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Effects of Females and Nestboxes on the Reproductive Condition of Male European Starlings, *Sturnus vulgaris*, during the Breeding Cycle

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Introduction

For most temperate zone birds, photoperiod provides the major environmental variable for the control of annual reproductive cycles (for reviews see LOFTS & MURTON 1968, MURTON & WESTWOOD 1977, FARNER & GWINNER 1980). In many species studied so far, seasonal photoperiodic changes have been shown to be sufficient to bring ♂ birds into full reproductive condition as judged by spermatogenesis or androgen production of the testes (e.g. FARNER & FOLLETT 1979). Other environmental stimuli which might provide supplementary information (FARNER & LEWIS 1971) for the control of ♂ reproduction have received little attention. There is evidence, however, that a variety of environmental and social cues can modify the time course of testicular growth and regression (SOSSINKA 1974, GWINNER 1975, MOORE 1983a, b, HEGNER & WINGFIELD 1984, review in WINGFIELD 1983). In contrast to ♂, supplementary factors are required for the ♀ of many species to attain full reproductive condition (BROCKWAY 1962, 1965, LEHRMANN 1965, FARNER & LEWIS 1971, LEWIS & ORCUTT 1971, IMMELMANN 1973, FARNER & GWINNER 1980, WINGFIELD 1980, 1983).

In the European starling, the presence of ♀ has been shown to affect the patterns of testicular growth and regression in ♂ when held under restricted experimental conditions by BURGER (1953), SCHWAB & LOTT (1971) and GWINNER (1975). Since in the field, ♂ starlings normally occupy nest sites before acquiring a ♀ (reviewed in FEARE 1984) the question arises of what relative importance ♀ and nestboxes have on the reproductive state of ♂. Therefore, we examined the reproductive cycles of four groups of ♂ starlings held in outdoor aviaries with or without the presence of ♀ and nestboxes. In addition to measuring testicular size, bill color and body mass we investigated the plasma concentrations of luteinizing hormone (LH) and androgens, in the hope that such endocrine data might provide particularly subtle indicators of external modifying stimuli.

Methods

The starlings were caught near Mannheim F.R.G. in 1977. They were kept in two adjacent but visually isolated outdoor aviaries (3 × 5 × 2.2 m) located in Seewiesen (48° N, 11°11′ E). All birds were at least one year old at the onset of the experiment. The compositions of the groups are shown in Table 1. From November 1977 to June 1978, ♂ with ♀ and nestboxes (Group 1) were compared with ♂ without both. In November 1978 the groups were adjusted to control for density so that one group (3) contained equal numbers of ♂ and ♀ with nest boxes and the other group (4) 20 ♂ with

nestboxes. In both years there was an aviary with ♀ and nestboxes. In 1978 the ♂ from this group were compared to ♂ alone and in 1979 to ♂ with nest boxes. All birds were fed chick bran pellets ad libitum. This was supplemented for all birds by strips of beef heart, meal worms and dried insect feed (Aleckwa) while the parents were raising young.

Table 1: Composition of Experimental Groups

		numbers of		
Group	Year	♂	♀	nestboxes
● 1	1978	12	10	10
□ 2	1978	10	—	—
Δ 3	1979	10	10	10
Δ 4	1979	20	—	10

Blood samples (400 µl) were taken from the wing vein at regular intervals throughout the breeding season. At the same time, beak color which has been shown to be testosterone dependent (Witschi & Miller 1938) was noted according to an indexing system from 1, completely black beaks, to 5, completely yellow beaks. Gonadal size was determined by laparotomy (see Gwinner 1975 for details). The birds were also observed on a weekly basis to determine which birds were breeding and which occupied nestboxes.

Plasma titers of LH and androgens (testosterone and dihydro-testosterone) were determined by radioimmunoassays. LH was measured in duplicate in 20 µl plasma samples according to Follett et al. (1972) using a purified chicken LH (AE-1) and an anti-chicken LH antisera (16/6). Androgens were measured in 100 µl of plasma after a five ml diethyl ether extraction in an assay previously described in Dittami (1981). Using the U-Test, we examined whether differences existed between the two groups of each year during the times reproductive parameters were maximal, increasing or decreasing. To do this, we compared the groups at their maximal mean values, the point before and the point thereafter. There were no significant differences between groups at other phases of the cycle.

Results

Testes had minimal size in January. Recrudescence began in all groups in Febuary and maximal testicular sizes were reached in April and May (Fig. 1A). There appeared to be a difference between the two years as gonadal sizes in May 1979 were smaller than they had been in 1978. In addition to the differences in the timing of sampling, this may have been due to a period of low temperatures in late April and early May 1979. In 1978 ♂ with ♀ and nestboxes (group 1) tended to regress their testes later than the ♂ group with neither (2) but the difference was not statistically significant. In 1979, the testes of ♂ with nestboxes only (4) were indistinguishable from those with both nestboxes and ♀ (3). No differences were seen in *beak color* between the groups during the phase of testicular regression. However, during the testicular growth phase the group 1 birds (with ♀ and nestboxes) tended to have more yellow beaks in March and April than those with neither ♀ nor nestboxes (group 2, Fig. 1B). This tendency was not found in 1979 when the group without ♀ had access to nestboxes (group 4). *Body mass* (Fig. 1C) showed rather variable seasonal changes. It tended to be highest in January and to decline throughout the experiment.

Plasma titers of *androgens* showed both group and year differences (Fig. 1D). In groups with ♀ and nestboxes androgen levels tended to increase earlier in 1979 (3) than they had in 1978 (1) although none of the differences between the years were statistical-

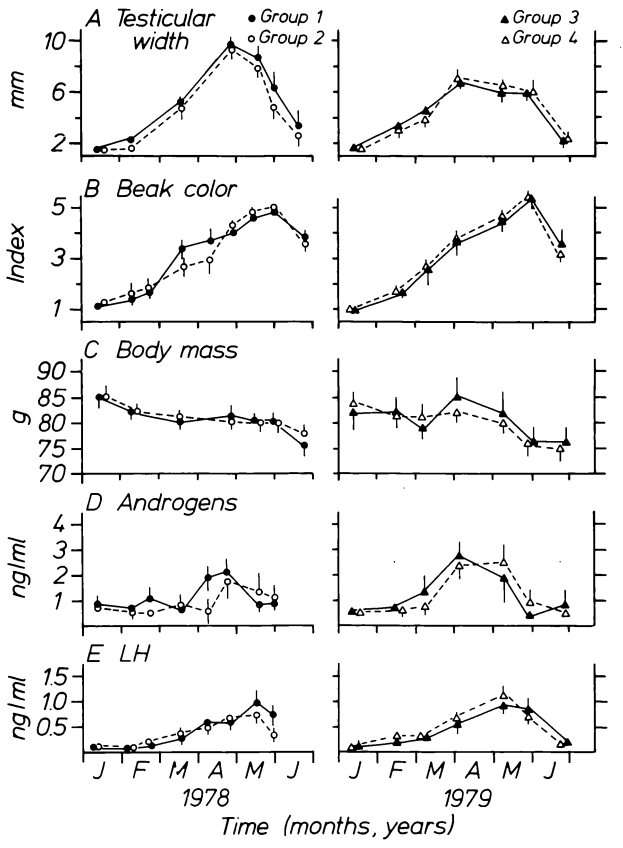

Fig. 1: Changes in testicular width (A), beak color (B), body mass (C) and plasma concentrations of androgens (D) and LH (E) in four groups of ♂ European starlings held with access to ♀ and nestboxes (● Group 1, Δ Group 3) with nestboxes (Δ Group 4) or without ♀ and nestboxes (♀ Group 2). Means with 95 % confidence intervals are given.

Abb. 1: Änderung des Hodendurchmessers (A), der Schnabelfarbe (B), des Körpergewichts (C) und der Plasmatiter von Androgenen (D) und LH (E) bei vier Gruppen männlicher Stare, die mit ♀ und Nistkästen (● Gruppe 1, Δ Gruppe 3), mit Nistkästen (Δ Gruppe 4) und ohne beides (♀ Gruppe 2) gehalten worden sind. Die Mittelwerte sind mit 95 % Vertrauensintervallen angegeben.

ly significant. In 1978, The plasma titers of androgens of the group with ♀ and nestboxes (1) increased earlier than in the group with neither (2, Fig. 1D). The values of the two groups in early April were significantly different ($p < 0.01$). In 1979 there was a tendency for ♂ with ♀ and nestboxes (3) to increase and decrease their androgen levels earlier than ♂ with only nestboxes (4) but none of the differences were statistically significant. The pattern of *LH* were identical in all the groups early in the breeding season (Fig 1E). Later, however, LH plasma titers decreased earlier in the ♂ only group in 1978 (2) than in the ♂/♀ group (1) with nestboxes. At the end of May the LH values in the two groups were significantly different ($p < 0.01$).

To determine whether the differences found between groups with and without nestboxes existed on an intra-group level, we split up groups 1, 3 and 4 into birds which oc-

cupied nestboxes and birds which did not. We found no significant differences between the subgroups although in group 4, ♂ without nestboxes tended to have lower androgen titers during periods of increasing and maximal levels than those which occupied nest sites.

Discussion

The ♂ starlings studied in outdoor aviaries here had seasonal changes in LH and androgen plasma titers similar in form and amplitude to those which have been found in free-living starlings (Dawson & Goldsmith 1982, Dawson 1983). Body mass also showed similar patterns of change to those which have been reported on free-living birds (Dawson & Howe 1983) although the amplitude of change was smaller in our aviary birds.

Although the differences found between groups were small, the present results suggest that environmental factors in captivity can, to a certain extent, affect the reproductive physiology of ♂ European starlings. These factors did not appear to be necessary for the expression of seasonal changes in reproductive activity but may provide modifying or supplementary information (Farner & Lewis 1971, Wingfield 1983) for its fine tuning. When we compared the effects of nestboxes versus those of ♀ it seemed that the presence of nestboxes was more important. When they were absent as in group 2, the androgen increase in spring was delayed, gonadal regression tended to occur earlier and LH plasma titers decreased earlier than in the ♂ group with nestboxes and ♀ group (1). Clearcut differences were not found between ♂ with nestboxes and ♀ (Group 3) and ♂ alone with nestboxes (Group 4), the increase and decrease in androgen titers only tended to be later in the group without ♀ (4) than in the group with ♀ (3). Hence, the presence of ♀ appeared to have less of an effect than the presence of nestboxes. In a number of other experiments with starlings, mentioned in the introduction, ♀ were shown to have an effect on the gonadal cycles of ♂. Since the designs of these experiments were completely different (small cages without nestboxes) no direct comparisons can be made. It is also possible that other factors like nesting, re-nesting and feeding offspring could have dramatic effects on the reproductive physiology of the ♂ (see Wingfield 1980 for a review) but our data are not comprehensive enough to attack this question.

It seems reasonable that the presence of nestboxes is generally an important environmental variable for ♂ hole-nesting birds whose reproductive success depends heavily on the possession of a suitable nest site. So far, few investigators have tried to separate out the possible effects of various potentially significant environmental and social variables like nesting sites, mates and social interactions on the reproductive state of the ♂. This was our first attempt at a problem which should certainly be investigated in more detail.

Summary

European starlings were held in large outdoor aviaries under various conditions: Group 1 and 3 with access to ♀ and nestboxes, Group 4 with nestboxes alone, and Group 2 with neither ♀ nor nestboxes. The aim was to determine whether either of these factors could affect the reproductive cycles of ♂ starlings. Testes size, beak color, body mass and the plasma titers of LH and androgens were investigated. It was found that the effects of these two parameters on the annual cycles were marginal, the only significant differences being associated with the availability of nestboxes. Without nestboxes the vernal increases in androgens were significantly later, beaks tended to yellow later, and LH decreased earlier than in ♂ with access to nestboxes.

Zusammenfassung

Einfluß von Weibchen und Nistkästen auf den Fortpflanzungszyklus männlicher Stare, *Sturnus vulgaris*.

Vier Gruppen männlicher Stare wurden in großen Außenvolieren gehalten: die ♂ der Gruppen 1 und 3 hatten sowohl ♀ als auch Nistkästen zur Verfügung, die der Gruppe 4 nur Nistkästen und die der Gruppe 2 weder ♀ noch Nistkästen. Bei allen Vögeln wurde in regelmäßigen Abständen die Hodengröße, die Schnabelfärbung, das Körpergewicht und die Plasmakonzentration von LH und Androgenen bestimmt. Während die Anwesenheit von ♀ keinen nachweisbaren Einfluß hatte, wirkte sich die Verfügbarkeit von Nistkästen auf einige der gemessenen Größen aus. Bei den ♂ mit Nistkästen stiegen die Plasma-Androgenwerte zu Beginn der Fortpflanzungsperiode früher an und die Schnäbel färbten sich früher nach Gelb um als bei den ♂ ohne Nistkästen; am Ende der Fortpflanzungsperiode sanken die LH Werte dieser ♂ später ab. Die Ergebnisse sprechen dafür, daß der Besitz eines Nistkastens ein wichtiger Faktor für die Kontrolle der Fortpflanzungsaktivität männlicher Stare ist.

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