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Aspects of the ecology of the Grey Falcon *Falco hypoleucos* in the South Australian arid zone

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Breeding productivity and diet of the Grey Falcon *Falco hypoleucos* were recorded in the Strzelecki Creek region of arid north-eastern South Australia in 1982–85 and 1995–2000, by systematic searches for nests (*n* = 4 found), inspection of their contents on repeat visits within a season by climbing or by pole-mounted mirror, and by analysis of prey remains and pellets collect from within and beneath nests. One nesting pair was found in each of 1982 (C/2 failed), 1984 (B/2 chicks), 1996 (B/3 chicks) and 1998 (B/3 feathered nestlings ~5 weeks old). Nests were vacant stick nests of Black Kites *Milvus migrans* and corvids in the canopies of Coolibahs *Eucalyptus coolabah*, and laying occurred in August–September (*n* = 4 clutches/broods). Diet was entirely birds (*n* = 20 prey items from the three nests with chicks). General habits, interspecific conflict and defence of the nest against humans are described. Ethical issues relating to the banding of the Falcon chicks in 1984 are discussed.

INTRODUCTION

The scarce, little-known Grey Falcon *Falco hypoleucos*, of the remote Australian arid zone, is officially listed as *rare* in South Australia (see Sutton 2011 for a review). Its breeding range has contracted inland since the 1950s, and it is suspected to have been adversely affected by human impacts in the arid and semi-arid zones (e.g. Olsen and Olsen 1986; Marchant and Higgins 1993; Garnett and Crowley 2000). The little previous research in South Australia has concerned amateur observational/photographic studies of the behaviour and diet of nesting pairs on the Strzelecki Creek/Cooper Basin in the north-east (Cupper and Cupper 1980, 1981; Hollands 1984).

In at least some years, the Strzelecki and Cooper Creek drainage systems are among South Australia's most important raptor breeding areas (e.g. Cupper and Cupper 1981; Mace 1981; Hollands 1984). Expeditions have been mounted to the Strzelecki Creek since 1980 to document breeding events and band raptors, including Grey Falcons, although there have been ethical issues relating to these activities (e.g. Baker-Gabb 1986; Dennis 1986, 1989). These issues have included:

- trail-blazing (vehicle tracks) directly to raptor nests;
- unauthorised marking of eggs, by non-researchers;
- failure to notify rangers of visits to the Strzelecki Creek;
- unauthorised climbing to nests and handling eggs or chicks (i.e. without research permits or sufficient expertise);
- photographers and observers keeping adult raptors off nests, and thus exposing eggs or young to sun, heat and predetation;
- 'rally' banding and band 'transplants', including listed *vulnerable* species, by unlicensed and inexperienced banders.

During raptor surveys along the Strzelecki Creek in the breeding seasons of 1982–85 and 1995–2000, I recorded four Grey Falcon breeding events. In this paper are described aspects of the Falcon's field characteristics, breeding biology, reproductive success and interspecific interactions observed during these surveys. Also discussed are some ethical issues relating to the banding of one brood of Falcon chicks in 1984, partly relating to band size (see Schoenjahn 2011), and about which rumours have been circulating ever since among banders and raptor biologists. That is, the chicks were banded (by another member of the survey team) at a young age with inappropriately large bands (size 27) for this species, notwithstanding one chick being sexed as male, thus risking the welfare of the chicks. Those rumours, of alleged injury to one chick, are here clarified.

STUDY AREA

The arid zone of South Australia, north of a line from the Murray River where it crosses the South Australian/Victorian border to Morgan (34°S) and Port Augusta (32°S) thence westwards to the Western Australian border, comprises approximately 80 percent of the state's land area, with about half of this area under pastoral leases and half under conservation reserves and Indigenous land use (see Ehmann 2005). The Strzelecki Desert, in the north-eastern corner of South Australia (28–29°S), is dissected by the Strzelecki Creek, which is lined by a narrow riparian woodland surrounded by linear, parallel sand dunes. The Strzelecki Creek receives flows from the Cooper Creek only under extreme flood conditions and, consequently, is inundated much less frequently than the Cooper (see Falkenberg *et al.* 2000 for further details and map). The study area has low and highly variable rainfall (<50 mm to almost 300 mm p.a. at Merty Merty Station, with a mean of 138 mm p.a. over the study period; Figure 1). Important land types are watercourse and floodplain systems. Effective rainfall (spread throughout the cooler months) is more important than total rainfall, e.g. summer thunderstorms that generate runoff

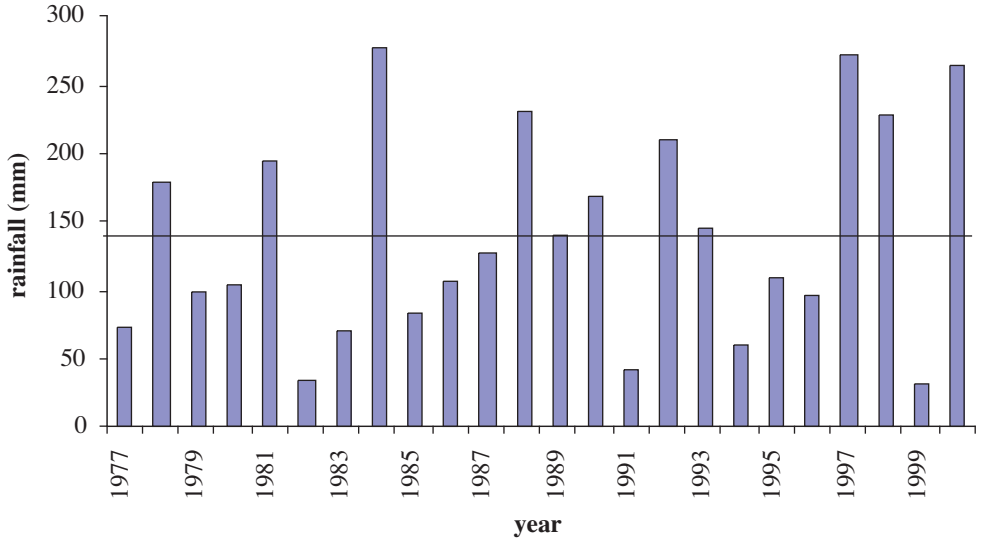

Figure 1. *Annual rainfall (mm) and long-term average for Merty Merty Station, Strzelecki Creek, South Australia (1977 to 2000).*

but little sustained plant growth and recruitment or improved rangeland condition, although the benefit of effective rainfall can be depressed by heavy total grazing pressure (stock plus rabbits). The main land uses in the region are cattle and sheep grazing, mining and mineral exploration, oil and gas production, conservation and tourism.

The survey area was that part of the lower and middle Strzelecki floodplain (0.5–3 km wide) from Tinga Tingana Crossing to Toolache Waterhole (see Figure 1 of Falkenberg *et al.* 2000). In the 1980s survey period, total grazing pressure (pre-calicivirus) was extremely high, with introduced European Rabbits *Oryctolagus cuniculus* in plague numbers causing, in concert with other grazing animals, a significant impact on rangeland condition and habitat quality. For instance, rabbits had all but destroyed (by ringbarking and burrowing under the roots) the formerly common, but now rare, stands of Dune Wattle *Acacia ligulata* on the floodplain and dunes.

In the 1990s survey period (post-calicivirus), after good rains and a very low rabbit population (see Falkenberg *et al.* 2000), much of the desert and drainage-system vegetation had responded positively, with improved vegetative cover and increased herbage and seed production. The Strzelecki Regional Reserve was de-stocked in the mid 1990s, and has been ungrazed for approximately 15 years. A 10-kilometre section of creek and dune system from Mundibarcooloo Waterhole to Merty Merty which is outside the reserve, has been stocked intermittently during this period.

METHODS

Grey Falcon nests were located during surveys of breeding raptors on the Strzelecki Creek and a biological survey of the Cooper Basin in 1982–85 (e.g. Baker-Gabb 1986), including banding by some participants, and during surveys of the effect of Rabbit Haemorrhagic Disease (calicivirus) on rabbits and raptors in 1995–2000 (Falkenberg *et al.* 2000). Extensive searches by teams of people were undertaken in the study area to locate active raptor nests in the two time periods (early 1980s and mid to late 1990s), with two surveys undertaken during each breeding season (August/September and October/November according to seasonal conditions) to determine raptor productivity and nesting success (following Postupalsky 1974; search protocol described by Falkenberg *et al.* 2000). During the 1982 to 1985 surveys, active raptor nests were located by systematically searching creek drainage channels and associated floodplain habitats (including trees in the inter-dune swales). Nest activity was determined by inspecting each nest with binoculars, then climbing each tree to determine the number of eggs or young. Less invasive search and nest-assessment methods (by pole-mounted mirror rather than climbing) were adopted during the later survey (1990s), as described elsewhere (Falkenberg *et al.* 2000). Databases (ABBBS, RAOU Nest Record Scheme) were also used to ascertain the raptor breeding community of the Strzelecki Creek in 1982–87, as determined by banders and other researchers (see Falkenberg *et al.* 2000).

The previous occupants (i.e. original builders) of the stick nests of falcons were determined by their site and construction, and/or by observing the former owners nesting in the preceding years. In 1995–2000, all raptor and corvid nests were recorded by GPS and mapped, so the owners in the prior year were known for 1996–2000. The 1984 Grey Falcon nest had been a corvid nest in 1983, and the 1982 nest was a corvid nest on the basis of its construction, lining, size and location in the tree.

Grey Falcon nestlings were aged and sexed on the basis of my familiarity with known-age captive and wild nestlings of the analogous Peregrine Falcon *Falco peregrinus*, information on its nestling growth stages (e.g. Marchant and Higgins 1993), and known reversed sexual size dimorphism of the Grey Falcon and published photographs of its known-age chicks (e.g. Cupper and Cupper 1981; Hollands 1984). Observations of behaviour were obtained incidentally during nest checks for diet and productivity data, and sustained observations were made of nesting behaviour from a distance using binoculars and telescope, especially in October 1984 when observations were recorded over a period of seven days.

Prey remains were collected from within and under each active Grey Falcon nest, and pellets were collected from beneath nests that contained young and from under the male's plucking and perching sites (if known). Prey remains were identified to species where possible, to give a minimum number of prey individuals per nest. The number of items per nest was determined by counting body parts (e.g. beaks, feet) and main flight-feathers, and not by assuming one individual in each pellet (e.g. Olsen *et al.* 2004). Prey items were assigned to the current Grey Falcon nesting event, rather than possible prior occupants of the nest in the previous year(s), on the basis of freshness (as opposed to old, weathered remains).

RESULTS

Field characteristics

Grey Falcons are confiding and tolerant of people and passing vehicles, and often sit motionless in the canopies of trees. Perched in the upper canopies of Coolibahs *Eucalyptus coolabah* and River Red Gums *E. camadulensis*, they can be cryptic and difficult to see, as their plumage blends with the grey and white branches. They also perch on exposed dead branches of eucalypts, where their grey plumage similarly blends (Figure 2). An active Grey Falcon nest in 1984 was approximately 30 metres from a well-used public route, and two experienced ornithologists passing by on several occasions did not see the adults perched in the nest tree or detect the active nest with young.

Interspecific interactions

At a Grey Falcon nest with two small young in early October 1984, the male aggressively attacked individual corvids, Black Kites *Milvus migrans* and other raptors that strayed towards the nest tree. He vocally defended the nest by stooping repeatedly from a height of approximately 20–25 metres above the ground (~2.5 × treetop height), the attacks intensifying as the corvids and Black Kites approached to approximately 80 metres. Black Kites were attacked more intensely than corvids. The female Falcon was brooding the chicks at this stage, and was not observed to leave the nest during these attacks.

On one occasion, about 20 Black Kites and six corvids had congregated at a dead rabbit approximately 200 metres from the above 1984 nest, two corvids and three Kites feeding on the carcase while the others waited. A Brown Falcon *Falco berigora* also landed on the ground a few metres away, but did not attempt to feed. A Black Falcon *F. subniger* (assumed male on relative size) landed on the ground, then approached and fed alongside the corvids and Kites. Among a few squabbles between the Black Falcon, Kites and corvids, the Black Falcon fed on the carcase until the male Grey Falcon launched a vigorous attack, from the nest tree, at the Black Falcon. The latter flew off immediately, under great acceleration, with the Grey Falcon in close pursuit. The Grey Falcon outflew the Black, with more rapid wing-flapping (7 vs 5.5 wing beats per second). In fast horizontal flapping flight at a low rate of climb, the Grey Falcon overtook the Black Falcon several times before terminating the attacks, each of which had lasted approximately 30–40 seconds and covered 160–200 metres in that time. This behaviour was repeated several times over a two-day period and each time, the Grey Falcon dominated in attacking horizontal flapping flight. However, on the third attempt to feed on the carcase, the Black Falcon appeared to be less deterred by the attacking Grey Falcon. There was an active Black Falcon nest approximately 2.5 kilometres to the north-east.

Figure 2. *Adult pair of Grey Falcons perched cryptically on dead branch near active nest in the Strzelecki Creek region, South Australia, 1998 (see text).*

Photo: the late Jim Robinson (courtesy Neil Jarvis).

Nest defence and banding ethics

Two young Grey Falcon chicks approximately 14–18 days old (one sexed as male, one as female) were banded on 3 October at the 1984 nest (bands supplied by the ABBBS). Both adults vigorously defended the nest when the tree was climbed: the female initiated repeated attacks, with intensity similar to that of a Peregrine Falcon, although the male maintained more distance from the climber. As the climber made his way to the nest, the Falcons stooped repeatedly and almost vertically through the tree canopy, and as the climber reached the nest the female struck him on the shoulder. The female was the more vocal of the pair, although both adults called while defending. The adults' calls were similar to those of the adult Peregrine Falcon's defensive cackle, though a little harsher and not as loud or piercing. The chick's defensive calls were very similar to those of Peregrine chicks.

There were some ethical issues relating to the inappropriate band size (27) used to band the two falcon chicks, especially the putative male (see discussion by Schoenjahn 2011). Although the weather was mild on this day, adult falcons and chicks may be stressed in hot weather, so both chicks were returned to the nest as quickly as possible and morphometric measurements were not taken. Contrary to rumours that have been circulating among banders and raptor biologists, there were only two healthy chicks in the brood (as confirmed by photographic evidence) and both were returned safely to the nest, without injury to either. However, over-sized bands on small and developing young may slip over the ball of the foot, thus crippling it and compromising the bird in later life: a risk heightened in this case by the age of the young, whose tarsi and feet had not fully developed.

Breeding biology

All four nests used by Grey Falcons in the Strzelecki Creek system were the disused nests of corvids and Black Kites approximately 11–15 metres above ground, in the upper canopy of Coolibahs. Two nest trees were located along the edge of the drainage channel and the others were on the edge of the floodplain, close to the dune system. The nest in 1982 had eggs on 3 September; the nest in 1984 had young approximately 14–18 days old on 2 October; the nest in 1996 had young approximately 10–14 days old on 1 October; and the nest in 1998 had near-fledged nestlings approximately 5 weeks old on 20 November. Thus, egg-laying at these four nests would have been spread across the months of August and September, based on an incubation period of approximately 5 weeks (Marchant and Higgins 1993; Sutton 2011).

There appeared to be much competition for nest sites, particularly disused corvid nests (Australian Raven *Corvus coronoides* and Little Crow *C. bennetti*). Black Falcons used the vacant nests of the Wedge-tailed Eagle *Aquila audax*, Black-breasted Buzzard *Hamirostra melanosternon*, Little Eagle *Hieraaetus morphnoides* and corvids in some seasons, and Brown Falcons used Wedge-tailed Eagle and Black Kite nests as well as those of corvids. I did not record Grey Falcons nesting in other than corvid and Black Kite nests, although Cupper and Cupper (1981) and Hollands (1984) recorded Grey Falcons using nests of the Whistling Kite *Haliastur sphenurus* in the region. I also did not record Grey Falcons using the same nest in consecutive seasons, despite checking the known 1982, 1984, 1996 and 1998 Grey Falcon nests in the following years (i.e. in 1983, 1985, 1997 and 1999 and throughout the study period while these nests existed).

During the 1984 breeding season, the male Grey Falcon typically arrived with prey (usually plucked and sometimes partly eaten) on a dead tree in the nest area. The female almost immediately flew to the dead tree and took the food from the male, and he then flew to the nest and incubated the eggs or brooded small young. On two occasions following feeding, the female returned to the nest tree and perched beside the nest while the male continued to incubate. The adults' calls around the nest were similar to equivalent calls of the Peregrine Falcon, but much softer in volume and did not carry as far.

Breeding productivity

One pair of Grey Falcons was found breeding in each of 1982 and 1984 (pre-calicivirus). In 1982 (a drought year) the clutch of two eggs failed, and in 1984 (a wet year, with good rains in April–June and September) the falcons had a brood of two chicks. During surveys in 1995–2000 inclusive (post-calicivirus), one pair of Grey Falcons was found breeding in 1996 and 1998, in each case with a brood of three chicks (the last near fledging age, though in no case, in either survey period, was fledging confirmed by checking the nests at fledging age). 1997 and 1998 were wet years (Figure 1). Well-grown and feathered nestlings can be assumed to have fledged successfully (e.g. Postupalsky 1974), although this assumption can only be applied to the 1998 brood of three. Without marked birds, it is unknown whether the same individual adult Falcons were involved in these various events. Based on the location of nests over the years, it appeared that there were two pairs of Grey Falcons along the relevant section of the Strzelecki Creek, between Merty Merty and the crossing.

Grey Falcons, Brown Falcons and Australian Hobbies *Falco longipennis* were the only falcon species observed to produce young successfully on the Strzelecki Creek during the drought year of 1996, a period of lowest rainfall (Figure 1). Nesting territories of Grey Falcons were also checked in 1983, 1985, 1995, 1997, 1999 and 2000, and no pairs were found in the study area during the breeding season (other than 1995, when one pair was sighted though not found nesting). These were dry years, except for 1997 and 2000 (Figure 1). Grey Falcon productivity data from 1988 to 1994 are not available.

It appeared that, in pre-calivirus times, Grey Falcons produced a small clutch (C/2) that failed in drought, or produced a small brood (B/2, notwithstanding a wet year), whereas in post-calicivirus times Grey Falcons produced large clutches and broods (B/3 × 2) in both dry and wet years (cf. Figure 1). However, coupled with the possibility of undetected nests in inter-dune swales, sample sizes are too small to draw definitive conclusions on the effect of the calicivirus or total annual rainfall on Grey Falcon productivity, although the effect on prey resources (e.g. habitat and seed for granivorous birds) was dramatic.

Prey

Prey remains at Grey Falcon nests consisted exclusively of birds in both time periods: almost equally pigeons, small–medium parrots and passerines, and mostly flocking granivores (Table 1). All observations of Grey Falcons feeding also involved exclusively avian prey. However, sample sizes were small. Given the stages of the breeding cycle when prey remains were collected (i.e. young 14–18 days old, and the seven-day watch at the 1984 nest), it is likely that most or all of the recorded items were caught by the male. The Grey Falcon was not observed to attempt to feed on the rabbit carrion discussed above, and no evidence was obtained of rabbit in the diet, nor of prey-switching during the surveys (e.g. pre- versus post-calicivirus).

DISCUSSION

The confiding nature, cryptic plumage and perching habits of the Grey Falcon may mean that it is under-recorded in its remote core range and habitat, as noted by Hollands (1984) and Harrison (2000). This aspect may suggest that its population in the arid zone is underestimated although, conversely, there are many false records of other grey-and-white or grey-backed raptors as 'Grey Falcons' in its peripheral or extralimital range, and even its core range (e.g. Schoenjahn 2010).

Interspecific conflict between Grey Falcons and other raptors may represent competition for nest sites and defence against potential nest predators. In the case of the Black Falcon, which was singled out for particularly intense attack, it may also include competition for foraging space and prey, as the two species take similar, predominantly avian prey (e.g. Marchant and Higgins 1993; Debus and Olsen 2011; Sutton 2011). The Grey Falcon's flight capability (e.g. outflying the Black Falcon) may have been related to more rapid acceleration of a lower body mass (cf. Debus and Olsen 2011; Schoenjahn 2011), but may also have been related to motivation, e.g. nest defence.

TABLE 1

Prey items (minimum number of individuals) in one nest of the Grey Falcon in each of 1984, 1996 and 1998, Strzelecki Creek (SA).

Prey species	1984	1996	1998	Total
Crested Pigeon *Ocyphaps lophotes*	5	1	1	7
Blue Bonnet *Northiella haematogaster*		1		1
Red-rumped Parrot *Psephotus haematonotus*	3			3
Budgerigar *Melopsittacus undulatus*	2		2	4
Woodswallow *Artamus sp.*	1			1
Zebra Finch *Taeniopygia guttata*	1			1
Unidentified passerine	2		1	3
Total	**14**	**2**	**4**	**20**

The Grey Falcon's nest defence against humans, when the tree was climbed, was similar to that previously described (Cupper and Cupper 1980, 1981; J. Kershaw and N. Favaloro in Olsen and Olsen 1980; Sutton 2011), including calling while defending. Its defensive vocalisations are similar to those of the Peregrine Falcon (cf. Marchant and Higgins 1993) and, among Australian falcons, its cackling call is most like that of the Peregrine. From the various descriptions (Cupper and Cupper 1980, 1981; Hollands 1984), it is apparent that the Grey Falcon's vocal repertoire consists of the typical falcon cackle, wail, guttural double cluck ('ee-chip'), maternal 'chup', and other chittering and whining sounds (as described for other large falcons by Cade 1982).

Aspects of the Grey Falcon's breeding biology and behaviour were similar to those previously reported for the Strzelecki Creek and elsewhere, including some broods of three young (cf. Cupper and Cupper 1980, 1981; Hollands 1984; Olsen and Olsen 1986; Marchant and Higgins 1993; Aumann 2001a; Sutton 2011). The suggestion that breeding success and brood size may be lower in years of below-average rainfall, and higher in years of high effective rainfall, supports the similar conclusions of Sutton (2011). The Grey Falcon's breeding diet on the Strzelecki Creek was entirely avian, as confirmed by other recent studies in that area and elsewhere (see Sutton 2011 for a review), and included a wider range of avian prey than recorded by Aumann (2001b) for the south-west of the Northern Territory.

The above tentative conclusions on breeding ecology require further study, with larger sample sizes. The suggestion that Grey Falcons might not use the same nest in consecutive years is possibly also supported by the findings of Aumann (2001a) and Sutton (2011). This aspect deserves investigation, given that such a situation may place nest sites at a premium, as most medium-sized and large falcon species of the arid and semi-arid zones rely entirely on vacant, pre-constructed stick nests (see also Olsen *et al.* 2006; Debus and Olsen 2011). The Strzelecki Creek area may be one of the more accessible areas for further study of the Grey Falcon, in relation to distance from research institutions.

The issue of banders' ethics discussed herein and elsewhere (Baker-Gabb 1986; Dennis 1986, 1989) relates to a notorious period in the 1980s, when the conduct of some banders and other raptor enthusiasts on the Strzelecki Creek may have risked the welfare of raptors, and the standing of legitimate raptor research with the authorities. These matters should stand as an object lesson, and henceforth encourage best practice; Baker-Gabb (1986) has provided a code of practice for raptor research on the Strzelecki Creek. In addition, banding should not be undertaken in hot weather (>35°C), as it stresses both adults and young; corvids may prey on eggs when adult raptors are forced off the nest for prolonged and unnecessary periods; raptor chicks should only be banded when observations establish that they are almost full-sized and feathered (though not old enough to fledge prematurely); and Buzzard and other raptor nests, precariously situated in dead branches potentially unable to support the weight of a person, should not be climbed. In the case of the Grey Falcon, the recommended band size for this species should be officially reviewed by the ABBBS (see also Schoenjahn 2011). Further, there seems little point in research projects focussed on banding only, where the likelihood of band returns is poor.

Finally, human management of the arid zone (e.g. total grazing pressure) may have a bearing on Grey Falcon abundance and conservation status, through impacts on vegetation and prey resources (this study; Sutton 2011). Therefore, the statement by Hollands (1984) that Man interferes with deserts less than other habitats deserves challenge in the light of findings by, for example, MacMillen and MacMillen (2009) in relation to grazing. For instance, the piosphere (grazed zone around water sources in the arid rangelands) can be severely degraded in fenced, set-stocked runs watered by bores (e.g. Debus *et al.* 2006; MacMillen and MacMillen 2009). Although the Strzelecki system does not suffer the same degree of piosphere effect because remaining cattle-grazing is based around bores and ephemeral, natural water sources, the creation of the Strzelecki Regional Reserve has been of obvious benefit to rangeland health and, therefore, probably to the benefit of the Grey Falcon's prey base and hence the Falcon too.

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