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The movement and survival of Star Finches *Neochmia ruficauda subclarescens* in the Wyndham Region of Western Australia

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This study uses capture-recapture data from four years of mistnetting in the Wyndham district of Western Australia to investigate the movement, longevity and survival probability of the Star Finch *Neochmia ruficauda subclarescens*. Results show that Star Finches should be described as locally mobile rather than sedentary; juvenile survival during the study period was low and differed between years; and, the maximum time between banding and recapture was 3.4 years. The impact of rainfall and fire on survival are also discussed.

INTRODUCTION

The Star Finch *Neochmia ruficauda* is a non-migratory, granivorous passerine that inhabits the tropical savannahs of northern Australia. Along with several other granivore species, numbers have declined since European settlers changed land-use practices in the region (Franklin 1999; Franklin *et al.* 2005). The decline of these species is believed to reflect reduced availability of important grass seed resources resulting from changes in fire regimes and the expansion of pastoralism (Dostine and Franklin 2002). Research in the last decade has investigated the effects of fire/fire management in north-western Australia (Dostine *et al* 2001; Legge *et al.* 2011; Maute 2011) and the availability of nesting habitat (Brazill-Boast 2013; Brazill-Boast *et al.* 2010, 2011).

The subspecies *subclarescens*, occurs as separate populations in the Pilbara, Fitzroy River Valley and from the East Kimberley to the Northern Territory/Queensland border (Johnstone and Storr 2004). In the East Kimberley, the main population strongholds are in the vicinity of the townships of Kununurra and Wyndham where they usually inhabit low lying areas near permanent water (Barrett *et al.* 2003; Evans and Fidler 2005).

Star Finches sometimes share habitats and food resources with several other finch species including the Gouldian *Erythrura gouldiae*, Long-tailed *Poephila acuticauda,* Masked *P. personata*, Crimson *Neochmia phaeton* and Double-barred *Taeniopygia bichenovii* finches. They form larger flocks relative to similar species, roost together in large numbers at night (Johnstone and Storr 2004; Higgins *et al*. 2006), crèche newly fledged juveniles in dense bushes in the middle of the day while adults seek food and move farther to forage than other finches, apart from the Gouldian Finch (Legge and Murphy – cited in O'Malley 2006b; Woinarski and Tidemann 1992).

Only 129 individuals had been captured in previous banding studies and no movement of banded birds had been recorded (ABBBS 2013). While male Star Finches may live seven or eight years in captivity (B. Hockley pers. comm.), the previous longevity record established in a banding study was less than 1.5 years (ABBBS 2013). This study aimed to investigate the survival probability and longevity of Star Finches in the wild over a four-year period, and to provide insight into their movements.

METHODS

Mist nets were erected at locations along water courses, at drinking sites and at night-time roosts in three areas in the Wyndham area (Figure 1):

- Area 1: the margins of the King River floodplain (between 15°37'39"S, 128°05'49"E and 15°32'40"S, 128°08'58"E),
- Area 2: Wyndham town-site (15º29'01"S, 128º07'11"E and 15º30'06"S, 128º09'54"E).
- Area 3: Parry Creek floodplain (between 15º35'33"S, 128º16'08"E and 15º28'12"S, 128º11'58"E),

Birds were captured at six different locations within Area 1, with 11.6 kilometres the maximum straight-line distance between the outer sites. Two locations 6.5 kilometres apart were used in Area 2 and five locations in Area 3, with 16 kilometres being the longest distance between sites.

Fieldwork periods and number of banding days at each area are presented in Table 1. Mistnetting occurred in the 3–4 hours following first light, and, on occasions, later in the day if nets could be erected in shade. The length of a banding session each day was dependent on weather conditions – primarily temperature and wind speed. Banding locations used within areas varied according to the availability of water. Some locations dried up shortly after the wet season ended while others still provided access to water in September.

Adult males and females were distinguished by differing head and chest plumage (Higgins *et al*. 2006). Juveniles, which do not breed in their first year (Lewis 2012), were distinguished from adults on the basis of plumage and bill colour, but could not be sexed in the field. Every adult captured was banded on the right tarsus with a numbered metal band issued by the Australian Bird and Bat Banding Scheme (ABBBS). Captured

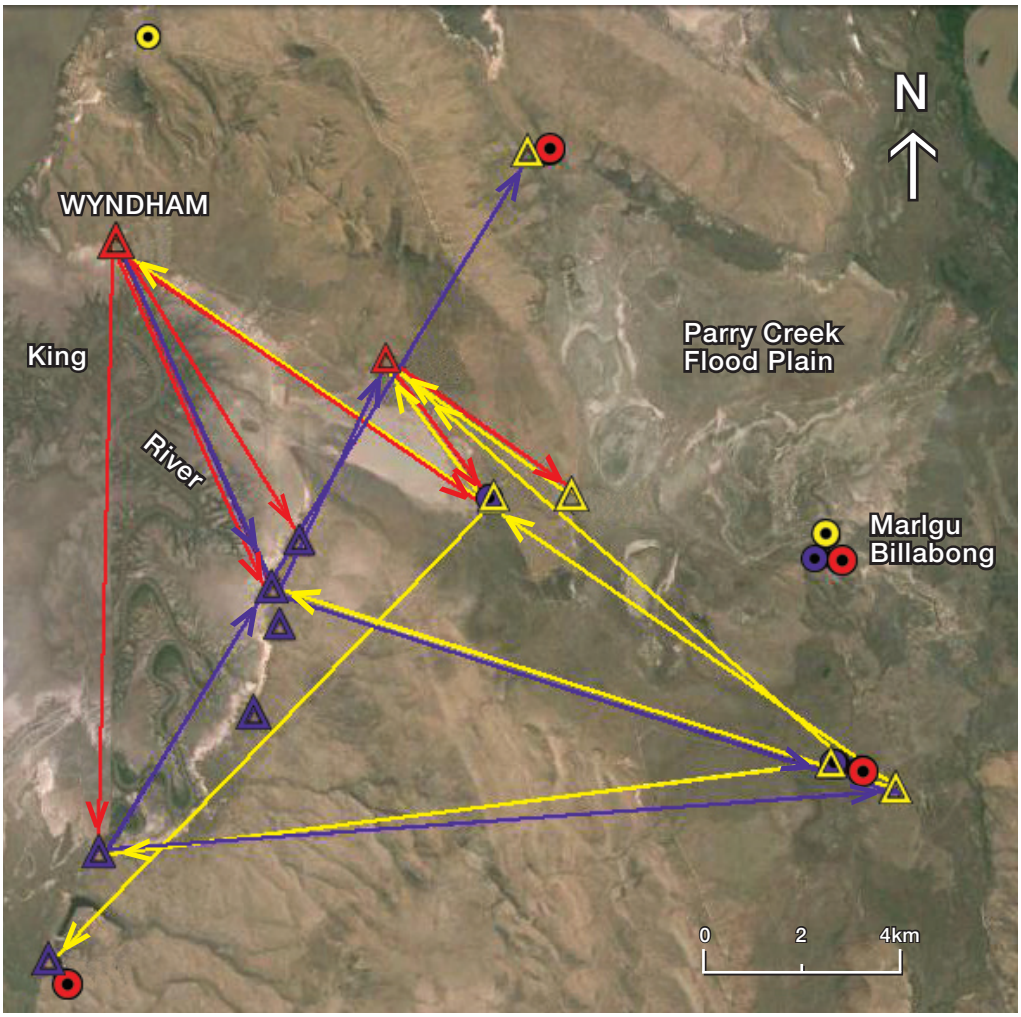

Figure 1. *Figure 1: Satellite image of study area adjacent to Wyndham, showing banding locations within Area 1 (△), Area 2 (△) and Area 3 (△) and resightings of colour-banded Star Finches from Area 1 (●), Area 2 (●) and Area 3 (●). Arrows indicate the direction of travel. Image courtesy of Google Earth.*

juveniles were banded on the left tarsus with a numbered metal band and, in 2009 and 2010, fitted with a colour band over the metal band to indicate the area and year of capture. From late September onwards, juveniles could not be distinguished from adults with certainty. The period when birds had active brood patches was used to identify the breeding season.

Sighting banded Star Finches within the Wyndham area occurred via a range of methods:

- Sighting attempts focussed at all known Star Finch sites within and immediately adjacent to the project area (search effort totalled 468 days).
- Researchers studying Gouldian Finches in the Wyndham area recorded colour-banded Star Finches sighted during their field season and the annual Gouldian Finch census in September.
- Requests to report banded or colour-banded Star Finches were made to bird watchers resident in Kununurra and the general population of Wyndham via posters at camping sites, articles in the local newspaper and word of mouth. Ornithologists resident and visiting Parry Lagoon Reserve (in Area 3) and El Questo were also asked to relay any sightings.

To investigate possible movements of birds between Wyndham and Kununurra habitats, known Star Finch locations and potential Star Finch habitat were searched for banded birds within a 50-kilometre radius of Wyndham several times each year of the study.

Survival analysis was carried out using the RMark package (vers. 2.1.14; Laake *et al*. 2012) in software R version 2.15.2 (R Development Core Team 2013) which is an interface to the MARK software (vers. 6.0, White and Burnham 1999). Analysis was undertaken for all Star Finches captured and recaptured in Area 1 plus 13 individuals originally captured in Area 1 and recaptured at another location. Adult survival was analysed using 359 females and 383 males. Juvenile survival was analysed using a different data set of 1166 juveniles.

Annual apparent (local) survival was analysed using Cormack-Jolly-Seber (CJS) models for capture-recapture data (Lebreton *et al*. 1992). 'Goodness of fit' was tested using

Table 1

Banding periods and number of banding days per site in 2009–12.

Area no.	2009 6 May – 11 Sep	2010 4 Mar – 20 Sep	2011 14 Apr – 27 Sep	2012 20 Apr – 20 Sep	Totals
1	24	38	35	21	118
2	7	5	3	0	15
3	4	12	15	1	32
Totals	**35**	**55**	**53**	**22**	**165**

Table 2

Total numbers of captured and recaptured Star Finches per year.

	Juveniles banded	Adults banded	Recaptures	% of recaptures that were banded as juveniles in previous years
2009	706	431	307	n/a
2010	838	561	399	24% n=94
2011	373	316	259	24% n=62
2012	11	30	70	51% n=36
Total	**1928**	**1338**	**1035**	

RELEASE, implemented in the MARK software. Annual adult and juvenile survival were estimated separately. Only physically recaptured individuals (as opposed to observations of colour-banded individuals) were taken into account for this analysis. Because of the relatively short study duration (4 years), variation between years was not tested. Sex was included as a parameter to test if adult males and females differed in their annual survival. Model averaged estimates are presented.

RESULTS

During this study a total of 3266 Star Finches was banded with 1035 (31.7%) subsequently recaptured. Total yearly captures of both juveniles and adults are presented in Table 2.

Breeding

The Star Finch breeding season was concentrated in a short period at the end of the wet season. The latest date in any year of the study that a bird with an active brood patch was found was 26 May. Despite extensive search efforts, only one nest, containing four almost fully-fledged juveniles, was found during the four-year study period. No recaptured juvenile had an active brood patch and no other evidence of a juvenile breeding in the breeding season in which they hatched was found.

Breeding success was inferred from observations (13–27 April 2010) of family size when juveniles first appeared with adults and discrete family units could be identified. The average number of recently-fledged juveniles in a family group was 2.95 (±1.2 SD). This was based on a sample of 20 family groups.

Movements

Of the 890 birds banded in Area 1 during 2009, 326 birds (37%) were recaptured between 2009 and 2012 with 40 percent being retrapped twice or more.

Of the birds banded within Area 1 in 2009, 108 (19%) recaptures were made at a different place from the original capture location. In 2010 and 2011, 41 percent and 43 percent respectively, of recaptured birds had moved within Area 1 (Table 3). The average distance moved was 4.05 kilometres (± 1.7 SD). Intra-area movements were not necessarily caused by water sources becoming dry as 75 percent of intra-area movements in 2009 were between drinking sites where water was always available. At each of the three areas, intra-area movements were more common than longer inter-area movements. Only 52 individuals (6%) of all birds recaptured had moved between areas – 17 were males, 6 females and the remainder unsexed juveniles. The average inter-area distance moved was 10.2 kilometres (± 4.95 SD). The longest single movement of 20 kilometres was recorded by an unsexed juvenile banded in April 2010 on Parry Creek floodplain and recovered after 4.2 months on the Wyndham town oval. Multiple recaptures of a male bird allowed it to be tracked for 35.8 kilometres. This comprised, while only a few months old, a flight from Area 1 to Area 3 and back again in June 2009, and a subsequent intra-area movement in 2011. On occasions, inter-area movements were for a short period only, e.g. an unsexed juvenile made a 14 kilometre-journey from Area 1 to 3 in June 2009 and was recaptured back at the original capture site 20 days later.

The movement records generated by resighting or recapturing of colour-banded birds are detailed in Figure 1. Some birds banded from all three areas were recaptured or resighted over the entire study area but none were located outside this area. Small flocks of Star Finches were found in a few locations between Wyndham and Kununurra, however none of these birds was banded, and no banded birds were sighted or captured amongst the Star Finch population of Kununurra.

Table 3

Intra- and inter-site movement of Star Finches banded at Area 1 based on recaptures from 2009 to 2012.

	No. Captures	No. Recaptures	Intra-area movements	Inter-area movements
2009	890	571	19% (n=108)	0.9% (n=8)
2010	615	199	41% (n=82)	1.5% (n=3)
2011	408	117	43% (n=50)	0.85% (n=1)
2012	41	11	100% (n=11)	0

Table 4

Year to year survival of Star Finches based on recaptures from Area 1.

	Juvenile		Adult female		Adult male	
Year of capture	2009	2010	2009	2010	2009	2010
Sample size (n)	557	367	152	116	154	132
Known to be alive after 1 year	13%	6%	25%	9%	35%	12%
Known to be alive after 2 years	6%	2%	8%	4%	16%	5%

Survivorship

Of 557 juveniles banded at Area 1 in 2009, 74 individuals (13 %) were known to be alive in 2010 (Table 4). This is based on 57 birds recaptured in 2010 and 17 recaptured in subsequent years. 1.8 percent of the 2009 juvenile cohort, 8 males and 2 females, were known to be alive in their fourth year in 2012.

Fewer juveniles than adults from the same banding cohort were recaptured in subsequent years. Of the 2009 Area 1 adult cohort, 38 of 152 females (25%) and 54 of 154 males (35%) were known to be alive in 2010 (Table 4); 5 females and 3 males (2.6%) were known to be alive in 2012.

Of the 2010 juvenile cohort (*n*=367) only 23 individuals (6%) were known to be alive in 2011 (Table 4), 15 males and 8 females. Eight of these birds, 5 males and 3 females, were recaptured in 2012. Adult recapture rates were also lower compared to 2009 (Table 4).

The longest period of time between banding and recapture was 3 years 4.5 months – a juvenile banded on 6 May 2009 and recaptured on 21 September 2012. This was approximately the maximum time achievable due to the duration of this study. This surpasses the previous longevity of less than 1.5 years in the wild (ABBBS 2013). Average lifespan can be calculated on the basis of the modelled annual survival estimates as (1/-ln(survival)). Accordingly, on average adult Star Finches live 1.15 years and juveniles 0.7 years. This study period of only four years is a relatively short period to estimate annual survival so average lifespan could be higher. Star Finches have been reported living up to eight years in captivity.

Modelling annual apparent survival

Survival estimates based on the analysis of the capture-recapture data provide a more sophisticated analysis. Annual apparent survival of juveniles was 0.23 ± 0.04 (mean ± SE; 95% confidence interval: 0.16–0.32). In subsequent years, annual survival of these then adults was 0.42± 0.06 (0.32–0.53) (Appendix 1 and 2). This is higher than the rate for birds banded as adults, 0.38 ± 0.04 (95% confidence interval 0.3–0.47), because the adult sample may have contained birds already several years old when captured.

The goodness of fit test revealed that the data were slightly underdispersed ($\hat{c} = 0.81$), yet the two most important assumptions behind CJS models – 'equal catchability' and 'equal survival chances' – were not violated.

The models tested (Appendix 3) suggested that sex was an important parameter explaining annual adult survival, but the differences were small: annual apparent survival of adult females was 0.38±0.04 (0.3–0.47) and of males 0.38±0.04 (0.31–0.47). The sexes also differed in recapture probabilities, with females showing a lower probability of being recaptured (0.42±0.07; 0.29–0.55) than males (0.47±0.07; 0.34–0.6) (Appendix 4).

Habitat

Observations made during this study suggest that loss of foraging habitat due to fire and the variability in annual rainfall in the Wyndham district (Table 5) are the major factors influencing Star Finch movement and survival.

In the 2008–9 wet season, above average rainfall fell early in the season resulting in extensive flooding across much of Area 3 and dense growth of *Sorghum stipoideum,* a favoured Star Finch food, in Area 1. Few Star Finches could be found in Area 3; many juveniles fledged and were captured in Area 1.

Early rainfall in October 2010, which triggered *Sorghum* germination, followed by little rain in November to sustain its growth, combined with a fall of 266 millimetres on 3–4 April 2011 that scoured creek banks and floodways, impacted negatively on *Sorghum* production. In April 2011 almost no *Sorghum* was present at sites that had previously been highly productive. Lack of a primary food source, and the possibility that the nests of many breeding birds were washed out in the heavy April 2011 rain, may explain the relatively low numbers of juveniles relative to adults captured in 2011 (Table 2) and the reduced numbers of 2010 juveniles recaptured in 2011 (Table 4).

Table 5

Monthly rainfall (mm) measured at Wyndham weather station during the study period.
(Sourced from www.bom.gov.au for Wyndham weather station 001013).

	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Annual
2008-2009	0	0	3	37.8	45.8	676.6	298.2	412.8	45.4	0	5.8	0	1525.4
2009-2010	0	0	0	13.6	26.8	154.8	243.6	175.4	43	92.4	76.6	0	826.2
2010-2011	0	1.8	3.6	160.6	19	201.2	316.7	345.5	317.2	347.8	0	0	1713.4
2011-2012	0	0	0	30.6	0	148	150	122.4	334	21.8	0	0	806.8
Mean rainfall (mm) for 1968 –2013	3.1	0	4	22.8	54.7	151	184.9	204.3	163.2	35.9	8.4	3.9	832.7

In 2011 and 2012 many of the foraging areas in Area 3 were destroyed by fire and birds had to fly several kilometres over burnt and therefore open country to access the permanent water sources on the floodplain. In 2012, much of the foraging habitat in Area 1 was burnt by July. The below-average rainfall meant that several waterholes had dried earlier than previous years which further reduced suitable habitat options. By the end of the field season, in each year of the study, most Star Finch habitat had been burnt.

To counter the disadvantages of fire and variable rainfall Star Finches demonstrated some interesting behaviours. Each year after fires in their natural habitat around Wyndham, a house on the edge of the town with a large stand of bamboo in the yard was claimed as a night time roost by several hundred Star Finches. Furthermore, recapture data indicated a tendency for birds from Area 1 to fly into Wyndham town-site to drink and feed on the grass of the artificially-watered oval and/or cemetery. The observation that birds were only present at those sites when the sprinklers were on was of particular note. Birds were never observed utilising the large permanent dam (Moochalabra Dam) supplying the town's water even though it was nearer to Area 1 than the township. Perhaps this was because the dam's rocky slopes provided little cover from predators or feeding opportunities.

DISCUSSION

The success of capturing birds by mistnetting is always subject to the vagaries of wind, rain, predator presence and vegetation cover. Particularly noticeable in this study was that, by 2011, the behaviour of Star Finch flocks had altered, in what appeared to be, attempts to avoid capture. Some previously regularly utilised waterholes, where banding was focussed, were avoided. Birds would immediately depart when they spotted nets or mistnetting poles, despite the poles being painted dark brown to resemble tree trunks. Approach routes to waterholes changed as birds flew in and out near-vertically instead of making short low flights as they had done previously. This may have influenced recapture probabilities because new mistnetting locations had to be utilised, although, the 'goodness of fit' test did not indicate any trap-shyness. Another challenge when estimating survival rates was distinguishing between emigration from the study area and mortality. Movement and resighting data from this study do not suggest that high rates of dispersal occur in Star Finches, but to err on the side of caution, the estimates presented here are apparent (or local) survival rates.

In contrast to earlier observations that describe Star Finches as 'sedentary or resident with some local movements' (Birdlife International 2009 and 2013), the results from this study suggest that the Wyndham population of Star Finches should be regarded as one entity exploiting a home range of up to 100 square kilometres and the species should more accurately be described as "highly mobile within a limited range". The lack of banded birds outside the study area also suggests that the Wyndham and Kununurra populations are largely separate, although genetic analysis would be required to confirm this.

The results show that survival probability for adults is higher than for juveniles. Recapture data suggest that year-to-year survival for both adults and juveniles differed greatly between 2009/10 and 2010/11. Several studies have shown that the effect of environmental variation can override any differences in the intrinsic success between individuals (Clutton-Brock 1987).

The relatively high mobility of Star Finches seems to enable juveniles to gain familiarity with their environment while they move between different food and water sources as conditions change. This appears to support a more boom-bust life cycle than that of sedentary seed-eaters such as Crimson and Masked finches observed at the same location. Counts and observations indicate that numbers of these sedentary species remained relatively stable throughout the study period whereas higher numbers of Star Finches built up when conditions were favourable and reduced after difficult years.

While this study may not have gathered sufficient reliable data for a formal population viability analysis (Boyce 1992; Noon and Sauer 1992), simple analysis of lifetime reproductive success based on the study data is not encouraging. If annual survival probability of juveniles is 0.23, then an adult pair needs to fledge over nine juveniles over the course of their lifetime to replace themselves with reproducing offspring. At an average of 2.95 juveniles raised per year, this requires an adult pair to survive at least three breeding seasons. Although it is thought that in most populations only a minority of individuals are able to produce the juveniles necessary to keep a population viable,

this study does raise some questions both about the viability of the Wyndham Star Finch population and the assertion by Birdlife International (2013) that "subspecies *subclarescens* is thought to be relatively stable as its habitat is protected by seasonal rains." To increase the chance of sustainability of this particular population, the results from this study indicate both the need for better management of habitat around Wyndham so that fire does not destroy the majority of Star Finch feeding grounds each year, and to ensure there is no significant reduction in available habitat caused by clearing or development.

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REFERENCES

Australian Bird and Bat Banding Scheme (ABBBS) (2013) Banding and recapture data for Star Finch. http://www.environment.gov.au/cgi-bin/biodiversity/abbbs/abbbs-search.pl. Accessed on 4/4/2013.

Barrett, G., Silcocks, A., Barry, S., Cunningham, R. and Poulter, R. (2003). 'The New Atlas of Australian Birds.' (Royal Australian Ornithologists Union: Hawthorn East).

BirdLife International (2009). Species factsheet: *Neochmia ruficauda*. http://www.birdlife.org. Accessed on 9/8/2009.

BirdLife International (2013). Species factsheet: *Neochmia ruficauda*. http://www.birdlife.org. Accessed on 25/03/2013.

Boyce, M. S. (1992). Population Viability Analysis. *Annual Review of Ecology and Systematics* **23**: 481–506.

Brazill-Boast, J. (2013). Competition for resources mediated by intrinsic social dominance in sympatric finches. *Ibis* **155**: 189–193.

Brazill-Boast J., Pryke, S. R. and Griffith, S. C. (2010). Nest-site utilisation and niche overlap in two sympatric, cavity-nesting finches. *Emu* **110**: 170–177.

Brazill-Boast, J., Pryke, S. R. and Griffith, S. C. (2011). Selection of breeding habitat by the endangered Gouldian Finch (*Erythrura gouldiae*) at two spatial scales. *Emu* **111**: 304–311.

Bureau of Meteorology. (2013). Rainfall data for Wyndham weather station 001013. www.bom.gov.au. Accessed on 20/3/2013.

Clutton-Brock, T. H. (1987). Reproductive success, selection and adaptation. In: 'Reproductive success: studies of individual variation in contrasting breeding systems'. (Ed. Clutton-Brock, T. H.) Pp. 1–10. (University of Chicago Press: Chicago, lllinois, USA).

Dostine, P. L. and Franklin, D. C. (2002). A comparison of the diet of three finch species in the Yinberrie Hills area, Northern Territory. *Emu* **102**: 159–164.

Dostine, P. L., Johnson, G. C., Franklin, D. C., Zhang, Y. and Hempel, C. (2001). Seasonal use of savanna landscapes by the Gouldian finch, *Erythrura gouldiae*, in the Yinberrie Hills area, Northern Territory. *Wildlife Research* **28**: 445-458.

Evans, S. M. and Fidler, M. E. (2005). 'The Gouldian Finch'. (Indruss Productions: Queensland).

Franklin, D. C. (1999). Evidence of disarray amongst granivorous bird assemblages in the savannahs of northern Australia, a region of sparse human settlement. *Biological Conservation* **90**: 53–68.

Franklin, D. C., Whitehead, P. J., Pardon, G., Matthews, J., McMahon, P. and McIntyre, D. (2005). Geographic patterns and correlates of the decline of granivorous birds in northern Australia. *Wildlife Research* **32**: 399–408.

Garnett, S.T. and Crowley, G.M. (2000). 'Action Plan for Australian birds 2000". (Environment Australia: Canberra, ACT).

Garnett, S., Szabo, J. and Dutson, G. (2011). 'Action Plan for Australian Birds 2010.' (CSIRO Publishing: Collingwood, Victoria).

Higgins, P. J., Peter, J. M. and Cowling, S. J. (Eds) (2006). 'Handbook of Australian, New Zealand and Antarctic Birds. Vol.7: Boatbill to Starlings.' (Oxford University Press: Melbourne).

Johnstone, R. E. and Storr, G. M. (2004). 'Handbook of Western Australian Birds. Volume II – passerines.' (Western Australian Museum: Perth).

Laake, J., with contributions from Rakhimberdiev, E. and Augustine, B. (2012). Package "RMark": R Code for MARK Analysis, version 2.1.4.

Lebreton, J-D., Burnham, K.P., Clobert, J. and Anderson, D.R. (1992) Modeling survival and testing biological hypotheses using marked animals: a unified approach with case studies. *Ecological Monographs* **62(1)**: 67–118.

Legge, S., Murphy, S., Kingswood, R., Maher, B. and Swan, D. (2011). EcoFire: restoring the biodiversity values of the Kimberley region by managing fire. *Ecological Management and Restoration* **12(2)**: 84–92.

Lewis, J. (2012). Post juvenile moult and associated bare part changes in Star Finches (*Neochmia ruficauda*) in the Wyndham region of Western Australia. *Amytornis* **4**: 1–4.

Lowe, K. (1989). 'The Australian Bird Bander's Manual,' (ANPWS: Canberra).

Maute, K. (2011). 'Variations in the health of tropical finches in relation to conservation status, season and land tenure'. PhD thesis. University of Wollongong, NSW.

Noon, B. R. and Sauer, J. R. (1992). Population models for passerine birds: Structure, Parameterization, and analysis. In 'Wildlife 2001: Populations' (Eds. D. R. McCullough and R. H. Barret,). Pp. 441–464. (Elsevier Applied Science: New York.)

O'Malley, C (2006). 'Appendix to National Recovery Plan for the Gouldian Finch (*Erythrura gouldiae*). Background information'. (WWF-Australia, Sydney and Parks and Wildlife NT, Department of Natural Resources, Environment and the Arts, NT Government: Palmerston).http://www.environment.gov.au/biodiversity/threatened/publications/pubs/e-gouldiae-background.pdf

R Development Core Team (2013). 'R: A language and environment for statistical computing'. (R Foundation for Statistical Computing: Vienna, Austria).

Woinarski, J. C. Z. and Tidemann, S. (1992). Survivorship and some population parameters for the endangered Gouldian Finch *Erythrura gouldiae* and two other finch species at two sites in Tropical Northern Australia. *Emu* **92**: 33–38.

Appendix 1

Candidate models to test differences in juvenile and adult survival. Given are number of parameters, Deviance, AIC_c, ΔAIC_c and weight. Only birds banded as juveniles were included and age-class effect was tested separating first year of life (year-of-marking) and subsequent years.

model	no. parameters	Deviance	AIC_c	ΔAIC_c	weight
ϕyear-of-marking *P* const.	3	20.9	1029.57	0	0.86
ϕconst. *P* const.	2	26.5	1033.16	3.59	0.14

Appendix 2

Apparent annual survival ϕ and recapture probability *p* in juvenile and adult Star Finch.

parameter	annual survival ± SE	95% confidence interval
ϕjuvenile	0.22 ± 0.04	0.16 – 0.32
ϕadult	0.42 ± 0.04	0.32 – 0.53
P const.	0.37 ± 0.07	0.25 – 0.51

Appendix 3

Candidate models to test whether sex (males/females) had an influence on survival. Given are number of parameters, Deviance, AICc, ΔAICc and weight.

model	no. parameters	Deviance	AIC_c	ΔAIC_c	weight
ϕconst. *P* sex	3	34.877	1006.92	0	0.34
ϕconst. *P* const.	2	36.974	1007.00	0.08	0.33
ϕsex *P* const.	3	35.967	1008.01	1.09	0.20
ϕsex *P* sex	4	34.776	1008.84	1.92	0.13

Appendix 4

Apparent annual survival ϕ and recapture probability p in male and female Star Finch.

parameter	annual survival ± SE	95% confidence interval
ϕfemale	0.38 ± 0.04	0.30 – 0.47
ϕmale	0.38 ± 0.04	0.31 – 0.47
P female	0.42 ± 0.07	0.29 – 0.55
P female	0.47 ± 0.07	0.34 – 0.60