Sexy birds are superior at solving a foraging problem

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Yellow, red or orange carotenoid-based colorations in male birds are often a signal to prospecting females about body condition, health status and ability to find food. However, this general 'ability to find food' has never been defined. Here we show that more brightly ornamented individuals may also be more efficient when foraging in novel situations. The results highlight the fact that evolution may have provided females tools to evaluate cognitive abilities of the males.

1. INTRODUCTION

The plumage of many bird species is coloured by carotenoids. Since carotenoid pigments must necessarily be acquired from food, it has long been suggested that bright coloration in males signals their ability to procure these compounds [1–3]. It is not yet known, however, what exactly is implied by this ability.

The siskin (*Carduelis spinus*) is a small finch that has a yellow stripe on its wings. The length of this stripe is assessed by females when selecting a mate [4]. The aim of the present study was to investigate whether the size of this patch could be used to discriminate between males that perform differentially a foraging task. As an index of this ability, we examined how siskins performed in accessing food from a partially blocked feeder. The task required birds to remove one or two toothpicks from the feeder in order to reach the pine seeds below. We used the time taken to access the food as a measure of performance.

2. MATERIAL AND METHODS

Male siskins (*C. spinus*) used in the experiments (*n* = 29) were captured in northeast Spain in the autumn and winter of 2007–2008. Birds were separated in groups of four and kept in cages provided with eight feeders spaced along 1 m. This prevented competition for food within the group. To estimate overall patch size, we measured the length of the yellow stripe on the primary wing feather six (P6) (descendent) from the distal edge of primary covert four to the distal end of the yellow colouring, according to Senar & Escobar [5]. This measurement is strongly correlated with the size of the whole yellow patch [5]. Siskins also show a black badge that reflects their dominance within the social group. The size of this black badge is uncorrelated with the yellow wing strip length [6,7]. We also measured the size of this black patch, following Senar *et al.* [6]. Four hours before the trial, birds were isolated and food-deprived to foster motivation. After fasting, a small feeder containing pine seeds was placed on an elevated platform in each test cage. Access to the pine seeds was partially blocked by toothpicks that were criss-crossed from side to side through lateral holes in the feeder. The toothpicks protruded 4 cm on each side. The birds could see the

food, but they were unable to reach it without removing at least one of the sticks. They could do this by moving them sideways, until one end of the stick slid out of the side hole in which it was inserted.

An observer measured the time spent by each bird from the moment they landed on the platform or on the feeder trying to get the food, until the moment when they solved the problem, reaching the pine seeds. If the bird did not go on the platform within 3 min, the trial was considered ended. The maximum time set to solve the problem once birds reached the platform was 5 min. Each bird was observed for a maximum of five trials. If, for instance, a bird got the food source in the third trial, after 62 s, we computed $300 + 300 + 62$ s as the total time needed to solve the problem.

We analysed, using generalized linear models (GLM), differences in the length of the yellow wing stripe, measured on primary six (*n* = 29), between slow and fast problem solvers, including age (yearling versus adult) as a covariate. We defined slow solvers as birds that either did not solve the problem or needed more than one trial to solve the problem (greater than 300 s). Fast solvers were defined as birds that solved the problem within the first trial (less than 300 s). Time to solution was then related to the length of the yellow wing stripe, age, size of the black badge and size of the bird (as measured from tarsus length), using a Cox proportional hazards regression model (*n* = 21). All analyses were implemented in the R statistical computing environment, v. 2.12.2 [8]. Cox regressions were applied using the *survival* package [9].

3. RESULTS

Results showed that fast problem solvers had longer yellow wing stripes than slow problem solvers (GLM: *t*-value = 3.65, *p* < 0.01; figure 1). Birds with longer yellow wing stripes solved the problem faster than those with shorter stripes (table 1 and figure 2). Neither age, nor size of the black bib, nor size of the bird (as measured from tarsus length) had any significant effect on solving time (table 1). Latency time to land on the platform/feeder was not related to the length of the yellow wing stripe (Cox analysis: $z = 0.03$, $p = 0.98$).

4. DISCUSSION

The results of this study showed that the length of the carotenoid-based yellow wing stripe of siskins is related to the ability to solve a foraging problem. This trait did not reflect, though, the latency time to approach the problem, eliminating the possibility of a neophilia effect. The approach we used to test their problem-solving ability may be considered not to measure all aspects of this ability and to be rather artificial. However, we chose this approach because evolution cannot have provided animals with a built-in solution for novel situations of this type, and they have not had a chance to learn what to do through trial and error. This explains why older individuals were not able to take advantage of their experience. Hence, the performance shown while facing this novel task should reflect the ability to solve at least some categories of problems [10]. Challenges of this type are not uncommon in nature, and birds are known to develop singular feeding innovations [11]. A classical example may be the ability of wild tits to manipulate and open milk bottles [12].

Traditionally, the idea that carotenoid-based coloration is related to foraging ability had been tested within the framework linking diet to coloration [3]. Here we show that exploiting carotenoids for colouring ornaments is not only a question of availability and ingestion but also of ability to get them. Moreover, while we do not know yet the breadth of the task
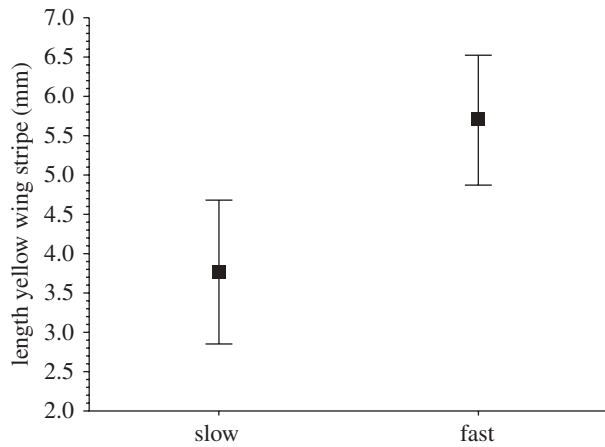
Figure 1. Differences in the length of the yellow wing stripe, measured on primary six ($n = 29$), between slow and fast problem solvers. We defined slow solvers as birds that either did not solve the problem or needed more than one trial to solve the problem (greater than 300 s). Fast solvers are defined as birds that solved the problem within the first trial (less than 300 s). Fast solvers displayed longer yellow wing stripes than slow solvers (s.e. bars shown).
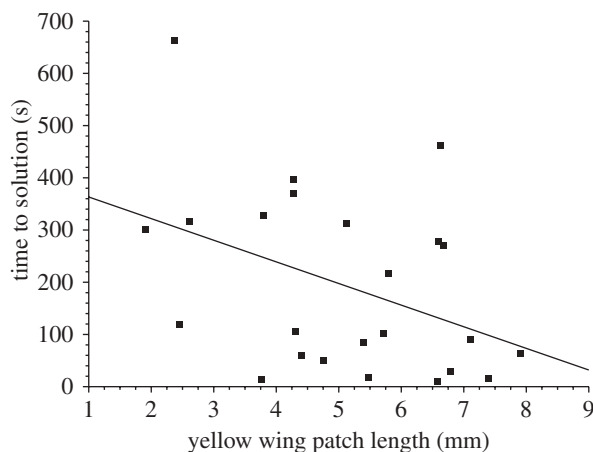

Figure 2. Relationship between the length of the yellow wing stripe ($n = 21$) and the time taken to solve the foraging problem. Birds with longer yellow wing stripes solved the problem faster (table 1). The figure only includes birds that solved the problem.

domain over which our index applies, it also appears that, at least for one dimension of problem-solving, females' choice criteria may be adapted to gauge cognitive performance.

Table 1. Cox proportional hazards analysis relating length of the yellow wing stripe, size of the black bib, age and size of the bird (tarsus length) with the time taken to solve a foraging problem ($n = 21$). (Interactions were not included since they were not significant.)

variable	coef	exp(coef)	s.e.(coef)	z	p-value
yellow wing stripe	0.38	1.47	0.18	2.13	0.03
black bib	−0.94	0.39	0.60	−1.57	0.12
tarsus	−0.37	0.69	0.56	−0.66	0.51
age	−0.02	0.98	0.02	−1.10	0.27

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