic stage in summer (Francis 1988). In addition, schools of juvenile and adult yellow-eyed mullet first move into estuaries from coastal waters in early summer. Therefore, during Jul- Nov, when black shags are feeding large chicks and fledglings, some of their main prey species are spawning. It is not known whether spawning makes these fish vulnerable to capture by black shags.

The principal prey species of black shags breeding at inland colonies along the Hutt River are unknown. The fish species present in the river were, in order of abundance: red-finned bully (*Gobiomorphus huttoni*); blue-gilled bully (*Gobiomorphus hubbsi*); long-finned eel (*Anguilla dieffenbachii*); brown trout (*Salmo trutta*); Cran's bully (*Gobiomorphus basalis*); common bully (*Gobiomorphus cotidianus*); and short-finned eel (*Anguilla australis*) (Jowett & Richardson 1996). Black shag prey items are often difficult to identify to species, but all the genera listed by Jowett & Richardson (1996) are known to be eaten by black shags (Falla & Stokell 1945; Dickinson 1951; Lalas 1983; Marchant & Higgins 1990). Phillipps (*in* McDowall 1990) reported that in the 1880s "cartloads" of whitebait (*Galaxias* spp.), another food source of black shags (Marchant & Higgins 1990), were taken from the Hutt River. Galaxiids have declined drastically in abundance in the Hutt River over the past 125 years and very few whitebait are caught in the river today (McDowall 1990). Most fish species in the Hutt River either migrate upstream as juveniles from coastal waters or estuaries in spring (Sep-Nov) to mature (eels, galaxiids, red-finned bully, blue-gilled bully, common bully), or hatch upstream in spring (Cran's bully, brown trout). If the peak of egg-laying of black shags nesting along the Hutt River is early Jul, (observations at 2 colonies; Table 1), then the period of peak food demand for the shags (late chick to juvenile stages) would be Sep-Nov. This period coincides with an influx of juvenile fish of several species into the river (McDowall 1990), but whether these small fish would be suitable prey for adult black shags rearing large chicks or fledglings

is unknown. Given that we determined the timing of egg-laying for just 2 inland colonies, and have no information on the diet of shags at these colonies, our conclusion that there is a 3-month difference in the timing of the nesting seasons of coastal versus inland black shag colonies is, of course, speculative, but we hope that our observations will stimulate others to make comparative observations of coastal and inland black shag colonies elsewhere in New Zealand.

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