Feather characteristics for eye protection in an insectivorous passerine: the Iberian grey shrike Lanius meridionalis, in southern France

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Abstract

In the French Mediterranean plain, the northern extreme of its native range, the Iberian grey shrike, Lanius meridionalis, predominantly feeds on arthropods. Its type of loral plumage plays a key role in protecting its eyes while transporting large prey. The aims is to understand the role played by feathers in protecting the animal from various types of defensive prey. We combine an inspection of large insect prey types found on larders with a review of bird specimens found in museum collections to examine the morphometric characteristics of rictal feathers and culmen. In addition, precision photographs are used to observe the posture of the plumage in natura. We could identify four categories of protective feathers: clustered bristles, semi-bristles, semi-plumes distributed in the loral area, and semi-plumes above the eyes. Our results suggest that the Iberian grey shrike has a complex structure of loral feathers, specific to its foraging activity and prey types. In France, local species have longer beaks than their Spanish counterparts which suggests a more insect-based diet.

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Keywords: rictal bristle, beak, feather, shrike, prey, south France

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Summary

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The aims are to understand the role played by feathers in protecting the animal from various types of defensive prey.

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Introduction

Various studies have examined the variation in the size and shape of rictal hairs in birds and proposed several hypotheses as to their function (Lederer 1972, Stettenheim 1973, Cunningham et al. 2011). Particularly in birds who use their beaks to immobilise their prey, such as diurnal insectivorous birds of the "sit-and-wait" type or species that capture their prey in flight, it appears plausible that rictal hairs serve the function of eye protection or prey retention (Dyer 1976, Cunningham et al. 2011).

Bristles provide eye and face protection from spiny appendages and other prey threats (Dyer 1976, Conover & Miller 1980, Sherry & McDade 1982). Facial bristles are modified hair-like feathers and are typically rigid, stiff, and tapering (Lederer 1972).

Avian bristle feathers are found especially at the base of the bill and nostrils, as well as in the lore (between the bill and eye), malar (cheek, below the eye), and rictal (corner of the mouth) regions and forehead, and can sometime take the form of "eyelashes" (Chandler 1914, Stettenheim 1973).

There is a range of bristle types, from the basic structural plan of the feathers from which they are derived, through variously branched semi-bristles, to the stiff, unbranched bristles seen around the slit in many aerial insectivores (Chandler 1914, Stettenheim 1972, 1973). The bristle rachis is generally pointed and dark in colour, particularly at the tip (Stettenheim 1973). This dark coloration is caused by heavy deposits of melanin, which increases the strength and abrasion resistance of feather keratin (Bonser 1996) and also contributes to bristle stiffness (Stettenheim 1972, 1973).

The *Laniidae sp* . are a very distinctive group of small to medium size predatory passerines (14–27 cm), capable of preying on large insects and small vertebrates (lizards, rodents, and occasionally other birds). They are known for their distinctive behaviour of impaling prey (up to 10 mm) on thorns and twigs for food reserves.

Their hunting technique is mostly sit-and-wait or perch-and-pounce. Usually, they approach their prey by flying at altitudes of two to three meters, sometimes briefly hovering over the prey, before quickly descending to it.

The shrike's beak is highly specialized for predaceous feeding. The maxilla has a strongly decurved, sharp hook at the end with a subterminal, tomial tooth on each side, and corresponding mandibular incurvations, which work in opposition to the teeth (Cade 1967, 1995).

The shrike's large, heavy-headed appearance is related to the cranial adaptation of large jaw muscles required for a powerful bite (Cade 1995). Shrikes kill prey with their beaks, and they execute vertebrate prey by biting the neck and disarticulating cervical vertebrates (Sustaita & Rubega 2014).

Shrike eye position is elevated and probably contributes to a wider binocular field of vision (Schön 1996). Undoubtedly, they possess extremely keen eyesight, especially for moving objects (Cade 1967).

The area between the eye and the beak is a sensitive zone when catching poisonous or urticantic food. These types of prey vary in composition of noxious organs or secreting chemical substances, with hard and thick carapaces.

The Iberian grey shrike, *Lanius meridionalis* , is a monotypic species of the family that is geographically restricted to the Mediterranean region of the Iberian Peninsula and southern France. Given their tendency to colonize dry open environments, they are scarce at altitudes above 1000 m.

A remarkable range of prey species are available to them, from mosquitoes and tiny ants and spiders to tetrapod vertebrates with a body mass equal to or exceeding their own. Both as an individual and as a

population, the Iberian grey shrike can be very opportunistic due to its specialization in temporally and spatially limited prey abundance (Hódar 2006).

While insects are the most common prey item of the Iberian grey shrike, their diet also includes arthropods, lizards, birds, and small mammals in Spain (Hódar 2006).

The diet varies both regionally and seasonally. Insects dominate in its French habitats with only few mammals and birds (Lepley 1998) . Regarding seasonal variations, Hymenopterae are mainly consumed in autumn, Arachnidae in autumn and winter, Orthopterae in summer and autumn, and Lepidopterae larvae in winter and spring including by young birds. Coleopterae were ingested in large numbers throughout the year. Carabidae were the main prey in winter and Melolonthidae were particularly important for adults during nestling, as were Cetoniidae for the chicks (Lepley et al. 2004).

The loggerhead shrike, *Lanius ludovicianus* , is able to overcome the toxic defences of a variety of chemically defended invertebrates such as the grasshopper (*Romalea guttata*), the bella moth (*Utetheisa ornatrix*), and the beetle (*Lytta polita*) (Yosef & Whitman 1992, Yosef et al. 1996). The same behaviour has been observed in the Levantine *shrike Lanius excubitor aucheri* in Israel with the highly venomous Orthoptera *Poikylocerus bufonius* . A three-day period likely is presumably allowed for detoxification and subsequent consumption of unsavoury prey (Fuisz & Yosef 2001).

The present study focuses on the particular structure of the loral plumage of the Iberian grey shrike in southern France, where they feed on arthropods which they capture primarily with their beak. Our hypothesis is that the composition of loral bristles is morphologically highly specialized for this particular type of diet and prey capture mode, directly affecting the shape, length, and arrangement of feathers in the area between the eyes and beak.

Materials and methods

In order to examine the structure of rictal bristles in the Iberian grey shrike in southern France and evaluate their potential protective function against venomous prey, we first studied larders with potentially venomous prey species in order to assess the danger these prey may pose to the shrike's eyes after being caught and carried in the beak. In a second step, we examined zoologically naturalized and recovered Iberian grey shrike in natural history museums and combined them with high-resolution photographs that show the structure and orientation of the rictal bristles in natura during arthropod capture.

* Study of noxious arthropods found on the Iberian Grey Shrike larders.

Since the Iberian grey shrike mainly impales its prey in winter, we focussed on the period between December 2018 and the end of February 2019 to record a total of 341 prey items on a vineyard in southern France (43.810070 N, 4.201536 E) (Labouyrie 2020). Eight additional large prey were photographed in November 2021 at another location twelve kilometres away (43.791740 N, 4.04955 E). As smaller prey (<10mm) are eaten directly and do not appear to be impaled, we mostly found large arthropod prey items, including species with spiny parts or spines with chemical secretions that could get into the eyes during handling on the floor or in larders.

* Examination of specimens in museum collections.

Vibrissae are a highly specialized type of feather in which the spine is relatively stiff, more tapered, and free of beards for most of its length. Essentially, vibrissae are functionally simplified contour feathers that are found almost exclusively on birds' heads, and they are still clearly visible on the specimens stored in the collections.

We measured the length of the rictal bristles and beaks (from the base of the culmen to the tip of the upper mandible) on all available specimens from the Mediterranean plains in southern France (outside the Iberian Peninsula) registered in the collections of the Natural History Museum of Nimes and the National Natural History Museum of Paris (both France) (Table 1).

Rictal bristles form a cluster of four to five hairs at the base of the beak (Figure 1) and we measured the longest of these hairs with a digital calliper. The length of the beak was measured at the base of the culmen.

*** Photographic study in natura.**

We took high-resolution images of the head of Iberian grey shrikes from short distances of seven to eight meters, using an ornithological blind and a progressive approach to minimize the disturbance of the birds.

Results

Larders contained mostly invertebrates (Table 2). Hymenoptera accounted for 87.4% of impaled prey, of which the common bumblebee, *Bombus terrestris* , was by far the favourite prey item accounting for 85.4% of all Hymenoptera. The second most frequent prey group were Orthoptera (7.4%), consisting of large specimens, with the migratory locust*Locusta migratoria t* he most commonly found species (3.7%). Beetles were the third most frequent prey group accounting for 3.4% of all prey collected. These are also large subjects and included*Carabus coriaceus* coprophage and Scarabaeidae such *as Bubas bubalus* . We also found some vertebrates (0.6%) such as the wood mouse*Apodemus sylvaticus* and the white-toothed shrew *Crocidura russula* , which are particularly important for fresh biomass. Other marginal prey included the earthworm *Lumbricus terrestris*(1.2%).

Among the Hymenoptera prey observed on the larders (Figure 2) were invasive and aggressive yellow-legged hornet ,*Vespa velutina* , which was likely speared for detoxification.

There were also some large orthoptera with broad wings and jagged legs and Coleopterae with strong shells and chemical defences. The devil's coach beetle, *Ocypus olens* , in particular, is known for raising its long and uncovered abdomen and opening its jaws like a scorpion when threatened. Though it does not have a stinger, it can deliver a painful bite with its strong, pincer-like jaws. It also gives off a foul-smelling odour that stems from a defensive liquid secreted by two white glands at the end of its abdomen.

We also found the praying mantid ,*Mantis religiosa,* among the prey items. They possess a raptorial foreleg with unusually long coxa, which, together with the trochanter, give the impression of a femur. The femur itself is the proximal segment of the grasping portion of the leg.

Measurements of the bristles and beaks on museum specimens yielded the following mean lengths (+- one standard deviation) (Figure 4):

Bristles: 10.27+-0.12 mm

Beak 15.96+-0.21 mm

The high-resolution digital photographs clearly show a row of feathers above the eyes (Figure 5). These coverts form a dense network of barbels pointing upwards, like a thick eyebrow. In the loral area, between the eye and the beak, there are feathers with black rachis and vanes ending with an open pennaceous portion with vertical barbs (Figure 6). Furthermore, there is a cluster of four strong rictal bristles with bare shafts at the commissure of the mandibles on the upper maxilla, thick, curved down, and protruding from the lower mandible (Figure 6).

In addition, a series of smaller bare shaft bristles occupy the loral region at the base of the culmen, covering a narrow band of the upper part of the mandible (Figure 6).

During these photographic sessions, we noticed a different type of behaviour related to the protection of the beak area, namely the cleaning of residual dirt by rotating the head very quickly (Figure 7).

Discussion

Shrikes have often been compared to birds of prey (particularly falcons) because of their morphological and behavioural similarities. The shape of the shrike's beak bears many striking resemblances to a falcon's beak, complete with hook and tomial tooth. The slightly protruding position of the eyes facilitates binocular vision and the gives an appearance of a heavy head (Cade 1967, 1995, Schon 1996).

Shrikes kill prey with their beaks and carry the largest prey with them. They then hold them with their feet on a piece of vegetal support to manipulate them or impale them on a thorn bush to dismember them with their beak. In Southern France, the northern extent of its range, the diet of the southern grey shrike consists mainly of insects. Museum specimens possess a powerful beak with an average length of 15.96+-0.21 mm which is slightly longer than on specimens found in Spain (13.96 +-0.64 mm, Gutierrez-Corchero et al. 2007).

It is well known that bill size and shape in shrike vary as a function of geography and climatic factors and may result in varying degrees of suitability for certain species of vertebrate and arthropod prey (Strong 1901, Sustaita & Rubega 2014). Shrikes with narrower culmen and longer hook tips produce lower bite forces than those with thicker culms and shorter hook tips. It could be hypothesized that the Iberian grey shrike has adapted to feeding on arthropods on the Mediterranean plains.

Only few bristle measurements have been carried out on the genus*Laniidae* . In long-tailed shrike, *Lanius schach* , and great grey shrike, *Lanius excubitor* , black barbed bristles can be up to 11 mm long in the schach, and 7 mm in the excubitor. They also possess numerous shorter, barbed, black nasal bristles that curve over the sides of the beak and nostrils, before merging into loral half-bristles (Stettenheim 1973).

In the Iberian grey shrike, the rictal bristles are clustered into bundles of four or five strands with a maximum length of 10.27+-0.12 mm. They can block wings or serrated leg parts when the bird is manipulating large insects of the genera Orthopterae and Mantidae (Guillaumot 2021) and are likely to play a role in protecting the birds' eyes when transporting large prey. Another possible function of rictal vibrissae that remains utterly unexplored is the detection of movement of beaked prey, providing a sensory function similar to whiskers in some mammals (Cunningham et al. 2011).

On the loral zone there are several types of bristles, ranging from the basic structural plan of the feathers, from which they are derived, over variously branched semi plumes to stiff, unbranched bristles. The bristle spindle is pointed and dark coloured especially at the base. This dark coloration is caused by a large deposition of melanin which increases the strength and abrasion resistance of feather keratin (Bonser 1996) and also contributes to bristle rigidity (Stettenheim 1972, 1973). Bristles around the nostrils and ear openings can protect these openings (Stettenheim 1973).

Above the eyes, shrikes have a row of small tight feathers that form a white eyebrow. While the skull of shrikes is quite similar to that of typical passerines, except that the distance between the eyes is slightly increased, the position of the eyes in grey shrikes is somewhat peculiar in that their relatively large eyes protrude slightly on the side of the head while the adjacent parts of the head are slightly depressed (Schon 1996). This thick frown forms part of the range of eye protection feathers.

Shrikes are capable of rapid axial head rolls which rotate their prey's bodies around their own necks creating accelerations equivalent to about 6 g. These accelerations are sufficient to kill mammalian vertebrate prey and by causing pathological damage to the cervical vertebrae and spinal cord (Sustaita et al. 2018). Similarly, the Iberian grey shrike uses these rapid head turns to dislodge broken or irritating insect prey particles after beak-handling.

Analysis of the rictal plumage of the Iberian grey shrike in southern France shows that the species has adapted to the native trophic conditions. Complementary morphological studies and mitochondrial DNA analysis of the entire population, including the Iberian Peninsula and France, could refine the knowledge of the species in the north of its range.

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Tables

Table 1. Examples of the examined specimens of Iberian grey shrikes preserved in the museums.

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`image1.emf` available at https://authorea.com/users/496531/articles/577855-feather-characteristics-for-eye-protection-in-an-insectivorous-passerine-the-iberian-grey-shrike-lanius-meridionalis-in-southern-france

Table 2. Number of prey items collected (NP) and relative frequency (RF%) in Iberian grey shrike larders in southern France between December 2018 and February 2019 and in November 2021.

Hosted file

`image2.emf` available at https://authorea.com/users/496531/articles/577855-feather-characteristics-for-eye-protection-in-an-insectivorous-passerine-the-iberian-grey-shrike-lanius-meridionalis-in-southern-france

Figure legends

Figure 1. Illustration showing a cluster of rictal bristles of the Alder flycatcher *Empidinax traullii.* Seven millimeters in length; reproduced from Lederer (1972).

Figure 2. Examples of noxious prey found on Iberian grey shrike larders in southern France.

Figure 3. Specimens of the Iberian grey shrike (National Natural History Museum of Paris) and detail of the head of a naturalized bird (Natural History Museum of Nimes). (c) Frederic Labouyrie.

Figure 4. Range of measured bristle and beak lengths from museum specimens of the Iberian grey shrike, showing the length of the longest bristle and longest beak, the mean, minimum and maximum of the data.

Figure 5. Iberian grey shrike head seen from the front. (c) Gilbert Lacassin.

Figure 6. Iberian grey shrike head seen from the side showing details of the different types of protective feathers.

Figure 7. Rapid head rotation of an Iberian grey shrike after regurgitating a pellet.

Figures

Figure 1

Violet carpenter bee *Xylocopa violacea*

Buff-tailed bumble bee *Bombus terrestris*

Yellow-legged hornet *Vespa velutina*

Migratory locust *Locusta migratoria*

Blue-winged grasshopper *Œdipoda caerulescens*

Carabus coriaceus

Devil's coach-horse beetle *Ocypus olens*

Bubas bubalus

White-faced bush-cricket *Decticus albifrons*

Praying mantid *Mantis religiosa*

Figure 2

Figure 3

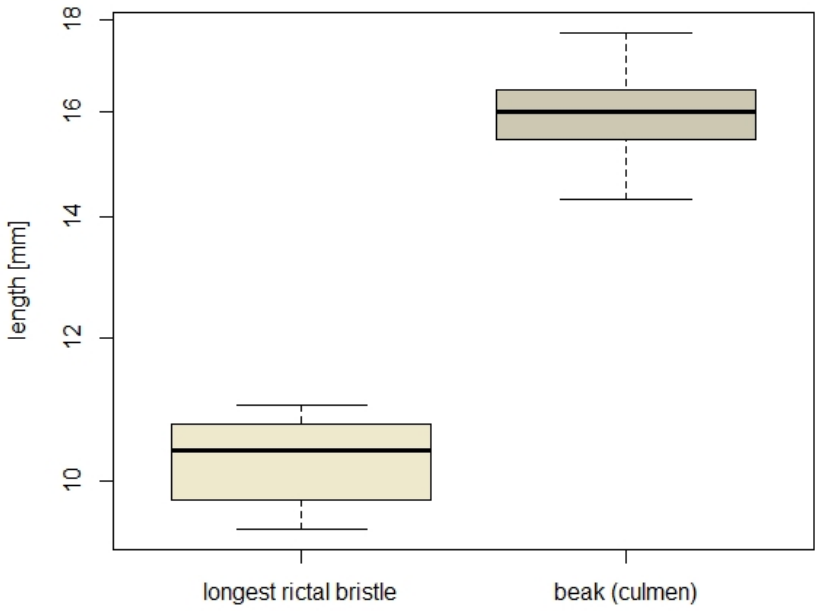

Figure 4

Figure 5

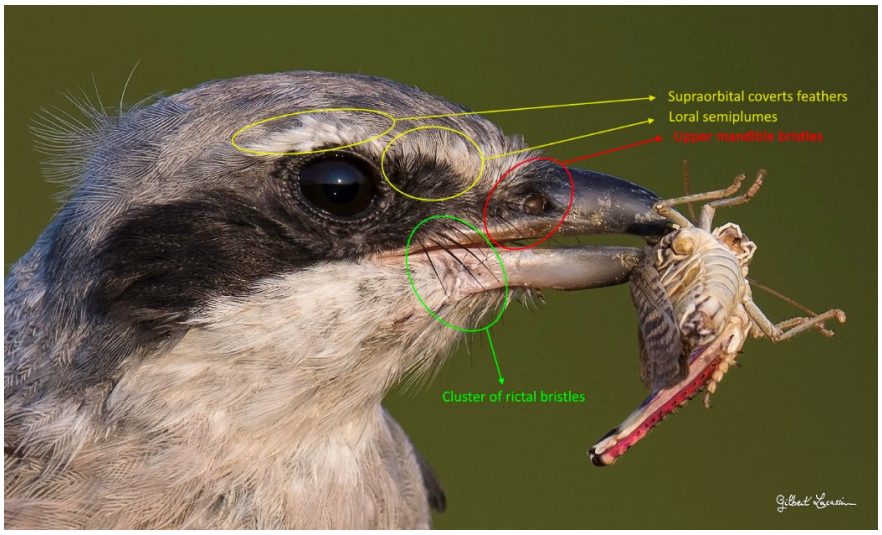

Figure 6

Figure 7