Spatial variability of fruit fly agricultural pests (Diptera: Tephritidae) in rural areas and tropical forests of Central Congo

Virgilio M.[1], Backeljau T.[2,3], Emeleme R.[4], Baelo P. [4], Juakaly, J.L.[4], De Meyer M.[1]

[1] Royal Museum for Central Africa - Tervuren, Belgium
[2] Royal Belgian Institute of Natural Sciences - Brussels, Belgium
[3] Department of Biology, University of Antwerp - Antwerp, Belgium
[4] Faculty of Sciences, University of Kisangani – Kisangani, Democratic Republic of Congo


Dacus punctatifrons male (TAMU/ICIPE 1292 ex Peponium vogelii) [© R.S. Copeland 2005]

Introduction

The family of tephritid flies or fruit flies (Diptera: Tephritidae) is widespread and comprises potentially invasive, phytophagous fruit parasites, causing major agricultural losses. Most of the current knowledge about the ecology and distribution of African tephritids originates from studies performed in agricultural areas (*e.g.* Vayssières et al., 2009; Mwatawala et al., 2010) while information about the structure of assemblages in tropical forests, is extremely scarce (but see Copeland et al., 2005). The comparison of assemblages from areas with different levels of human-mediated disturbance (*sensu* Balée, 1998) could provide valuable information on those "natural" and human-mediated processes that can affect the distribution of fruit flies. In this respect, the Congo River basin (DRC) represent an ideal study area due to the co-occurrence of large portions of pristine habitats (*i.e.* primary and secondary tropical forests) and small rural villages where (limited) agricultural and trading activities take place. This study aims at (1) providing a first quantitative survey of tephritid assemblages in Central Democratic Republic of Congo (RDC) (2) quantifying patterns of species composition and abundance at different spatial scales and (3) verifying differences between pristine and disturbed habitats.

Fig. 1: Map of the study area and sampling locations.

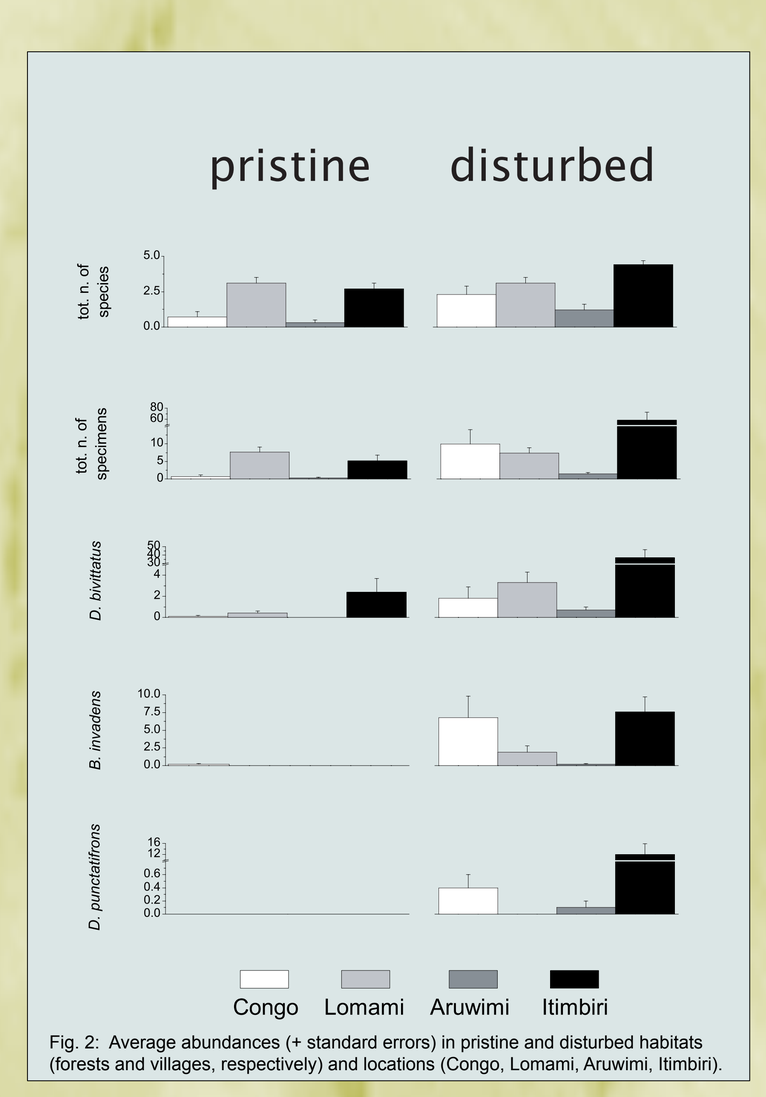

Fig. 2: Average abundances (+ standard errors) in pristine and disturbed habitats (forests and villages, respectively) and locations (Congo, Lomami, Aruwimi, Itimbiri).

Methods

Fruit fly samples were collected in May 2010 along a 250 km stretch of the Congo River (Fig. 1). Four locations were sampled, Congo (0°49'02"N, 24°16'31"E), Lomami (0°41'20"N, 24°15'12"E), Itimbiri (2°02'39"N, 22°49'32"E) and Aruwimi (1°16'11"N, 23°43'51"E). In each location three sites, hundreds of meters apart, were chosen randomly in pristine habitats (tropical forests), and three in disturbed habitats (rural villages). At each site, three replicate plots of traps were placed. Replicate plots consisted of 4 modified McPhail traps, each baited with a different attractant (Trimedlure, Methyl Eugenol, Cue Lure and protein hydrolysate). Traps were left in the field for 7 days and tephritid taxa were collected and identified at the Royal Musem for Central Africa (Tervuren, Belgium). Abundances of taxa were calculated as total n. of specimens collected in each replicate plot. Univariate and multivariate patterns of distribution of species were analyzed through Analysis of Variance (ANOVA), Similarity Percentage Procedure (SIMPER) and Permutational Multivariate Analysis of Variance (PERMANOVA).

Results

Sampling yielded 819 tephritid specimens of 30 species from seven genera: *Bactrocera* Macquart, *Carpophthoromyia* Austen, *Ceratitis* MacLeay, *Dacus* Fabricius, *Perilampsis* Bezzi, and *Trirhithrum* Bezzi. PERMANOVA (Tab. 1) showed significant differences across locations and sites. *A posteriori* comparisons indicated that assemblages in pristine and disturbed habitats were significantly different in two out of the four locations. SIMPER showed that the three most abundant species, *D. bivittatus*, *D. punctatifrons* and *B. invadens*, accounted for 98.29% of the overall dissimilarity between habitats. For these three species, ANOVA showed significant variations of abundance across sites. *D. bivittatus* also showed differences either among locations (with significantly higher abundances in Itimbiri) and between habitats (with higher abundances in disturbed habitats). *D. punctatifrons* showed no consistent variation across locations and habitats, with Itimbiri as the only location with significantly higher abundances in disturbed compared to pristine habitats (see Fig. 2).

Tab. 1: PERMANOVA and *a posteriori* comparisons (t statistic) testing differences in multivariate patterns of 30 tephritid taxa in response to Disturbance (pristine *vs.* disturbed), Location (Congo, Lomami, Aruwimi, Itimbiri) and Site (3 sites in each combination of Disturbance and Location). P-values were obtained using 10^5 unrestricted permutations of raw data. d.f.: degrees of freedom; MS: mean square estimates; F: pseudo-F. Probability of Monte Carlo simulations: n.s.: not significant a P<0.05; ***: P<0.001, **: P<0.01; *: P<0.05.

Source of variability	d.f.	MS	F	
Disturbance = Dist	1	59.77	3.02	n.s
Location = Loc	3	109.72	7.62	***
Site (Dist x Loc)	16	7.62	3.41	***
Dist x Loc	3	36.3	4.63	**
Residual	48	2.3		

Euclidean distances, data square root-transformed

Pair-wise *a posteriori* comparisons: Loc x Dist

Congo:	pristine = disturbed
Lomami:	pristine ≠ disturbed (**)
Aruwimi:	pristine = disturbed
Itimbiri:	pristine ≠ disturbed (**)

Discussion

The three most abundant species, *D. bivittatus*, *B. invadens* and *D. punctatifrons* are major agricultural pests in Africa (White, 2006) and represent 82.5% of specimens collected (50.3%, 18.3% and 13.9%, respectively). These species show different patterns of distribution across sites, locations and habitats. Multivariate analyses reveal a remarkably patchy distribution of species at scales ranging from hundreds of meters to hundreds of kilometers and show that differences among locations and sites, rather than between habitats, are the main source of variability among assemblages. Hence, the patchy distribution of fruit fly assemblages in central RDC appears mainly related to differences in the environmental features of locations and sites, while differences among disturbed and non disturbed habitats (*i.e.* villages and forests) were observed only in part of the locations sampled. These data suggest that, in rural villages of Central RDC, human activities such as small scale agriculture and local commerce do not always represent a relevant source of disturbance that can promote differences between the tephritid assemblages of villages and those of the surrounding tropical forests.

References

Vayssières JF, Korie S, Ayegnon D (2009) Correlation of fruit fly (Diptera Tephritidae) infestation of major mango cultivars in Borgou (Benin) with abiotic and biotic factors and assessment of damage. *Crop Protection* ***28, 477-488.***

Mwatawala M, Maerere AP, Makundi R, De Meyer M (2010) Incidence and host range of the melon fruit fly *Bactrocera cucurbitae (Coquillett) (Diptera: Tephritidae) in Central Tanzania. International Journal of Pest Management* ***56, 265 - 273.***

Balée W (1998) Historical ecology: premises and postulates. In: *Advances in historical ecology (ed. Balée W), pp. 13-29. Columbia University Press, New York.*

Copeland RS, Okeka W, Freidberg A*, et al. (2005) Fruit flies (Diptera, Tephritidae) of Kakamega forest, Kenya. Journal of East African Natural History* ***94, 247-278.***

Acknowledgements:

MV was funded by the Belgian Science Policy Action 1 (project MO/37/017). Data were collected during the expedition Boyekoli Ebale Congo 2010 (www.congo2010.be) organized by the Congo 2010 Consortium composed of the University of Kisangani, Royal Museum for Central Africa, Royal Belgian Institute of Natural Sciences and the National Botanic Garden of Belgium, funded by Belgian Development Aid and Belgian Science Policy. We are grateful to Erik Verheyen (RBINS) for stimulating discussion and to Hilde Keunen and Koeki Claessens (RMCA) for continuous assistance in the organization of field activities. This work would not have been possible without the active support of the people from the villages of Yaekela, Lieki, Bomane and Mwenge (DRC)