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Biodiversity of beetles (Coleoptera) in areas under participatory forest management in Kafa Biosphere Reserve, Ethiopia

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Introduction

The UNESCO Kafa biosphere reserve is located in western Ethiopia, in the Southern Nations Nationalities and People's Region. Kafa is one of the last mountain cloud forest regions in Ethiopia. Kafa biosphere reserve is around 760,000 hectares and is largely covered by mountain cloud forests with wild coffee *Coffea arabica*. Areas under participatory forest management (PFM) are mostly used to grow coffee as understorey tree in the montane rainforest. However, creeping deforestation and the spreading of agriculture are threatening the reserve. As part of the project 'Biodiversity under Climate Change: Community-Based Conservation, Management and Development Concepts for the Wild Coffee Forests' funded by the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) within the framework of the International Climate Initiative, NABU has conducted an International Biodiversity Assessment. A team of 16 German, 1 Dutch and 12 Ethiopian experts supported by 22 field local guides conducted intense field work from the 3rd to the 13th of December 2014. The overall goal of the assessment was to specify and verify flora and fauna assessments conducted in the Kafa Zone before 2014, record and list species, identify indicator and flagship species and determine their status in order to help to preserve the area's unique diversity and secure a regular monitoring. Here results on beetles (Coleoptera) are reported.

Material and Methods

The study sites are listed in Table 1. The study sites visited included coffee forests (montane forests), bamboo forest, secondary forest, river banks, and wetlands. A variety of sampling methods and trap types were used. Beating umbrella: With the help of a beating umbrella, insects found on foliage can be caught. The umbrella is held beneath the foliage while the collector strikes it with a stick, and insects fall into the umbrella. It is especially effective with tough and scrubby or spiny plants. An aspirator is used to collect the insects from the umbrella. Sifter: With the help of a sifter, accumulations of organic material like leaf litter, and / or the top layer of soil is sampled. In forest habitats, one square meter of leaf litter, and the top layer of soil was sampled. This was repeated three times, i.e. a total of three square meters were sampled. In every forest, the following sieving sites were chosen: a relatively open site, one close to the buttress root of a tree, one close to decaying wood, respectively. Additional special micro-habitats like organic material in tree hollows or on aerial roots, bark and fungi were sampled when possible. Sweeping net: A sweeping net is used e.g. to catch insects present on herbs, grasses or flowers. A solid cloth or gauze is mounted on a metal frame. Aerial insect car net: Many beetles fly from one place to another. Those beetles can be caught by aerial nets. In Kafa, an aerial insect car net mounted on a four wheel drive jeep was used (Figure). The net was constructed by the author, as such nets are not commercially available. The length of the net was 2 m, the opening measured 0.5 m^2, and the net was attenuate towards the end. A removable collecting bag was attached to the end of the net. The nylon material had a mesh width of 0.2 mm x 0.25 mm. The time and speed of collecting were standardised: one hour between 17:30 and 18:30 with a constant speed of 30 km /h, i.e. a distance of 30 km. GPS-data and altitude was recorded for the start and the end of the distance driven. Barber pitfall trap: The Barber pitfall trap is a tool for the quantitative assessment of terrestrial arthropods. Primarily nocturnal insects fall into it. Barber traps were positioned in three forest sites and at the Bonga Guest House for a period of six days. Flight intercept trap: Flight intercept traps are used to catch flying insects. They hit the glass-window of the trap and fall through the funnel into a cup filled with the liquid killing agent (1 part glycerine and 2 parts 75% ethanol). Generally flying insects are randomly caught. The traps were used continuously for a period of six days in three sites. Light trap: Many, but not all insects are attracted by light. When conditions are ideal, large numbers of insects can be caught. Ideal conditions are temperatures above 18°C, little or no moonlight, and little wind. A generator was used to power white light bulbs, set in front of a white sheet and a gauze light tower. Yellow dish trap: Yellow dish traps mimic yellow flowers and attract flower visiting insects. These insects fall into the liquid killing agent. Previous studies on Afrotropical insect diversity found a range of sampling methods to yield more diverse material than any single method operated with high replication, and morphospecies composition in trap catches to be more strongly influenced by habitat type than by sampling methods (Missa et al., 2009).

Table 1: Study sites and characteristics

No	Code	Area	Woreda	Habitat	Sites
1	BA	BONGA	Adiyo	Bamboo forest / Riverine vegetation	Bamboo forest
2	BK	BONGA	Adiyo	Montane forests	Boka forests
3	KO	BONGA	Gimbo	Montane forests	Komba forests
4	AW	BONGA	Decha	Montane forests / Riverine vegetation	Awurada valley (Gummi River, PFM sites)
5	AG	BONGA	Gimbo	Wetland	Alem Gono
6	SHO	BONGA	Gimbo	Wetland	Shoriri
7	MA	BONGA	Decha	Montane forests	Mankira forests
8	GO-wet	BOGINDA	Gawata	Wetland	Gojeb wetland
9	GO-riv	BOGINDA	Gawata/Gimbo	river/floodplain forests	Gojeb river
10	BO	BOGINDA	Gawata	Montane forests	Boginda forests
11	BG	BONGA	Guesthouse	anthropogen settlement	KDA Guest House + environment

Beetles were identified to the family level, and, where possible, information on subfamily, tribe, genus and (in a few cases) species are given. The number of species was estimated by morpho-species analysis. Beetles were classified according to the family-group names proposed by Bouchard et al. (2011). Due to the lack of collection reference in European museums, a number of species are still being identified, a process which will take time. Only a qualitative analysis was conducted.

Results and Discussion

A total of 400 beetle species from 79 families / subfamilies were recorded. Almost all major beetle families were present. The number of beetles recorded at each collection site is listed in Table 2. The species numbers given for the different sites do not reflect differences in biodiver-sity, because the same collection effort was not possible for all sites, and e.g. traps could only be placed at three sites. However, Mankira, Komba, Boka, Ufa and Alem Gono, respectively, are more or less comparable, and all these sites revealed about 100 species each. Within 10 sampling days during an unfavourable season, 164 Staphylinidae species were recorded, out of ca. 530 known for Ethiopia (30%).

Table 2: Number of beetle species collected depending on study site

MA	AW	KO	BK	BG	SHO	AG	Go-riv	BO	BA
103	99	51	129	35	5	108	9	14	18

With the sifter, typical soil arthropods such as woodlice, Myriapoda, and insects like Collembola were found. However, the number of arthropods sieved was generally low. Few beetles were found, ranging from 1 to 5 per square meter. Numbers were too low to compare forest sites. Micro-habitats like organic material on aerial roots were more diverse, cockroaches were found, as well as rove beetles and ground beetles. No beetles were found on fungi. The leaf litter and the top layer of soil were relatively dry. This could be due to the climatic conditions during the dry season. Observations on seasonality of soil invertebrates were published by Rybalov (1990) for Ethiopia, indicating that many species survive the dry season e.g. as diapausing eggs. The only exception was the Saja-Forest. This forest, as well as the forest adjacent to the Shoriri-wetlands, should be examined for possible higher diversity in the future. Use of the forests for coffee production could also be responsible for the dryness of the soil, e.g. due to the removal of decaying wood, herbs, shrubs and shading trees. The investigation of the area should be repeated at other times of the year, at least at the start of the rainy season.

With the help of the aerial insect car net, insects in the following orders were obtained: Coleoptera, Hemiptera, Psocoptera, Thysanoptera, Hymenoptera, Diptera Nematocera, Diptera Brachycera, Lepidoptera. Additionally mites were caught, which are presumably phoretic on the insects.

While hand-held aerial nets have been used to catch beetles for a long time, little data is available on aerial insect car nets. A large number of insects was obtained. The factors affecting this method have to be studied in more detail in the future. To explore the insect diversity, the aerial insect car net can be recommended, as almost none of the species obtained with this method was obtained with other methods. Moreover, beetles were caught that are difficult to collect by other methods, like small myrmecophilous Staphylinidae. Flight intercept traps should be used as a standard technique in the future. Techniques should be evaluated to place these traps higher in the canopy. When placed in a certain plant, e.g. a tree, this trap type can specifically trap insects presumably associated with the respective plant. When used over a longer period, seasonal effects on insect activity can also be monitored in this way. During the study period, the number of insects caught was too low to compare the forest sites. However, it was possible to show that insects are also actively flying in the relatively dark low mountain forest layers during the dry season.

Conclusions and Outlook

Information on the insect fauna of Ethiopia was never reviewed, i.e. no check-list for the insects of Ethiopia is available. For few taxa only, this information can be quickly extracted from existing catalogues or keys (e.g. for dragonflies). Comparatively few museum specimens are available in European museums. Existing information (Biondi et al., 2015; Borowiec, 1994; Medvedev, 2000; Selman, 1973) suggests that the insect fauna of Ethiopia differs considerably from that of the neighboring countries. However, only Kenya was comparatively well studied concerning the insect fauna. On the species level, the beetle fauna of Ethiopia is composed of Afrotropical and Palaearctic elements. The study of museum specimens of leaf beetles, Chrysomelidae, by the author suggests the presence of only few Palaearctic elements. Generally, higher species diversity was expected in lowland ecosystems compared to montane forests. An influence of seasonality was expected because most Ethiopian beetles traced in museum collections were collected in April and March. The impact of settlements and habitat fragmentation on beetle species composition cannot be predicted so far, because the ecological demands of the different species are not yet known. The results on the Staphylinidae from this expedition point to poor knowledge of the fauna. Most of the recommendations for insect conservation are focused on habitat conservation. The insect communities reflect the situation of habitat as well as its richness in microstructures and plant diversity. Within the Kafa Biosphere reserve, many natural ecosystems were altered to agro-ecosystems. This caused a mosaic landscape comprised of simple and complex agro-ecosystems and patchily distributed rain forest fragments of varying quality. The distance of such agro-ecosystems to rain forest fragments should be minimised and connections between the different natural habitats should be established. Some forest areas should be protected from all kind of use, such as agroforestry and the trespass of cattle. A screening for the potential natural composition of tree species should be followed up by a screening of phytophagous insects on these trees. Recent studies like those of Biondi et al. (2015) point to the use of groups of beetles to characterize both the biogeography and ecology of the Afrotropical region and, which could potentially be used to aid conservation biology. However, such groups have to be well known and there are few examples such as the genus *Chaetocnema* with representatives in Ethiopia. Currently, the afromontane moist forests, where the coffee grows as understorey trees, are traditionally managed through the thinning of the shade tree canopy and the slashing of competing undergrowth (Hundera et al., 2015). In Participatory Forest Management sites (PFM) with coffee forest, preservation of micro-habitats like climbing plants, accumulation of organic material in and on trees, decaying wood and shrubs other than coffee should be encouraged. Ideally, at least small exclosures should allow the natural regeneration of the forest trees.

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