Biodiversity and seasonality of Pyraloidea (Lepidoptera) in the woody savannah belt in Mali

Alexander N. Poltavsky[1], Vasiliy D. Kravchenko[2]*, Mohammed M. Traore[3], Sekou F. Traore[3], Petrányi Gergely[4], Thomas J. Witt[3,5], Harry Sulak[5], Robert H.-T. Beck[6], Amy Junnila[7], Edita E. Revay[8], Seydou Doumbia[3], John C. Beier[9] & Günter C. Müller[3,10]

[1]Botanical Garden of the Academy of Biology and Biotechnology, Southern Federal University, 7 Botanicheskiy spusk Str., Rostov-on-Don, 344041 Russia. E-mail: poltavsky54@mail.ru
[2]The Steinhardt National History Museum and Research Center, Tel Aviv University, Tel Aviv, 69978 Israel
[3]Malaria Research and Training Center, Faculty of Medicine, Pharmacy and Odonto-Stomatology, University of Bamako, Bamako, Mali
[4]Zoologische Staatssammlung München, Münchhausenstraße 21, München, D-80217 Germany
[5]Museum Witt, Tengstraße 33, München, D-80796 Germany
[6]Eversbuschsstraße 83b, München, D-80999 Germany
[7]Northwestern Scientific Consulting, Thunder Bay, Ontario, Canada
[8]Department of Human Biology and Medical Sciences, Faculty of Natural Sciences, University of Haifa, Haifa, 3498838 Israel
[9]Department of Public Health Sciences, Leonard M. Miller School of Medicine, University of Miami, 1120 NW 14th Street, Miami, FL 33136, USA
[10]Department of Microbiology and Molecular Genetics, IMRIC, Kuvin Centre for the Study of Infectious and Tropical Diseases, Faculty of Medicine, The Hebrew University of Jerusalem, Jerusalem, 91120 Israel
**Corresponding author: vasiliy1953@yandex.com*

ABSTRACT

Seventy-nine species of Pyraloidea moths were collected from light traps in the vicinity of Bamako in Mali during 2014. Thirty-one species—for which over 10 specimens each had been trapped—were chosen for analysis of their seasonal dynamics. According to the similarity in their patterns of seasonal flight, three clusters were recognized by non-metric MDS ordination: (1) The beginning of the rain season was associated with a peak in several multivoltine, widespread, and highly abundant species, thus reducing to a minimum both the effective number of species index and index of evenness. In the middle of the rain season, the number of both species and specimens was low, probably reflecting the period of larval development for most of the species; (2) The first half of the wet–dry (transitional) season featured the highest diversity and highest evenness in the representation of species. More than half of 31 species are univoltine in the study region, and thus were found only during this period. All the species are Afrotropical or Paleotropical in their general distribution; (3) A group of 10 species peaked during the dry season. Five of these also occurred earlier, while the other five were specific to the dry season: *A. simplella*, *B. asialis*, *P. phoenicealis*, *A. calligrammalis*, and *P. pictalis*.

KEYWORDS: Lepidoptera, Pyraloidea, snout moths, woody savannah, West Africa, seasonality.

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INTRODUCTION

The Republic of Mali covers an area of 1,240,000 km^2, stretching from the southern part of the Sahara Desert with less than 100 mm of annual precipitation across the Sahel region and woody savannah to the tropical savannah, which receives almost 1,400 mm of rainfall in the south (Giannini *et al.* 2017). From a broad ecological perspective Mali is considered a complex ecotone between forest and desert (Rian *et al.* 2009), with the woody savannah region classified as a forest/savannah transition belt (Torello-Raventos 2013).

Despite the vast and ecologically diverse area of Mali, faunistic and ecological knowledge of this country is grossly inadequate. For example, all 79 species of the superfamily Pyraloidea (Lepidoptera) collected by us in the vicinity of Bamako represent new records for Mali, and 17 of them are new records for West Africa (Poltavsky *et al.*, in press). In the present article, we examine the seasonal pattern of flight of these pyraloid moths.

Many Pyraloidea species are known worldwide as serious agricultural pests. Their caterpillars cause economic damage and affect crops such as rice, sugarcane, corn, tomato, grains, and fruits (Solis 1996; Munroe & Solis 1998). A few publications deal with the control and biology of some West-African pyraloid pests of rice (Heinrichs & Barrion 2004), vegetables (James *et al.* 2010), olives (Ghoneim 2015), and okra (Ogbalu 2015).

The superfamily Pyraloidea currently comprises 16,000 described species in the families Pyralidae and Crambidae. The species are highly diverse in their ecologies and biologies: some (Crambidae: Wurthiinae) are parasites in ant nests, the larvae of the Acentropinae (Crambidae) live underwater, and certain snout moths (Phycitinae and Pyralinae) are adapted to very dry environments and their larvae feed on stored products, while others sustain on animal remains such as carrion and feces.

MATERIALS AND METHODS

Our research was carried out during 2014 near the Ouronina village, 75 km south-west of Bamako (12°05'39.78"N 8°24'3.16"W) (Fig. 1). Mean annual precipitation in the area is <1,200 mm, with 90% of rainfall occurring from June to September.

For most species of nocturnal Lepidoptera, the light-trap remains the primary method to determine their flight activity, and thus to monitor their life cycle. This approach has been used for Pyraloidea as well, for *Eldana saccharina* Walker (Carnegie & Leslie 1990) and *Ostrinia nubilalis* (Hubner) (Rak Cizej & Trematerra 2017; Keszthelyi *et al.* 2018) in Europe. The light-trap data also provide a basis for revealing phenological groups of species, e.g. for pyralids in southern Russia (Poltavsky 2014). Within the framework of the National Institutes of Health International Collaborations in Infectious Disease Research (U01) project *Attractive toxic sugar baits for malaria vector control in Africa* we had an

Fig. 1: Position of the study area (Ouronina village) in Mali.

opportunity to collected non-target insects. In woody savannah near Ouronina, we established 20 automatic light traps, 40 m from each other, supplied with cold UL cathode lamps 12 V, 30 cm long, and powered by motorcycle batteries (12 A/H). The light traps were powered every night from the beginning of January 2014 until the end of December 2014, except on civic holidays.

To describe the general pattern of distribution of the studied species, we used the terrestrial classification of Olson *et al.* (2001): (1) Afrotropical (af), species known only in Africa south of the Sahara; (2) Paleotropical (pl), species occurring in the tropics of the Old World (Africa, India, South-East Asia and northern Australia); (3) Paleotropical with penetration into the Palearctic (pl+); (4) Pantropical (pn), species occurring throughout the tropical regions including South and Central America; (5) Pantropical with penetration into the Palearctic (pn+); and (6) Cosmopolitan (c), species occurring throughout all biogeographical regions (Table 1).

For calculation diversity indices and nonparametric multidimensional scaling we used the PAST – Paleontological statistics software package (Hammer *et al.*

2001). Number of specimens collected per month was aggregated into one sample. Diversity was estimated using the Shannon index H (entropy), which varies from zero for communities with a single taxon to high index values for communities with many taxa, each with several specimens:

$$H = -\Sigma (n_i/(N*\log(n_i/N)),$$

where: n_i – number of specimens of ‘i^{th}’ species, N – total sum of all specimens.

The exponential version of Shannon’s H index was transformed to the “effective number of species” (Chao *et al.* 2014, 2017) by software available in *The New Synthesis of Diversity Indices and Similarity Measures*[*].

Evenness of distribution reveals the extent of numerical equality of the species community and is measured as H/S, where H is the Shannon Weaver index and S is the number of species (Magurran 2004).

RESULTS

A total of 9,643 specimens of Pyraloidea belonging to 79 species were collected (Poltavsky *et al.*, in press). Seasonal patterns of flight were examined only for 31 species, for which over 10 specimens had been trapped (Appendix 1, Table 1).

According to the data provided by the meteorological station in Bamako, the rain season runs from June to September, corresponding to the highest air humidity and lowest temperature (dark gray on Fig. 2). October–December is an intermediate period between the rain and dry seasons (light gray in Fig. 2). During the transitional period rainfall is short and sporadic, but still wet soil results in a high evaporation rate that causes the temperature to drop to a seasonal minimum (24.7 °C). The dry season begins in January, when soil becomes dry and the temperature gradually rises, reaching a maximum in April (32.7 °C).

Based on the number of specimens, three peaks are evident (Fig. 3), in July, September, and January, corresponding to the middle and the end of the rain season, and to the beginning of the dry season, respectively. While the two latter peaks positively correlate with peaks in the number of species, there is a greater number of specimens in July.

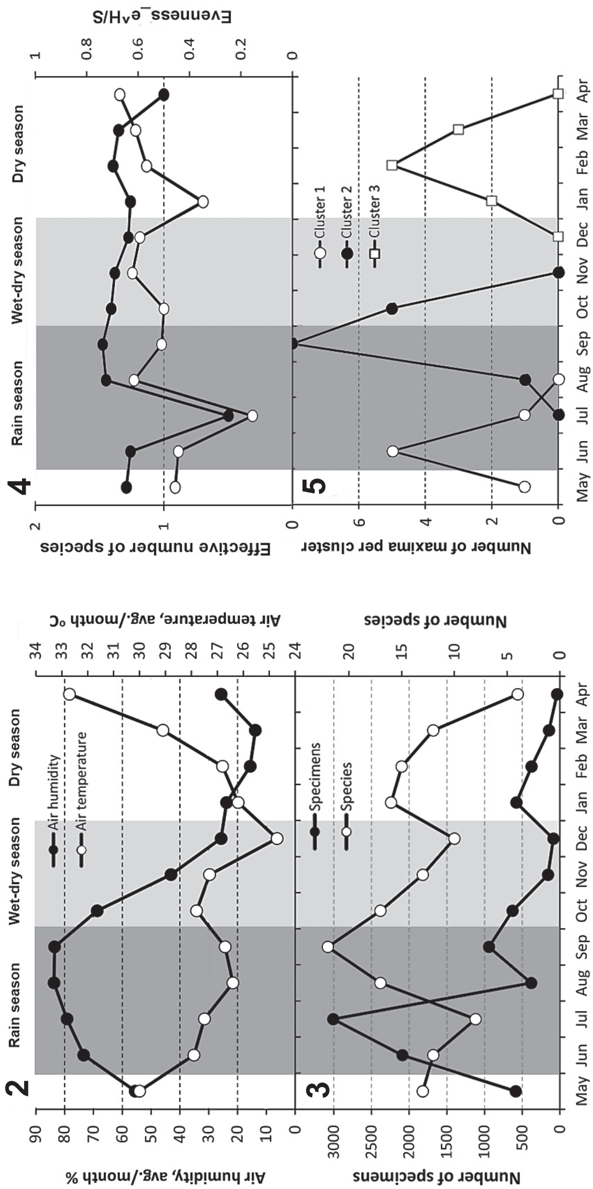
During the seasons, the effective number of species varied between 1.48–1.26 and evenness 0.67–0.35 (Fig. 4) except July, when the values of both indices were exceptionally low (diversity, 0.5; evenness, 0.16). The greatest values of species diversity (>2) were in August–September and February.

Most species demonstrate several periods of flight (multimodal dynamics), i.e. the same species could have contributed to more than one peak (Table 1). However, regardless of the number of peaks, 60–80 % of specimens of these species were collected during only one of the peaks (shaded gray in Table 1). Another 13 species occurred only during one of the peaks, i.e. displaying unimodal dynamics (asterisked in Table 1).

* http://www.loujost.com/Statistics%20and%20Physics/Diversity%20and%20Similarity/Diversity%20of%20a%20single%20community.htm

Table 1. Seasonal dynamics of species for each of which 10 or more specimens had been collected. Asterisked are species with unimodal season dynamics; gray cells – highest number of specimens collected; Distr. – type of general distribution; blank cells = 0.

Cluster	Species	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Total	Distr.
1	*S. cancellalis*	163	150		6	62	22		5	18	12	12	25	475	pl
1	*P. impia*	187	556							288	28	8		1067	af
1	*P. vitrealis*	35	261	47	67	11				13				434	c
1	*S. recurvalis*	106	180	5	25	29	9						3	357	pn+
1	*B. diniasalis*	9	74	5	7	1				14	20	10		140	pl+
1	*G. negatalis*	18	39							1	22	11		91	pl+
1	*P. balteata*	32	789	2898	53	19		27						3818	pl+
2	*P. callixantha*		4	12	53	38				9	20			136	af
2	*M. vitrata**				2	321	246	13	5					587	pn
2	*S. ovialis*	10	23	19	44	82	23	23						224	af
2	*A. marginata**			19	60	96	33							208	pl
2	*M. separatella**					71	54	6						131	pl
2	*G. bitriangulalis*	10		3	12	11					1			37	af
2	*D. indica*	7	1		5	13	10							36	pl
2	*U. conigeralis**					6	5	4	2					17	af
2	*E. warreni*	1				6	1	0	2	1				11	af
2	*S. traducalis*	4	5		8	45	79	44	12					197	pl
2	*U. flavicepsalis**				21	24	38	10						93	af
2	*H. basalis**					34	35	1						70	pl
2	*H. derogata**				3	27	28	2						60	pl
2	*B. concinnella**					18	23	2						43	af
3	*P. olesialis*				4	14	19	20	40	114	22			233	pl
3	*A. simplella**								3	7	2			12	af
3	*T. africana*				2	9	2			38	135	61	7	254	pn
3	*H. bamakoensis*		7		9	8			10	27	53	1		115	af
3	*B. asialis**									20	26	8		54	pl
3	*P. phoenicealis**									19	21	9		49	c
3	*G. hirtusalis*	1						3	4	2	5	1		16	af
3	*P. fluctuosalis*						2	3	4	5	1	9		24	pl+
3	*A. calligrammalis**									1	9	8		18	af
3	*P. pictalis**											7	3	10	c



Figs 2–5: Seasonal variations in weather parameters and Pyraloidea diversity.

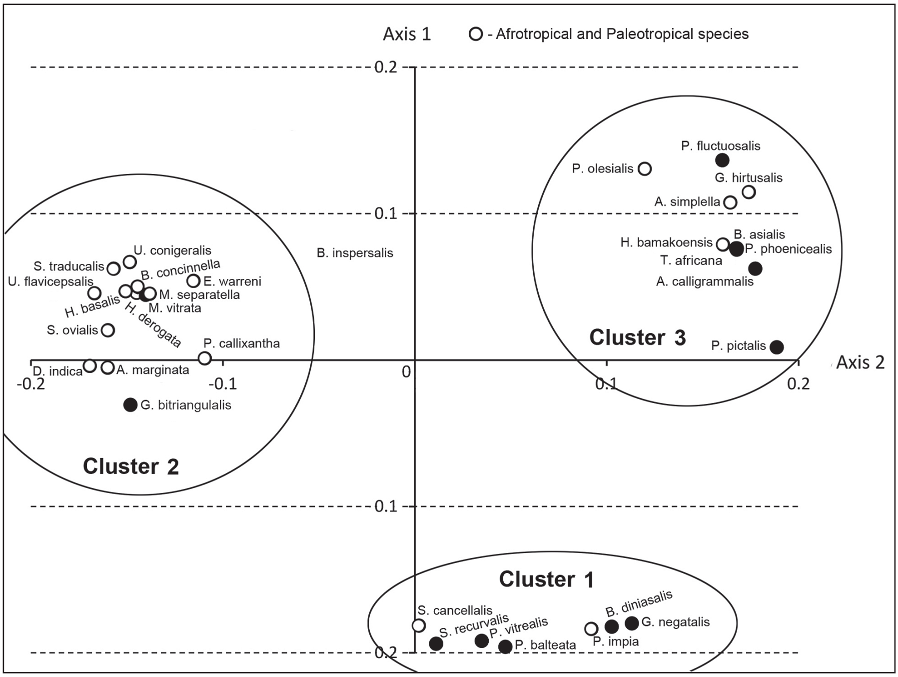


Fig. 6: Non-metric Multi-Dimensional Scaling of species' patterns of flight. The similarity is measured by the coefficient of correlation.

Non-metric Multi-Dimensional Scaling (Fig. 6) provided three clusters of species, with each cluster displaying a similar shape of phenological curves. Cluster 1 comprises seven species that occur predominantly at the beginning of the rain period (May–June). Cluster 2 comprises the most numerous group (14 species) occurring mainly at the end of the rain season and during the transitional period. Cluster 3 comprises 10 species found largely during the dry period, January–March. The dominant flight period of each cluster is approximated as the sum of maxima (gray cells in Table 1) (Fig. 5).

According to the type of general distribution, the majority of species (64.5 %) belong to the Afrotropical and Paleotropical type. Most of them are found at the end of the rain season and during the transitional period (cluster 2 in Fig. 6).

DISCUSSION

Insects can adapt their cycle of development to the seasonal variations in suitability of their habitat by shifting from activity to different types of diapause (Danks 2007; Saulich & Musolin 2007). The obtained data thus cannot be considered as species-specific but rather as habitat-specific for this faunistic complex of the Pyraloidea. Some tropical insects continuously develop for several generations (Chown & Nicolson 2004), though for most of the species such information is absent.

In the Palearctic steppe zones the Lepidoptera in general fall in diapause during winter, thus their period flight is associated with warmer seasons. In the steppe zone of European Russia the early summer, late summer and autumn phenological groups of Pyraloidea are recognized (Poltavsky 2014). In Sub-Saharan Africa the temperature factor is less controlling the diapause, thus making comparison of the Afrotropical arid zone with the Palearctic difficult.

The beginning of the rain season is associated with the appearance of several multivoltine, widespread, and highly abundant species of Pyraloidea. Three of the pests that peak at this time comprise 51.1 % of the total number of specimens collected: *P. balteata* (3818 specimens), pest of cashew and mango trees; *P. vitrealis* (434), pest of olive trees; and *S. recurvalis* (357), pest of spinach, beet, cotton, maize, and soybean. This imbalance in abundance of species reduces the effective number of species index and index of evenness to the lowest level.

During the following period of intensive rains and high rate of vegetation growth, the number of species and specimens was found to be low, probably reflecting the period of larval development for most of the species.

The end of the rain season and the first half of the transitional period is marked by the highest diversity and evenness in species representation. More than half of the species (8 out of 14) are unimodal, and thus they are found only during this period. All of them are Afrotropical or Paleotropical. Several pests peaked during this period: *M. vitrata*, pest of pigeon pea, cowpea, mung bean, and soybean; *M. separatella*, polyphagous on many crops; *S. traducalis*, pest of jujube; and *H. derogata*, pest of cotton.

The dry season peak is represented by a group of 10 species. Five of them are also found earlier, while the other five are specific to this period: *A. simplella*, *B. asialis*, *P. phoenicealis*, *A. calligrammalis*, and *P. pictalis*. Among them *P. phoenicealis* is a pest of shiso, fruit mint, knobweed, and *P. pictalis* is a pest of stored food.

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Appendix 1. A list of Pyraliodea species from Mali used in the present study.

Analyta calligrammalis Mabille, 1879
Ancylolomia simplella de Joannis, 1913
Autocharis marginata Guillermet, 1996
Biafra concinnella (Ragonot, 1888)
Botyodes asialis Guenée, 1854
Botyodes diniasalis (Walker, 1859)
Diaphania indica (Saunders, 1851)
Euclasta warreni Distant, 1892
Ghesquierellana hirtusalis (Walker, 1859)
Glyphodes bitriangulalis Gaede, 1917
Glyphodes negatalis (Walker, 1859)
Haritalodes derogata (Fabricius, 1775)
Herpetogramma basalis (Walker, 1866)
Hypsopygia bamakoensis Leraut, 2006
Maliarpha separatella Ragonot, 1888
Maruca vitrata (Fabricius, 1787)
Palpita vitrealis (Rossi, 1794)
Parapoynx fluctuosalis (Zeller, 1852)
Pardomima callixantha Martin, 1955
Parotis impia (Meyrick, 1934)
Patania balteata (Fabricius, 1798)
Pioneabathra olesialis (Walker, 1859)
Pyralis pictalis (Curtis, 1834)
Pyrausta phoenicealis (Hübner, 1818)
Sameodes cancellalis (Zeller, 1852)
Spoladea recurvalis (Fabricius, 1775)
Syllepte ovialis (Walker, 1859)
Synclera traducalis (Zeller, 1852)
Terastia africana Sourakov, 2015
Ulopeza conigeralis Zeller, 1852
Ulopeza flavicepsalis Hampson, 1912