Notornis, 2021, Vol. 68: 161-165
0029-4470

SHORT NOTE

Common starling (*Sturnus vulgaris*) laying dates, 1970–2019, have not changed in New Zealand, in contrast to those in Denmark

JOHN E.C. FLUX*
MEG M. FLUX
23 Hardy Street, Waterloo, Lower Hutt 5011, New Zealand

That the breeding seasons of many bird species in the northern hemisphere is becoming earlier, in line with the temperature increase associated with climate change, is now well established (Halupka & Halupka 2017; Hallifors *et al*. 2020). There could be confusion in widespread studies as species extend their ranges northward into cooler areas (Singer 2017), but long-term studies in the same location avoid this problem. Hence, one of the most convincing examples is a 45-year study of common starlings (*Sturnus vulgaris*) in Denmark (Thellesen 2017). A review in *Nature* by Fox & Heldbjerg (2017) says this paper, by a Danish farmer, "provides a world-class example of the effects of climate change on the natural world" and "his patient and systematic observations far exceed the duration of any funded research project".

Our starling projects, to study diet, and selection for clutch size in a wild population (Flux & Flux 1982, 2015), were government funded for the first 20 years. The 1,500 ha research area at Belmont (41°10´S, 174°54´E, 17 km NE of Wellington) was all open pasture, with 62 concrete army munitions bunkers spaced about 100 m apart. We built 500 nest boxes in the ventilation shafts of 42 bunkers (Fig. 1) by wiring a sheet of asbestos board outside to two interlocking wooden planks inside. See Flux & Flux (1981) for a photograph of the area, and details of the study protocol. Because starlings over the whole area started laying at the same time, within seven days of the median first-egg date, after 1994 a subset of 50 boxes was sufficient to monitor the laying date (Evans *et al*. 2009).

In contrast to the earlier breeding being recorded overseas, and even in other species such as penguins in New Zealand (cf. Challies 2019), we found starlings at Belmont, after 17 years, were nesting 17 days later (Fig. 2A) in 1987 than in 1970, when the study began (Flux 1987). The 50 years of data now available change that interpretation, a salutary reminder of the frailty of statistics and short-term studies in ecology. The laying dates appear to have stabilised by 1975 about a mean (20 October) that was maintained until 2019 (Fig. 2B, the dashed horizontal line is the 1975–2019 regression). The descending line (Fig. 2C) is the regression line $R^2 = 0.25$ from Thellesen (2017) showing the significant ($P < 0.003$) change to nine days earlier laying of starlings in Denmark from 1971 to 2015.

Received 10 August 2020; accepted 10 October 2020
*Correspondence: *johnmeg.flux@xtra.co.nz*

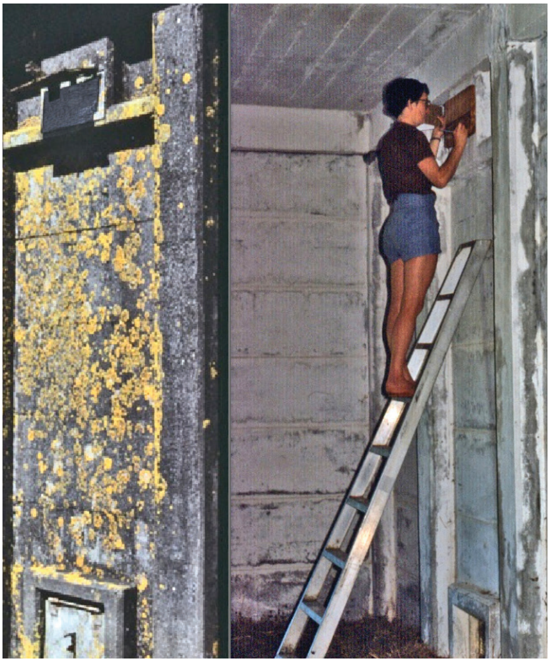

Figure 1. Starling boxes built at Belmont (17 km NE of Wellington NZ) in ventilation shafts could be inspected from inside the bunkers by lifting the top plank held in place by a wooden latch.

Why starlings nested earlier at the start of the Belmont study remains uncertain. However, supplementary feeding has been shown to advance starling laying by 5 days in a wild population (Kallander & Karlsson 1993). It is likely that the erection of nest-boxes allows a small initial population to breed in greater abundance until a new balance with the food supply in the nesting area is established. Thus, the initial Belmont population in 1969 consisted of 26 pairs attempting to nest on ledges, and a total 300 birds; by 1978 there were 3,000 birds competing for 500 boxes (Flux & Flux 1981). Over-exploitation of the food available is likely because breeding pairs forage within 800 m of their nests (Tinbergen 1981), 92% within 500 m (Heldbjerg *et al*. 2017), and boxes are usually positioned close together for convenience. This is supported (Fig. 3) from unreported trends from early to later nesting in newly established box colonies in America (Kessel 1957), Holland (Kluijver, in Lack 1948; Tinbergen 1981), Sweden (Karlsson 1983), and Denmark (Thellesen 2017). Although individually none are statistically significant, the combination is convincing (linear regression, $R^2 = 0.97$, $F = 155.0$, $P < 0.0001$). In contrast, the Scottish study (Fig. 3C), does not show this trend: it aimed to measure the effect of starlings on their food supply, and "most of the natural sites were replaced by nest-boxes, care being taken not to alter the number of available

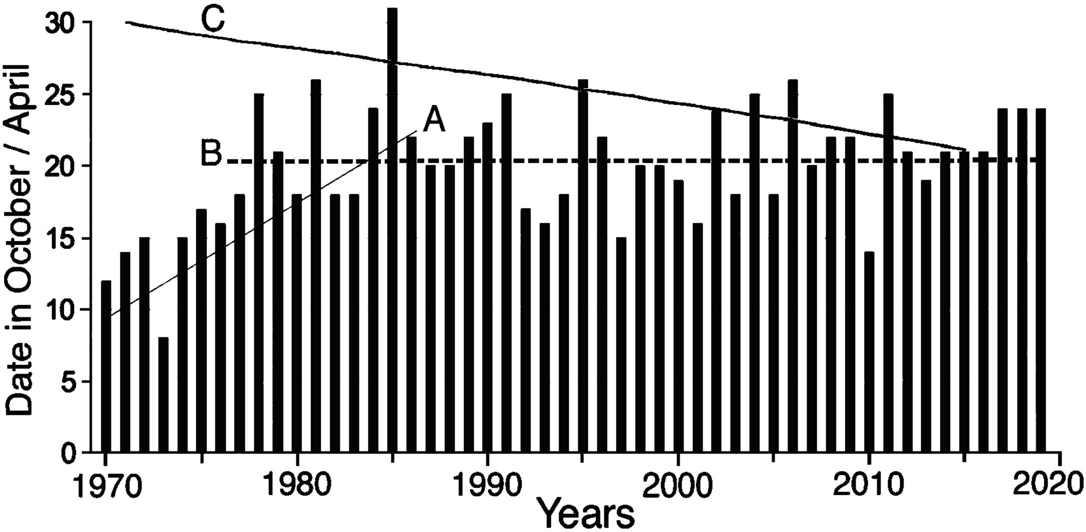

Figure 2. Median first-egg dates (laid in October) for common starling at Belmont (New Zealand), showing, (A) the highly significant but misleading regression for the first 17 years, 1970–1987 (solid line, linear regression, $y = 0.8554x + 11.01$, $R^2 = 0.59$, $F = 21.22$, $P = 0.0003$); (B) the stability around 20 October since 1975 (horizontal dashed line, linear regression, $y = 0.0039x + 20.75$, $R^2 = 0.0002$, $P = 0.93$); (C) Danish starlings now lay nine days earlier in April (descending line, linear regression, $y = - 0.2013x + 518$, $R^2 = 0.25$, $P = 0.003$ [Thellesen 2017]).

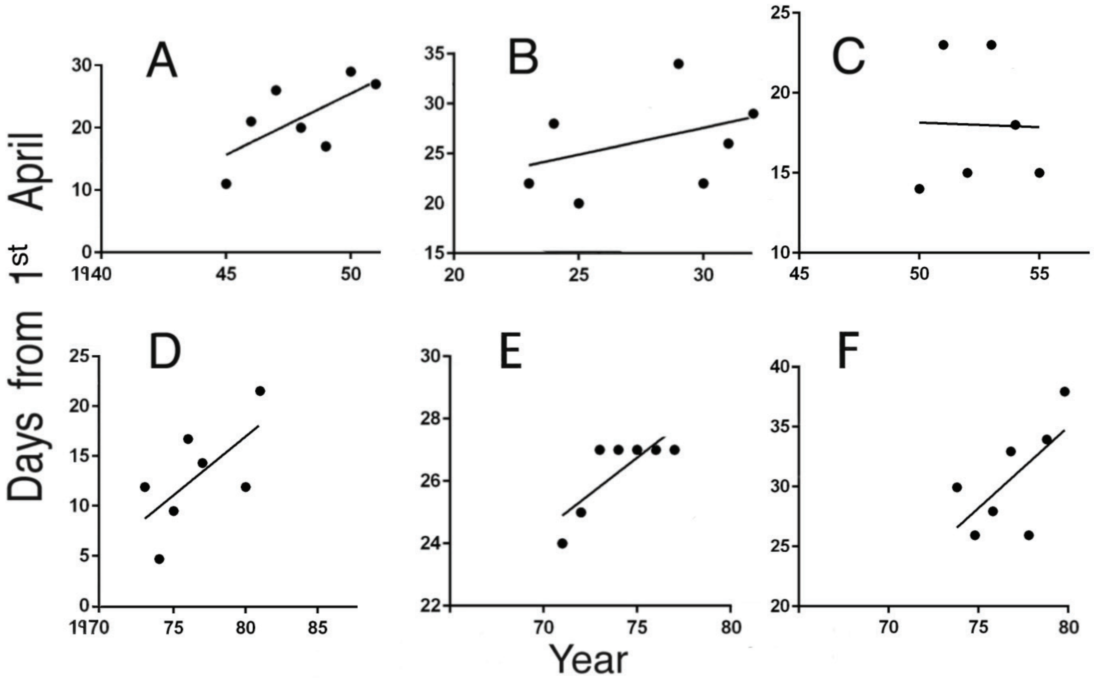

Figure 3. Median first-egg dates for newly established common starling nest-box colonies in (A) America (Kessel 1957); (B) Holland (Lack 1948); (C) Scotland (Anderson 1961); (D) Sweden (Karlsson 1983); (E) Denmark (Thellesen 2017); (F) Schiermonnikoog, Netherlands (Tinbergen 1981). Note: the Scottish study replaced natural sites (see text).

nesting places" (Anderson 1961). Similarly, eight nest-boxes put up in 1976 in a small urban garden in Lower Hutt, which were unlikely to have an effect on the local population, did not show any trend to later nesting over the next eight years (linear regression, $R^2 = 0.04$, $F = 0.24$, $P = 0.643$, Dr P.C. Bull, *unpubl. data*).

Starlings respond differently to mean monthly April/October temperatures in Denmark/New Zealand (Fig. 4). Clearly, Danish starlings always face far colder temperatures when they start laying than those in New Zealand, and it seems logical that they find less food and have to breed later in cold years. The Danish starlings have a second clutch when spring is early (Thellesen 2017) and this correlation was also significant at Belmont (linear regression, $R^2 = 0.64$, $F = 14.32$, $P = 0.005$). That the New Zealand starlings do not start earlier is probably due to an innate response to photoperiod. A comparison of their laying dates and annual day-degrees (an index of temperatures exceeding 10°C, which influences vegetation growth and insect emergence) showed no relationship ($P = 0.4124$). We also checked for correlations with rainfall, temperature (maximum, mean, and minimum), sunshine hours, and total incoming solar and sky radiation, but found none. In New Zealand the food supply at the start of laying is good in mild springs, for obvious reasons, but also good in harsh springs when many lambs die and supply maggots. Hence the relationship with climate is complex, and also involves the El Nino Southern Oscillation (Tryjanowski *et al.* 2006; Flux & Flux 2015).

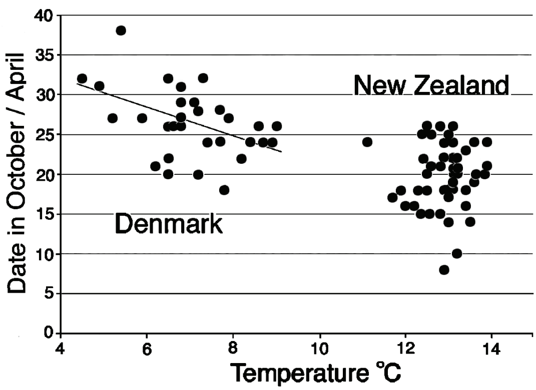

Figure 4. Laying date for common starling responds to temperature in Denmark (Thellesen 2017), but not at Belmont (New Zealand) where temperatures are higher.

Finally, one reason starlings at Belmont have not adapted to climate change turns out to be curiously simple: since 1970, Oceania, which includes New Zealand, has had far less temperature rise (0.7°C) than Europe (1.3°C) and all other continents – the highest is North America (1.9°C) (www.worlddata.info, quoting German Weather Service). Wellington temperatures show the 0.7°C rise from 1950–2019, but the rise was only 0.4°C and not significant (linear regression, $R^2 = 0.03$, $F = 1.40$, $P = 0.24$) over the 1970–2015 years of our study, compared to the 1.7°C increase (linear regression, $R^2 = 0.28$, $F = 16.42$, $P < 0.0002$) in Denmark (Fig. 5). Wellington's now significant ($P = 0.0022$) increase in temperature over the 1970–2019 period (NIWA 2020) is due to record temperatures in the last four years, 2016-2019. It will be interesting to see how starlings respond to this new normal, which on average world projections will be an increase at Belmont of 2.25–2.75°C by 2081–2100 (NIWA 2017).

ACKNOWLEDGEMENTS
Average annual temperatures are from Kelburn, Wellington, courtesy NIWA 2017, 2020, and the National Climate Database, CliFlo; and Cappelen (2016) for Copenhagen. We thank Lands and Survey, later LandCorp, then Greater Wellington Regional Council, for access to Waitangirua farm, and are grateful to our sons Ian and the late Douglas for opening gates and taking notes in their early years. Thanks also to Dr A. Moeed who recorded data in 1976 when we were overseas, and Drs Christoph Imboden, Charles Thompson, Mike Double, and Dan Ardia, visiting scientists working on the starling colony, for information they collected. MMF, who died in 2016 before the study ended, organised the field work, tabulated data, and shared the climbing. Financed by Ecology Division, DSIR, (1970–90), and a US-NZ Cooperative Science Program grant NSF (INT 84-10955) in 1984. We are grateful to Craig Symes and reviewer Henning Heldbjerg for many very helpful comments.

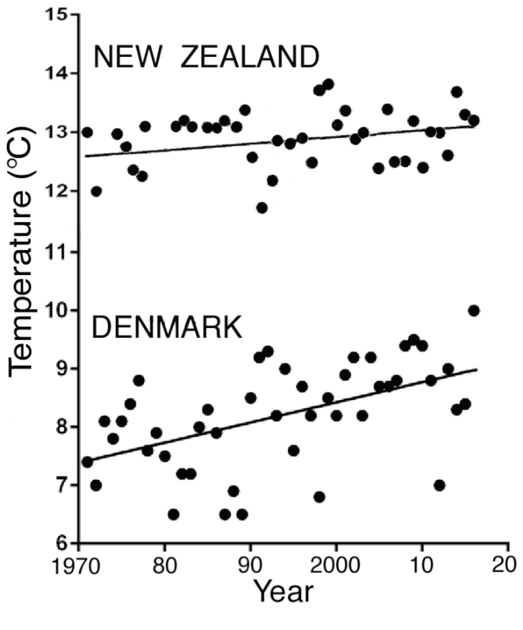

Figure 5. The mean annual temperatures over the 46 years studied, 1970–2015. New Zealand (Kelburn, Wellington) shows only a slight rise (0.4°C) which is not significant ($y = 0.0061x + 12.74$, $R^2 = 0.031$, $P = 0.243$). The Danish (Copenhagen) temperature rise (1.7°C) is highly significant ($y = 0.0347x + 7.39$, $R^2 = 0.275$, $P = 0.0002$) (Cappelen 2016).

LITERATURE CITED

Anderson, A. 1961. The breeding of the starling in Aberdeenshire. *The Scottish Naturalist 70*: 60–70.

Cappelen, J. (*ed.*) 2016. Denmark – DMI Historical Climate Data Collection 1768– 2015. DMI Report No. 16-02. Copenhagen. 111 pp.

Challies, C.N. 2019. Earlier laying by little penguins (*Eudyptula minor*): a possible effect of global warming. *Notornis 66*: 221–223.

Evans, L.E.; Ardia, D.R.; Flux, J.E.C. 2009. Breeding synchrony through social stimulation in a spatially segregated population of European starlings. *Animal Behaviour 78*: 671–675.

Flux, J.E.C. 1987. Drift in laying dates of starlings *Sturnus vulgaris*. *Ornis Scandinavica 18*: 146–148.

Flux, J.E.C.; Flux, M.M. 1981. Population dynamics and age structure of starlings (*Sturnus vulgaris*) in New Zealand. *New Zealand Journal of Ecology 4*: 65–72.

Flux, J.E.C.; Flux, M.M. 1982. Artificial selection and gene flow in wild starlings, *Sturnus vulgaris*. *Naturwissenschaften 69*: 96–97.

Flux, J.E.C.; Flux, M.M. 2015. The fertility clinic: a bird's-eye view of our future. *New Zealand Journal of Zoology 42*: 284–289. doi: 1908/03014223.2015.1099549

Fox, T.; Heldbjerg, H. 2017. Danish dairy farmer delivers data coup. *Nature 550*: 333.

Hällifors, M.H.; Antão, L.H.; Itter, M.; Lehikoinen, A.; Lindholm, T.; Roslin, T.; Saastamoinen, M. 2020. Shifts in timing and duration of breeding for 73 boreal bird species over four decades. *PNAS 117: 18557-18565.* doi: 10.1073/pnas.1913579117

Halupka, L.; Halupka, K. 2017. The effect of climate change on the duration of avian breeding seasons: a meta-analysis. *Proceedings of the Royal Society B 284*: 20171710. doi: 10.1098/rspb.2017.1710

Heldbjerg, H.; Fox, A.D.; Thellesen, P.V.; Dalby, L.; Sunde, P. 2017. Common starlings (*Sturnus vulgaris*) increasingly select for grazed areas with increasing distance-to-nest. *PLoS ONE 12(8)*: e0182504. doi: 10.1371/journal.pone.0182504

Kallander, H.; Karlsson, J. 1993. Supplemental food and laying date in the European starling. *The Condor 95*: 1031–1034.

Karlsson, J. 1983. Breeding of the starling (*Sturnus vulgaris*). Doctoral dissertation. Lund, University of Lund. 82 pp.

Kessel, B. 1957. A study of the breeding biology of the European starling (*Sturnus vulgaris* L.) in North America. *The American Midland Naturalist 58*: 257–331.

Lack, D. 1948. Natural selection and family size in the starling. *Evolution 2*: 95–110.

NIWA (National Institute for Water and Atmospheric Research) 2017. Climate change and variability – Wellington Region. Report prepared for Greater Wellington Regional Council, June 2017. 193 pp.

NIWA (National Institute for Water and Atmospheric Research) 2020. Annual Climate summary: 2019. 35 pp.

Singer, M.C. 2017. Shifts in time and space interact as climate warms. *PNAS 114*: 12848–12850. doi: 10.1073/pnas.1718334114

Thellesen, P.V. 2017. Kuldstorrelse og yngletidspunkt hos Staer i Sydvestjylland 1971-2015. (Common starling *Sturnus vulgaris* clutch size, brood size and timing of breeding during 1971-2015 in Southwest Jutland, Denmark). *Dansk Ornitologisk Forenings Tidsskrift 111*: 87–95.

Tinbergen, J.M. 1981. Foraging decisions in starlings (*Sturnus vulgaris* L.). *Ardea 69*: 1–67.

Tryjanowski, P.; Flux, J.E.C.; Sparks, T.H. 2006. Date of breeding of the starling *Sturnus vulgaris* in New Zealand is related to El Nino Southern Oscillation. *Austral Ecology 31*: 634–637.

www.worlddata.info. 2020. Climate change and global warming: Increase of temperatures by continents 1950 to 2019.

Keywords: Common starling, *Sturnus vulgaris*, laying date, climate change, Denmark, nest-boxes