

Is the white wing-stripe of male House Sparrows *Passer domesticus* an indicator of the load of Mallophaga?

Gregorio Moreno-Rueda

Moreno-Rueda G. 2005. Is the white wing-stripe of male House Sparrows *Passer domesticus* an indicator of the load of Mallophaga? *Ardea* 93(1): 109–114.

Male House Sparrows *Passer domesticus* have a white wing stripe that is not present in females, and is displayed during courtship. Chewing lice eat white barbs preferentially, which suggests that the presence of white barbs depends on the presence and abundance of chewing lice. Therefore, the white wing stripe might be an indicator of the load of Mallophaga. In this work, albino birds appeared to have more chewing lice than non-albino birds, although differences were marginally significant. Moreover, males with longer wing stripes had lower Mallophaga load. Therefore, white plumage may be an honest signal of Mallophaga load. This might be used by females to choose mates that are more resistant to chewing lice.

Key words: *Passer domesticus* – badge size – ectoparasites – honest signal – sexual selection

Departamento de Biología Animal y Ecología, Facultad de Ciencias, Universidad de Granada, E-18071, Granada, Spain (gmr@ugr.es).



INTRODUCTION

Parasites are organisms that obtain resources from their hosts thereby reducing the host's fitness. Common ectoparasites of birds are the feather or chewing lice, belonging to the order of the Mallophaga. These parasites eat barbs, provoking the destruction of feathers and the consequent deleterious effects on birds (Kose & Møller 1999, Pap *et al.* 2005). The deleterious effects of parasites on their hosts give rise to a selective pressure that favours the development of mechanisms of resistance to parasites in the hosts (e.g. Møller & Erritzøe 1996). If such mechanisms of resistance are heritable, females that choose males resistant to parasites as mates will produce offspring that will inherit that resistance, and, therefore, will be of better quality, thus increasing the fitness of such

females (Hamilton & Zuk 1982). Different characteristics of plumage and courtship in birds have been suggested to be indicators of parasite load (and therefore, indicators of the resistance of those males to parasites), being signals selected by the females (Hamilton & Zuk 1982, Kirkpatrick & Ryan 1991, Møller *et al.* 1999). Even if resistance to parasites is not heritable, females may benefit from choosing males with lower parasite load, because they would reduce their chance of becoming infected (Able 1996, Møller *et al.* 1999). In this framework, sexual selection on plumage colour has received much attention (Gray 1996, Badyaev & Hill 2000). However, researchers have studied principally melanin- and carotenoid-based plumage (e.g. Møller 1989, Hill 1991), and few studies have focused on the importance of white plumage in sexual selection. It has been suggested that some

chewing lice prefer white barbs (Kose & Møller 1999, Kose *et al.* 1999). If this is correct, then white patches may be reliable indicators of the resistance to Mallophaga. In fact, the existence of sexual selection has been linked to white plumages (Kose & Møller 1999, Kose *et al.* 1999; also see Sheldon & Ellegren 1999, Qvarnström *et al.* 2000, Griffith & Sheldon 2001).

Black bib size is a sexually selected trait in the House Sparrow *Passer domesticus* (Møller 1988, 1989, Veiga 1993). Møller *et al.* (1996) found that the size of the bursa of Fabricius increases with Mallophaga load, and decreases with bib size. Therefore, a negative relationship between bib size and Mallophaga load may be predicted in the House Sparrow. Nevertheless, other traits, which have not been subject to study, may also be affected by this type of selection. One of those traits is the white wing stripe, which is present only in males, being of brown colour in females. During the courtship, males display the white wing stripe as much as they display the black bib (Summers-Smith 1988). Furthermore, the stripe, like the bib, is much less conspicuous in winter (Cramp 1998). For these reasons, I propose the hypothesis that the white wing stripe may be a reliable indicator of Mallophaga load, and therefore, of the resistance to these parasites, and that females could use it for mate choice. According to this idea, I predict that males with longer stripes should have fewer chewing lice. In this study, I compare how both signals (bib and wing stripe) serve as indicators of Mallophaga load in the House Sparrow.

METHODS

This study was carried out in a population of House Sparrows breeding in captivity at the University of Granada. Because animals were in an aviary, they faced the same environmental conditions and all birds were equally subject to transmission of parasites. Animals had food and water *ad libitum*. They also had thirty nest-boxes for breeding and abundant material for nesting.

Breeding performance was not different in this colony from that in the wild. For more details about the conditions of captivity, see Moreno-Rueda & Soler (2002).

During December of 2000, I carried out various measurements on 20 males with adult plumage. In November of 2001 I measured 37 males, those measured the previous year plus 17 yearlings. The height and the width of the breast badge and the wing stripe length were measured in all these specimens with a digital calliper (accuracy 0.1 mm). The length of the wing stripe was measured by extending the wing, so that the advanced edge of the wing formed an angle of 45° with an imaginary axis of the bird's body. In this way, the white wing stripe is a line easy to measure. I did not measure the wing stripe width because it is very irregular and I did not find any point where a reliable measurement was possible. The bib size was calculated using the formula $166.7 + 0.45 \times \text{height (in mm)} \times \text{width (in mm)}$ (Møller 1987). The Mallophaga load was estimated by examining the birds' wings and tails exposed to a light, and counting the small holes in the feathers made by the chewing lice. I used the number of holes as an indicator of the Mallophaga load. This measure seems a good assessment of Mallophaga load because it is usually strongly correlated with parasite load in birds (Møller 1991). Unfortunately, I could not identify the species of lice that made the holes in the Sparrows. I also measured tarsus length (to the nearest 0.1 mm), wing chord (to the nearest 1 mm) and weight (to the nearest 0.5 g). A Principal Components Analysis (PCA) was performed with these measurements to generate a factor of body size (Pascual & Senar 1997).

I assessed the reliability of my measurements by calculating their repeatability according to Lessells & Boag (1987; see also review in Senar 1999). Each trait was measured twice on 12 individuals (Mallophaga load, wing stripe length, and badge size inclusive). Repeatability for all measurements was always higher than 0.85. For this reason, I decided to measure each trait only once, thus minimising handling of the animals. Measure-

ments of patches (bib size and wing stripe length), combined with an index of body size (the PC1 of PCA), were introduced in a stepwise multiple regression model on the Mallophaga load.

If chewing lice prefer white feathers (Kose *et al.* 1999), and holes are produced by lice (Møller 1991), one could predict that albino birds (those with some white feathers) have more holes than normal birds. In 2001, I used a set of 82 Sparrows (37 males and 45 females) to compare the Mallophaga load between partial albino birds ($n = 10$) and normal birds ($n = 72$). I used a t-test for comparisons. Because number of holes was not different between males and females (males: 3.0 ± 2.68 ; females: 3.0 ± 1.41 ; $t_{80} = 0.09$, $P = 0.93$), data from males and females were combined in this analysis.

Parametric statistics were used because all variables were normally distributed according to a Kolmogorov-Smirnov test. G-Power program (Faul & Erdfelder 1992) was used to calculate the power ($1 - \beta$) of the tests. Data shown are mean \pm standard deviation.

RESULTS

In 2000, the number of holes showed a significant negative correlation with wing stripe length ($r = -0.52$, $P < 0.02$, $n = 20$, $1 - \beta = 0.73$; Fig. 1A), but not with bib size ($r = 0.05$, $P = 0.85$, $n = 20$, $1 - \beta = 0.08$; Fig. 1B). Body size showed no significant relationship with the number of holes ($r = -0.36$, $P = 0.12$, $n = 20$, $1 - \beta = 0.37$). Body size and wing stripe were positively correlated ($r = 0.58$, $P < 0.01$, $n = 20$). The stepwise multiple regression model found only a significant relationship between number of holes and wing stripe length ($F_{1, 18} = 6.79$; $r = -0.52$, $P < 0.02$).

In 2001, the relationship between number of holes and wing stripe length was only a non-significant negative trend ($r = -0.18$, $P > 0.2$, $n = 37$, $1 - \beta = 0.19$). The discrepancy with the previous year's results may have been a consequence of the earlier date of measurements. Consequently, some of the birds were still moult-

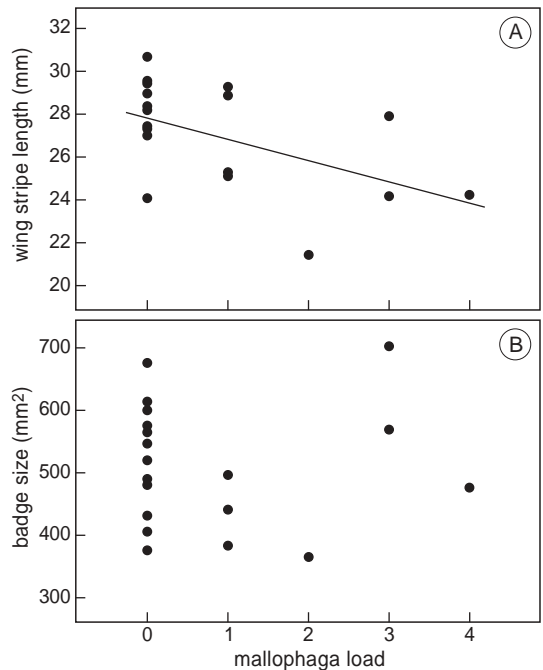


Figure 1. A) Number of holes in the feathers of wings and tail (an index of Mallophaga load) plotted against the white wing stripe length (in mm). B) Number of holes plotted against breast badge size (in mm²).

ing whereas in the first year all birds had completed the moult. If chewing lice prefer white feathers, one could predict that albino birds have more holes than non-albino birds. Indeed, albino birds appeared to have a higher number of holes than normal birds, although the difference was marginally significant (albino: 4.4 ± 2.55 , $n = 10$; normal: 2.8 ± 2.42 , $n = 72$; $t_{80} = 1.94$, $P = 0.056$, $1 - \beta > 0.9$).

DISCUSSION

White plumage may be important as indicator of the resistance to Mallophaga because chewing lice prefer white feathers (Kose *et al.* 1999). In agreement with this, albino birds appeared to have more holes than normal birds, although differences were marginally significant. Because chew-

ing lice prefer to feed on white barbs, individuals with many chewing lice should have a shorter wing stripe, due to the feeding by Mallophaga. Individuals more resistant to Mallophaga, then, would have a longer wing stripe. Indeed, results show that white wing stripe may be used as an indicator of Mallophaga load in the House Sparrow, while breast badge size is not. This study supports the work by Kose & Møller (1999) and Kose *et al.* (1999) that white patches in swallows may act as indicators of Mallophaga load.

Other individuals, especially females looking for mates, could obtain benefits from the information transmitted by the wing stripe. For example, if bib size is not heritable (Griffith *et al.* 1999), obviously, females that mate with males with higher breast badges do not obtain genetic benefits, but they may obtain direct benefits, for example a more effective nest defence (Reyer *et al.* 1998). If wing stripe length is an indicator of the heritable resistance to Mallophaga, females could obtain genetic benefits by mating with males with longer wing stripes, but this possibility has not yet been studied. If chewing lice are directly transmitted among individuals passing from one bird to another one (horizontal transmission), then females could benefit by copulating with males that have lower chewing lice load (Able 1996).

Many studies on sexual selection concerning breast badge size have been carried out in the House Sparrow (e.g. Møller 1988, 1989, Veiga 1993; and, more recently, Evans *et al.* 2000, Whitekiller *et al.* 2000, Gonzalez *et al.* 2001, Václav *et al.* 2002), but the white wing stripe has never been studied, although it is a dimorphic trait and is conspicuously displayed during courtship. Here, I have shown that this trait might be an indicator of Mallophaga load, while bib size was not. Møller *et al.* (1996) found a relationship between health and bib size, and between health (i.e., the size of the bursa of Fabricius) and Mallophaga load. Therefore, a negative relationship between bib size and Mallophaga load is predicted from their study, which was not supported by my results, however. The lack of any relationship between bib size and Mallophaga load may be

because bib size is related with the general condition of birds, as the study of Møller *et al.* (1996) suggests, but not directly with Mallophaga load. Mallophaga load may affect the condition of birds in the wild (Kose & Møller 1999, Pap *et al.* 2005), but, perhaps, not in our aviary because food was provided *ad libitum*. In sum, the function of both signals seems different, with bib size indicating general condition and wing stripe signalling specifically Mallophaga load. The various signals exhibited by males may indicate different traits or resistance to parasites (Wedekind 1992), and the reaction by females may depend on prevailing conditions (Jennions & Petrie 1997). For example, in a population highly infected by Mallophaga, females might prefer males with longer stripes above males with greater badges. These results point to promising avenues for studies on sexual selection in the House Sparrow.

ACKNOWLEDGEMENTS

Juan Diego Ibáñez, Lola G. López de Hierro and, especially, Rubén Rabaneda helped me during capturing and measuring the animals. Comments from Manuel Soler, Juan J. Soler, Raivo Mänd, Douglas W. Mock, Jed Burt and anonymous referees improved this work. Linda Patricia Hollinger, Rubén Rabaneda and Manolo Martín corrected the English. This study was partially financed by myself.

REFERENCES

- Able D.J. 1996. The contagion indicator hypothesis for parasite-mediated sexual selection. *Proc. Nat. Acad. Sci.* 93: 2229–2233.
- Badyaev A.V. & Hill G.E. 2000. Evolution of sexual dichromatism: contribution of carotenoid- versus melanin-based coloration. *Biol. J. Linn. Soc.* 69: 153–172.
- Cramp S. 1998. The complete birds of Western Palearctic on CD-ROM. Oxford University Press, Oxford.
- Evans M.R., Goldsmith A.R. & Norris S.R.A. 2000. The effects of testosterone on antibody production and plumage coloration in male house sparrows (*Passer domesticus*). *Behav. Ecol. Sociobiol.* 47: 156–163.
- Faul F. & Erdfelder E. 1992. GPOWER: A priori, post-hoc, and compromise power analysis for MS-DOS [Computer program]. Bonn University, Bonn.

- Gonzalez G., Sorci G., Smith L.C. & de Lope F. 2001. Testosterone and sexual signalling in male house sparrows (*Passer domesticus*). *Behav. Ecol. Sociobiol.* 50: 557–562.
- Gray D.A. 1996. Carotenoids and sexual dichromatism in North American passerine birds. *Am. Nat.* 148: 453–480.
- Griffith S.C., Owens I.P.F. & Burke T. 1999. Environmental determination of a sexually selected trait. *Nature* 400: 358–360.
- Griffith S.C. & Sheldon B.C. 2001. Phenotypic plasticity in the expression of sexually selected traits: neglected components of variation. *Anim. Behav.* 61: 987–993.
- Hamilton W.D. & Zuk M. 1982. Heritable true fitness and bright birds: a role for parasites? *Science* 218: 384–387.
- Hill G.E. 1991. Plumage coloration is a sexually selected indicator of male quality. *Nature* 350: 337–339.
- Jennions M.D. & Petrie M. 1997. Variation in mate choice and mating preferences: a review of causes and consequences. *Biol. Rev.* 72: 283–327.
- Kirkpatrick M. & Ryan M.J. 1991. The evolution of mating preferences and the paradox of the lek. *Nature* 350: 33–38.
- Kose M., Mänd R. & Møller A.P. 1999. Sexual selection for white spots in the barn swallow in relation to habitat choice by feather lice. *Anim. Behav.* 58: 1201–1205.
- Kose M. & Møller A.P. 1999. Sexual selection, feather breakage and parasites: the importance of white spots in the tail of the barn swallow (*Hirundo rustica*). *Behav. Ecol. Sociobiol.* 45: 430–436.
- Lessells C.M. & Boag P.T. 1987. Unrepeatable repeatabilities: a common mistake. *Auk* 104: 116–121.
- Moreno-Rueda G. & Soler M. 2002. Cría en cautividad del Gorrión Común *Passer domesticus*. *Ardeola* 49: 11–17.
- Møller A.P. 1987. Variation in badge size in male house sparrows *Passer domesticus*: evidence for status signalling. *Anim. Behav.* 35: 1637–1644.
- Møller A.P. 1988. Badge size in the house sparrow *Passer domesticus*: effects of intra- and intersexual selection. *Behav. Ecol. Sociobiol.* 22: 373–378.
- Møller A.P. 1989. Natural and sexual selection on a plumage signal of status and on morphology in house sparrows, *Passer domesticus*. *J. Evol. Biol.* 2: 125–140.
- Møller A.P. 1991. Parasites, sexual ornaments and mate choice in the barn swallow *Hirundo rustica*. In: Loye J.E. & M. Zuk (eds.) *Ecology, behavior, and evolution of bird-parasite interactions*, 328–343. Oxford University Press, Oxford.
- Møller A.P., Christe P. & Lux E. 1999. Parasitism, host immune function, and sexual selection. *Quart. Rev. Biol.* 74: 3–20.
- Møller A.P. & Erritzøe J. 1996. Parasite virulence and host immune defense: host immune response is related to nest reuse in birds. *Evolution* 50: 2066–2072.
- Møller A.P., Kimball R.T. & Erritzøe J. 1996. Sexual ornamentation, condition, and immune defence in the house sparrow *Passer domesticus*. *Behav. Ecol. Sociobiol.* 39: 317–322.
- Pap P.L., Tökölyi J. & Szép T. 2005. Frequency and consequences of feather holes in Barn Swallows *Hirundo rustica*. *Ibis* 147: 169–175.
- Pascual J. & Senar J.C. 1997. La medición del tamaño corporal en aves. *Etología* 15: 9–16.
- Qvarnström A., Pärt T. & Sheldon B.C. 2000. Adaptive plasticity in mate preference linked to differences in reproductive effort. *Nature* 405: 344–347.
- Reyer H.-U., Fischer W., Steck P., Nabulon T. & Kessler P. 1998. Sex-specific nest defense in house sparrows (*Passer domesticus*) varies with badge size of males. *Behav. Ecol. Sociobiol.* 42: 93–99.
- Senar J.C. 1999. La medición de la repetibilidad y el error de medida. *Etología* 17: 53–64.
- Sheldon B.C. & Ellegren H. 1999. Sexual selection resulting from extrapair paternity in collared flycatchers. *Anim. Behav.* 57: 285–298.
- Summers-Smith J.D. 1988. *The Sparrows, a study of the genus Passer*. T & AD Poyser, Calson.
- Václav, R., Hoi H. & Blonqvist D. 2002. Badge size, paternity assurance behaviours and paternity losses in male house sparrows. *J. Avian Biol.* 33: 314–318.
- Veiga J.P. 1993. Badge size, phenotypic quality, and reproductive success in the house sparrow: a study on honest advertisement. *Evolution* 47: 1161–1170.
- Wedekind C. 1992. Detailed information about parasites revealed by sexual ornamentation. *Proc. R. Soc. Lond. B* 247: 169–174.
- Whitekiller R.R., Westneat D.F., Schwagmeyer P.L. & Mock D.W. 2000. Badge size and extra-pair fertilizations in the house sparrow. *Condor* 102: 342–348.

SAMENVATTING

Mannetjes Huisvuur *Passer domesticus* hebben een witte vleugelstreep, die ze tijdens de balts gebruiken en die bij de vrouwtjes ontbreekt. Veerluizen (Mallophaga) eten bij voorkeur witte veerdeeltjes. Daarom zou je verwachten dat de grootte van de witte vleugelstreep afhangt van de aanwezigheid van veerluizen en het aantal luizen. Andersom geredeneerd zou de grootte van de

vleugelstreep als index kunnen fungeren van de hoeveelheid luizen in het verenpak van een mannetje. Deze studie laat zien dat (gedeeltelijk) albino Huisvossen meer luizen hebben dan normale vossen, al was het verschil statistisch net niet significant. Daarnaast hadden mannetjes met een lange witte vleugelstreep minder luizen dan vossen met een kortere vleugelstreep. Op grond hiervan concludeert de auteur dat de witte vleugelstreep een "eerlijk signaal" is voor de aanwezigheid van veerluizen en de aantallen luizen. De vleugelstreep zou dan ook door vrouwen gebruikt kunnen worden om partners te kiezen die minder vatbaar zijn voor luizen. (BIT)

Corresponding editor: B. Irene Tieleman

Received 25 January 2005, accepted 14 April 2005