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The safou red borer caterpillar *Pseudonoorda edulis* (Lepidoptera, Crambidae): first observations from field surveys on its biology and morphometrics in Gabon

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Pseudonoorda edulis Maes & Poligui (Lepidoptera: Crambidae), the safou red borer caterpillar (SRBC), is a new insect species from Central and West Africa, recently reported as a fruit pest of *Dacryodes edulis* in Gabon. Damage in Gabon was estimated at 22 % in terms of fruit loss. Two peaks of attacks were recorded at the end of September and November, respectively. Fully grown larvae were red and the moth was earthen in colour. Average length and breadth of eggs were 0.86 ± 0.01 mm and 0.47 ± 0.01 mm, respectively. First, second, third, fourth and fifth instar larvae measured in length as 4.80 ± 0.09 mm, 8.00 ± 0.12 mm, 13.03 ± 0.32 mm, 15.17 ± 0.08 mm and 19.69 ± 0.43 mm and in breadth as 0.87 ± 0.02 mm, 1.87 ± 0.02 mm, 2.30 ± 0.32 mm, 2.67 ± 0.03 mm and 2.75 ± 0.21 mm, respectively. The male and female wingspan average was 19.64 ± 1.05 mm and 22.60 ± 1.40 mm, respectively. Further investigations are needed to assess suitable strategies for biological control of this pest.

Key words: Safou, *Pseudonoorda edulis*, biology, control, survey, Gabon.

INTRODUCTION

Dacryodes edulis is one of the most cultivated fruit trees in central Africa, particularly in the Gulf of Guinea area. Its fruits (called safou or African pear) are greatly appreciated and consumed by local populations (Silou 1996; Tabuna & Tanoe 2009). Several studies have been undertaken on nutritional and chemical properties of the pulp and oils of safou (Arisa & Lazarus 2008; Bratte 2011; Kapseu 2009; Law 2010; Umoti & Okyi 1987), on some diseases (Mouaragadja & Mbatchi 1994; Nwufu *et al.* 1989), but there was little knowledge about pests. Recently, work focusing on *D. edulis* cultivation development pointed to the need for in-depth studies on insect pests (Kengué 2006). Poligui *et al.* (2013) have shown that among the insect pests occurring on *D. edulis* in Gabon, the larvae of *Pseudonoorda edulis* Maes & Poligui (Lepidoptera: Crambidae), also called safou red borer caterpillars (SRBC), were found devouring safou kernels, causing 22 % of fruit loss. Thus, *P. edulis* is a major limiting factor of *D. edulis* production in Gabon (Poligui *et al.* 2014), and even in surrounding countries. Nevertheless, no scientific reports are available on the biology and ecology of *P. edulis*. Therefore, our main objectives in this

paper were field monitoring and the study of the biology and the morphometrics of *P. edulis*, in the Haut-Ogooué province in Gabon.

MATERIAL AND METHODS

Study area

The province of Haut-Ogooué is located in southeastern Gabon. The average weekly temperature during the sampling period was 24.4 ± 1.1 °C and the rainfall was 716.1 mm (44.8 ± 9.7 mm/week). The flowering of *D. edulis* occurs from August to October, a period during which attacks of *P. edulis* are frequent. Fruits ripen starting from the end of December and harvest is fully effective between February and April. Field studies were carried out among trees in urban home gardens (at Franceville), respectively in Maboukou ($1^{\circ}37'52.93''S$ $13^{\circ}33'59.79''E$, elevation 368 m), Mangoungou ($01^{\circ}38'48.0''S$ $013^{\circ}35'47.4''E$, elevation 314 m), Ongwegné ($01^{\circ}35'32.6''S$ $013^{\circ}34'47.3''E$, elevation 335 m), Engalla ($01^{\circ}37'24.9''S$ $013^{\circ}36'54.9''E$, elevation 311 m) and Epilla ($01^{\circ}37'24.1''S$ $013^{\circ}38'26.9''E$, elevation 462 m). The laboratory observations were performed at the University of Sciences and Technologies of Masuku, Franceville, Gabon).

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Field survey

The safou red borer surveys were conducted during the period of fruit growth, and the presence of the attacked fruits was recorded over 16 weeks. At each site, a single flowering fruit tree was selected, and observed once per week. The immature fruits infested by the caterpillar *Pseudonoorda edulis* were collected from fruit trees at the five sample sites. All trees were grown without use of pesticides. The laboratory and field surveys were conducted from the 31 August to 12 December 2011.

Biology

The biology study of the safou red borer was focused on larval stage and adult behaviour. The larval stage observations were carried out by examining fresh or rotted fruits with boreholes or with partial or total necrosis, in the field (on trees) and in the laboratory (under stereomicroscopic magnifying glass), to check the presence and record the number of all larval stages. Larval behaviour and pupation were observed in the laboratory (at an average temperature of 25 °C and 66–80 % relative humidity), from caterpillars reared singly in circular transparent plastic vials (45 mm × 120 mm) covered with insect gauze. The SRBC larvae were fed with seeds of immature fruits of *D. edulis*. The rearing was checked daily until the end of pupation, or the emergence of adults. Alternative host plants of *P. edulis* were assessed to determine one part of adult behaviour. Then, fruits of some surrounding fruit trees, namely *Mangifera indica*, *Citrus* sp, *Persea americana*, and *Pseudospondias microcarpa* were monitored weekly for boreholes and presence of larvae during their fruiting season. Natural enemies were checked in the field and in the laboratory. Bunches and fruits with boreholes were visually examined to search for predators and parasitoids of *P. edulis* eggs or larvae. Parasitoids were also searched for using larvae collected in the field and kept singly in transparent plastic vials (45 mm × 120 mm), until pupation and emergence of adults, in the same laboratory conditions as described above.

The morphometrics of the safou seed borer were studied in the laboratory, from the eggs extracted from adult moths, and from the field neonate and other larval instars collected in infested fruits. The sizes of eggs, larval instars, pupae and adult moths were recorded. Mean standard error was calculated as:

$$MSE = \delta \frac{S}{\sqrt{n}},$$

with δ as standard error parameter, s standard deviation and n sample size.

RESULTS

Field surveys

The surveys of *P. edulis* and fruit growth were conducted at the same time (Fig. 1). The five locations revealed three kinds of trees: those with large fruits (average size 90.26 ± 4.67 mm × 47.15 ± 1.40 mm), with medium-sized fruits (56 ± 3 mm × 32.3 ± 0.91 mm to 66.5 ± 1.4 mm × 30.6 ± 1.36 mm) and with small fruits (42.30 ± 3.30 mm × 26.8 ± 1.97 mm). The large fruits were recorded from the Ongwegné site, the medium fruits from trees at the Epilla, Engalla and Mangoungou sites, and the small fruits from the Mingara site. As illustrated (Fig. 1A), the active growth period occurs from the fruit setting stage (13 ± 5 mm length) to the seventh week when the fruits reach their larger size (62.5 ± 11 mm length). From the seventh to the 11th week, the fruits size did not increase, but at the 12th week the fruit length regresses slightly to keep its definitive fully grown size (62.2 ± 10.6 mm length). Regarding the *P. edulis* occurrence in fruits within each site (Fig. 1B), it appeared two peaks of which the most important occurs at the active stage of safou fruit growth (between the fourth and the eighth week), and the second one corresponds to the last stage of fruit growth (between the 12th and the 14th week).

Biology

The study of larval stages was performed on 3814 immature fruits (Table 1). A total of 861 fruits were found with boreholes or with partial or total necrosis related to the safou red borer attacks. There were no boreholes on any ripe fruit. The fruit losses on bunches varied from 17.5 % to 25.03 % and the average loss is estimated at 22 % of all fruits. Outside our area of investigation, we observed that damage levels can rise up to 66 % of fruit loss on some trees.

First instar larvae were found in the kernel space in groups of five to 13 individuals, whereas one single final instar larva was generally found per damaged fruit. Nevertheless, some fruits revealed two to five mature larvae. Field observations recorded up to 13 *P. edulis* individuals of the third larval instar. It was possible to see three different

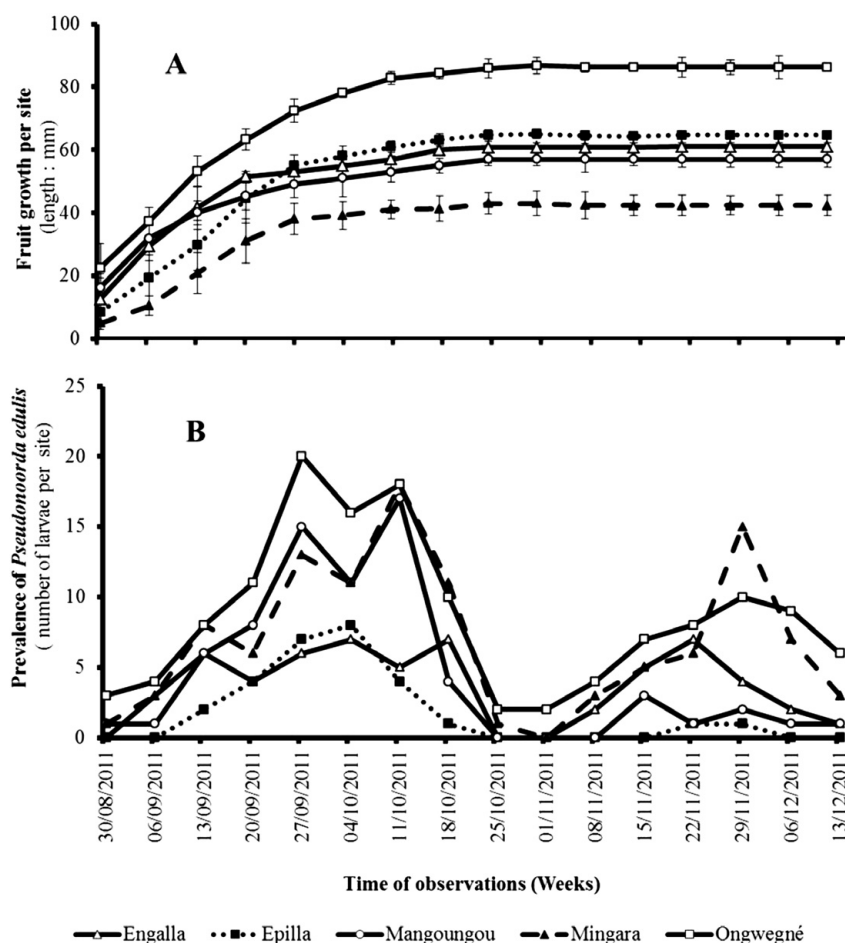


Fig. 1. A, Fruit growth: at the top, large fruit growth (Ongwagné); the intermediate curves correspond to growth of medium-sized fruits (Epilla, Engalla, Mangoungou), at the bottom the small fruit growth (Mingara). **B,** Prevalence of *Pseudonoorda edulis*: the curves of abundance are represented according to sampling locations. The most important peak is recorded between the fourth and eighth weeks; the secondary peak appears between the 12th and 15th weeks. Both peaks correspond to two different generations of *Pseudonoorda edulis* larvae.

larval instars in the same fruit. Concerning the caterpillar incidence on fruits, one single mature larva was observed as able to destroy more than one fruit. When the seed was completely destroyed before full-grown larval stage, the caterpillar exited and bored a hole of 2–3 mm diameter on a new fruit, entered and remained there until reach-

ing its fully grown stage. The first instar larvae fed mainly on very soft forming kernels and internal endocarps, whereas the mature stages fed essentially on seed, but also on fruit flesh. When the fruits were infested, they rotted on the bunch or dropped (Fig. 2).

When a larva reached its full grown size, it left

Table 1. Fruit loss caused *Pseudonoorda edulis* larvae in the Franceville area, 2011.

Site	Maboukou	Mangoungou	Ongwagné	Engalla	Epilla	Total
Sampled fruits	855	591	1056	815	497	3814
Damaged fruits	214	123	239	198	87	861
Damage rates (%)	25.0	20.8	22.6	24.3	17.5	22.0

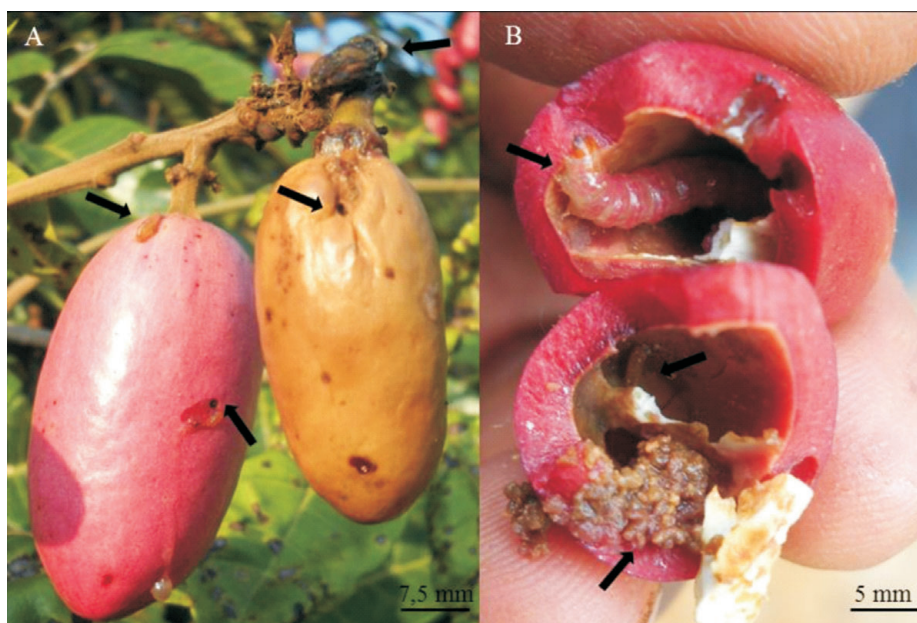


Fig. 2. Fruits damaged by the safou red borer caterpillar, *Pseudonoorda edulis*. **A**, Left, on top of the fresh fruit (near peduncle), a third larval instar boring into the fruit to reach the kernel. Right, the fruit with complete necrosis. On both fruits, boreholes are arrowed. **B**, Broken open immature fruit showing a red, fully grown larva (top) with its excrement (each excrement 2×1 mm) constituted by kernel residues (bottom). A first instar larva can be seen in upper part of lower fruit piece. (Image in colour online.)

the fruit and pupated in a silky cocoon mixed with plant residues. The pupation occurred 9 to 11 days before the adult emerged. Search of the infested tree did not reveal pupae on trunks, branches, in the fruit or in bark crevices.

The adult was a night moth not visible during diurnal observations. The search of alternative host plants of *P. edulis* showed no infestation on *M. indica*, on *Citrus* sp. and on *P. americana*. Nevertheless, some fruits of *P. microcarpa* presented boreholes similar to those of *D. edulis* on safou fruit. After keeping two fully grown larvae collected from *P. microcarpa* in the laboratory, the related emerging adult moths were identified as the same species *P. edulis*.

Morphometrics

The morphometrics of the safou seed borer were focused on measurements of 30 eggs, 50 larvae and 30 adult moths (Fig. 3). The eggs (extracted from ovaries of females) were ovoid in shape and yellow in colour, and 0.86 ± 0.01 mm $\times$ 0.47 ± 0.01 mm in size (Fig. 2A). First, second and third larval instars were generally cream-coloured, with respective sizes of 4.80 ± 0.09 mm $\times$ 0.87 ± 0.02 mm, 8.00 ± 0.12 mm $\times$ 1.87 ± 0.02 mm, and

13.03 ± 0.32 mm $\times$ 2.30 ± 0.04 mm. The fourth instar was brown to reddish and 15.17 ± 0.08 mm $\times$ 2.67 ± 0.03 mm in size. The fully grown larvae (the fifth instar with length varying from 16 to 21 mm) were generally red in colour, 19.69 ± 0.43 mm $\times$ 3.60 ± 0.03 mm in size (Fig. 3B, C). The pupae were orange-coloured and 9.2 ± 0.01 mm $\times$ 2.1 mm in size (Fig. 3D) and characterized by a prominent cremaster turning black and emerging among two pairs of hooks. Before the adult emerged, the pupae turned greyish in colour. The adult moth was earthen to light brown in colour, with darker subterminal forewing areas (Fig. 3E, F). Labial palps and pro-mesothorax were ventrally white. There was a presence of brush-like black hairs on the upper side of the mesothoracic tibiae. Some phenotypic characteristic differences were observed between males and females. Males had a simple frenulum and a rounded abdomen apex protrusion, and generally presented larger wingspans (varying from 17 to 27 mm, with an average of 22.60 ± 1.40 mm). Females had a double frenulum and their abdomen apex was pointed (Fig. 3E, F left), with an extensible long ovipositor. Their wingspan varied from 15 to 23 mm (with an average of 19.64 ± 1.05 mm).

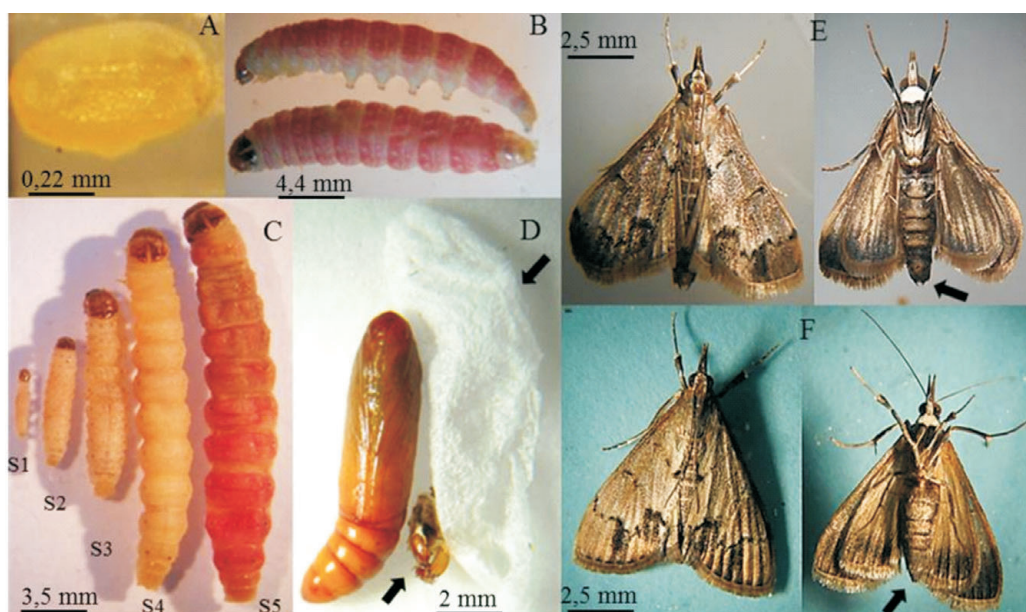


Fig. 3. Morph stages of *Pseudonoorda edulis*. **A**, Egg; **B**, the fully grown larvae in lateral and dorsal views; **C**, the five larval instars (with S1 = first instar, S2 = second instar, S3 = third instar, S4 = fourth instar, S5 = fifth instar); **D**, pupa with a white silky cocoon and larval exuvia; **E**, **F**, adult moths in dorsal and ventral views (E = male, F = female). (Image in colour online.)

CONCLUSION

The SRBC (*P. edulis*) was well established as a harmful pest of the African pear fruits (safou) in Gabon. Before this study, there was no consistent knowledge about this pest in the selected working area, nor in neighbouring countries. The present paper provides basic information about the field occurrence, biology and morphometrics of this pest. All the *P. edulis* stages, as well as related observed damage, were identified and illustrated. Symptoms on *D. edulis* and the alternative host plant *P. microcarpa* were also provided. These

results constitute a first step towards a better understanding of *P. edulis*, but there is a need for studies on the control of this pest, which could result in a considerable increase in safou production in Gabon as well as in surrounding countries.

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