Review of the diet specialisation of the Blue-cheeked bee-eater (*Merops persicus*)

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Abstract

Ecological specialisation, e.g. in terms of prey preferences, can have important implications for population biology. Bee-eaters are considered diet specialists; they hunt aerial insects, particularly hymenopterans. However, the Blue-cheeked bee-eater (*Merops persicus*) has been considered a special case, as it preferentially feeds upon dragonflies (Odonata). Here we review current literature on the diet of the Blue-cheeked bee-eater, and conclude that this species is not as restricted to dragonflies as previously suggested. Instead, populations in different parts of the breeding and wintering ranges seem to specialise on various types of insects (such as wasps, bees, dragonflies, butterflies and mosquitoes).

Keywords Prey specialisation · Foraging · Bird · Odonata · Dragonfly

Zusammenfassung

Ein Überblick über die Nahrungsspezialisierung des Blauwangenspints (*Merops persicus*). Eine ökologische Spezialisierung, beispielsweise im Hinblick auf die Beutepreferenzen, kann weitreichende Folgen für die Populationsbiologie haben. Bienenfresser gelten als Nahrungsspezialisten, welche Fluginsekten – speziell Hymenopteren – jagen. Der Blauwangenspint (*Merops persicus*) galt jedoch bisher als Spezialfall, da er sich vorzugsweise von Libellen (Odonata) ernährt. Hier geben wir einen Überblick über die aktuelle Literatur zur Ernährung des Blauwangenspints und kommen zu dem Schluss, dass diese Art weniger auf Libellen beschränkt ist als bislang angenommen. Stattdessen scheinen sich die Populationen in unterschiedlichen Teilen der Brut- und Überwinterungsgebiete auf verschiedene Insektentypen zu spezialisieren (wie zum Beispiel Wespen, Bienen, Libellen, Schmetterlinge und Mücken).

Introduction

Ecological specialisation can occur at any level and during different time frames (Devictor et al. 2010). In many species, co-occurring individuals actively select different prey from their shared environment. For example, individuals of many bird species tend to specialise on one particular food source for short or long periods of time (Araújo et al. 2011). Sometimes extreme individual feeding specialisation occurs, where individual birds specialise very strictly on one or a few particular feeding modes (Werner and Sherry 1987).

Specialisation may also involve whole populations or even entire species. The degree of such specialisation can have important ecological implications.

Bee-eaters (Meropidae) are specialist predators that feed almost exclusively upon flying insects, especially hymenopterans (wasps and bees, Fry 1984). Here we focus on the diet of the Blue-cheeked bee-eater (*Merops persicus*). Traditionally, this species has been considered a highly specialist predator, with a large proportion of dragonflies (Odonata) in its diet. It has also been suggested to have morphological adaptations, such as long wings, that enable the hunting of dragonflies (Fry 1984). The most comprehensive publications on bee-eater biology portray the Blue-cheeked bee-eater as mainly consuming odonates:

“Eats dragonflies and damselflies and to a much lesser extent Hymenoptera and other flying insects. Analysis of 100 pellets from four West African sites shows that

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two-thirds of the diet (65.5%) are odonates, and bugs and flies together equal the Hymenoptera” (Fry 1984). “Bees and wasps feature importantly, but this bird is more a dragonfly-eater than a bee-eater” (Fry et al. 1992).

The four West African sites that Fry (1984) referred to include Lake Chad, the River Niger in Nigeria and Bangui in the Central African Republic. It is thus clear that the above conclusions are based on data from a restricted part of the species range. There are two recognised subspecies of the Blue-cheeked bee-eater: *Merops persicus* breeds in the Nile Delta and in Asia and winters in eastern and southern Africa, whereas *Merops chrysocercus* breeds on the fringes of Western Sahara and winters in West Africa, south of 15°N. Overall, *M. persicus* is a desert-edge bird that breeds in gravelly and sandy habitats near bodies of water (Fry et al. 1992). During non-breeding seasons, flocks of birds inhabit a wide variety of environments, often in the vicinity of open water (Britton and Backhurst 1980).

In more recent publications, the general view that *M. persicus* is a dragonfly specialist has been modified, with, for instance, Kossenko and Fry (1998) stating that it is more of an opportunistic feeder. The *Handbook of the Birds of the World* (hereafter HBW; del Hoyo et al. 2001) indicates that it feeds mostly on dragonflies in Africa but mainly on hymenopterans in Asia (with dragonflies constituting about 15% of the diet). Nonetheless, this species is still often regarded as a dragonfly specialist due to the original statements regarding its diet. In order to broaden the understanding of this issue, we reviewed the current literature on the feeding preferences of Blue-cheeked bee-eaters from different parts of the breeding and wintering ranges and in various environments. We also formally tested the assertion that this species is unusually long-winged, which would likely be an adaptation to dragonfly hunting.

Materials and methods

Between 1 March and 30 April 2017, we performed extensive literature searches using the search engines and databases Google Scholar, Web of Science, Africa-Wide Information, BIOSIS Previews, DiVA, SpringerLink, and Medical and Veterinary Entomology, as well as Google-based web searches. Search terms (in English only) included combinations of “Bee-eater”, “Blue-cheeked bee-eater”, “Merops”, “*Merops persicus*”, “Predation”, “Forage”, “Hunt”, “Diet”, “Anatomy”, “Body”, “Habitat” and “Migration”. In addition to primary scientific literature, we also included information from Corbet (1999), Fry et al. (1992) and Fry (1984), as well as del Hoyo et al. (2001) and references therein. Until recently, the Olive bee-eater (*M. superciliosus*) was

considered conspecific with *M. persicus*. We thus checked older references and removed any observations likely to relate to taxa other than the actual Blue-cheeked bee-eater.

Statistical analyses and plotting were conducted using R (v.3.3.1). Outlier detection was based on Bonferroni-corrected *p* values of the residuals from a linear model, obtained using the *outlierTest* function of the R package *car*.

Results and discussion

We identified seven published studies investigating the feeding preferences of *M. persicus*, including data from 12 different locations (Table 1). The mean proportion (across all studies) of Odonata in the diet was 28.4%, compared with a mean proportion of Hymenoptera of 41.5%. However, the distribution of prey types varied considerably between different study populations, ranging from almost exclusive feeding on dragonflies (e.g. 83%, Lake Chad; Fry 1981) to only feeding on other types of prey, e.g. bees (Borrett 1973) or butterflies (Larsen 1992). A large proportion of Odonata in the diet, 55.7–83.6%, was especially common in the studies reported by Fry (1981), which were conducted in areas very close to large bodies of freshwater e.g. River Niger or Lake Chad, while populations occurring in drier environments or close to the sea had other types of flying insects as their main food source. This is in line with statements made in the HBW (del Hoyo et al. 2001).

The previously generally held notion that the Blue-cheeked bee-eater is best described as a “dragonfly eater” is thus partially erroneous due to biased sampling in terms of habitat in the original studies (Fry 1981). Those study sites were situated very close to large lakes and rivers. In drier habitats, Blue-cheeked bee-eaters seem to be more generalistic, predating on different kinds of flying insects, or temporarily specialising on other taxa such as bees and butterflies. In addition to habitat differences, there may also be seasonal and geographical components to the observed variation in feeding preferences (Table 1). For example, it was found that attacks of *M. persicus* on honey bee colonies in Iraq were negligible in the pre-breeding and breeding seasons but increased significantly in the post-breeding season (Glaïim 2014). Such variation is likely to be directly linked to the relative abundances of different prey types as well as inter- and intraspecific competition for available food resources.

There was a strong positive correlation between wing length and weight among bee-eaters ($r_p = 0.95$, $df = 17$, $p < 0.001$; Fig. 1). While the Blue-cheeked bee-eater has the longest wings of all 19 analysed species, it is not a significant outlier in terms of the wing length to weight ratio ($t = -0.62$, $p = 0.54$). Therefore, it cannot be said that

Table 1 Summary of results from published investigations of *M. persicus* prey

Location	Habitat	Life stage	Sample type	Number of colonies/ individuals/populations	Prey proportions (%, means)	Source
Atrak Delta, Turkmenistan (mixed colonies)	Dry delta	Breeding	Pellets	9 colonies	Odonata: 15.5 Hymenoptera: 65.8	Kossenko and Fry (1998)
Atrak Delta, Turkmenistan (mono-specific colonies)	Dry delta	Breeding	Pellets	7 colonies	Odonata: 13.7 Hymenoptera: 58.6	Kossenko and Fry (1998)
Batinah, Oman	Sea coastal plain	Breeding	Pellets	1 colony	Odonata: 0.2 Hymenoptera: 55.5 Heteroptera: 32.3	Kossenko and Fry (1998)
Lake Chad, Nigeria, 1967	Shore	Migration?	Pellets	44 individuals	Odonata: 69.5 Hymenoptera: 4.7 Hemiptera: 10.9	Fry (1981)
Lake Chad, Nigeria, 1968	Shore	Migration?	Pellets	12 individuals	Odonata: 83.6 Hymenoptera: 9.8	Fry (1981)
River Niger, Nigeria	River	Breeding?	Pellets	40 individuals	Odonata: 55.7 Hymenoptera: 28.0	Fry (1981)
Oued Khrouf (El-oued), Algeria	Saharan habitats	Breeding	Pellets	42 individuals	Odonata: 1.0 Hymenoptera: 17.2 Diptera: 40.7	Marniche et al. (2007)
Bangui, Central African Rep.	Near river forest	Wintering	Gizzards	2 individuals	Odonata: 65.0	Fry (1981)
Free State, South Africa	Plains	Wintering	Stomach content	9 individuals	Odonata: 8.5 Hymenoptera: 76.0	Kopij et al. (2000)
Zimbabwe	Farmland	Wintering?	Stomach content	1 individual	Exclusively bees; <i>Apis mellifera</i>	Borrett (1973)
Okavango River, Botswana	River	Wintering	Field observation	1 population	Only butterflies; <i>Catopsilia florella</i> ^a	Larsen (1992)
South of Lake Chad, Nigeria	Plains	Wintering?	Field observation	–	Mainly butterflies	Holmes (1972)

^a Temporary specialisation due to a very large local abundance of one particular prey species

Fig.1 Relationship between wing length and weight for 20 species of bee-eaters (male measures). *Dashed line* represents the linear regression line (slope=0.48, intercept=− 21.7, $R^2=0.90$, $p<0.001$). Data

from Fry et al. (1992). Silhouettes of wing shapes from Fry (1984) are also depicted in the plot

the Blue-cheeked bee-eater is morphologically adapted to hunting dragonflies by having exceptionally long wings in relation to body weight, as was previously suggested (Fry 1984). Furthermore, the longer wings observed in some bee-eater species are most likely related to migration strategy rather than hunting specialisation. In general, wing length is positively correlated with migration distance in several bird taxa (Nowakowski et al. 2014). The European and Blue-cheeked bee-eaters (the two species with the longest wings) are both long-distance migrants and are the two bee-eater species that breed furthest from the equator (Fry 1984).

We conclude that the Blue-cheeked bee-eater cannot be universally defined as a “dragonfly eater”, as individual populations are more or less specialised to different types of prey. Some populations have a large proportion of dragonflies in the diet, while others seem to be specialised on other food sources, including bees, mosquitoes and butterflies. Furthermore, the Blue-cheeked bee-eater is not an unexpectedly long-winged species in relation to its weight, as previously stated. We wish to emphasise the importance of continuously assessing old “truths” in ornithology using current literature, and we highlight the need to include broad sampling (in terms of geography and habitat variables) when making general statements about bird ecology. In this particular case, more studies are clearly needed in order to quantify the proportions of different prey types in the diet of *M. persicus* under different circumstances, as the seven

studies cited here are not likely to provide an accurate representation of the entire species distribution.

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