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Will the elephant dung flies go extinct after the elephants disappear?

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Abstract – Extinction of a single large-bodied species is often presumed to provoke co-extinction of several parasite, mutualist, nest dwelling and coprophagous species. This paper examines whether potential loss of African Elephants, the largest terrestrial animals, would necessarily cause co-extinction of the species-rich dipterous fauna currently living on elephant dung. We have taken semi-quantitative samples from dipterous adults associated with elephant and cattle dung in the Republic of South Africa. Sixty species representing four families (Hybotidae, Sepsidae, Sphaeroceridae, Muscidae) have been collected. The species composition of the fly assemblages collected on elephant versus cattle dung overlap considerably. Thus it seems safe to presume that a large proportion of the dipteran guild inhabiting elephant dung can shift to cow pats or vice versa, at least as far as the most speciose group (Sphaeroceridae) is concerned. On the contrary, some dung flies appear to be more exclusively associated with elephants. Further taxonomic investigations and more extended ecological studies are needed to understand the conservational issues potentially arising at the local extinction and local re-introduction of elephants. With one table.

Key words – Ecology, elephant dung, cattle dung, Diptera identifications, South Africa.

INTRODUCTION

Large-bodied animal species, like mammals, tend to attract several small-bodied species living in closer or looser associations with them as parasites, mutualists, commensals or even as coprophages. Thus the potential extinction of a single large-bodied mammal might induce a series of co- extinction events (STORK & LYAL 1993). Parasites are often more host-specific than other types of associates, thus loss of parasite species is of considerable concern (WHITEMAN & PARKER 2005). In Africa, a major human-induced change is the replacement of the native large herbivore fauna to non-native herds of domesticated cattle, sheep and goats. Thanks to conservation efforts carried out in the Republic of South Africa (RSA), the opposite shift may also occur; some areas are currently re-colonized by formerly extinct large herbivores, like the African Elephant, *Loxodonta africana* (BLUMENBACH, 1797). This prompts the question whether or not the guild dipterans living on elephant dung go extinct with elephants. This question is relevant for conservation biology at least for two reasons. Firstly, this guild is quite species rich (40 species in the present sample, see below), thus embodies a considerable part of insect biodiversity in itself. Secondly, coprophagous dipterans play an important role in the degradation of faeces and, therefore, probably influence the nutrient cycling of ecosystems shaped by large grazing herbivores (see e.g. WALL & STRONG 1987).

There is no easy answer to the question, however, the overestimation of host specificity may easily lead us to overestimate co-extinction rates. *Columbicola extinctus* MALCOMSON, 1937, the louse specific to the extinct passenger pigeon, *Ectopistes migratorius* (LINNAEUS, 1766) is often used as an icon of extinct parasites. However, it has been 'brought back' from extinction by showing it to be conspecific with lice from the extant Land-tailed pigeon (CLAYTON & PRICE 1999). In case of large-bodied grazing herbivores, MORGAN *et al.* (2005) have recently shown that the species composition of the helminth fauna of the Saiga Antelope, *Saiga tatarica* (LINNAEUS, 1766) is almost totally identical with the helmith fauna of domestic cattle herds in Kazakhstan. Extensive studies carried out in the Western Palearctic indicate that horse dung attracts a rather specific fly community, while the fly assemblages living on cattle or sheep dung are less specific to the dung type, rather they are shaped by biogeographical processes and habitat characteristics (PAPP 1971, 1976, 1985, 1992). No similar studies were carried out on the dung flies of other continents.

Motivated by these controversies, here I set out to compare the species composition of elephant dung fly assemblages to that of cattle dung fly assemblages living in the same habitat. Although the consistency of elephant dung is different from that of all domestic mammals, cattle dung was chosen for comparison since cattle is one of the most abundant large-bodied grazing animals in the sub-Saharan livestock.

MATERIALS AND METHODS

Collection – Adult flies were netted in five sites on the surface of dung (several pieces each), mostly by covering them with a sweeping net. This enabled us to capture the vast majority of imagines, including those that did not fly readily, but were crawling up on the net. Samples were selected and representatives of each species were minuten-pinned under a stereomicroscope at the field sites. The main purpose of this effort was to obtain specimens for our museum collection and, therefore, not all individuals have been selected for pinning. All collected specimens were considered in the case of scarce species (one or a few individuals), while the more abundant species are each represented by several number of specimens. This field-based selection method enabled us to collect the vast majority, or perhaps all, of the fly species occurring on the dung pats.

Identification – The field-selected proportion of the sample was moved into the Diptera Collection of the Department of Zoology, Hungarian Natural History Museum (HNHM), Budapest. These specimens, a total of 515 flies from elephant dung, and 632 flies from cattle dung represent all species collected in the field. They were mounted and labelled (double-mounted; prepared on minuten-pins, and fixed in cards of 12 × 5 mm on a collection pins) before identification. The main sources of identification keys were NORRBOM & KIM (1987), OZEROV (2005), SMITH (1969) and ZIELKE (1971), with approximately 25 further works also consulted (not listed here). The identification procedure was supported by the HNHM collection as a material for comparison, especially in the case of sphaerocerids and muscids. Some species were only identified at generic level. It should be emphasized that they are not so-called 'morphospecies', but appear to be separate biological species on the base of male genitalia and other characters. I have either refrained from naming them, or they are species new to science.

All representatives of the four most abundant families (Hybotidae, Sepsidae, Sphaeroceridae and Muscidae) were taken into consideration. Apart from them, only a few sciarids and phorids were captured, however, they were omitted from the present study.

RESULTS

Identifications results are summarised in Table 1. As mentioned above, the numbers indicate only the number of imagines collected as museum specimens. In case of abundant species, the number of captured individuals was higher by several magnitudes.

Some species that were present in our cattle samples but absent from our elephant sample are known to occur on elephant dung according to literature sources. These are marked with an 'L' in the Table.

Table 1. Occurrence of dipterans on elephant dung and cattle dung pats (South Africa, January 2007). Elephant dung: Eastern Cape Prov., Shamwari Game Reserve, S33° 24' 47.0" E26° 05' 45.0", 301 m, Jan 11 (No. 14). Cattle dung: Eastern Cape Prov.: Hogsback, S32° 36' 23.5" E26° 57' 55.3", 1101 m, Jan 9 (No. 11); farmlands nr Happy Lands, S33° 28' 38.1" E25° 35' 49.7", 51 m, Jan 11 (No. 15); Sandvlakte Farm nr Paterson, cattle pasture, S33° 26' 14.2" E25° 56' 54.8", 300 m, Jan 12 (No. 18); KwaZulu Natal: N Drakensberg, Cathedral Peak Park, S28° 55' 55.7" E29° 16' 06.2", 1359 m, Jan 31 (No. 47). L: the species also occurs on elephant dung according to literature sources. The species signed with an asterisk (*) are new to the fauna of the RSA, and the species new to science are obviously so. The numbers indicate only the number of imagines collected as museum specimens. In case of abundant species, the numbers of captured individuals were higher by several magnitudes.

	Elephant dung	Cattle dung, No.			
		11	15	18	47
HYBOTIDAE					
Crossopalpus sp. 1.	13	–	1	27	–
Crossopalpus sp. 2.	–	–	2	4	–
Crossopalpus sp. 3.	1	3	–	1	2
Crossopalpus sp. 4.	4	–	–	–	–
Crossopalpus sp. 5.	4	–	–	2	3
SEPSIDAE	–	–	–	–	–
Paratoxopoda amonane VANSCHUYTBROECK, 1961	4	–	–	–	–
Toxopoda ?au OZEROV, 1998	–	3	–	–	–
Sepsis bigemmis DUDA, 1926	–	1	–	10	11
Sepsis lateralis WIEDEMANN, 1830	–	–	2	–	–
Sepsis aff. *thoracica* ROBINEAU-DESVOIDY, 1830	5	6	–	5	7
Sepsis sp. 1.	3	1	–	2	1
Sepsis sp. 2.	–	–	–	–	2
SPHAEROCERIDAE					
Afromyia flavimana L. PAPP, 1978	L	1	–	–	–
Ischiolepta pansa HAN et KIM, 1990*	1	–	–	–	–
Lotobia arcuata (SÉGUY, 1933)*	3	–	–	3	12
Lotobia nigra KIM et HAN, 1990*	2	4	–	2	4
Lotobia southafricana HAN et KIM, 1996	6	–	2	–	–
Achaetothorax rhinocerotis (RICHARDS, 1939)	5	4	4	55	19
Achaetothorax vojnitsi PAPP et NORRBOM, 1992*	2	–	6	48	–
Achaetothorax sp. n.	–	–	1	9	1
Gymnometopina clunicrus (DUDA, 1923)*	1	–	2	18	25
Gymnometopina garambaensis (VANSCHUYTBROECK, 1959)*					
Norrbomia gravis (ADAMS, 1905)*	1	–	1	–	–
Norrbomia marginatis (ADAMS, 1905)	L	–	5	3	9
Norrbomia sarcophaga L. PAPP, 1988	20	–	–	–	–
Norrbomia sp. n.	1	–	–	–	–
Chaetopodella cursoni (RICHARDS, 1939)	27	8	–	18	5
Elachisoma afrotropicum L. PAPP, 1983*	73	–	4	5	–

Table 1. (continued)

	Elephant	Cattle dung, No.			
	dung	11	15	18	47
Elachisoma sp. n.	33	3	2	52	11
Leptocera decisetosa (VANSCHUYTBROECK, 1950)*	–	–	6	2	–
Leptocera salatigae (DE MEIJERE, 1914)	–	5	–	–	9
Philocoprella africana sp. n.	140	–	3	1	–
Coproica ferruginata (STENHAMMAR, 1855)	1	–	–	–	–
Coproica hirticula COLLIN, 1956*	–	–	4	2	–
Coproica hirtula (RONDANI, 1880)	L	–	1	–	–
Coproica serra (RICHARDS, 1938)*	31	–	–	–	–
Coproica vagans (HALIDAY, 1833)	4	–	1	–	–
Coproica albiseta L. PAPP, 2008*	5	–	15	–	–
Coproica pseudolacteipennis L. PAPP, 2008*	3	–	–	–	–
Coproica perlugubris L. PAPP, 2008*	70	12	1	8	35
Spelobia sp.	1	–	–	–	3
Spinilimosina sp.	3	–	–	3	1
Opacifrons sp.	1	2	–	–	4
Nudopella operta (ROHÁCEK et MARSHALL, 1986)*	7	–	1	2	1
Trachyopella sp. n. 1.	3	–	–	5	2
Trachyopella sp. n. 2.	8	–	1	20	6
Trachyopella sp. n. 3.	10	–	–	1	–
MUSCIDAE					
Musca conducens WALKER, 1859	–	1	–	13	–
Musca confiscata SPEISER, 1924	–	–	–	1	–
Musca gabonensis MACQUART, 1855	–	–	–	–	1
Musca lusoria WIEDEMANN, 1924	–	–	1	6	–
Musca ?pseudocorvina EMDEN, 1939	–	–	–	–	2
Musca sorbens WIEDEMANN, 1830	–	–	–	–	1
Neomyia viridifrons (MACQUART, 1842)	–	–	–	1	–
Pyrellia scintillans BIGOT, 1888	4	–	–	–	–
Muscina ?stabulans (FALLÉN, 1817)	–	–	1	–	–
Stomoxys sp.	1	–	–	–	–
Stomoxidini sp.	5	–	–	–	–
Mydaeinae sp.	1	–	–	–	–
Limnophorinae sp.	5	–	–	–	–

I have identified representatives of 60 species from the 4 families mentioned above. Forty of them occurred on elephant dung, 46 on cattle dung, and the number of shared species was 26. However, the proportion of shared species differs across families. To express these differences, I apply a simple similarity coefficient based solely on presence/absence, i.e. the Jaccard index. This equals the number of shared species per a total number of species.

Five hybotid species were found. They belong to the genus *Crossopalpus* BIGOT, 1857. I could not identify them at the species level using SMITH's (1969) comprehensive work; they appear to be new to science. Both adults and larvae live a predaceous way of life, they are found in different kinds of dung. The present hybotid material is small (22+45 individuals, 4 spp. each). Three out of the 5 species shared, thus Jaccard i = 0.6.

The case of sepsids seems rather controversial due to the small sample size. A total of 15 specimens of 4 species are preserved from elephant dung and 48 specimens of 5 species from cattle dung. Only 2 species are shared (Jaccard i = 0.29).

The material of the family Sphaeroceridae is the richest both as regards the number of individuals and the number of species. Representatives of a total of 35 species have been preserved; 27 species from elephant dung (462 specimens) and 29 species from cattle dung (511 specimens). The number of shared species is 21; thus Jaccard i = 0.6. Taking into consideration the comparatively low individual numbers, this is indeed a high proportion. Ten of the 35 species are new to science, being under description at the present, while further 12 are new for the fauna of the RSA.

Representatives of 13 different species of the family Muscidae have been preserved. Five of them developed in elephant dung, and 8 in cattle dung, and no shared species was found. This is remarkable, even though the individual numbers (16+28) are relatively low (Jaccard i = 0.0)

DISCUSSION

Admittedly, the present study is based on a quite limited number of samples, i.e. 1+4 dung samples acting as 'habitat patches', several thousand flies studied in the field, and 1147 flies studied in the HNHM. Therefore, I consider the present results as a preliminary outcome. However, it is clear that results appear to differ across families.

The families Hybotidae and Sphaeroceridae provide the majority (two-third) of all the species collected. The majority of their species occurs simultaneously both on elephant and cattle dung suggesting that most of them can shift between elephant dung and cow pats as alternative nutrient sources. In case of sepsid flies, the proportion of species occurring on both types of dung is reduced to about half of the above value. Finally, no muscid species occurred on both types of dung in our samples.

There are two types of biases potentially influencing my results. Firstly, low sample size can cause an underestimation of the proportion of shared species. Secondly, some species may occur on a particular type of dung without necessarily depositing eggs in it, thus causing an overestimation of shared species. Consequently, these biases may potentially act in opposite directions; however, the amount of their influence is not yet understood.

Further studies are needed for a better understanding of the potential conservation value of the dung fly communities associated to large herbivores. Firstly, we need species descriptions and taxonomic reviews to quantify more accurately the similarities among different fly communities associated to different herbivores. Secondly, specificity of a dipteran to a particular dung type should be characterised by the development of the larvae within the dung, rather than by pure occurrence of imagines in the pats. Finally, elephant-dominated versus cattle-dominated grazing fields could be considered as two extremes of a single habitat continuum, and a better-substantiated project would be extended along this continuum. I simply hope that the preliminary results presented above can signify the importance of the insect communities living in association with the large-bodied 'megafauna'.

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