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Seasonal and altitudinal structure of drosophilid communities on Mt Oku (Cameroon volcanic line)

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ABSTRACT

We assessed the potential of drosophilids as indicators of the response of tropical ecosystems to climatic factors over an annual cycle in the montane forest of Mt Oku, by collecting samples at seven sites evenly spaced from 2200 m to 2800 m asl. Only 0.1% of the 11,000 specimens collected belonged to invading species or those commensal with humans, showing the weakness of anthropogenic factors. Species abundance was highly skewed. One species, *Zaprionus vittiger*, made up 81% of the sample, whereas 42 of the 62 morphological species found were represented by fewer than 20 individuals. Many of the most abundant species occurred over a narrow period, in the dry or in the rainy season, others also occurred at intervening periods. These different patterns of population dynamics, determined a succession of species over the annual cycle. Abundant species departed significantly from each other in their distribution over collection sites. The drosophilid populations from the central African montane forests are highly dependent on climatic factors, either directly, or indirectly through climatic effects on the biotic environment of the insects.

1. Introduction

Understanding how biodiversity responds to climate change is among the main issues of ecological studies. It is thus instructive to examine how organisms have responded to Quaternary climatic fluctuations because these responses are an important source of information that can be useful in predicting the future dynamics of ecological systems. Particularly instructive are the responses of organisms in the rain forests of western and central Africa. This is because these forests are among the World's major biodiversity hotspots (Myers et al., 2000). It is therefore probable that their fluctuations during the Quaternary induced huge changes in the distribution of organisms. During cold periods, montane forests extended to low altitudes. Connections then existed between montane forest patches that are now isolated (Maley, 1996; Plana, 2004). Such events are revealed by the current distribution of some species (Lachaise and Chassagnard, 2001; Lamotte and Petter, 1981; Missoup et al., 2012). Montane forests may thus constitute refugia for fauna and flora that predominated during the last glacial maximum of the Pleistocene. But with time,

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admixture and loss of species of different ecological affinities also happened in montane forest (Lézine et al., 2013). Today, drosophilids are one group whose biodiversity retains the signature of Quaternary changes. Among species related to *Drosophila melanogaster* (the melanogaster subgroup), these signatures are found in patterns of genetic diversity in the forest species *Drosophila teissieri* (Cobb et al., 2000; Lachaise et al., 1981), as well as in patterns of speciation (Lachaise et al., 1988) and in the presence of two endemic species, *D. orena* and *D. santomea*, along the Cameroon volcanic line (CVL), (Lachaise et al., 2000). Drosophilid species are abundant in African ecosystems. Most species are primary consumers, feeding on mushrooms, flowers and, the majority, on decaying fruits (Lachaise and Tsacas, 1983). Thus they are highly dependent on the vegetation and may constitute a valuable indicator of its history. Given their short generation time and their high reproductive potential, their populations are able to respond quickly to changes in the distribution of their resources.

The responses of African drosophilid species to climate can be examined by their responses to seasonal changes in climatic factors. However, despite the attention paid to African drosophilds, little attention has been given to the dynamics of drosophilid biodiversity through the entire year. Whatever the model community studied, temporal patterns of biodiversity have received much less attention than spatial ones (Magurran, 2011). Most studies have consisted of collecting trips in the most favourable season. It is nevertheless clear that the population dynamics of the drosophilid guild in Africa respond in complex ways to resource availability and seasonal climate changes. This complexity was revealed by the extensive pioneering work carried out by Lachaise (1974) in Ivory Coast. In order to improve assessments of the dependence of drosophilid populations on climatic factors, and of the variety of their responses, we studied the dynamics of populations along two environmental gradients. These were the succession of seasons over the annual cycle and the altitude between the lower and upper limits of the Mt Oku montane forest in the CVL.

2. Materials and Methods

2.1. Study site

The study site was in the Community Forest and the Plant life Sanctuary of Mt Kilum-Ijim in Oku. This mountain is one of the major peaks of the Cameroon Volcanic Line (CVL) in the Northwest Region of Cameroon. It is covered by montane forest extending from 2200 m to 2800 m asl between farmland (below 2200 m) and grassland (from 2800 m to 3000 m). The dominant tree species of the forest include *Carapa grandiflora* (Meliaceae), *Nuxia congesta* (Loganiaceae), *Syzygium staudtii* (Myrtaceae) and *Arundinaria alpina* (Poaceae) (Momo Solefack, 2009). *Podocarpus milanjianus* (Podocarpaceae) occurs above 2500 m. A number of endemic species are known from the mountain including plants, birds, amphibians and mammals (Cheek et al., 2000; Fotso, 2001; Maisels et al., 2000; Nussbaum, 1981; Petter, 1986). Oku village just below the study site (at 2000 m) but close to it provided a useful logistic base in a region where access to primary forests may be difficult during the rainy season. Rainfall and temperature data were obtained from the Oku village weather station where records are made at 07:00 every day. These records indicate the main seasonal changes on the mountain.

2.2. Collecting samples

Flies were collected using traps made from 1.5 L plastic bottles. A minute-hole was made that allowed drosophilid flies to enter but prevented entry by larger insects. The traps were baited with crushed soft banana and hung in the understorey vegetation. Three traps were used at each site: two of them being on the right side of the trail, approximately five meters away from each other, the third being about ten meters away on the left side of the trail. The traps were left for three days before collecting. There were seven trapping sites and they were spaced about every 100 m of elevation from 2200–2800 m along the KJ and the KA trails. The sites were thus at 2206, 2301, 2400, 2520, 2603, 2683, and 2804 m. All collections were made by SWM between 08:00 and 11:00 from the lowest to the highest collection site. The collection period began on 20 October 2008 and continued until 06 October 2009. The 29 collecting dates were as regularly spaced as possible given weather conditions.

2.3. Data analysis

Almost all the insects trapped were drosophilids. SRP classified the drosophilids into morphospecies under a binocular stereomicroscope with coupled numerical imaging. The classification was based on the external characteristics routinely used in drosophilid systematics (e.g. Prigent and Chen, 2008; Prigent and Toda, 2006). For taxonomical reference, we used the extensive collection of drosophilids in the Paris Museum (Muséum National d'Histoire Naturelle, MNHN). This collection includes a large number of specimens from central Africa, many of them being holotypes collected between 1970 and 2000 by L. Tsacas, D. Lachaise, S. McEvey, J. David and M.-T. Chassagnard.

For analysis, samples were pooled into 12-monthly periods each beginning on the fourteenth of the month and lasting until the thirteenth of the following month. We thus designated 14 July to 13 August as "July" and other periods similarly by the month in which they started. Only traps with at least one fly were considered when averaging by trap. Statistical analyses were run using R (R Development Core Team, 2010). We tested whether repeated collections at a given site could affect the local population abundances by correlation. Pairwise homogeneity tests across the seven altitudinal points of capture were run between the six most abundant species. One trap containing three individuals was discarded from the elevation analysis due to an unreadable label. The interaction between season and altitude was investigated using a two-way analysis of variance for the number of individuals caught, the number of species found, and for two diversity indices: equitability and Shannon's H index. To this end,