EFFECT OF EMBRYONIC TESTOSTERONE CONCENTRATION ON TIMING OF MOULT AND MIGRATORY DISPOSITION IN JUVENILE STARLINGS (*Sturnus vulgaris*)

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ABSTRACT

Kossarev V. 2001. *Effect of embryonic testosterone concentration on timing of moult and migratory disposition in juvenile Starlings (Sturnus vulgaris).* Ring 23, 1: 167-172.

The studies were undertaken on the Courish Spit (eastern Baltic). In spring 1998, 400 ng of testosterone, dissolved in sesame oil, was injected into each yolk of 5 Starlings' eggs from two nests. The injected eggs were laid at one time with 7 controls from 3 other nests. At the age of 19-20 days, the nestlings were taken from the nests and kept under natural daylength until November. The birds from experimental group started moulting 5-7 days earlier than the controls. Migratory fat deposition in the control birds started to develop about 70 days earlier than in the experimental group. Nevertheless, birds from both groups reached maximum weight at the same time – in the middle of October. All differences were significant. Only one bird from the experimental group and one from the controls showed pronounced nocturnal activity. The bird from experimental group started to demonstrate restlessness about 30 days later than the control one. Probably, the low level of embryonic testosterone may have led to early development of migratory state in the control birds from local population of Starlings, and it could have been the physiological basis for summer migration of Starlings in eastern Baltic.

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Key words: testosterone, yolk, moult, migratory disposition, Starling, summer migration

INTRODUCTION

Seasonal events of the annual cycle of birds, such as breeding, moult, and migration are regulated by endogenous programs (for review: Dolnik 1975, Gwinner 1986). However, physiological mechanisms that underlay these programs remain largely unknown.

The relationships between separated events of annual cycle have been studied on the Chaffinch (*Fringilla coelebs*) – a mid-distance migrant. In adult birds during spring migration, gonads start to grow while increasing of daylength. During the unifactorial phase of gonadal development, which is controlled by photoperiod only, gonads grow logarithmically until they reach the maximum size for this phase. The moment at the end of unifactorial phase is the starting point for the annual cycle. After this moment, at fixed time, the moult and autumn migratory fattening start (Dolnik 1975).

Regulation of seasonal programs in juvenile birds is less studied. In juvenile Chaffinches the beginning of moult and autumn migratory fattening depends on the time of hatching (Schumakov 1972). Birds from late broods start their moult and migratory fattening in younger age than birds from the early ones. The acceleration of late born birds preparation for autumnal migration synchronises the beginning of migration in most of birds from the local population (Dolnik 1975). According to experimental data, among nestlings that had been taken from nests at the age of 6 days and kept under constant photoperiod, the birds from late broods developed seasonal stages faster and at younger age in comparison to the birds from early broods (Dolnik 1980). Two hypotheses can explain this fact:

1. Nestlings are able to obtain the information about their date of birth from the changes of day-length during the first few days of their life.
2. Female can shift the seasonal programs of nestlings through the material of eggs.

According to the first hypothesis, young birds should be able to recognise and measure changes of day-length during few days. Theoretically it is possible, but for birds, especially for those who were born close to the summer solstice, changes of photoperiod determined by weather conditions can be larger than astronomical changes in daylength. This makes such a method for correction of seasonal programmes rather difficult. Nevertheless, the results of some experiments may support the existence of such mechanism (Dawson and McNaughton 1992).

Several studies agree with the second hypothesis. First, the female may have more significant information about the date of eggs laying, because its photosensitive system was synchronised with astronomical changes of daylength during the whole spring (Dolnik 1975). Second, such a way for transmission of the information about date of birth from female to the offspring is already known for some insects (Danilevsky 1961). Third, an analysis of yolk shows that the concentration of testosterone varies with photoperiodical conditions during egg formation, and the testosterone concentration is higher in yolk from the first clutches than from the second ones (Schwabl 1996a). Nestlings from the eggs with high and low concentration of the testosterone differ in their postnatal morphology and behaviour at least during the first several days after hatching (Schwabl 1996b).

Therefore, at the moment, yolk testosterone seems to be one of the most probable regulators of the seasonal cycle in juvenile birds. In this pilot study, we tried to check this hypothesis on the Common Starling.

MATERIALS AND METHODS

The Starling is one of the most appropriate objects for such work, because in this colonial species laying eggs is very synchronised, and we can easily obtain nestlings of nearly the same age. It means that the photoperiodic conditions during eggs formation are identical for all the birds.

These studies were undertaken from 15 April to 4 November 1998 on the Courish Spit (eastern Baltic). During the period of laying eggs, we examined the Starlings' nesting boxes every day. On the day of eggs' appearance, we made single injections of 400 ng of testosterone dissolved in sesame oil into the yolks of 9 eggs from 2 clutches and left them in nests. The injections were made by insulin syringe. The hole made by the needle on the shell was banded by sticking plaster. All eggs used in experiment were laid within 9 days. 19-20 days after hatching, we took 5 nestlings hatched from the injected eggs and 7 – from the intact ones, hand-raised them until the beginning of independence and kept in individual cages under natural photoperiod. Water and food (dog food „Purina", Spain) were available *ad libitum.*

During the next two weeks, we have inspected the plumage every day in order to detect the exact age of starting the primary moult. In Starlings visible moult starts with the loss of the inner primary, and it is easy to fix this moment. Every week we measured the mass of the birds (exactness to 0.5 g). Through the whole experiment we registered locomotory activity of each bird. One perch in each cage was equipped with a micro-switch connected to a computer counting system. This system registered presence or absence of activity every minute.

Data were analysed by the analysis of variance (ANOVA), Pearson's coefficients were calculated for correlations. A difference in age of the beginning of moult was calculated by Mann-Whitney test, due to a few sampling units.

RESULTS

Moult

We found a difference in age of the beginning of moult between controls (hatched from intact eggs) and experimental birds (hatched from testosterone-injected eggs). In control group the mean age of shedding the first primary feather was 36 days (SE = 0.63, N = 7), in experimental group – 41.2 days (SE = 0.79, N = 5). The difference between groups was highly significant (Mann-Whitney test, $p < 0.001$).

Body mass

During the whole experiment, the body mass increased significantly in both control and experimental groups (for controls: $r = 0.69$, $p \leqslant 0.001$, $N = 198$; for experimental birds: $r = 0.64$, $p \leqslant 0.001$, $N = 124$). Up to 7 October, the mass increase was

higher in the control group ($r = 0.59$, $p \leqslant 0.001$, $N = 170$) than in experimental one ($r = 0.34$, $p \leqslant 0.001$, $N = 108$), with a significant difference ($p < 0.05$) (Fig. 1). Between 7 and 14 October, the mean mass increased dramatically by 11 g in birds from the experimental group. After 14 October, the mean masses of birds from the control and experimental groups did not differ significantly (ANOVA: $F = 3.504$, $df = 6$, $p < 0.11$) and remained high until the end of experiment.

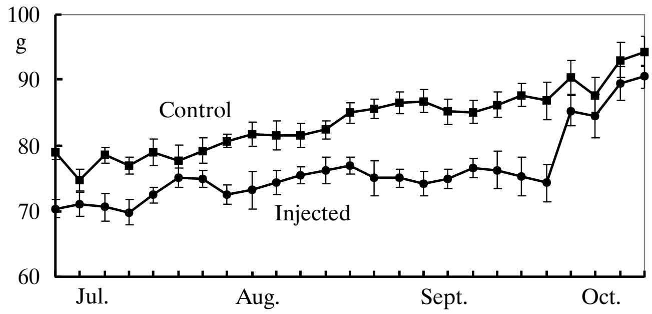


Fig. 1. Changes in body mass of Starlings from control and experimental groups. Means and *SE* are shown.

Locomotory activity

One bird from control and one from experimental group have demonstrated pronounced nocturnal activity. The control bird was active from 20 July to 18 August, the experimental one – from 2 September to 20 October. Occasionally, both birds demonstrated limited nocturnal activity in other parts of the season (Fig. 2).

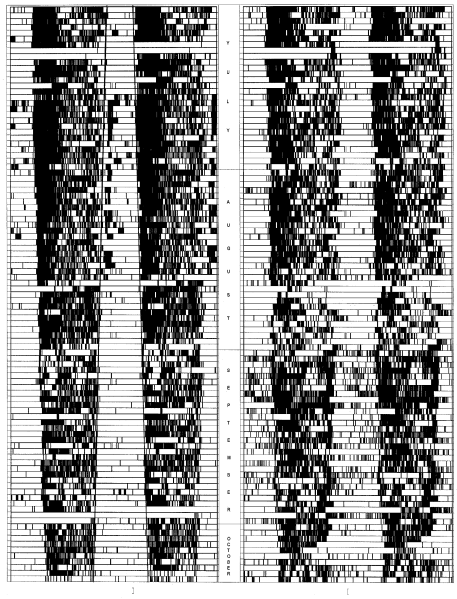
DISCUSSION

We found the differences between Starlings hatched from the testosterone injected and intact eggs in the timing of moult, migratory weight gain, and nocturnal activity.

We can compare the differences between experimental and control groups to the differences between birds from early and late broods in timing of moult and migratory fattening.

The birds from injected eggs started to moult 5-7 days later than the control ones. Identical difference in 4-11 days appeared between Starlings from early (May) and late (June) broods (Rymkevich 1990).

The increase of body mass in the birds from injected eggs started about 70 days later than in the control group. We did not find any data about such a difference between early and late broods of Starlings in literature, but in juvenile Chaffinches,



Control Injected

Fig. 2. Pattern of locomotory activity of one control and one experimental birds.

under natural photoperiod, birds from early broods start to increase body mass about 30 days later than in late broods (Schumakov 1972).

Starlings are not obligatory nocturnal migrants, and in Central Europe they do not show nocturnal activity in cages (E. Gwinner pers. comm.). In our experiment, only one bird from the experimental group and one from the control one showed a pronounced nocturnal restlessness. The bird from injected egg started to be active at night 30 days later than the control one.

Thus, the birds hatched from modified eggs do develop similarly to the birds from early broods, and the birds from intact eggs are comparable to the birds from late broods.

All eggs in this experiment were laid within 9 days. In each group there were eggs laid in the beginning, middle, and the end of this time, and hatched birds from both groups were exposed to the same photoperiod. It means that the source of the differences between them was in the quality of the eggs. If so, this is the testosterone from injections, what was the most probable cause of the differences between eggs. To be sure in this conclusion, we had to make the series of such experiments to exclude occasional results.

After our experiment, several suggestions could be done. First, if the single injection of testosterone into the yolk affects the timing of moult, migratory fattening, and nocturnal activity, it suggests that testosterone may regulate some events during months after injection. Similar characteristics of this hormone was shown for the regulation of spring migratory fattening in adult White-crowned Sparrows (*Zo-*

notrichia leucophris) – Schwabl and Farner (1989). Second, in the experiment, testosterone affected both moult and migratory disposition. Probably testosterone is an essential part of the general system that regulates annual cycle at the higher level than separate systems, which control moult, fattening, and restlessness by their own.

The results presented here may suggest the adaptive significance of different testosterone concentration in eggs. The intact control birds belonged to the local population of Starlings in eastern Baltic. The early development of nocturnal activity and constant increasing of body mass during the whole summer and autumn in our experiment may have reflected Starling's summer migration in this region. If low concentration of yolk testosterone leads to the early beginning of migratory disposition, it can be the mechanism for development of new migratory strategies depended on the timing of breeding season.

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