

# Status of Fruit Flies (Diptera: Tephritidae) in Côte d'Ivoire and Implications for Mango Exports

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**ABSTRACT :** In Côte d'Ivoire, the mango production, all varieties combined, is estimated to reach 100 000 tons, of which approximately 10,000 tons are annually exported since 1999. Fruit flies, Diptera (Tephritidae), represent the most important constraint for the development of export. The aim of this study was to identify the species responsible for the damages and to evaluate their economic impact. A survey was conducted in three different ecological regions in order to determine the relative importance and the population fluctuations of Tephritidae species, using traps baited with sexual and food attractants. In addition, the main mango varieties for export were sampled to identify the pests. The relative incidence of various pests was compared with the level of mangoes exported. In 2000, 42.3 % of mangoes intended for export were damaged by fruit flies. The six most frequent species were *Ceratitis cosyra* (83.43 %), *C. fasciventris* (8.24 %), *C. anonae* (6.84 %), *C. ditissima* (0.91 %), *C. punctata* (0.15 %) and *Dacus bivittatus* (0.42 %). Outbreaks were observed from February to June, with a peak in April corresponding to the mango season in northern Côte d'Ivoire, the region providing the major part of mango production. Since 2005, the outbreak of *Bactrocera invadens*, a newly introduced species, has modified this situation by overcoming *C. cosyra* in damage. To address this situation, a regional integrated pest management program should be initiated in West Africa.

**Key Words:** *Ceratitis cosyra*, *Bactrocera invadens*, *Dacus bivittatus*, economic importance

## 1. INTRODUCTION

Cotton (398,000 t), cashew nuts (80,000 t) and mangoes (40,000 t) are the main cash crops in northern Côte d'Ivoire, with respectively 62.5, 18.8 and 7 billions FCFA (N'da Adopo *et al.*, 2001). The total mango production is estimated to reach 100,000 t (ANADER, 2001) while export stagnates at about 10,000 t since 1999. Production for export is exclusively provided by the northern region. Four varieties are essentially exported: Amélie and Zill (less than 20 %), Kent and Keitt (more than 80 %).

Mango production and export are unfortunately threatened by two phytosanitary problems: the mango mealybug (*Rastrococcus invadens* Williams, Pseudococcidae) and fruit flies (Tephritidae) (N'guetta and Hala, 1999). Mango production losses were recorded these last years: 34 % were caused by fruit

flies (Hala and Kéhé, 2002) and 53 % by *R. invadens* (Hala *et al.*, 2004).

Since the beginning of Ivorian crisis in September 2002, research activities on fruit flies have gone slow in the non governmental zone represented by the half northern part of the country. Research on this topic has been restricted to the half southern country and dealt essentially with the inventory and the population fluctuations of tephritids.

This paper describes the evolution of the status of fruit flies from 2000 to 2006 in Côte d'Ivoire.

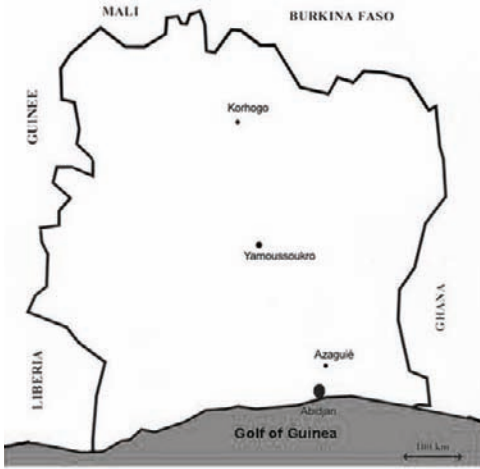
## 2. MATERIAL AND METHODS

### Localisation

Surveys were carried out in Korhogo, Yamoussoukro, Azaguié and Abidjan areas (Figure 1). The northern part of the country is located in the beginning of dry tropical zone characterized by savannahs and one rainy season. The wet period in this area extends from May to November with a peak in

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August with a total raining reaching 1,200 to 1,600 mm/year. The Central part of the country includes pre-forestry and savannah vegetations and presents two dry and to wet seasons, with only 1,100 mm rainfall per year. The southern part of the country extends from the dense forest of humid tropical zones to the littoral and shows two short dry and two long rainy seasons with more than 1,500 mm/year.



**Figure 1:** Sites of fruit flies survey in Côte d'Ivoire.

### Collection of mangoes and fruit flies rearing

Three major exported varieties, Amelie, Kent and Keitt, were sampled from April to August, according to mangoes availability.

In 2000, samples were collected in farmer's orchards in the North within a radius of 150 km around Korhogo. In 2005 and 2006, qualitative and limited samplings were concentrated during June at Korhogo research station. Similar methods were carried out during May to June in Yamoussoukro and in May in Abidjan. Rearing devices to process collected fruits were set up in laboratory.

### Traps setting

Trapping activities were carried out at three research stations:

- During 2000, during 12 weeks, at Korhogo (with methyl eugenol, trimedlure, cue lure

and protein bait) in two sites (one mango orchard and one natural forest);

- From 2000 to 2002, in one mango orchard at Korhogo (with terpinyl acetate and methyl eugenol);

- During 2005 at Yamoussoukro in one mango orchard and from 2005 to 2006 at Azaguié in a mangosteen field (with methyl eugenol, trimedlure and cue lure).

### Fruit flies identification

After a first sorting out, all the samples of flies were sent for identification in 2000 to the International Center of Insect Physiology and Ecology (ICIPE) and to the Royal Museum of Central Africa (RMCA) from 2005 to 2006.

### Effect of fruit flies on mango export

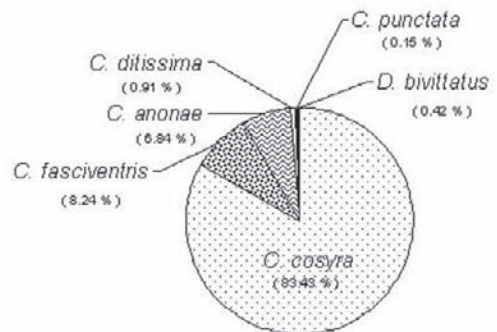
The level of exported mangoes was compared to the losses and various damages due to fruit flies (samples collected in farmer's orchards).

## 3. RESULTS

### Inventory of fruit flies species affecting mangoes in the three ecological study zones

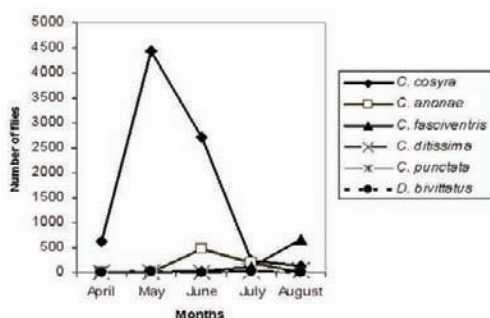
- Korhogo:

During 2000, 6 species of Tephritidae were identified in exported mangoes varieties (Figure 2):



**Figure 2:** Proportions of the six tephritid species reared from mangoes at Korhogo in 2000.

*Ceratitis cosyra* (83.43 %), *C. fasciventris* (8.24 %), *C. anonae* (6.84 %), *C. ditissima* (0.91 %), *Dacus bivittatus* (0.42 %) and *C. punctata* (0.15 %). *Ceratitis cosyra* appeared in April, early in the mango campaign and reached a peak in May before decreasing in July (Figure 3).



**Figure 3:** Populations fluctuations of the six tephritid species reared from mangoes at Korhogo in 2000.

*Ceratitis anonae* arrived in the middle of May and reached a maximum in June before disappearing in August. *Ceratitis fasciventris* and *C. ditissima* came up lately from middle of May to early June. *Bactrocera invadens*, a new species, has been identified in 2005 in the samples. In 2006, this species represented 63 % of fruit flies, supplanting *C. cosyra* (37 %) (Table 1).

- Yamoussoukro:

*Bactrocera invadens* represented already 99 % in 2005 and *C. cosyra* was absent; it was the only species present in mangoes in 2006 (Table 1).

- Abidjan:

In 2005 the rates were 97 % and only 3 %, respectively for *B. invadens* and *C. cosyra* in mangoes. By 2006, recent collections showed 50 % of *B. invadens* and 50 % of *D. bivittatus* (Table 1).

**Table 1:** Proportions (%) of the different fruit fly species reared from mangoes

Species	Korhogo			Yamoussoukro			Abidjan (*)		
	2000	2005	2006	2000	2005	2006	2000	2005	2006
<i>C. cosyra</i>	83.43	0.00	37.00	-	0.00	0.00	-	3.00	0.00
<i>C. fasciventris</i>	8.24	0.00	0.00	-	0.00	0.00	-	0.00	0.00
<i>C. anonae</i>	6.84	0.00	0.00	-	0.00	0.00	-	0.00	0.00
<i>C. ditissima</i>	0.91	0.00	0.00	-	0.00	0.00	-	0.00	0.00
<i>C. rosa</i>	0.00	0.00	0.00	-	0.40	0.00	-	0.00	0.00
<i>C. punctata</i>	0.15	0.00	0.00	-	0.00	0.00	-	0.00	0.00
<i>D. bivittatus</i>	0.42	5.70	0.00	-	0.20	0.00	-	0.00	50.00
<i>Dacus spp.</i>	0.00	4.70	0.00	-	0.40	0.00	-	0.00	0.00
<i>B. invadens</i>	0.00	88.60	63.00	-	99.00	100	-	97.00	50.00
<i>B. cucurbitae</i>	0.00	1.00	0.00	-	0.00	0.00	-	0.00	0.00

(\*): non eligible variety for export

## Trapping

From 2000 to 2002, in the mango orchard at Korhogo, 8 species of fruit flies were caught using terpinyl acetate (99.18 % of *C. cosyra*) and methyl eugenol (70.74 % of *C. breinii*) (Table 2). *Ceratitis cosyra* (major pest in the mangoes) was present all year long in the mango orchards in the North, with peaks from April to June (Figure 4).

In 2000, trapping results during 12 weeks, both in a mango orchard and in a natural forest, showed 22 species among which the most important were *C. cosyra*, *C. breinii*, *C. fasciventris*, *C. capitata* and *D. bivittatus* (Table 3). From 2005 to 2006, the population fluctuations of *B. invadens*, currently the major fruit fly in mangoes, revealed its presence all year long. Its populations showed low levels

**Table 2:** Proportions (%) of the different fruit fly species caught by trapping from 2000 to 2002 at the Korhogo research station

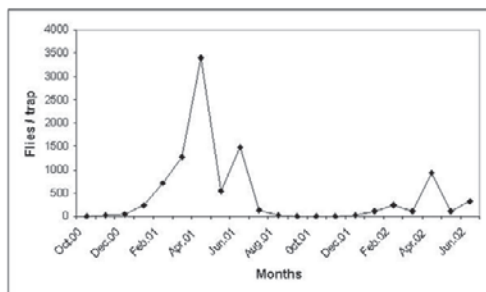
Espèces de Tephritidae	Parapheromone	
	Terpinyl acetate	Methyl eugenol
<i>C. cosyra</i>	99.18	1.06
<i>C. anonae</i>	0.55	11.17
<i>C. capitata</i>	0.05	3.19
<i>C. ditissima</i>	0.03	11.70
<i>C. quinaria</i>	0.14	0.00
<i>C. breinii</i>	0.01	70.74
<i>C. rosa</i>	0.03	0.00
<i>Dacus spp.</i>	0.01	2.13

**Table 3:** Tephritidae flies trapped in an orchard and in a dry forest during 12 weeks at Korhogo in 2000

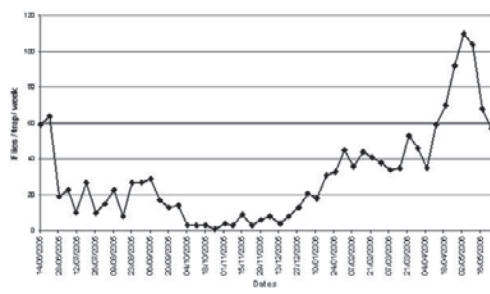
Tephritidae species	Mango orchard					Natural dry forest (non cultivated)				
	Protein bait	Cue Lure	Trimed-lure	Methyl Eugenol	Total	Protein bait	Cue Lure	Trimed-lure	Methyl eugenol	Total
<i>C. cosyra</i>	214	90	1	0	305	2	0	0	0	2
<i>C. silvestrii</i>	29	1	0	0	30	0	0	0	0	0
<i>C. capitata</i>	1	0	44	0	45	0	0	11	0	11
<i>C. rosa</i>	1	1	1	0	3	0	0	0	0	0
<i>C. breinii</i>	6	0	0	50	56	0	0	1	63	64
<i>C. quinaria</i>	1	1	0	0	2	0	0	0	0	0
<i>C. fasciventris</i>	2	3	16	0	21	9	0	187	0	196
<i>C. punctata</i>	56	0	0	2	58	0	0	0	1	1
<i>C. flexuosa</i>	0	1	0	0	1	0	0	0	0	0
<i>C. anonae</i>	4	0	6	0	10	0	0	4	0	4
<i>C. flava sp.n.</i>	2	0	4	0	6	3	0	9	0	12
<i>C. pedestris</i>	0	0	2	0	2	0	0	1	0	1
<i>T. coffeae</i>	0	0	0	1	1	0	0	0	0	0
<i>D. bivittatus</i>	134	2 448	0	1	2 583	0	50	0	0	50
<i>D. eclipsus</i>	0	14	0	0	14	0	4	0	0	4
<i>D. vertebrates</i>	0	0	0	0	0	0	3	0	0	3
<i>Dacus sp1</i>	1	0	0	0	1	0	6	0	0	6
<i>D. lounsburyii</i>	0	0	0	0	0	1	0	0	0	1
<i>B. cucurbitae</i>	1	18	0	0	19	0	0	0	0	0
<i>C. scutella (*)</i>	1	0	0	0	0	1	0	0	0	1
<i>Dacus sp2</i>	0	0	0	0	1	0	8	0	0	8
<i>Dacus sp3</i>	0	0	0	0	0	0	8	0	0	8
<b>Total</b>	<b>453</b>	<b>2 577</b>	<b>74</b>	<b>54</b>	<b>3 158</b>	<b>16</b>	<b>79</b>	<b>213</b>	<b>64</b>	<b>372</b>

(\*) : C. = *Carpophthoromyia*C. = *Ceratitis*; T. = *Trirhithrum*; D. = *Dacus*; B. = *Bactrocera*

from October to December and higher levels in May, reaching over than 100 flies / trap / week during that period (Figure 5).



**Figure 4:** Population fluctuations of *Ceratitis cosyra* caught in traps baited with terpinyl acetate in a mango orchard at the Korhogo research station from 2000 to 2002.

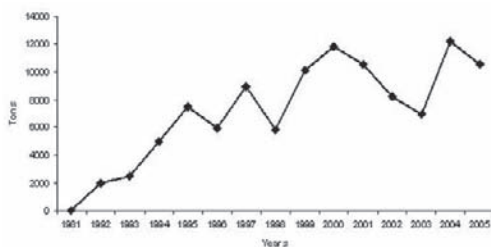


**Figure 5:** Population fluctuations of *Bactrocera invadens* caught in traps baited with methyl-eugenol at Azaguié during 12 months (2005-2006).

### Importance of mango export

Export of mango by the country began in 1981 and increased regularly up to 1996. A fluctuating production due to natural physiological behaviour of trees during blooming periods, is observed from one year to another (Figure 6). In 1997, Côte d'Ivoire with 8,939 tons exported, became the second supplier of mangoes on the European Union market, following Brazil and before South Africa. Since this period, shipments fluctuated from 8,000 to 10,000 tons per year. Unfortunately in 2003, due to the beginning of the crisis in September 2002, the rate of export following dropped to 6,943 tons. The operators of the sector reacted face to this situation and ship-

ments are increasing again. For 2006, the expectations are 10,000 tons. The mango campaign starts around the middle of March with varieties Amélie and Zill and ends in June with Kent and Keitt. The exporters are not farmers. The packaging stores belong to the exporters and are exclusively localised in the North, close to production areas. Seventeen exporters were recorded in 2006. Export is done mainly by shipping. Export by air reached 5 % to 6 %, respectively in 2004 and 2005. The export and local trade combined, generate a turn-over of about US \$ 13,500,000. This income is distributed among the producers, the exporters and all the private and public actors of the sector.



**Figure 6:** Evolution of mango export from Côte d'Ivoire.

### Impact of fruit flies

In 2000, according to a large assessment of losses and survey in fields and orchards, the proportion of the varieties for export affected by fruit flies was estimated to be 42.3 %. Usually, mangoes for export are selected in the orchards before harvest and checked a second time before packaging. The first sorting in the orchards permits a reduction of the risk to collect stung fruits. The second sorting on harvested mangoes in the packaging store, generally gives a maximum of 5 - 10 % of ineligible fruits due to fruit flies. Other undesirable factors detected before packaging (size or maturity stage, anthracnose and various diseases) are responsible for a maximum of 10 % of non exportable fruits. Owing to the dispositions taken to respect the norm for

export and the current rules on the European Union market, losses of expected income due to fruit flies are estimated around US \$ 285,000 for the mango export.

#### 4. DISCUSSION

##### Tephritidae species involved in mango infestations

In 2000, *C. cosyra* was identified as 83.43 % of fruit flies infesting mangoes in Northern Côte d'Ivoire. Its major importance was already noted by N'guetta (1994), Barbet (2000) and then by Hala and Kéhé (2002). This pest affects a wide range of host plants in a large geographical area through Africa. In Mali, it represents 86 % of the fly populations in fruits and also affects dangerously the neighbouring countries (Vayssières *et al.*, 2004).

*Bactrocera invadens* has modified the previous situation in Côte d'Ivoire by overcoming *C. cosyra* and becoming progressively the only species in most mango samples (Table I). This result suggests an interspecific competition among different mango fruit flies species. Coming from Asia, *B. invadens* was spread first in East Africa (Lux *et al.*, 2003) before reaching countries in other parts of Africa, especially Western Africa (Vayssières *et al.*, 2005; Drew *et al.*, 2005). Since 2000, *D. bivitatus* was regularly reported on mangoes in Côte d'Ivoire but with a low prevalence (Barbet, 2000).

##### Trapping

Twenty two species of Tephritidae of which 6 affect mangoes have been identified after being collected in Côte d'Ivoire by trapping. Fruit crops are subject to a high potential risk of injuries. In addition, the presence of fruit flies all year long indicates the importance of other host plants in the absence of mango fruits at a susceptible stage. Barbet (2000), using terpinyl acetate, trimedlure and methyl eugenol, collected 7 *Ceratitidis* species in the country while in Mali, 13 species were cap-

tured (Vayssières *et al.*, 2004). Like in Benin (Vayssières *et al.*, 2005), *B. invadens* becomes important in May and June, after *C. cosyra*.

##### Impact of fruit flies on mango export

The early apparition of *C. cosyra* at the beginning of mango campaign is an important problem in Côte d'Ivoire and Mali (Vayssières *et al.*, 2004). The high diversity of fruit flies and the important increase of their populations during this harvest period impose to end export in June. Due to their higher infestations beginning from this month, the proportion of removed mangoes from checking in packaging stores often exceeds the acceptable norms. Harvest for export becomes uneconomic and consequently mangoes collected are used exclusively for the local markets. A great deal of post harvest losses are commonly observed during this period in non export areas.

Owing to the prophylactic actions taken against fruit flies in the orchards and the sorting out upstream from the packaging stores, the quantities of ineligible mangoes for export remain relatively low. But the early end of export enormously reduces the potential production expected for shipment in the international trade. Incomes are affected and many farmers move towards other perennial cash crops like cashew nuts. In addition, these checking operations require an important well trained staff to identify the bites on the mangoes.

#### 5. CONCLUSION

Since 2005, the outbreak of *B. invadens* in Côte d'Ivoire has modified the previous mango pests' status by overcoming *C. cosyra* in damage. Export is strongly threatened by the new fruit fly species. *Dacus bivitatus* may also become another preoccupation for the actors of the mango channel despite its secondary importance. The presence of flies all year long underlines the importance of iden-

tifying the other host plants. The proliferation of these pests, and particularly of *B. invadens*, everywhere in West Africa is now of great concern. Against this problem, a regional integrated pest management program must be set up. The bio ecology of the major species listed will constitute a matter of urgency in future studies.

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