A new *Bactrocera* species in Benin among mango fruit fly (Diptera: Tephritidae) species

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A new *Bactrocera* species in Benin among mango fruit fly (Diptera: Tephritidae) species.

Abstract — Introduction. Tephritidae have a major economic importance in the tropical areas. In Benin, we had only very little information available on the mango fruit fly species, except the demonstration of their damage. We therefore carried out the first investigations in Northern Benin during the mango season in 2005. Our objectives were to study fluctuations of tephritid populations in orchards and to assess mango fruit fly infestations and mango losses due to tephritid species. **Materials and methods**. Experiments were carried out in the Parakou area (Borgou department, Northern Benin). Fruit fly males were captured on mango trees, in two different orchards, with parapheromone traps. To sample and characterize fruit fly species involved in mango infestations, fruits of 17 cultivars were collected in mango orchards from February to June 2005; then, they were brought to the laboratory for emerging species identification. To assess the loss of fruits, sampling of different mango cultivars was achieved in the same orchards. Infested fruits were counted and eliminated; potentially infested fruits were dissected. **Results and discussion**. Among eight mango fruit fly species found in Benin, four can be considered as species of economic significance: *Ceratitis cosyra*, *C. quinaria, C. silvestrii* and *Bactrocera invadens*. During the dry season, *C. cosyra* was the most abundant, whereas *B. invadens* was the most numerous during the rainy season (abiotic factor), in phenological accordance with the ripening of the different mango varieties (biotic factor). From and after mid-May, *B. invadens* was found more frequently than *C. cosyra* in the traps and from emergence of infested mangos. Loss averages varied globally from 12% at the beginning of April to 50% in June. **Conclusions**. Most of the tephritid species found on mangos during our experiments had already been observed previously in other West African countries except *B. invadens*, an invasive species lately described. Ecological and behavioral studies will be necessary in order to plan and to apply optimal methods for controlling this new pest of major economic importance in West Africa.

Benin / *Mangifera indica* / pests of plants / fruit-damaging insects / Tephritidae / identification / population dynamics / biological competition / colonizing ability

Une nouvelle espèce de *Bactrocera* détectée au Bénin parmi les mouches des fruits (Diptera : Tephritidae) inféodées au manguier.

Résumé — Introduction. Les Tephritidae ont une importance économique majeure dans les régions tropicales. Au Bénin, nous n'avions que très peu d'informations disponibles sur les espèces de mouches des fruits inféodées au manguier si ce n'est la manifestation de leurs dégâts. Nous avons donc effectué des observations préliminaires dans le Nord du Bénin durant la campagne de mangues en 2005 afin d'identifier les espèces en cause, de suivre leurs fluctuations de populations et d'estimer les pertes qui leur sont imputables. **Matériel et méthodes**. Ces expérimentations ont été effectuées dans la région de Parakou (département du Borgou). Les populations mâles de Tephritidae ont été suivies toutes les semaines dans deux types de vergers de manguiers grâce à des pièges à paraphéromones. Les fruits de 17 cultivars de manguiers ont été échantillonnés d'avril à juin 2005 ; ils ont été ensuite rapportés au laboratoire pour l'identification des espèces de mouches responsables des infestations lors de l'émergence des adultes. Pour évaluer les pertes, un échantillonnage de fruits appartenant à différents cultivars a été réalisé dans les mêmes vergers. Les fruits infestés ont été comptabilisés et éliminés ; les fruits potentiellement infestés ont été disséqués. **Résultats et discussion**. Parmi huit espèces de mouches des fruits issues des mangues au Bénin, quatre peuvent être considérées comme ayant une importance économique : *Ceratitis cosyra*, *C. quinaria, C. silvestrii* et *Bactrocera invadens*. Pendant la saison sèche, *C. cosyra* a été la plus abondante tandis que *B. invadens* a été largement dominante dès le début de la saison des pluies, en corrélation avec les stades de pré-maturité et maturité des fruits. Ainsi, à partir de la mi-mai, *B. invadens* a été de plus en plus abondante par rapport à *C. cosyra* dans les pièges de détection et parmi les adultes émergeant des mangues infestées. Les dégâts fluctuent en moyenne de 12 % en début avril à 50 % en juin, toutes espèces de Tephritidae confondues. **Conclusions**. La plupart des espèces de Tephritidae trouvées sur mangues au cours de nos expérimentations avaient déjà été observées précédemment dans d'autres pays ouest-africains à l'exception de *B. invadens*, espèce invasive nouvellement décrite. Des études écologiques et de comportement seront nécessaires afin de planifier et d'appliquer des méthodes de lutte optimales vis-à-vis de ce nouveau ravageur d'importance économique majeure en Afrique de l'Ouest.

Bénin / *Mangifera indica* / ravageur des plantes / insecte déprédateur des fruits / Tephritidae / identification / dynamique des populations / compétition biologique / aptitude à coloniser

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1. Introduction

Fruit flies are of major economic importance because many representatives of this family attack and severely damage important fruit crops, especially mangos, in tropical regions [1]. On the African continent, the genus *Ceratitis* has mostly been found associated with mango fruits. In West Africa, fruit flies attacking mangos have been studied in Ivory Coast [2], Guinea [3] and Mali [4].

In Benin, nothing was known about mango fruit fly species, except for observation of their damage symptoms. As a requisite for the knowledge of the pest insects causing such damage, individual involved species were identified and their population dynamic monitored. We therefore made the first observations in Northern Benin during the mango season of 2005. Our objectives were to study:

– fluctuations of tephritid populations from February to July in two orchard types,

– mango fruit fly infestations from February to June,

– mango losses due to fruit fly infestations from April to June.

2. Materials and methods

Our experiments were carried out in the Parakou region (Department of Borgou), in the "Northern Guinea savanna", zone which is an important area of mango production in Northern Benin.

Criteria for mango orchard selection were:

– surface with more than 8 ha of grafted cultivars ;

– plantations with more than four mango cultivars of commercial interest;

– plantations with good and regular spaces [(7 to 10) m] between the mango trees;

– plantations with owner's commitment to avoid any kind of chemical treatment.

To display fruit fly on mango trees, two different sites were chosen: a mixed mango orchard (75% mango trees and 25% guava-citrus trees) was compared with a homogeneous mango orchard (100% mango trees). Fruit fly males were monitored with parapheromone traps and are good indicators of tephritid populations. Attractants were terpinyl acetate and trimedlure for *Ceratitis* spp., and methyl eugenol for the remaining species. For each of the attractants four traps were set up at a 40-m distance from each other in both orchards.

Sampling of fruit fly species and their subsequent characterization was carried out by collecting 17 different mango cultivars: Gouverneur (= Amélie), Eldon, Zill, Julie, Ifac, Smith, Kent, Dabschar, Keitt, Springfield, Davis Haden, Palmer, Ruby, Sensation, Alphonse, Beverly and Brooks. The sampling period covered February to June 2005: every 2 weeks, ten fruits of each cultivar per site were collected and brought to the laboratory for identification of emerging species. The targeted fruit phenological stages were the prematurity stage (PMS) and the maturity stage (MS).

Fruit loss assessment was obtained by sampling different mango cultivars in the same orchards. Thus, from April to June, losses were assessed on seven main cultivars: Eldon, Smith, Kent, Brooks, Dabschar, Alphonse and Gouverneur. For control, 50 fruits were sampled per cultivar (10 per tree) in each site, every 2 weeks, in six mango orchards. Visual observations made it possible to check 300 fruits for each cultivar: infested fruits were counted and eliminated, potentially infested fruits were dissected.

Figure 1.
Bactrocera invadens Drew *et al.* A color version of this figure is available at www.edpsciences.org.

3. Results and discussion

3.1. Fruit fly trapping with parapheromone attractants

A total of nine tephritid species was obtained from the different traps: *Bactrocera invadens* Drew *et al.* (*figure 1*), *Ceratitis cosyra* (Walker)

(*figure 2*), *C. quinaria* (Bezzi), *C. silvestrii* Bezzi, *C. fasciventris* De Meyer, *C. anonae* Graham, *C. bremii* Guerin, *C. ditissima* (Munro) and *C. punctata* Wiedemann.

For the sake of clarity, only population fluctuations concerning the four main species, *B. invadens, C. cosyra, C. quinaria* and *C. silvestrii*, are presented in our article.

In the homogeneous mango orchard studied (*figure 3*), the earliest high fly density was represented by the marula fly, *C. cosyra*: in March 2005, some 400–500 males were captured per trap and per week and, in April, more than 900 males were counted per trap and per week. The abundance of this species decreased from June onwards. After the first significant rains in mid-April (35 mm on the 20th April), populations of *B. invadens* suddenly increased, reaching more than 900 males captured per trap and per week at the end of May and peaking at 1800 males per trap and per week in the middle of June. Moreover, increasing populations of *B. invadens* appeared to be directly linked to the ripening of different mango cultivars (*figure 3*) and to the rise in relative humidity at the beginning of the rainy season.

In the mixed mango orchard studied (*figure 4*), the earliest high fly density was also represented by the marula fly, *C. cosyra*: more than 200 males were counted per trap and per week in March 2005, and about 300 males per trap and per week in April. After peaking at 600 males per trap and per week in May, the *C. cosyra* populations also seriously decreased from June. As already observed for the homogeneous mango orchard, populations of *B. invadens* also suddenly increased after the first significant rains in mid-April (68 mm the 18th of April) reaching more than 900 males captured per trap and per week at the end of May and peaking at more than 2100 males per trap and per week in June. Increasing populations of *B. invadens* were also directly related to the ripening of different mango cultivars (*figure 4*) and to the rise in relative humidity at the beginning of the rainy season.

Bactrocera invadens, recorded for the first time in Benin by an IITA scientist team, is becoming an economically significant mango pest in the country; it is a new tephritid species recently described by Drew *et al.* [5], presumably originating from Sri Lanka and first recorded in East Africa, in Kenya, in 2003 [6] and also in Tanzania [7]. A mission in Senegal in 2004 gave us the opportunity to check the presence of this exotic species near Dakar [8].

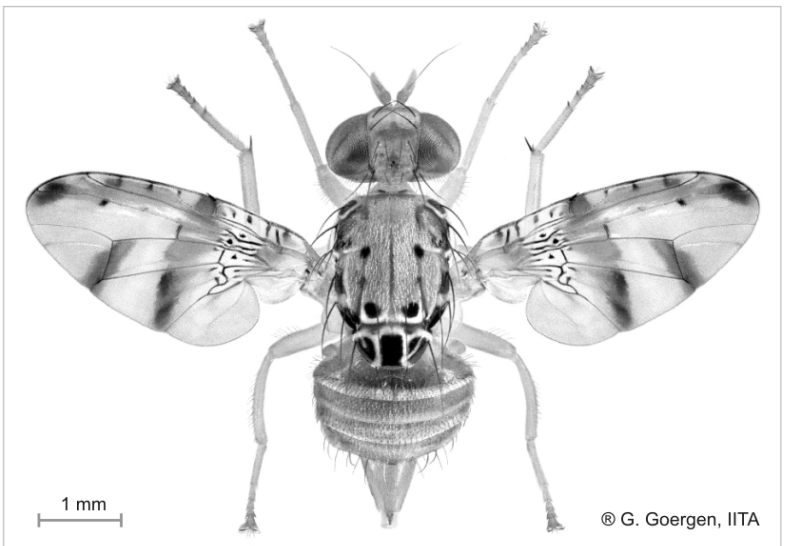

Figure 2.
Ceratitis cosyra (Walker).
A color version of this figure is available at www.edpsciences.org/fruits

3.2. Identification of tephritid species involved in mango infestations

Eight fruit fly species emerged from infested mangos from February to June 2005 in the Parakou area. Among them, there were four main pest species: *B. invadens*, *C. cosyra*,

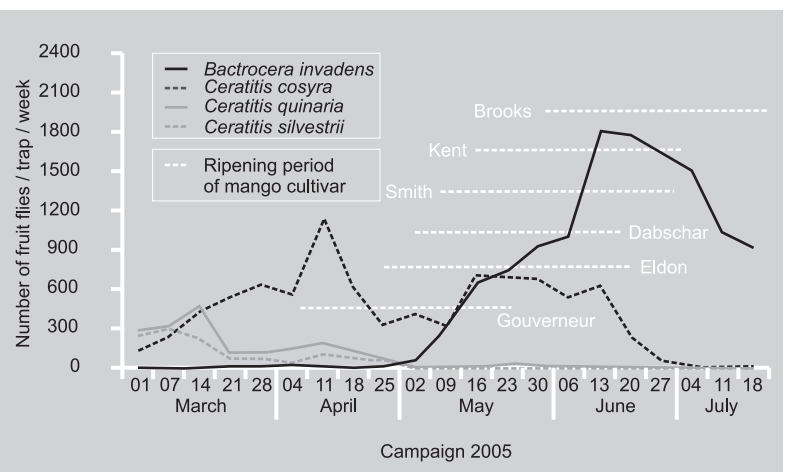

Figure 3.
Fluctuations of mango fruit fly populations, during the 2005 season, in a homogeneous mango orchard in relation to the ripening of different mango cultivars (Parakou area, Northern Benin).

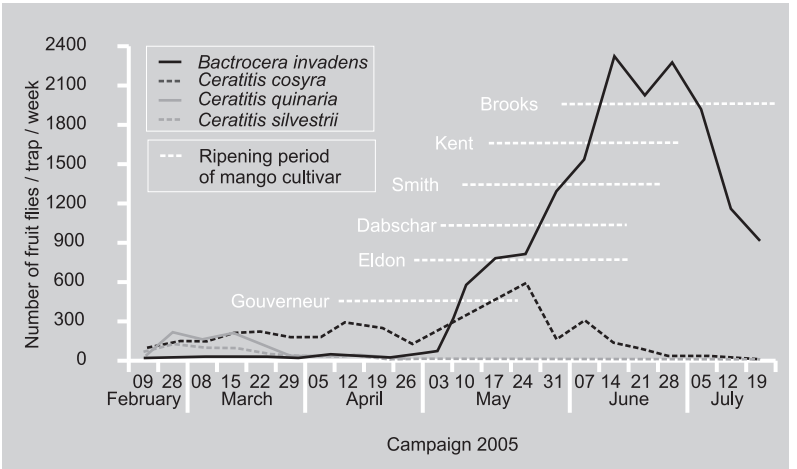

Figure 4.
Fluctuations of mango fruit fly populations in a mixed mango orchard, during the 2005 season, in relation to the ripening of different mango cultivars (Parakou area, Northern Benin).

C. quinaria and *C. silvestrii*, whose respective significance evolved throughout the 2005 season (*table I*). Two main species, *C. cosyra* and *B. invadens,* were present during the whole season. The marula fly was predominant during the maturity of earlier cultivars (Gouverneur and Eldon) in March and April, while *B. invadens* was more abundant in May and June on other cultivars (Dabschar, Smith, Kent and Brooks), even though this new pest could also be found on earlier cultivars (Eldon). *C. quinaria* and *C. silvestrii* played a role as pests during the dry season, just before the rainy season, while *C. fasciventris* and *C. bremii* were of minor importance. The study of percentages of tephritid species that emerged from infested mangos in the Parakou area (*figure 5*) showed some slight variations in sexual differentiation. At the emergence time during the dry season, males of *C. cosyra* were more abundant than females. Males of *B. invadens* were generally also more numerous than females, as were males of *C. quinaria*.

Our results give a new example of interspecific competition among different mango fruit fly species, but it may be too early to highlight competitive displacement of *C. cosyra* by *B. invadens* on mangos, because we do not have any data on fruit fly distribution from the previous years in this area. If we refer to the data of population fluctuations of tephritids in Mali and Guinea in similar ecological areas, *C. cosyra* was more abundant in mango orchards during the rainy season. So, by extrapolation, competitive displacement between *C. cosyra* and *B. invadens* seems likely. We could confirm it next year in the same orchards where we have maintained the traps in operation. Studies of yearly population levels might give us some useful information.

3.3. Loss assessment for different cultivars of mangos

In the orchards studied, according to the season, loss averages varied globally from 12% (4 to 8 April) to 50% (27 to 30 June) (*figure 6*). Thus, losses for Eldon varied from 14% (4 to 8 April) to 57% (13 to 17 June); for Kent from 9% to 42% for the same periods; for Smith from 10% to 57%; for Brooks

Table I.
Evolution of each fruit fly species emerged from infested mangos during the season in 2005 (*C.* = *Ceratitis*, *B.* = *Bactrocera*).

Mango fruit fly	28 February–4 March	14–18 March	4–8 April	18–22 April	2–6 May	16–20 May	30 May–3 June	13–17 June
	(%)							
B. invadens	0	2	13	24	42	60	72	87
C. cosyra	69	68	78	73	53	36	28	13
C. quinaria	10	18	7	3	0	0	0	0
C. silvestrii	21	12	2	0	0	0	0	0
C. fasciventris	0	0	0	0	3	3	0	0
C. bremii	0	0	0	0	2	0	0	0
Other *C.* spp.	0	0	0	0	0	1	0	0

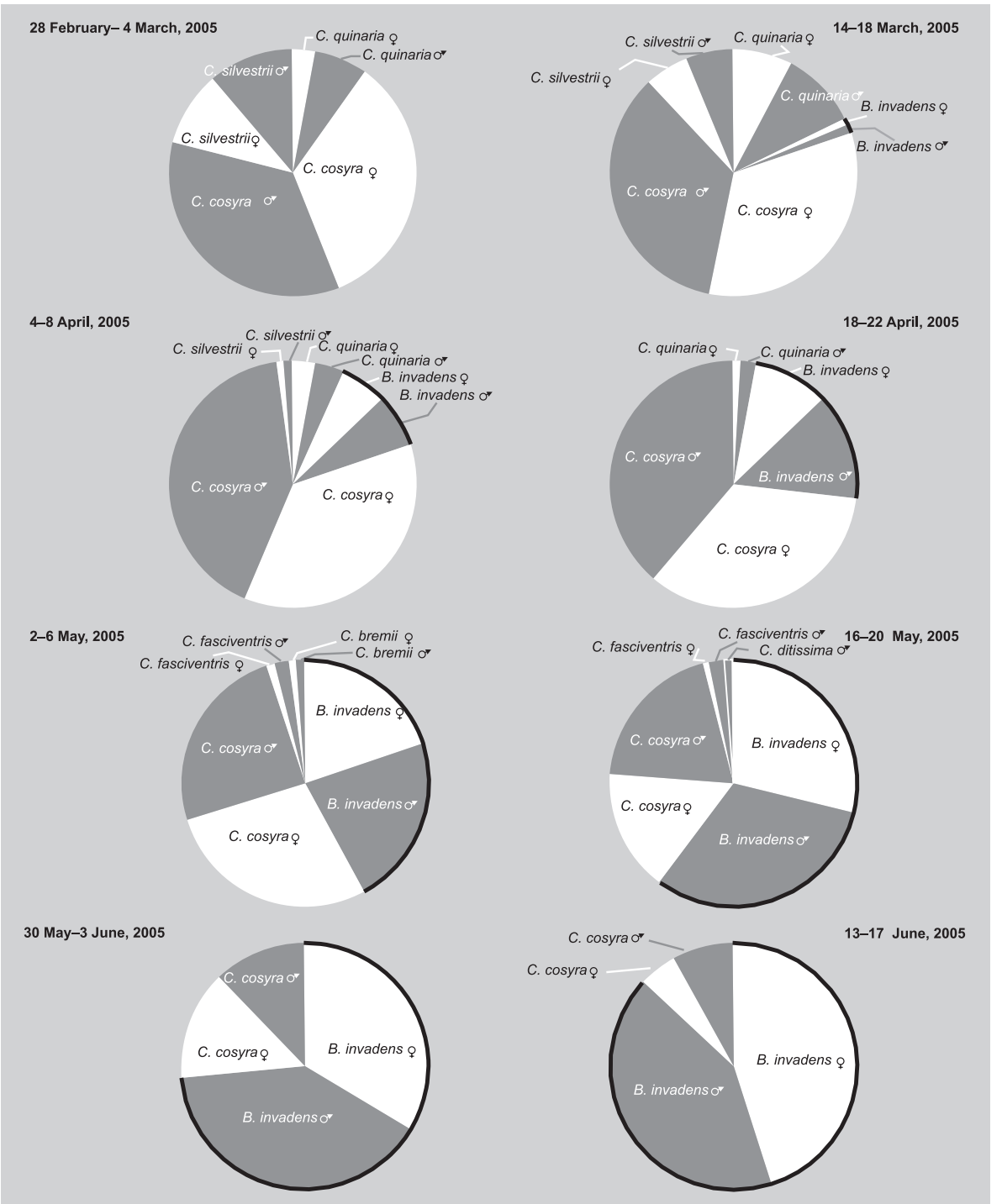

Figure 5.
Evolution of percentages of mango fruit fly species infestations during the season in 2005 (Parakou area, Northern Benin).

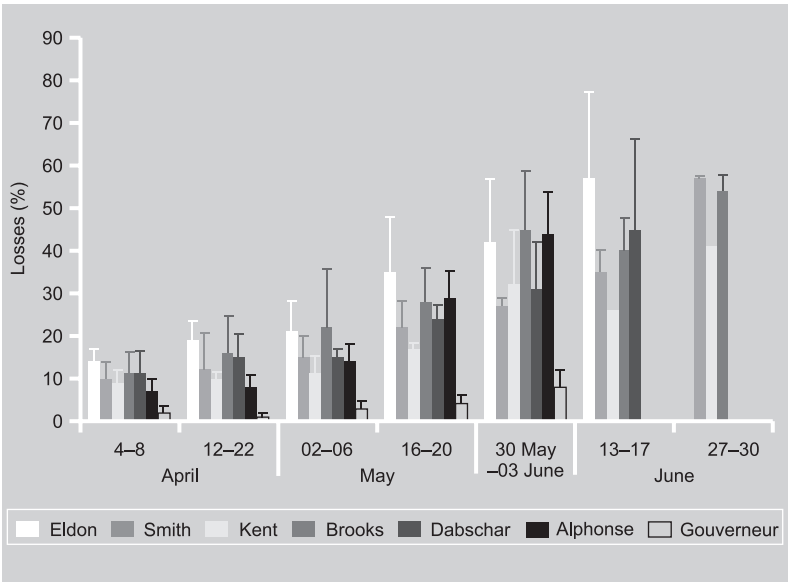

Figure 6.
Loss assessment on different mango cultivars in the Parakou area, Northern Benin, during the season in 2005.

from 11% to 54% and, for Dabschar, from 11% to 45%.

Mango losses were heavy after the first significant rains in April and can thus be linked with increasing populations of *B. invadens* in mango orchards. Evolution of fruit fly pupa number per kg of mangos during the 2005 season will be discussed in another publication, as well as first tests with GF120 (bait sprays) on these mango fruit fly infestations and comparison of attractants in order to improve female trapping.

B. invadens is involved in the majority of the mango damage after the first rains in this area, but also on other crops near mango trees. This new invasive species newly detected in Benin may quickly reach a high economic significance on many fruit crops of commercial interest, leading to heavy losses. Indeed, we also reared *B. invadens* in and around mango orchards from Rutaceae (*Citrus* spp.), Myrtaceae (*Psidium guajava*), Anacardiaceae (*Anacardium occidentale*), Ebenaceae (*Diospyros montana*), Caricaceae (*Carica papaya*), Annonaceae (*Annona muricata*) and Sapotaceae (*Vitellaria paradoxa*), as well as Cucurbitaceae (*Cucurbita* spp.) and Solanaceae (*Capsicum annuum*) crops. Of course, this list is far from being exhaustive for this polyphagous species now widespread in West Africa.

4. Conclusions

Fluctuations of trapped tephritid populations in Benin (department of Borgou) were similar to the percentages of mango fruit fly species infestations. Most of the observed mango tephritid species had previously already been observed in other West African countries (Ivory Coast, Guinea and Mali), except *B. invadens,* a newly described invasive species.

Among the species observed, four tephritid species are of economic importance, widely associated with mango orchards and infesting mangos. Among these four species, *B. invadens* infestation levels increased after the first significant rains, highlighting the importance of environmental factors in the invasion process. Though this new invasive species ("K" strategy species) is able to quickly dominate the indigenous species (genus *Ceratitis* with "r" strategy), a complete exclusion has not occurred for the moment. According to Duyck *et al.* [9] the classification along the r-K gradient is a good indicator for the invasiveness of different Tephritid species. It seems to be in correlation with the relationship between *B. invadens* and *C. cosyra*, possibly because K traits (large adult size, etc.) favor both exploitation and interference competition.

Further ecological studies, as well as behavioral ones, are needed in order to plan and implement Integrated Pest Management (IPM) methods for this economically important pest. Unfortunately, *B. invadens* will soon be a well-known name among fruit growers of West Africa.

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Una nueva especie de *Bactrocera* detectada en Benín entre las moscas de frutas (Diptera: Tephritidae) enfeudadas al mango.

Resumen — Introducción. Los Tephritidae poseen una importancia económica mayor en las regiones tropicales. En Benín, sólo teníamos pocas informaciones disponibles sobre las especies de moscas de frutas enfeudadas al mango, excepto la que se refiere a la manifestación de sus daños. Por ello realizamos observaciones preliminares en el norte de Benín durante la campaña de mangos en 2005 con el fin de identificar las especies en cuestión, de seguir sus fluctuaciones de poblaciones y de estimar sus pérdidas que les son imputables. **Material y métodos**. Estos experimentos se llevaron a cabo en la región de Parakou (departamento de Borgou). Se siguió a las poblaciones macho de Tephritidae todas las semanas en dos tipos de huertas de mangos gracias a trampas de paraferomonas. Los frutos de 17 cultivares de mangos fueron sometidos a muestreo de abril a junio de 2005, a continuación fueron examinados en laboratorio para la identificación de las especies de moscas responsables de las infestaciones en el momento de la emergencia de los adultos. Con el fin de evaluar las pérdidas, se realizó un muestreo de frutos pertenecientes a sendos cultivares en los mismos huertos. Los frutos infestados se contabilizaron y eliminaron; los frutos potencialmente infestados fueron disecados. **Resultados y discusión**. De cada ocho especies de moscas de frutas resultantes de mangos en Benín, cuatro pueden considerarse de una importancia económica: *Ceratitis cosyra*, *C. quinaria, C. silvestrii* y *Bactrocera invadens*. Durante la temporada seca, *C. cosyra* fue la más abundante mientras que *B. invadens* fue muy dominante desde el principio de la temporada de lluvias en correlación con los estados de pre-madurez y de madurez de los frutos. De este modo, a partir de mediados de mayo, *B. invadens* fue más abundante con respecto a C. *cosyra* en las trampas de detección y entre los adultos emergentes de los mangos infestados. Los daños fluctúan en una media del 12% a principios de abril hasta el 50% en junio, sin distinción de las especies de Tephritidae. **Conclusión**. La mayor parte de las especies de Tephritidae localizadas en mangos a lo largo de nuestros experimentos ya se observaron anteriormente en otros países del África oeste, salvo *B. invadens*, una especie invasora recientemente descrita. Se necesitarán estudios ecológicos y de comportamiento, con el fin de planificar y de aplicar métodos de lucha óptimos en relación con este nuevo devastador de importancia económica mayor en el África oeste.

Benin / *Mangifera indica* / plagas de plantas / insectos depredadores de los frutos / Tephritidae / identificación / dinámica de poblaciones / competencia biológica / aptitud colonizadora