RESEARCH

Insects Associated With *Jatropha curcas* Linn. (Euphorbiaceae) in West Niger

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ABSTRACT. *Jatropha curcas* has been introduced into Niger since 2004 by International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). This plant is cultivated for its oil, which can be used as a Biofuel. Through direct and indirect insect collection methods, an inventory of the insect associated with *J. curcas* has been conducted in Western Niger during two rainy seasons (from June to October) in 2010 and 2011. We have identified insects belonging to the following families: Acrididae (*Oedaleus senegalensis* Krauss, *Oedaleus nigeriensis* Uvarov, *Heteracris leani* Uvarov, *Catantops stramineus* Walker, *Parga cyanoptera* Uvarov, and *Acanthacris ruficornis citrina* Audinet-Serville), Pyrgomorphidae (*Poekilocerus bufonius hieroglyphicus* Klug), Cetoniidae (*Pachnoda interrupta* Olivier, *Pachnoda marginata aurantia* Herbst, *Pachnoda sinuata* Heinrich and McClain, and *Rhabdotis sobrina* Gory and Percheron), Meloidae (*Decapotoma lunata* Pallas), Pentatomidae (*Agonoscelis versicoloratus* Dallas, *Nezara viridula* Linn, and *Antestia* sp. Kirkaldy), Coreidae (*Leptoglossus membranaceus* Fabricius and *Cletus trigonus* Thunberg), and Scutelleridae (*Calidea panaethiopica* Kirkaldy). Origin and potential impact on *J. curcas* of all these insect species are presented and discussed. The lower insect's diversity indexes are observed in 2010 and 2011 for Niamey, Saga, and Gaya because of semi-arid character of the Sahelian area.

Key Words: physic nut, Pourghère, insect, Sahel area, Niger

Jatropha curcas L. (physic nut) is a drought resistant shrub originated from Central America and belonging to the Euphorbiaceae family (Legendre 2008). *Jatropha* genus is widely distributed in tropical countries (Heller 1996). In many west and central African countries, *J. curcas* is used as a hedge to protect crops against wind, hydrous erosion, and animals (Henning 2008). The seeds of *J. curcas* are rich in oil, which is used as a Biofuel, making this plant important for renewable energies research. In Niger, plantations of *J. curcas* are found at research institutions and in some private farms. There is no documentation on insect associated of *J. curcas* in Niger. Insect pests of *J. curcas* have been characterized in Nicaragua by Grimm and Maes (1997); in Brazil by Foidl et al. (1996), and Grimm and Maes (1997); in India by Shanker and Dhyani (2006); in Republic of Cape Verde by Freitas (1906), Ferrão and Ferrao (1984), and Munch and Kiefer (1986); and in West Africa by Terren et al. (2012). The most frequently observed insect pest of *J. curcas* in Nicaragua is *Pachycoris klugii* (Burmeister 1835) (Heteroptera: Scutelleridae; Grimm and Maes 1997, Grimm 1999, Peredo 2002), which feeds on flower and fruit, causing malformation of the seeds, which can reduce the quality of the oil. *Leptoglossus zonatus* (Dallas 1852) (Heteroptera: Coreidae) has also been observed in Nicaragua. It is polyphagous, and also infests sorghum, maize, and tomato (Grimm and Maes 1997). In Senegal, *Oedaleus senegalensis* (Krauss 1877) (Acrididae) was observed to cause damage to seedling leaves (Grimm and Maes 1997). The larvae and adults of *Calidea panaethiopica* (Kirkaldy 1909) (Scutelleridae) have also been observed in Senegal by Terren et al. (2012) and in Mexico by Tepole-Garcia et al. (2012).

This study aims to investigate insects associated with *J. curcas* in Western Niger and to identify those that can be pests of this shrub.

Materials and Methods

Inventoried Sites. The collecting sites were selected according to ecological area. Two sites were selected for their low precipitations: Sahelian area: Saga (Sa) and Niamey (Ni), and a third: Soudano Sahelian area: Gaya (Ga).

The plantation of *J. curcas* at Saga (Sa) (13° 45′ N; 2° 14′ E) is located 5 km South East from Niamey. It is an irrigated site created by an NGO: SIP 'School Instrument of Peace'. The plantation was installed in 2009 with 1-m intrarow spacing. The plantation is irrigated twice a week during the first 5 mo, except during rainfall. Precipitation in 2010 and 2011 was 545 and 441 mm, respectively, with a monthly temperature comprised between 28 and 35°C. The plantations of the two other sites Gaya and Niamey are not irrigated. The shrubs surrounding the plantation mainly include *Acacia albida* Del, *Azadirachta indica* A. Juss, and *Prosopis juliflora* (Sw). D.C. (Peyre and Fabregues 1970).

The second site (Niamey, Ni) consisted in a teaching field (3° 30′ N; 2° 05′ S) belonging to the Faculty of Agronomy at Abdou Moumouni University of Niamey. Two categories of plantations are present there: a small hedge of 4-yr-old plant and a second plantation of 400 m^2 with 1-m intrarow spacing and 2-m interrow spacing. The seeds used were obtained from International Crop Research Institute Semi-Arid Tropics (ICRISAT) and Senegal. A mixture of *J. curcas* varieties were planted including Baas 38; Baas 32; Katil; Bfb1; ISC14; SNES 44; Falou; GB 14; Las Pillas 11, and SENS 30. The precipitations were 442 and 341 mm in 2010 and 2011, respectively. The average temperature was comprised between 28 and 35°C. The shrubs surrounding this plantation included *Acacia nilotica* L., *Ziziphuss mauritiana* Lam., *A. indica* A. Juss, and *P. juliflora* (Sw). D.C. (Peyre and Fabregues 1970).

The third collecting site was situated at Gaya, and is located 280 km South East from Niamey. The site is a private farm of 135 ha located at 21° 23′ N and 3° 49′ E. Only 1.05 ha is occupied by *J. curcas*. The plantation is divided into two groups of trees according to the age and method of plantation: 250 m^2 planted by vegetative propagation in March 2006 with a spacing of 1 by 1 m, and 800 m^2 planted by direct seeding in June 2008 with 2.5 by 2.5 m spacing. The annual average rainfall in 2010 and 2011 was, respectively, 650 and 780 mm. The maximum average daily temperature was 25°C in 2010 and 34°C in 2011. The shrubs identified around the exploitation were: *Combretum*

micranthum, *Guiera senegalensis*, *Mangifera indica*, and *Citrus* spp. (Peyre and Fabregues 1970).

Collection of Insects. Two methods namely plugging and trapping were used to collect a maximum number of insects.

The plugging method was applied by using an umbrella under a branch of a physic nut shrub. All trees present along an 'M'-shaped transect were inventoried, for a total of 20 trees. The average number of branches per tree was 35–40, for 2-yr-old trees.

The branch was shacked and insects that fall into the umbrella were collected and transferred into bottles containing 70% ethanol. The operation lasts 10 min per shrub. The method is completed by visual observation and manual picking with a flexible gripper and butterfly net. Each site was visited twice per month between 8 a.m. and 4.30 p.m. on the same day because of the distance among the sites, but the traps are visited every day. Insects were collected for 5 mo, from June to October, in 2010 and 2011.

Three yellow traps containing water were also placed in each plantation, at the foliage level of the shrubs. The traps were distanced by 30 m and placed triangularly. The traps were checked at 8 a.m. and 6 p.m. every day. The traps were placed for 5 mo from June to October. This technique makes it possible to evaluate an insect's population dynamics on the plantation. The insects collected were placed in bottles containing ethanol, along with the following information: date, trap's number, and name of site.

The insects were identified in the laboratory. Binocular magnifying glass was used to observe and compare homologue specimens. We consulted the most recent and specialized literature. The families insect's keys used were those of Delvare and Aberlenc (1989), Mike et al. (2004), Lecoq (1988), Launois and Launois-Luong (1989), Launois-Luong and Lecoq (1989), and Zahradnik (1984). In addition, the identification of the most collected insects was confirmed by the insect's database of Niger in the National Institute of Agronomic research of Niger (INRAN) and the identification was confirmed by specialists from Gembloux Agro-Bio Tech (Belgium) and Museum of Paris (France).

The Diversity Index. In each study site, we have calculated the indices of diversity of Shannon Weavers and Simpson. These indices evaluate the importance of insects diversity found on *J. curcas* in order to make comparisons between localities and year.

The diversity index of Shannon–Weaver (1948) is based on the formula: $H' = -\Sigma((N_i/N) \times \log_2 (N_i/N))$, where N_i the number of individuals of a given species, varying from 1 to S (the total number of species) and N total numbers of insects, H' lies between 1 and 5 bits. The maximum index is attained when all the individuals are equally distributed for all species. It is accompanied by the Pielou equitability index (1966), also called the equal distribution index (Blondel 1979), which represents the report/ratio of H' to the theoretical maximum index of the population (H_{max}).

The index of Simpson (1949) measures the probability that two randomly selected individuals belong to the same species: $D = \Sigma\ N_i\ (N_i - 1)/N\ (N - 1)$, where N_i the number of individuals of a given species and N is the total number of insects. When this index has a value of 0, there is maximum diversity; when it is equal to 1, diversity is minimal, with the aim of obtaining 'the best diversity index values'. The diversity index of Simpson is calculated by $1 - D$. Maximum diversity is represented by 1, and minimal diversity by 0. This index of diversity gives greater importance to abundant species.

Statistical Analysis. Mean numbers of insects were subjected to a one-way analysis of variance ANOVA followed by Tukey's post hoc tests ($P < 0.05$). The software used was MINITAB16. Values are expressed as means ± standard deviation.

Results and Discussion

In total, 25 insect species were collected from Niamey site in 2010 and 2011. These insect species belong to 16 families (Table 1). Hymenoptera were the most frequent order, representing 44% of the collected insects. Orthoptera and Coleoptera represented 30 and 11% of the total capture, respectively. Diptera, Heteroptera, and Plecoptera are 10, 4, and 1% respectively.

The locality of Gaya is significantly different from the other sites because it is not only a strongly sprinkled zone, but also the Jatropha plantations are older (Table 2).

In Niamey, there were fewer Acrididae (*O. senegalensis*, *Oedaleus nigeriensis*) in June, but their numbers increased between July and August (Fig. 1).

Cetoniidae (*Pachnoda interrupta*) was more abundant during the period of flowering. Pentatomidae (*Agonoscelis versicoloratus*, *Nezara viridula*) were captured only during the flowering period of the plant (between July and August).

At Saga, 955 insects belonging to 34 species and 23 families were collected during the 2 yr between June and October. Orthoptera were the most numerous (36%) Hymenoptera, Coleoptera, Diptera, Heteroptera, and Plecoptera counted for 25, 15, 14, 8, and 2%, respectively (Tables 1 and 2).

Heteracris leani (Uvarov 1941) was frequently collected in Saga, because of the presence of rice plantations. Cetoniidae were captured between July and August during the flowering period of the plant (Fig. 2).

The species *Rhabdotis sobrina* (Gory and Percheron 1833) was observed only at this site. Pentatomidae were also captured during the flowering period (between July and August) of the plant.

In the Gaya site, 38 insects' species were observed in 2010 and 2011. These species are grouping into 24 families. Hymenoptera and Heteroptera were found to be the most frequent orders with 24% for each order. Coleoptera, Orthoptera, Diptera, and Plecoptera represented 23, 20, 9, and 0%, respectively, of the total captures. The numbers of Acrididae were greater at the beginning (June and July) and end of the rainy season (September and October) (Fig. 3).

The presence of *Acanthacris ruficornis citrina* (Audinet-Serville 1838) (Acrididae) in June and July marks the uniqueness of this site. The Pentatomidae were observed during the flowering of *J. curcas* (between July and August).

Table 1. Abundance of insect orders in different sites of Niger

Orders	Niamey				Saga				Gaya			
	Ind	Fa	Sp	Freq (%)	Ind	Fa	Sp	Freq (%)	Ind	Fa	Sp	Freq (%)
Coleoptera	41	3	4	11	149	4	5	15	562	3	5	23
Orthoptera	109	1	5	30	341	1	5	36	472	2	6	20
Heteroptera	13	2	3	4	74	4	7	8	573	4	7	24
Hymenoptera	156	4	6	44	235	7	10	25	567	9	12	24
Diptera	36	5	6	10	138	6	6	14	224	5	7	9
Plecoptera	2	1	1	1	18	1	1	2	9	1	1	0
Total	358	16	25	100	955	23	34	100	2407	24	38	100

Ind: Number of individuals number; Fa: number of families; Sp: number of species; Freq (%): Frequency.

Table 2. Comparative of insect's families and species number observed in tree localities of Niger

Sites	Individuals	Families	Species
Probability	0, 007	0.03	0.022
Niamey	178 ± 10b	13 ± 2b	22 ± 3b
Saga	457 ± 68b	21 ± 3ab	32 ± 2ab
Gaya	1268 ± 204a	24 ± 0a	37 ± 1a

a and b are the group of average.

The insects associated with *J. curcas* mainly belonged to Orthoptera, Coleoptera, Heteroptera, Hymenoptera, and Diptera in Niger (Table 3). The two major families of Orthoptera were Acrididae and Pyrgomorphidae. The most frequent insects species during our observations were *O. senegalensis* (Krauss 1877), *O. nigeriensis* (Uvarov 1926); *Catantops stramineus* (Walker 1870), *Parga cyanoptera* (Uvarov 1926); *H. leani, A. ruficornis citrina*, for Acrididae, and *Poekilocerus bufonius hieroglyphicus* (Klug 1832) for Pyrgomorphidae. Acrididae were observed in all the localities, whereas *H. leani* was

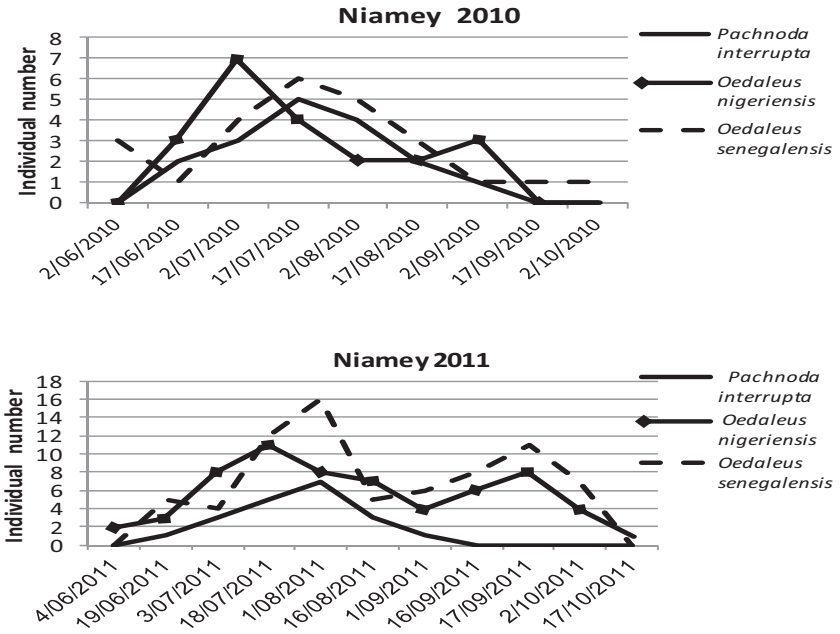

Fig. 1. Three most important insect pests of *J. curcas* at Niamey in 2010 and 2011.

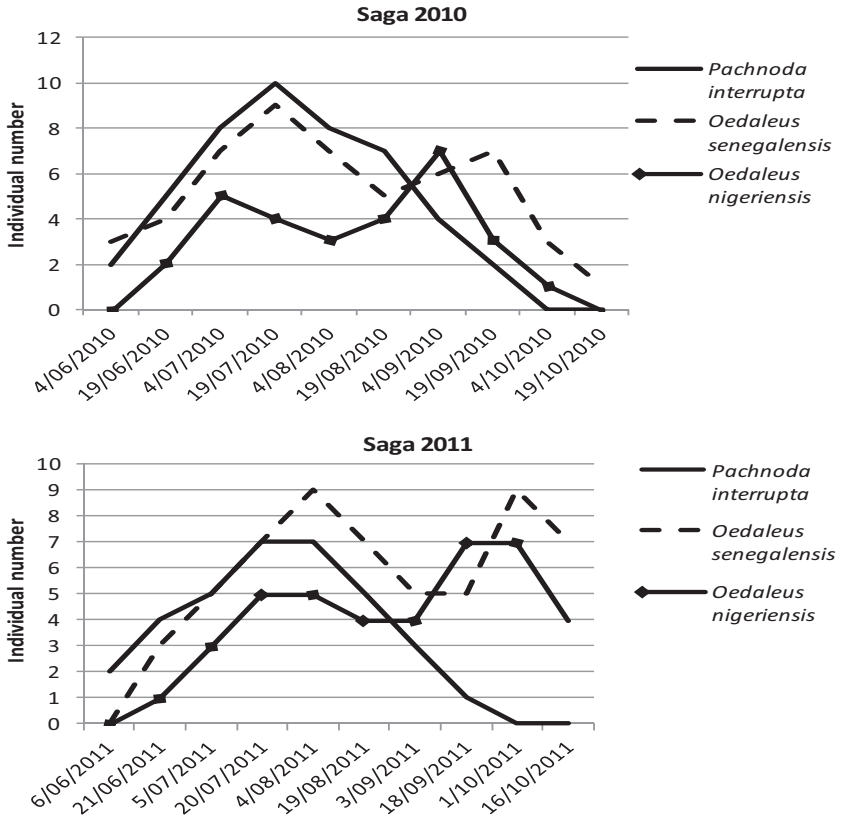

Fig. 2. Three most important insect pests of *J. curcas* at Saga in 2010 and 2011.

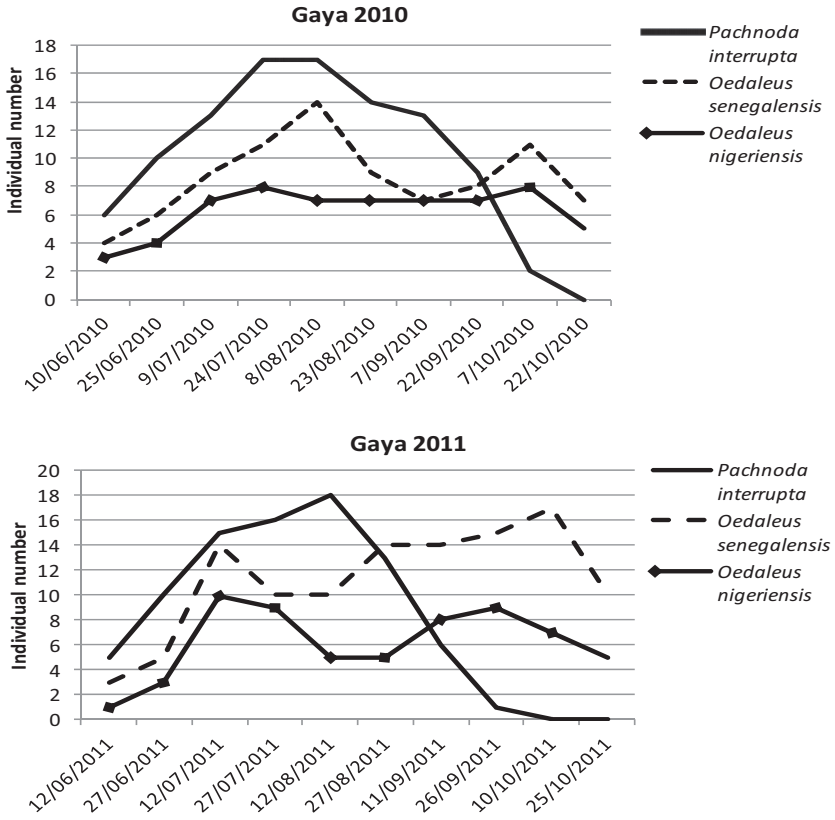

Fig. 3. Three most important insect pests of *J. curcas* evolution at Gaya in 2010 and 2011.

specific to Niamey and Saga sites. *A. ruficornis citrina* (Acrididae) and *P. bufonius hieroglyphicus* (Pyrgomorphidae) were observed only at Gaya. *O senegalensis* was previously observed on *J. curcas* in Senegal (Grimm and Maes 1997). This Acrididae feeds on leaves and seedlings. They are also pests of cereals (millet, sorghum) in the Sahelian area, because of the damage they cause to the panicle and leaves (Boys 1978). *Corynorhynchus radula* (Klug 1820) and *Stiphra robusta* (Mello-Leitão 1939) (Orthoptera: Proscopiidae) were observed in Brazil by Saturnino et al. (2005); they destroy the leaves and the flowers of *J. curcas.*

The Coleoptera insects observed on *J. curcas* in Niger include *P. interrupta* (Olivier 1789), *Pachnoda marginata* (Herbst 1790), *Pachnoda sinuata* (Heinrich and McClain 1986); *R. sobrina* (Cetoniidae) and *Decapotoma lunata* (Pallas 1772) (Meloidae). They are all phytophagous, and their adults feed on flowers (Brown 1991). This explains their presence in large numbers during the flowering stage of *J. curcas. Oxycetonia versicoloratus* (Fabricius 1775) (Coleoptera: Cetoniidae) has been observed on *J. curcas* in India by Shanker and Dhyani (2006). It was found to feed on leaves and flowers of *J. curcas*. *Bostrichus* sp. (Coleoptera: Bostrichidae) has been identified on *J. curcas* in Republic of Cape Verde by Freitas (1906) and Munch and Kiefer (1986). This insect makes galleries in the wood of *J. curcas. Aphtona dilutipes* (Jacoby) (Coleoptera: Chrysomelidae) is observed in Mozambique by Gagnaux (2009). This Coleoptera feeds on leaves of *J. curcas. Pantomorus femoratus* (Sharp 1891) (Coleoptera: Curculionidae) and *Lagocheirus undatus* (Voet 1778) (Coleoptera: Cerambycidae) were observed on *J. curcas* by Grimm and Maes (1997) in Nicaragua. The first insect feeds on the leaves, and the second on the seedlings.

Heteroptera species observed on *J. curcas* in different localities of Niger included: *A. versicoloratus* (Dallas 1851); *N. viridula* (Linn 1758); *Antestia lymphata* (Kirkaldy 1909) (Pentatomidae), *Leptoglossus membranaceus* (Fabricius 1781), *Cletus trigonus* (Thunberg 1783), and *C. panaethiopica* (Kirkaldy 1909) (Scutelleridae). They feed on flowers and fruits of *J. curcas. N. viridula*, and *L. zonatus* are pests of *J. curcas* in Nicaragua (Grimm and Maes 1997). They feed on fruit of *J. curcas.*

In the lower valley of the Senegal River *C. panaethiopica* was observed on *J. curcas* by Terren et al. (2012). The adults and nymphs of *C. panaethiopica* attack the flowers and capsules of *J. curcas* and suck the sap. Another bug, *Calidea stigmata*, was observed in Republic of Cape Verde and Sao Tomé by Ferrão and Ferrao (1984) and Munch and Kiefer (1986). This insect feeds on fruits of *J. curcas*.

Several Hymenoptera species were observed on *J. curcas* in Niger: *Apis melifera adansonii* (Linn 1761) (Apidea), *Thyreus delumbatus* (Vochal 1903) (Anthophoridae); *Tricarinodynerus guerinii* (Saussure 1856) (Eumenidae); *Oecophylla longinoda* (Latreille 1802); *Camponotus maculatus* (Fabricius 1782); *Lepisiota capensis* (Mayr 1862) (Formicidae); *Smicromyrme atropos* (Smith 1855) (Mutillidae), and *Stizus fuscipennis* (Smith 1856) (Sphecidae). They visit the flowers of *J. curcas* and take part in the pollination of this plant (Table 3).

The insect pollinators species associated with *J. curcas* belong to a family of Apidae (Grimm and Maes 1997, Solomon Raju and Ezradanam 2002). Banjo et al. (2006) reported that honeybee species as the main insects pollinators of *J. curcas* flowers in north of Nigeria.

Several insects such as *Camponotus compressus* (Fabricius 1787), *Crematogaster* sp., *Solenopsis geminata* (F. 1804), and *Pheidole spathifer* (Forel 1902) belonging to the Formicidae family were observed on *J. curcas* flowers in India (Solomon Raju and Ezradanam 2002, Regupathy and Ayyasamy 2011). The latter authors also showed that these insect species play important role in the pollination during the season of *J. curcas* flowers.

Table 3. Summary table of insects collected on *J. curcas* at different localities of Niger

Orders	Families	Species	2010			2011			Status
			Ni	Sa	Ga	Ni	Sa	Ga	
Coleoptera	Cetoniidae	*P. sinuata* (Heinrich and McClain 1986)	0	0	67	0	0	31	F
	Cetoniidae	*P. interrupta* (Olivier 1789)	16	35	117	9	13	78	F
	Cetoniidae	*P. marginata* (Herbst 1790)	0	0	42	3	11	26	F
	Cetoniidae	*R. sobrina* (Gory and Percheron 1833)	5	28	0	0	27	0	F
	Meloidae	*D. lunata* (Pallas 1772)	5	9	86	2	19	105	F
	Lycidae	*Lycus trabeatus* (Guérin-Méneville 1835)	0	5	9	0	0	1	F
	Tenebrionidae	*Stenocara dentate* (Herbst 1799)	1	2	0	0	0	0	F
Orthoptera	Acrididae	*O. nigeriensis* (Uvarov 1926)	18	23	32	3	24	53	L
	Acrididae	*O. senegalensis* (Kraus 1877)	6	12	36	46	62	143	L
	Acrididae	*A. ruficornis citrina* (Audinet-Serville 1838)	0	0	53	0	0	67	L
	Acrididae	*H. leani* (Uvarov 1941)	12	85	0	3	63	0	–
	Acrididae	*C. stramineus* (Walker 1870)	7	18	23	11	41	36	L
	Acrididae	*P. cyanoptera* (Uvarov 1926)	2	6	9	1	7	18	–
	Pyrgomorphidae	*P. bufonius hieroglyphicus* (Klug 1832)	0	0	2	0	0	0	L
Heteroptera	Pentatomidae	*A. versicoloratus* (Dallas 1851)	0	2	48	0	8	76	F
	Pentatomidae	*N. viridula* (Linn 1758)	0	7	65	0	21	46	F
	Pentatomidae	*A. lymphata* (Kirkaldy 1909)	0	1	32	0	0	14	F
	Scutelleridae	*C. panaethiopica* (Kirkaldy 1909)	0	0	0	0	0	56	F
	Pyrrhocoridae	*Dysdercus nigrofasciatus* (Stal 1855)	8	4	56	0	1	42	F
	Coreidae	*C. trigonus* (Thunberg 1783)	1	4	12	0	11	36	F
	Coreidae	*L. membranaceus* (Fabricius 1781)	1	3	26	3	8	64	F
	Tingidae	No. id	0	4	0	0	0	0	–
Hymenoptera	Sphecidae	*S. fuscipennis* (Smith 1856)	2	5	37	1	8	53	V
	Halictidae	*Lasioglossum* sp.	0	0	14	4	3	29	V
	Halictidae	*Nomioides* sp.	0	1	3	0	0	1	V
	Melittidae	*S. atropos* (Smith 1855)	2	6	11	0	1	25	V
	Masaridae	*Jugurtia jemenensis* (Kostylev 1935)	3	9	23	5	17	36	V
	Megachilidae	*Coelioxys* sp	0	1	13	0	0	9	V
	Eumenidae	*T. guerinii* (Saussure 1856)	0	2	6	0	0	14	V
	Anthophoridae	*T. delumbatus* (Vachal 1903)	0	3	18	0	1	7	V
	Formicidae	*L. capensis* (Mayr 1862)	33	26	41	22	39	26	V
	Formicidae	*O. longinoda* (Ledoux 1950)	25	12	37	46	51	72	V
	Pteromalitidae	*Pteromalus puparum* (Dalman 1820)	5	3	0	1	0	0	V
	Apidae	*A. mellifera adansonii* (Linn 1761)	0	0	16	0	2	53	V
	Formicidae	*C. maculatus* (Fabricius 1782)	8	15	5	5	33	18	V
Diptera	Conopidae	*C. zonatus* (Linn 1758)	6	25	47	2	41	35	V
	Syrphidae	*Eristalis* sp.	0	5	8	0	1	1	V
	Muscidae	No. id	3	8	16	1	21	34	V
	Tachinidae	*Gonia* sp.	6	12	16	0	0	0	V
	Tephritidae	*Ceratitis* sp.	1	0	2	2	3	1	V
	Syrphidae	*Asarkina africana* (Bezzi 1908)	0	0	6	0	3	1	V
	Tabanidae	No. id	8	11	25	1	5	32	V
Plecoptera	Perlidae	No. id	2	17	9	0	1	0	–
Isoptera	Termitidae	No. id	0	0	56	0	0	74	VL
Total			186	409	1124	171	546	1413	
				1719			2130		

F: feeds on flowers and leaves, L: feeds on leaves and seedlings, V: visited flowers, No.id: no identified.

In Niger, the collected insect species of Diptera from *J. curcas* were found to belong to the following families: Conopidae (*Conops zonatus*—Krober 1915); Syrphidae (*Eristalis* sp.) Muscidae (*Stomoxys calcitrans*) Tachinidae (*Gonia* sp.), and Tephritidae (*Ceratitis* sp.) (Table 2). We also observed that these species regularly visited the *J. curcas*'s flowers. According to Solomon Raju and Ezradanam (2002), the contribution of Diptera in the pollination of *J. curcas* remains weak.

Many species of Lepidoptera were observed on *J. curcas* flower in Niger, but in individual number. The alcol, which was used for preservation, caused color damage, making Lepidoptera identification more complicated.

In the low valley of Senegal River leaf miner *Stomphastis thraustica* (Meyrick 1908) (Lepidoptera: Gracillariidae) and the leaf and stem miner *Pempelia morosalis* (Saalmuller 1880) (Lepidoptera: Pyralidae) have been identified (Terren et al. 2012). These caterpillars are observed in many sites in Africa but not in our sites because of the young plantations.

Evaluation of Species Diversity. The numbers of insects of both trapping and plugging methods are summarized in Table 3. In 2010, 1,719 insects were collected between June and October, with 186 from Niamey, 409 at Saga, and 1,124 at Gaya. In 2011, 2,130 insects were collected at the same sites, with 171 insects from Niamey, 546 at Saga, and 1,413 at Gaya. These large differences in abundance observed between the three localities can be due to the microclimate. Niamey and Saga are located in the Sahelian area, whose isohyets lie between 500 and 600 mm of rain. The site at Gaya, with the greatest number of insects, is located in the Soudano-Sahelian area, with isohyets ranging from 700 to 800 mm.

Table 4. Diversity index

Index	2010			2011		
	Niamey	Saga	Gaya	Niamey	Saga	Gaya
Shannon index (H')	1.36	1.36	1.43	0.99	1.27	1.41
Equitability (H_{max})	0.97	0.88	0.91	0.76	0.85	0.9
Simpson (index D)	0.91	0.92	0.95	0.79	0.93	0.95

The Shannon–Weaver diversity indexes in 2010 were 1.36, 1.36, and 1.43 for Niamey, Saga, and Gaya, respectively (Table 4). These values correspond to a low diversity of insect species in *J. curcas* plantations.

The sites of Niamey and Saga have a similar diversity index; they belong to the same climatic area. The Shannon–Weaver diversity indexes in 2011 were 0.99, 1.27, and 1.41 for Niamey, Saga, and Gaya, respectively. Lower indexes were observed in 2011 at Saga and Niamey because the rain fallen was more important in 2010 (442 mm in Niamey, 545 mm in Saga) than in 2011 (341 mm in Niamey and 441 mm for Saga).

The indexes of equitability (H_{max}) in 2010 were 0.97, 0.88, and 0.91 for Niamey, Saga, and Gaya, respectively. The indexes for 2011 were 0.76, 0.85, and 0.90 for Niamey, Saga and Gaya, respectively. Indeed, no dominant species were found in the plantations.

The 2010 Simpson indexes were 0.91, 0.92, and 0.95 for Niamey, Saga, and Gaya, respectively, the 2011 indexes were 0.79, 0.93, and 0.95 for the same sites. This index shows the low diversity of the species of insects on *J. curcas* in all the localities.

Jatropha curcas, which was recently introduced into Niger, is visited by several insects belonging to different families. In Niger, the majority of insect pests associated with *J. curcas* belonged to the following families: Acrididae and Pyrgomorphidae that feed on leaves and seedlings; and the Cetoniidae, Pentatomidae, Coreidae, and Scutelleridae that feed on flowers and fruits of *J. curcas.*

As a result, all insect species associated with *J. curcas* in Niger were previously observed on other favorable crops such as cereal (millet, sorghum). *J. curcas* was found to be attacked by Acrididae in the beginning of the rain season before the plantation of cereal crops. Others insects' species belonging to Coleoptera, Hymenoptera, and Diptera were found to be attracted by the *J. curcas* flowers. The species that appear specific to *J. curcas* are *C. panaethiopica* observed only at Gaya and *Calidea* sp. observed at Maradi.

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