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First record of *Dacus* (*Lophodacus*) *hamatus* (Diptera: Tephritidae) in Cameroon, with emphasis on a new host plant *Lagenaria siceraria* (Cucurbitaceae)

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In Cameroon, fruit flies (Diptera: Tephritidae) represent a major constraint to fruit production in cucurbits. They are known to feed essentially on fruits, but some species are flower specialists. The present study aims to assess the oviposition preference of fruit flies on seven species of cucurbits along with two varieties (bitter and sweet) of *Lagenaria siceraria* (Molina) Standley at two locations namely Yaounde and Koutaba (Cameroon). The infested flowers and fruits were collected, examined and incubated individually under laboratory conditions. *Dacus* (*Lophodacus*) *hamatus* Bezzi (Diptera: Tephritidae) was recorded for the first time, from the male flowers of *L. siceraria*. Under field conditions, the females laid their eggs only on male flowers of both varieties of *L. siceraria* and no adult was obtained from their fruits and from both flowers and fruits of other six cucurbit species in this study. However, under laboratory conditions, larvae were able to develop on flowers and fruits of all cucurbits used in present investigation. The infestation rate and the mean number of larvae per male flower were significantly greater on the bitter variety than on the sweet of *L. siceraria*, suggesting specificity in the feeding preference of *D. hamatus*. This fly affects considerable the yield of *L. siceraria* at both the studied locations *viz*. Yaounde and Koutaba with mean infestation rates of 52.36 ± 5.72% and 57.63 ± 3.41%, respectively on male flowers of *L. siceraria.*

Key words: Fruit fly, *Dacus hamatus*, new record, feeding specificity, infestation rate, cucurbits.

INTRODUCTION

The dipteran family Tephritidae, whose members are commonly known as true fruit flies, is among the largest and the most diversified pest species with a world-wide distribution (Cogan and Munro, 1980; Drew, 1989; De Meyer and Copeland, 2005; Aluja and Mangan, 2008; Prabhakar et al., 2012). In this family, the genus *Dacus* Fabricius which is widely distributed in the Old World, comprises 177 described species mainly associated with three host plant families: Cucurbitaceae, Passifloraceae and Apocynaceae (White and Elson-Harris, 2004; White,

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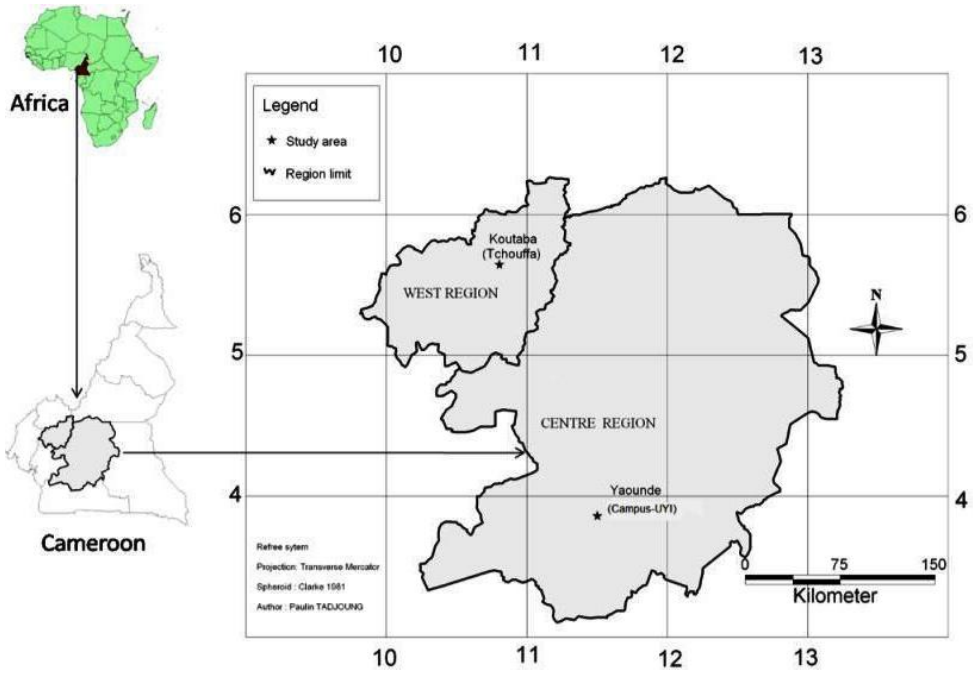

Figure 1. Maps of the studied locations in the southern part of Cameroon.

2006; Virgilio et al., 2009; White and Goodger, 2009).

Although, most of fruit fly species are known to develop essentially on fruits or pods, some species are specialized on other plant organs such as flowers or stems on which they constitute a serious threat to the farm production (De Meyer and Copeland, 2005; White, 2006). Among *Dacus*, species from the subgenus *Lophodacus* Collart are mainly associated with male flowers of cucurbits. This is the case of *Dacus* (*Lophodacus*) *hamatus* Bezzi reported only from male flowers of *Lagenaria sphaerica* (Sonder) Naudin (Cucurbitaceae) and *Dacus* (*Lophodacus*) *inornatus* Bezzi from *L. sphaerica* and *Peponium mackenii* (Naudin) Engler (Cucurbitaceae) (White, 2006).

Both species are encountered in Democratic Republic of Congo, Ethiopia, Kenya, Rwanda, South Africa, Tanzania, Uganda, Zimbabwe and Nigeria (Cogan and Munro, 1980; Thompson, 1998; White, 2006). By contrast, *D*. (*Lophodacus*) *hamatus* was solely observed in Malawi, Angola, Burundi, Mozambique and Togo (Cogan and Munro, 1980; Thompson, 1998. White, 2006; White and Goodger, 2009), whereas *D.* (*Lophodacus*) *inornatus* in Gabon, Guinea and Liberia (White, 2006).

Until now, none of these fruit fly species has been reported in Cameroon, even less on male flowers of cucurbit species. However, at the best of our knowledge, no detailed study has been conducted under field conditions on whether the female fruit flies within *Dacus* (*Lophodacus*) exhibit some preference in the selection of oviposition sites among several species of cucurbits. The present paper reports the first record of *D. hamatus* in Cameroon with some notes on its newly described host plant, *L. siceraria*.

MATERIALS AND METHODS

Study sites

The study was carried out in two sites situated in two agro-ecological zones in the southern part of Cameroon (Figure 1): (1) the southern plateau at Yaounde (Centre Region), in an experimental garden of the University of Yaounde I (Campus-UYI) (3°51'28.9"N, 11°29'52.2"E, 729 m asl), with humid tropical bimodal rainfall regime and (2) the western highlands at Koutaba (West Region), in the domain of the Catholic Cistercian Monastery, situated near Tchouffa village (5°38'47"N, 10°48'20" E; 1181 m asl) with humid tropical unimodal rainfall regime. Observations were conducted from November 2010 to February 2011 during dry period at both sites.

Biological model

The biological material involved the cucurbit species, which are among the most important and domesticated flowering plants with a world-wide distribution (Dupriez and De Leener, 1987; Schippers, 2004). In this family, seven species belonging to six genera: *Citrullus lanatus* (Thumberg) Mansfeld, *Cucumis melo* Linneaus, *Cucumis sativus* Linneaus, *Cucumeropsis mannii* Naudin, *Cucurbita moschata* (Duchesne ex Lamark) Duchesne ex Poiret, *Sechium edule* (Jacquin) Swartz and *Lagenaria siceraria* (Molina) Standley with two varieties (the bitter and the sweet) were experimentally followed. Over the all sample, flowers of *L. siceraria* and *S. edule* are white in colour while those of the five other species range from yellow to bright orange.

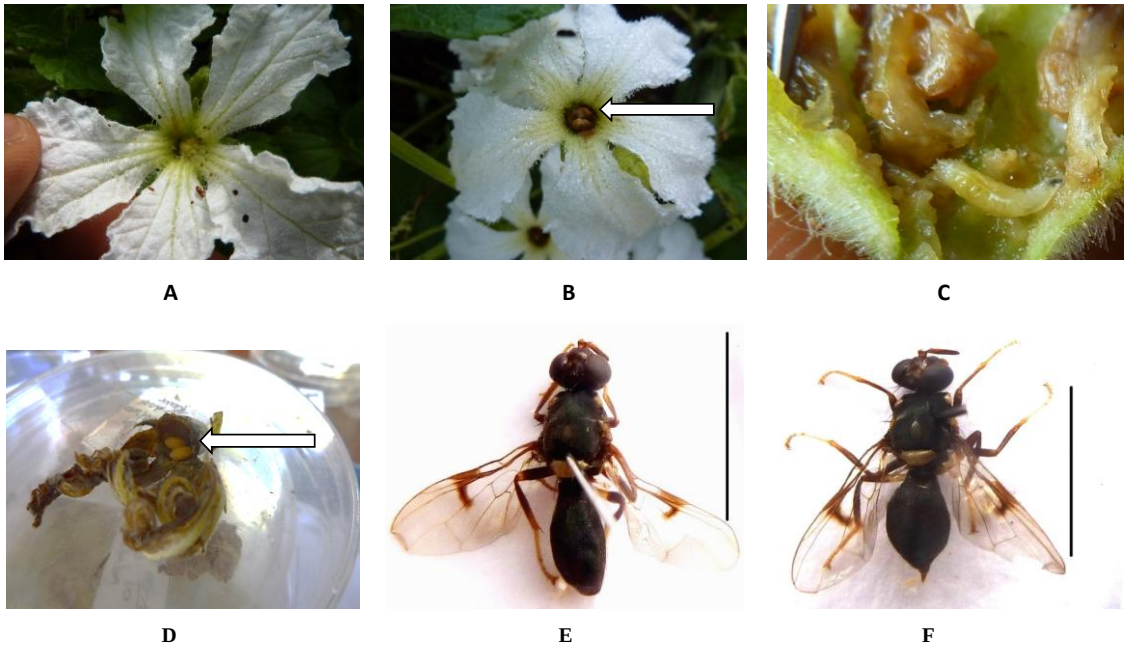

Figure 2. Fly's damage on *Lagenaria siceraria* males flowers (A-D) and adult flies of *Dacus* (*Lophodacus*) *hamatus* (E-F). Legend: A = healthy flower, B = damaged flower, C = dissected damaged flower showing fly larvae, D = dissected damaged flower showing fly pupae, E = male of *D. (Lophodacus) hamatus*, and F = female of *D. (Lophodacus) hamatus.*

Experimental design

The experimental design consisted of 16 plots of 16 m^2 each (8 m × 2 m), with two plots per plant species or varieties.

Collecting data and identification methods

With exception of *L. siceraria*, the male and female flowers of the other cucurbit species bloomed early in the morning, at the same time and started closing up in the afternoon. Concerning *L. siceraria*, this period was highly variable according to the regions.

To estimate the severity of pest infestations, as well as the number of individual per infested organs, crop must be sampled. During samplings, all the flowers and fruits of each plant species or variety were weekly examined. On young flowers before blooming, the oviposition sites were externally materialized by the presence of some black spots, while on those bloomed, decaying started before withering and fallen (Figure 2A, B, C and D). The infested plant organs were collected and taken individually to the laboratory. Then flowers were dissected and larvae (Figure 2C), when present, were counted and reared in Petri dishes provided with a piece of wet cotton. The attacked fruits were recognized by the presence of exudates at oviposition site. Fruits were weighted and incubated individually in plastic boxes, containing sand at the bottom and covered with a piece of gauze. Incubations were followed up to the emergence of adult insects (fruit flies and/or parasitoids). Emerged adults of fruit flies (Figure 2E and F) and parasitoids were preserved in 70% ethanol for further identification and voucher collections.

Initial identification was carried out with the help of identification keys developed by White (2006) and White and Goodger (2009) for the flies (Diptera: Tephritidae), Wharton and Gilstrap (1983) and Wharton et al. (1992) for parasitoids (Hymenopterans). Identifications of fruit fly were later checked and confirmed by Dr I. M. White at the Natural History Museum of London (NHML) and by the taxonomists of the Royal Museum for Central Africa (RMCA) at Tervuren (Belgium). The expertise of the taxonomist of the "Centre International de Recherche Agricole pour le Développement/Centre de Biologie et de Gestion des Populations" (CIRAD/CBGP) at Montpellier (France) was required for identification of parasitoids. Voucher specimens were deposited in the collection of the Laboratory of Zoology, Faculty of Sciences, University of Yaounde I (Cameroon) and in the collection of the above cited institutions.

Data analysis

On each variety of *Lagenaria siceraria,* the rate of infested male flowers (rt inf fl) was evaluated based on the following formulae:

$$\text{rt inf fl} = \frac{\text{nb inf fl}}{\text{nb fl ex}}$$

In which nb inf fl is the number of infested flowers while nb fl ex is the number of flowers examined. The mean number of *D. hamatus* larvae per male flower for each variety of *L. siceraria* was also recorded. Then, because the data did not follow a Gaussian distribution, the Kruskal-Wallis test with associated Dunnett's post-test was applied in order to check differences in the studied parameters, both among the two varieties of *L. siceraria* and the study localities. The significance level was preset at 0.05. These procedures were performed in GraphPad Prism 5. 04 (Prism 5, 2010).

RESULTS

A total of 1756 and 1413 male flowers from the seven

Table 1. Total number of male flowers produced by seven species of cucurbits and those infested by fruit flies (Diptera: Tephritidae) in two localities of southern Cameroon, from November 2010 to February 2011.

Localities		Yaounde	Koutaba	Yaounde	Koutaba	Yaounde	Koutaba
Cucurbit species studied		**Total number of male flowers produced**		**Total number of male flowers damaged**		**Total number of male flowers damaged by *Dacus* (*Lophodacus*) *hamatus***	
Lagenaria siceraria	Bitter variety	400	535	325	506	196	320
	Sweet variety	385	155	385	135	142	74
Citrullus lanatus		757	890	85	67	0	0
Cucumis melo		175	500	67	50	0	0
Cucumis sativus		200	345	99	87	0	0
Cucumeropsis mannii		600	900	97	63	0	0
Cucurbita moschata		1295	897	693	501	0	0
Sechium edule		650	1010	5	4	0	0
Total		4462	5232	1756	1413	338	394

species of cucurbits were examined at Yaounde and Koutaba respectively (Table 1). Out of 338 and 394 infested male flowers of *L. siceraria,* 57.99% and 42.01%; 81.22% and 18.78% from the two varieties (the bitter and the sweet) respectively in both localities were oviposited by the female of *D. hamatus* (Table 1). Indeed, the maggots of this fly were observed feeding and ending their development cycle on the flowers of this host plant chosen by females of *D. hamatus*. During day time, females of *D. hamatus* were rarely observed under field conditions. The oviposition was probably realized by night, mostly on the young male flowers before blooming. For instance, eggs and first instar larvae were frequently observed in the collected samples of this category; while old larvae were frequently observed in bloomed flowers of *L. siceraria* during sampling.

Under laboratory conditions, the larvae of *D. hamatus* were able to feed and achieve their development also on the flowers and fruits of the cucurbit species studied. Moreover, three other fruit flies species namely *Dacus* (*Dacus*) *bivittatus* Bigot, *Dacus* (*Dacus*) *punctatifrons* Karsch and *Dacus* (*Didacus*) *ciliatus* Loew were reared from the flowers of *C. moschata*.

In Yaounde, a mean of 46.29 ± 8.56 and 38.50 ± 7.08 male flowers of bitter and sweet varieties of *L. siceraria* respectively, were found infested during each sampling day by the larvae of *D. hamatus,* while in Koutaba, 101.20 ± 9.67 and 27.00 ± 4.35 male flowers of bitter and sweet varieties, respectively were also observed infested with the flower feeders. The density of *D. hamatus* expressed as the mean weekly infestation rate of male flowers was significantly ($P < 0.05$) greater in Koutaba than in Yaounde with 57.63 ± 3.41% (Min: 41.54%, Max: 76.92%) against 52.36 ± 5.72% (Min: 9.52%, Max: 90.91%), respectively. At the level of the plant variety, the weekly mean infestation rate of male flowers was significantly greater on the bitter variety than on the sweet (with the $P < 0.05$) at both the locations (Figure 3). Moreover, between localities, the weekly mean infestation rates of male flowers did not vary on the bitter variety (Figure 3). Koutaba hosted a significantly higher mean number of larvae per flower per sampling date (mean: 1.67 ± 0.05, Min: 1, Max: 5, N = 475) than Yaounde (mean: 1.45 ± 0.04, Min: 1, Max: 6, N = 394) ($P < 0.05$). Also, compared to the sweet variety, the bitter variety appeared the most suitable as it hosted significantly greater number of larvae per male flower at both locations ($P < 0.05$) (Figure 4). While on the bitter variety the mean number of larvae per male flower was significantly greater in Koutaba ($P < 0.05$), on the sweet variety, a reverse phenomenon was recorded (Figure 4).

A total of 3225 (57.12% of the total number of fruits investigated) and 1313 (47.87%) infested fruits of the seven cucurbit species investigated in this study were harvested at Yaounde and Koutaba (Table 2). No adult of *D. hamatus* emerged from damaged fruits of all the cucurbits species incubated while, four other fruit fly species namely *D. bivittatus*, *D. punctatifrons, D. ciliatus*, and *Dacus* (*Didacus*) *vertebratus* Bezzi were recorded. Therefore, *D. hamatus* appears to be

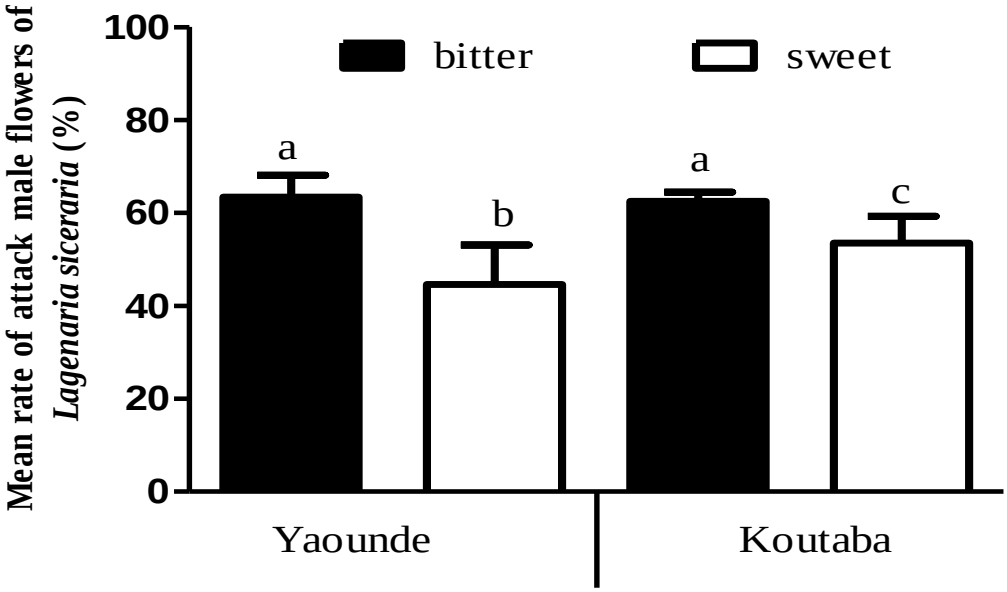

Figure 3. Mean infestation rate of male flowers of two varieties of *Lagenaria siceraria* by the larvae *Dacus* (*Lophodacus*) *hamatus* at two locations of Cameroon, from November 2010 to February 2011. Legend: bars with different letters are significantly different among sites and varieties at P < 0.05.

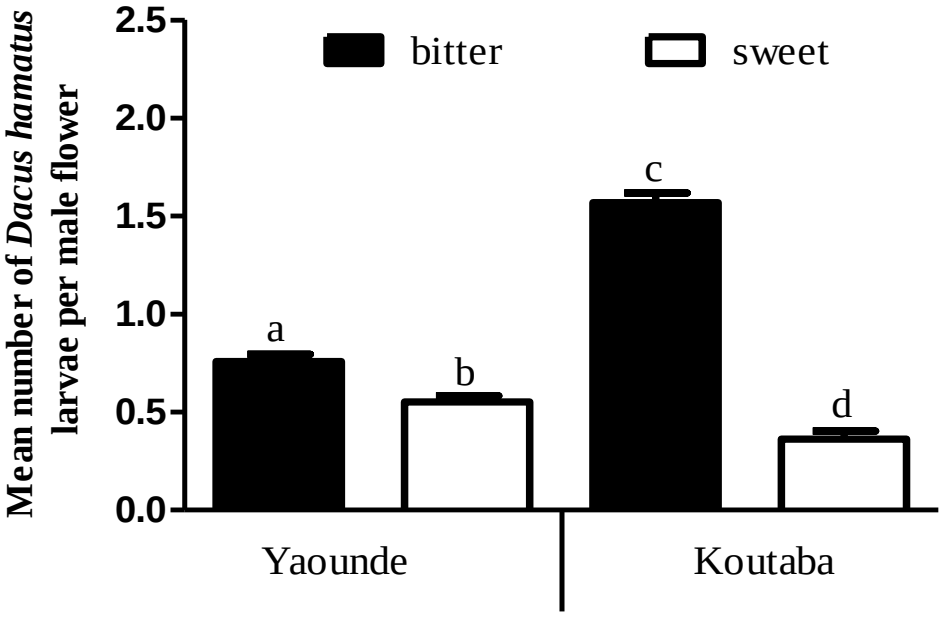

Figure 4. Mean number of *Dacus* (*Lophodacus*) *hamatus* larvae per male flower on two varieties of *Lagenaria siceraria* at two locations of Cameroon, from November 2010 to February 2011. Legend: bars with different letters are significantly different among sites and varieties at P < 0.05.

specific to the male flowers of *L. siceraria* at least under field conditions.

An unidentified parasitoid of the genus *Fopius* Wharton, (Hymenoptera: Braconidae: Opiinae) was recorded from parasitized larvae of *D. hamatus* from samples of Koutaba location. However, the parasitism rate remained

Table 2. Total number of fruits produced by seven species of cucurbits and those infested by fruit flies (Diptera: Tephritidae) in two localities of southern Cameroon from November 2010 to February 2011.

Localities		Yaounde	Koutaba	Yaounde	Koutaba
Cucurbit species		**Total number of fruit produced**		**Total number of fruits infested by fruit flies**	
Lagenaria siceraria	Bitter variety	520	273	240	82
	Sweet variety	87	84	52	54
Citrullus lanatus		290	68	176	53
Cucumis melo		407	47	76	11
Cucumis sativus		921	354	319	138
Cucumeropsis mannii		189	83	129	29
Cucurbita moschata		2454	1745	1913	997
Sechium edule		514	64	152	16
Total		5646	2743	3225	1313

low as only two individuals of parasitoid emerged *versus* 659 fruit flies.

DISCUSSION AND CONCLUSION

The present study reported here the first record of *D. hamatus* in Cameroon, where the reported species found in both the locations *viz*. Yaounde in the southern plateau and Koutaba in the western highlands of Cameroon. Presently, this fruit fly species has been recorded from several African countries (Cogan and Munro, 1980; Thompson, 1998; White, 2006; White and Goodger, 2009) including Nigeria, a border country of Cameroon.

In natural conditions, and among seven species of cucurbits studied, the female of *D. hamatus* laid eggs only on male flowers of *L. siceraria*. In Cameroon, *L. siceraria,* with two varieties, is cultivated either for the gourd or for seeds. The bitter varieties is known in Sanskrit as Katutumbi and a sweet one, called Alābu (Chinyere et al., 2009). Globally, cucurbits differ qualitatively in production of cucurbitacin whose rate increases the bitterness of the plant (Gould, 1978).

D. hamatus maggots were observed in the infested male flowers of *L. siceraria* but not in fruits. In fact, oviposition behaviour of phytophagous insects is influenced either by the variation of preference (choice of oviposition or nutrition sites) or motivation (accessibility of food resource, shape and colour) (Singer et al., 1992). Moreover, under laboratory conditions, larvae were able to develop on the flowers and the fruits of all the cucurbits investigated in the present study. This result corroborates the hypothesis of Raghu et al. (2004) who stated that in Diptera, larvae remain and feed only on plant organs on which eggs were laid, suggesting a high specificity in the oviposition site selection by females. In our study, the plant organs of these cucurbits were all available in the plots, thus, preference may have predominated in host plant selection by the females of the species.

Some species in the genus *Lagenaria* exhibits a strong relationship with certain species of fruit flies of the subgenus *Dacus* (*Lophodacus*) (White 2006).

However, the association observed between the fly *D. hamatus* and the plant *L*. *siceraria* is new, since hitherto, the only recorded host plant of this fly was *Lagenaria sphaerica* in Nigeria (White 2006). This discovery extends the host plants spectrum of the fly and argues in favour of the hypothesis that *D. hamatus* would be closely associated with male flowers of plants from the genus *Lagenaria*. Indeed, the ability of a phytophagous insect to expand its host plant range depends both of the digestive physiology of larvae and the adult plasticity in oviposition site selection (Fitt, 1986).

Even when flowers and fruits of the seven studied cucurbit species were available in the garden, no adult of *D. hamatus* emerged from incubated fruits, neither from those of *L. siceraria*. By contrast, our study showed other species of the genus *Dacus* which preferentially feed on fruits; their adults frequently emerged from infested fruits. White and Elson-Harris (2004) reported these *Dacus* species as fruits flies of economic importance in the Old World tropics. In the subfamily Dacinae, the relationship between host plants and flies is thought to be particularly strong, since the host plant is considered central for larval and adult feeding, mating and oviposition (Raghu et al., 2004).

Tephritids use both visual and chemical signals to locate and access habitat, adult food, oviposition sites and mating resources (Papadopoulos et al., 2006). The mean infestation rates of male flowers as well as the mean number of larvae per male flower were more important in Koutaba than in Yaounde. Furthermore, at each location, the mean rate of infested male flowers and the mean number of larvae per male flowers was significantly greater on the bitter variety than on the sweet one. This result suggests that the bitter variety is more suitable for the fly. Overall male flowers, those of *L. siceraria* and *S. edule* are white in colour while that of the

five other species range from yellow to bright orange. In this context, the variation of the infestation rate within male flowers of *L. siceraria* varieties suggests the existence of a recognition factor (such as among those of cucurbitacin) used by the adults in the identification of oviposition sites selection. The efficiency of this factor may be linked to the relationship between the chemical composition of the plant and the chemoreceptors of the insects and may vary within the plant species and/or varieties. According to Raghu et al. (2004), the microclimate and the host plant architecture influence significantly the abundance and the behaviour of phytophagous insects. Infestation by depredators may vary according to agro-ecological conditions (southern plateau *versus* western highlands) and the plants organs (flowers *versus* fruits) which can probably emit several specific volatile organic compounds. Further investigations are to be done in order to identify volatile organic compounds involved in the association between *L. siceraria* and *D. hamatus*.

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REFERENCES

Aluja M, Mangan RL (2008). Fruit fly (Diptera: Tephritidae) host status determination: critical conceptual, methodological and regulatory considerations. Annu. Rev. Entomol. 53:473-502.

Chinyere GC, Akubugwo EI, Chinenye NI, Ugbogu AE (2009). Nutritive value of *Lagenaria sphaerica* seed (wild bottle gourds) from South-Eastern Nigeria. Pak. J. Nutr. 8:284-287.

Cogan BH, Munro HK (1980). Superfamily Tephritoidea. In: Crosskey RW (ed) Catalogue of the Diptera of the Afrotropical Region, London, British Museum of Natural History, pp. 518-553.

De Meyer M, Copeland RS (2005). Description of new *Ceratitis* MacLeay (Diptera:Tephritidae) species from Africa. J. Nat. Hist. 39:1283-1297.

Drew RAI (1989). The taxonomy and distribution of tropical and subtropical Dacinae (Diptera: Tephritidae). In: Robinson AS, Hooper G (eds) Fruit flies: their biology, natural enemies and control, Netherlands, Elsevier, pp. 13-14.

Dupriez H, De Leener P (1987). Jardins et vergers d'Afrique, Paris, L'Harmattan.

Fitt GP (1986). The roles of adult and larval specializations in limiting the occurrence of five species of *Dacus* (Diptera: Tephritidae) in cultivated fruits. Oecologia 69:101-109.

Gould F (1978). Resistance of cucumber varieties to *Tetranychus urticae*: genetic and environmental determinations. J. Econ. Entomol. 71:680-683.

GraphPad Prism 5.04 (2010). Prism 5 for Windows, GraphPad Software Inc., San Diego Caliifornia USA, www.graphpad.com.

Papadopoulos NT, Kouloussis NA, Katsoyannos BI (2006). Effect of plant chemicals on the behavior of the mediterranean fruit fly. pp 97-106 *in* Fruit flies of economic importance: from basic to applied knowledge. Proceeding of the 7th international symposium of fruit flies of economic importance, Salvador, Brazil.

Prabhakar CS, Sood P Mehta PK (2012). Fruit fly (Diptera: Tephritidae) diversity in cucurbit fields and surrounding forest areas of Himachal Pradesh, a North-Western Himalayan state of India. Arch. Phytopathol. Plant Protect. 45(10):1210-1217.

Raghu S, Drew RAI, Clarke AR (2004). Influence of host plant structure and microclimate on the abundance and behavior of a tephritid fly, J. Insect Behav. 17:179-190.

Schippers RR (2004). Légumes africains indigènes, présentation des espèces cultivées. Wageningen, Margraf Publishers.

Singer MC, Vasco D, Parmesan C, Thomas CD, NG D (1992). Distinguishing between "preference" and "motivation" in food choice: an example from insect oviposition, Anim. Behav. 44:463-471.

Thompson C (1998). Fruit fly expert identification system and systematic information database are source for identification and information on fruit flies and maggots, with information on their classification, distribution and documentation, Leiden, Backhuys.

Virgilio M, De Meyer M, White IM, Backeljau T (2009). African *Dacus* (Diptera: Tephritidae): molecular data and host plant associations do not corroborate morphology based classifications. Mol. Phylogenet. Evol. 51:531-539.

Wharton RA, Gilstrap FE (1983). Key to and status of Opiinae braconid (Hymenoptera) parasitoids used in biological control of *Ceratitis capitata* and *Dacus s. l.* (Diptera: Tephritidae). Ann. Entomol. Soc. Am. 76:721-742.

Wharton RA, Shaw SR, Sharkey NJ, Wahl DB, Woolley JB, Whitfield JB, Marsh PM, Johnson W (1992). Phylogeny of the subfamilies of the family Braconidae (Hymenoptera: Ichneumonoidae): A reassessment. Cladistics 8:199-235.

White IM (2006). Taxonomy of the Dacina (Diptera: Tephritidae) of Africa and the Middle East. Afr. Entomol. Memoir 2:1-156.

White IM, Elson-Harris MM (2004). Fruit flies of economic significance: their identification and bionomics, London, CAB/ACIAR.

White IM, Goodger KFM (2009). African *Dacus* (Diptera: Tephritidae); new species and data, with particular reference to the Tel Aviv University Collection. Zootaxa 2127:1-49.