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LACK OF SYNCHRONY BETWEEN BREEDING IN TWO NEIGHBOURING STARLING (*STURNUS VULGARIS* L.) POPULATIONS IN NEW ZEALAND: EVIDENCE OF NO REGIONAL EFFECT OF THE ENSO?

ABSTRACT: Weather and climatic conditions may impact on many aspects of bird populations, including population size, the timing of breeding and synchrony between these variables in local populations. We examined synchrony in population size and the laying date of two starling *Sturnus vulgaris* populations 25 km apart, at Ohau and Belmont, in New Zealand. Data were collected in nest-boxes in both study plots from 1970 to 2003. Additionally we investigated possible relationships with a large geographical climate index, the El Niño Southern Oscillation (ENSO). Starlings at Ohau bred significantly earlier than at Belmont. The difference in the median of year median date of laying the first egg was 3 days. Simultaneously, the percent of nest boxes used by birds was much higher in Ohau (86%, SE = 4.1) than in Belmont (52%, SE = 2.9). However, we did not find a significant relationship between median dates of laying and the percent of nest boxes used by birds in each breeding season in the two populations. Furthermore, we found no influence of ENSO on (potential) synchrony in starlings' breeding parameters. We suggest that lack of synchrony between two close local populations, both in percentage of occupied nest boxes and time of laying, is due to starlings responding to very local conditions, like food availability. We urge future studies to take advantage of spatially close populations.

KEY WORDS: ENSO, long-term data, nest-boxes, starling *Sturnus vulgaris*, New Zealand

1. INTRODUCTION

Synchrony pattern in animal population size and life-history traits resulting from climate change have mainly been postulated and tested in the Northern Hemisphere (see Liebhold *et al.* 2004 for a review). In the literature on mammals, inter-specific patterns of synchrony have been a main theme to separate out hypotheses related to predation and food (*e.g.* Liebhold *et al.* 2004, Mysterud *et al.* 2007) and some evidence suggested population synchrony on a very broad scale (*e.g.* Post and Forchhammer 2002). Also, the effects of large scale climatological indices, like El Niño – Southern Oscillation called ENSO (see below), on avian populations were postulated for New Zealand as well (Tryjanowski *et al.* 2006). To the best of our knowledge no synchrony studies in the breeding date and population size of birds in Australasia have been documented (but for some suggestions see Bull and Flux 2006). El Niño is a natural feature of the global climate system. Originally it was the name given to the periodic development of unusually warm ocean waters along the tropical South American coast and out along the Equator to the dateline, but now it is more generally used to describe the whole "El Niño – Southern Oscillation (ENSO) phenomenon", the major systematic global climate fluctuation that occurs at the time of an 'ocean warming' event. El Niño and La Niña refer to opposite extremes of the ENSO cycle, when major changes in the Pacific atmospheric and oceanic circulation occur (see, for example, Stenseth *et al.* 2003).

Therefore, in this paper we present an analysis of synchrony among population size and the laying dates of the starling *Sturnus vulgaris* collected during long-term studies conducted in New Zealand. Although starlings were studied in other sites in New Zealand as well (Bull and Flux 2006) long-term no-gapped data exist only for two localities in Belmont and Ohau at the distance 25 km each from the other, and therefore we used these populations only to investigate synchrony. To our knowledge it is the first study from the Southern Hemisphere focused on exploring and understanding synchronous processes between animal populations and their potential link to climate factors.

We focus on breeding population size and the timing of breeding because these data already exist and because both these parameters strongly influence other life-history traits in birds generally and in starlings in particular (Flux and Flux 1981, Källander and Karlsson 1993, Christians *et al.* 2001, Smith 2004; Svensson 2004, Tryjanowski *et al.* 2006). Moreover, our goal was to examine similarity of changes in population size and breeding date as measures of synchrony in relation to a large scale climatic factor (ENSO index). We predict that due to the close location of the two study plots, and results from southern Swedish starling populations (Svensson 2004), local bird parameters should be correlated and being (at least in a local scale) in synchrony. Therefore, the degree of the synchrony in New Zealand should also be determined by the ENSO phenomenon, and its associated different weather and access to food sources.

2. STUDY AREAS, MATERIAL AND METHODS

2.1. Study species and study areas

The study was carried out in two areas in New Zealand in North Island, at Belmont (41°10'S, 174°54'E), and Ohau (40°40'S, 174°54'E). The distance between plots was only 25 km. The study sites have been described elsewhere (Flux and Flux 1981, Bull and Flux 2006).

At Belmont, the nest boxes were 4 m above ground in concrete buildings built in 1942 to store ammunition. Ten or 15 boxes were placed 2–3 m apart along the walls of each of 41 buildings. The buildings were spaced about 100 m apart over the centre of the farmland, facing in random directions to suit the hilly topography. Hence the nest boxes faced in all directions. Any effect of compass direction on nesting success was clearly over-ridden by the varying exposure of the buildings themselves to the prevailing westerly wind, or cold (southerly) storms.

At Ohau, traditional wooden boxes were placed 1.5 m above ground, 4–6 m apart along fence lines. They were oriented to face in different directions, as previous studies indicated that starlings became confused and fought over boxes in a line facing the same direction.

For a short description: the 1500 ha study area at Belmont ranges in altitude from 250 to 400 m a.s.l. and is extremely exposed, being entirely covered in pasture closely grazed by sheep. The Ohau study plot is near sea level, and is flat with a nice stable climate. In comparison to the extensive pastures at Belmont, the Ohau area is divided into 'lifestyle blocks' of about 5–10 ha per family, where they can grow fruit trees, run poultry, a few sheep or cattle, and keep horses.

The age structure for all laying females was known from banding at Belmont from 1970–79. Mean clutch size rises from age 1–3 years and then declines steadily to age 6–8 years (Flux and Flux 1981). Age structure, however, had no effect on laying dates: 28 banded females that bred from 1973 to 1978 showed the same pattern of laying dates as the whole population. Also, the modal peak of laying for adult and first-year layers in

1972 (when the largest proportion of first-years nested) was on the same day (Flux 1987). At Ohau the age structure was unknown, but banded pairs retained the same boxes for several years. Based on band recoveries, the mortality rate at Belmont population was similar to that for the rest of New Zealand (Flux and Flux 1981), so the age structure at Belmont and Ohau populations was probably similar.

There were few places for starlings to nest at Belmont except in boxes, but at Ohau there were many alternative sites in garages, sheds or farm buildings.

2.2. Data processing and analysis

Data on laying dates and some other aspects of starlings' breeding ecology were determined during thirty breeding seasons in years 1976–2005 from as many nests as possible. Nest boxes were inspected every two days during the laying period in October each year and less regular visits continued to the end of the breeding season. Based on these examinations the date of the first egg laying of each nest was established. From these data we calculated the median date of first egg laying in each population for each year.

Because the number of available nest boxes changed between years and varied between 48 and 500 in Belmont and 4 (only through three years) – 32 in Ohau, population size was expressed as percentage of occupied boxes. Where less than 10 nest-boxes were recorded at the Ohau site these data were dropped from and subsequent analysis.

As climate change indices we used Multivariate ENSO Index (MEI), which is based on six main variables over the tropical Pacific: sea-level pressure, the east-west and north-south components of the surface wind, sea surface temperatures, surface air temperature, and total amount of cloudiness. Negative values of the MEI represent the cold ENSO phase - La Niña, while positive MEI values represent the warm ENSO phase -El Niño.

During El Niño, New Zealand tends to experience stronger or more frequent winds from the west in summer, typically leading to drought in east coast areas and more rain in the west. In winter, the winds tend to be more from the south, bringing colder conditions to both the land and the surrounding ocean. In spring and autumn south-westerly winds are more common. La Niña events have different impacts on New Zealand's climate. More north-easterly winds are characteristic, which tend to bring moist, rainy conditions to the north-east of the North Island, and reduced rainfall to the south and south-west of the South Island (Kidson and Renwick 2002).

The areas studied are in the south-west of the North Island. Therefore, the La Niña weather should be more favourable for nesting starlings.

In this study we applied mean values for September and October of the bimonthly ENSO index for each year 1976–2005 as an indicator of climatic fluctuation (for reasons for this choice see Stenseth *et al.* 2003, and discussion on importance for starlings see Tryjanowski *et al.* 2006) obtained from http://www.cdc.noaa.gov/~kew/MEI/table.html.

Dates were converted to numerical values such that 1 = 1st October *etc.*

We explored correlation between environmental covariates and study plots with simple Pearson correlation coefficients. However, we also checked for potential non-linear relationships (see Tryjanowski *et al.* 2006).

All analyses were done in SPSS for Windows packages.

3. RESULTS

3.1. Laying date and use of nest boxes

The median of yearly median dates of laying differed between two populations studied (Wilcoxon matched-pairs test, Z = 3.00, n = 27, P = 0.003). Starlings in Ohau bred earlier than in Belmont (Fig. 1). Simultaneously, the percent of nest boxes used by birds was much higher in Ohau than in Belmont (Wilcoxon matched-pairs test, Z = 4.01, n = 26, P <0.001, Fig. 2). However, there was no significant relationship between median date of clutches initiation and percent of occupied nest boxes in each breeding season in both study areas (simple regression, Belmont: r = -0.11, n = 29, P = 0.57; Ohau: r = -0.31, n = 26, P = 0.12, Fig. 3). Moreover

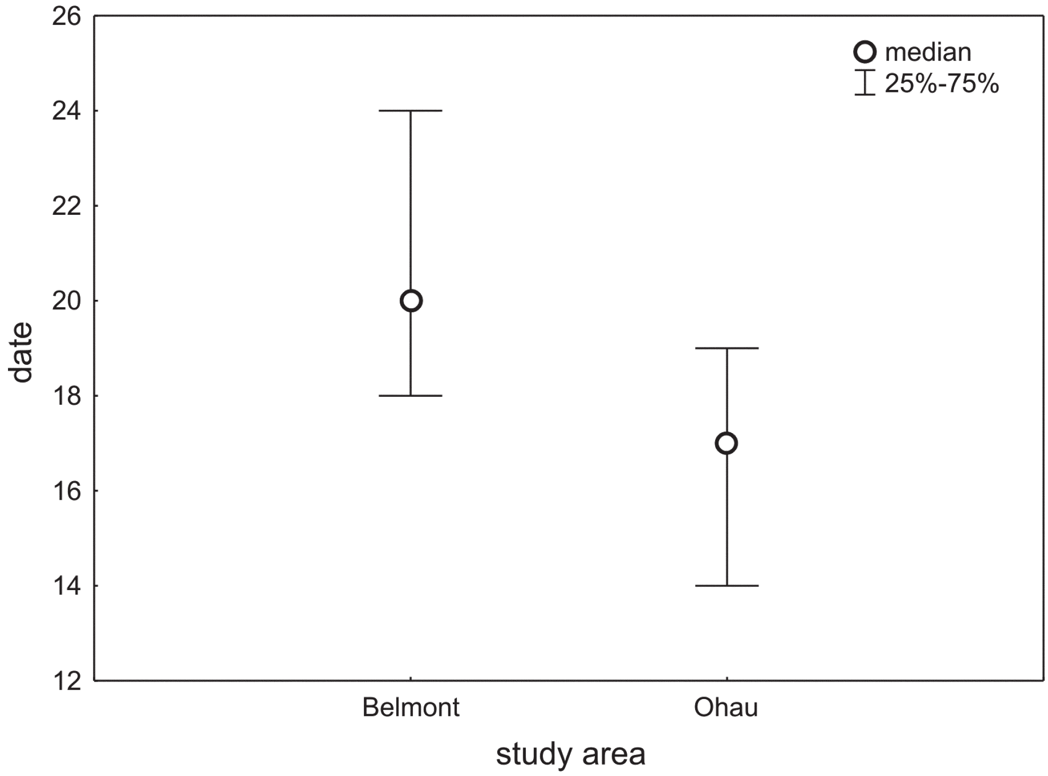

Fig. 1. Median of year median date (number of days after 30th of September) of laying the first egg in two studied starling populations at Belmont and Ohau (New Zealand).

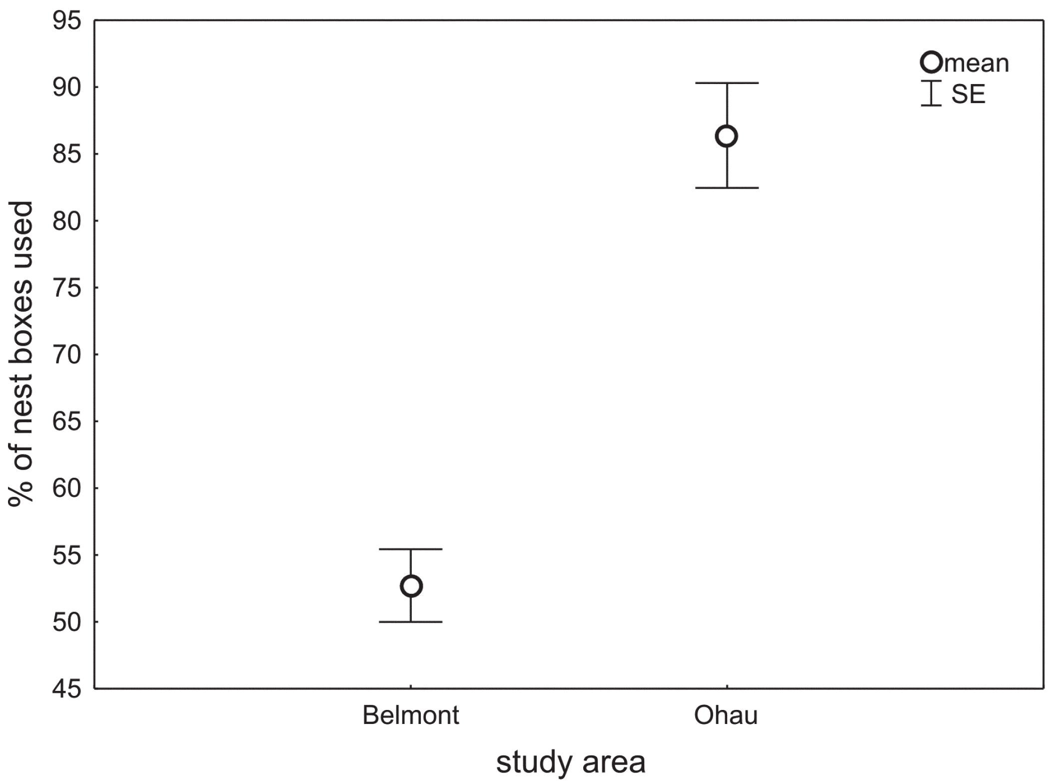

Fig. 2. The percent of nest boxes used yearly by starlings in two studied populations at Belmont and Ohau (New Zealand).

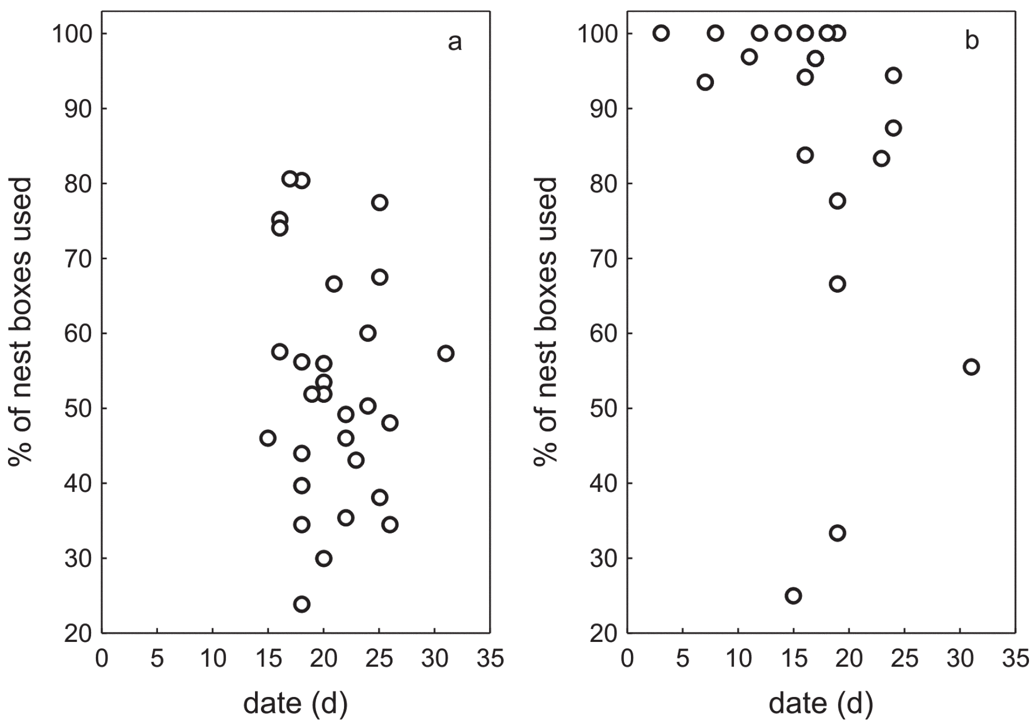

Fig. 3. The lack of relationship between the date of laying the first egg and the percent of nest boxes used in two studied starling populations at Belmont (a) and Ohau (b) (New Zealand), date is presented as a number of days after 30th of September.

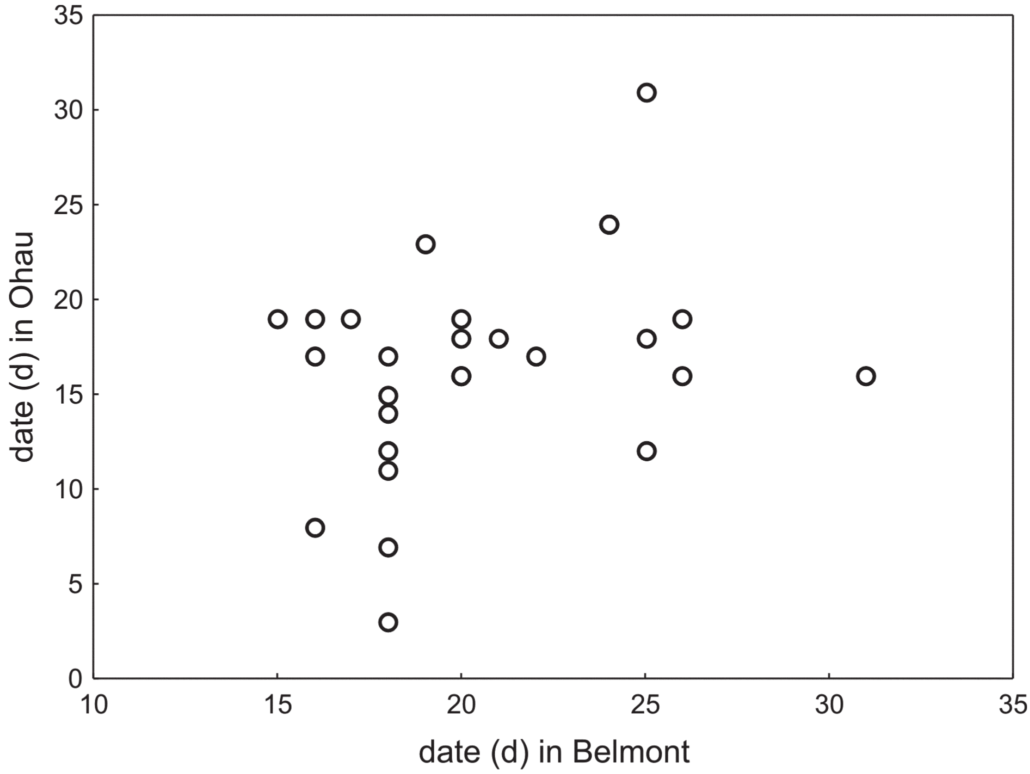

Fig. 4. Lack of relationship between the median date of laying the first egg in two studied starling populations at Belmont and Ohau (New Zealand); date is presented as a number of days after 30th of September.

there was no relationship in the percent of nest boxes used in each season between the two populations (percentages were *arcsin* transformed before analysis, r = 0.10, n = 26, *P* = 0.61).

3.2. Synchrony between areas and the influence of ENSO

We did not find any significant relationship between median dates of the first eggs laid in each breeding season in the two populations (simple regressions, r = 0.33, n = 27, *P* = 0.09, Fig. 4). Using residuals from a regression line of one study plot on another as a measure of the degree of synchrony in the breeding parameters of the two populations (with zero value to present total synchrony) we found no significant influence of ENSO on starlings' breeding phenology nor on the percentage of occupied nest-boxes (*P*> 0.30 in both analyses). Moreover, we did not obtain any significant results after checking quadratic relationships, nor when we added lag effects in autoregressive models (*P*> 0.5 in all analyses).

4. DISCUSSION

We expected that, like many animals in the Northern Hemisphere (Post and Forchhammer 2002, Liebhold *et al.* 2004, Mysterud *et al.* 2007) including starlings in southern Sweden (Svennson 2004), starlings in New Zealand should have a tendency to synchrony between two, very close local populations, but this was not the case. The reason may be that the environmental conditions differed between the two studied areas. The population at Belmont is characterised by lower breeding parameters than at Ohau. Secondly, movement of individuals between populations may be very limited. In New Zealand the starling is a resident species and from the Belmont population all ring recoveries have been within 20 km of the study area (Flux and Flux 1981, Flux unpubl. data).

Interestingly, we did not find any influence of ENSO on the degree of the synchrony of analysed breeding parameters between studied populations. Although, by definition as large-scale climatologically event, ENSO effects may be masked by very local conditions. Hence, our findings do not support ENSO operation in both study areas. As we showed in a previous paper, the time of breeding in Belmont is strongly influenced by ENSO (Tryjanowski *et al.* 2006), but this is not true for Ohau. Such results most probably are the effect of abundant food provided to starlings by humans at Ohau site: apart from domestic scraps, the birds would have access to fruit, and spilt food being supplied to poultry and farm stock. On the other hand, the Belmont starlings depend entirely on insects, spiders and earthworms. Analysis of 40 chick guts in 1973 and 1974 showed 25% of the diet was moths, followed by 22% spiders, 15% caterpillars, 13% diptera and 6% beetles; no other insect groups exceeded 3% (Moeed and Flux unpubl. data). This food supply is strongly influenced by the weather conditions, which are much more severe and changeable in comparison to Ohau. For example, a southerly storm with rain on 18 and 19 December 1973 killed 21 of 32 broods under 16 days old at Belmont, but had no effect at Ohau (Flux and Bull unpubl. data).

We suggest further studies comparing sympatric populations of starlings would be rewarding – both intra-specific synchrony and lack of it, will help us understand better the mechanisms by which climate impacts on birds (Mysterud *et al.* 2007). The lack of such studies probably arises from data limitation. Most monitoring is focussed only on population size. Data on aspects of breeding biology, especially food supply, topography, land use and weather, on both local and broader scales, are necessary to better understand synchrony, or patterns between different sites. Starlings are ideal experimental animals for such investigations as they readily nest in boxes placed in practically any open grassland environment.

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