REVIEW PAPER

Arthropods associated to Jatropha curcas *Linnaeus. Functions and strategy for their management*

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ABSTRACT: At present, *Jatropha curcas* Linnaeus constitutes one of the most studied plants worldwide due to its potential to produce oil, which can be transformed into biodiesel. However, there is not enough information yet about its ecological interactions with other plants and animals; for which the knowledge concerning the arthropods associated to *J. curcas* is an essential requisite for the adequate management of the crop. The objective of this paper is to present the results of a compilation made about these organisms (mainly insects, mites and spiders), to contribute to achieve a better exploitation of the plantations of this energy crop in Cuba. Within the group of plant-eaters, 151 insect species were found, among which two from order Hemiptera (*Pachycoris klugii* Burmeister (Scutelleridae) and *Leptoglossus zonatus* (Dallas)) stand out, in addition to four mite species. Among the beneficial ones, 90 insect, five mite and 13 predator spider species were found. Regarding pest management strategies, a higher emphasis is made on the chemical control measures and some cultural-type actions. Taking these antecedents into consideration, in Cuba it is essential to know the main organisms associated to this plant, in order to incorporate –with higher accuracy– the agroecological component in pest management, and thus contribute to the maintenance of the productive capacities of agroecosystems and their resilience.

Key words: plant-eaters, insects, pest

INTRODUCTION

*Jatropha curca*s Linnaeus (*Euphorbiaceae*), commonly known as piñón botija in Cuba (Roig, 1965), is native to Central America and northern South America. Nevertheless, since the 16th century it was distributed in other tropical regions by European sailors and explorers; and it is disseminated in tropical areas throughout the world, including the Sub-Saharan countries of Africa, the Asian Southeast, India, among others (Van der Putten *et al*., 2010). In the last decades it has become a very popular plant due to its potentialities and multiple usages, specifically for the particularity of being an oil-producing crop, which can be transformed into biodiesel (Fairless, 2007).

In that sense, this oil –easily extractable from its seeds (25-35 % of their content) –is also used for energy production, lighting and food cooking. In addition, it is used in medicine, as biopesticide, and in soap elaboration. Besides, the seed press cake –obtained as a byproduct of oil extraction– can be used as organic fertilizer and for biogas production (Brittaine and Lutaladio, 2010).

According to Quiroga *et al*. (2010), *J. curcas* is considered a perennial forest tree, highly rustic, resistant to drought and provider of litter as a source of organic matter. In addition, it is efficient in carbon sequestration and water retention, and can be used in degraded soils and as living fence.

Due to the toxic and biopesticide characteristics of the plant, the pests that affect it do not seem to cause highly significant damage; however, a high incidence of such noxious agents is reported in monocrop plantations. Hence its sensitivity to plant-eaters can depend on the intensity of the actions carried out (Brittaine and Lutaladio, 2010), which should respond to an agroecological pest management (APM) within the agriculture that moves towards sustainable production, according to the criteria expressed by Vázquez and Álvarez (2011).

For such reason, the objective of this paper is to present the results of a compilation made about the main arthropods associated to *J. curcas*, as well as their functions and the possible strategies for their management, in order to project better

the exploitation of plantations of this plant which recently began to be utilized as energy crop in Cuba

Main arthropods associated to *J. curcas* Linnaeus

In spite of the popular belief that the toxic and insecticide properties of *J. curcas* are enough to prevent insects from causing economic damage to its plantations, there are several groups that overcome this barrier. These groups are mentioned in a global list of plant-eaters compiled in Australia (where *J. curcas* is considered an invasive plant), which was integrated by 60 species –grouped in 21 families and four orders–, according to the report by Shanker and Dhyani (2006), and whose number of plant-eating species was similar to the one found in Chiapas (Mexico) by Quiroga *et al*. (2010), although not all of them coincide. Yet, in this bibliographic compilation 151 species were found, which represent 131 genera and are grouped into 57 families; as well as eight orders, among which the following stand out: Hemiptera, Coleoptera, Lepidoptera and Orthoptera, with 66, 36, 17 and 13 species, respectively (table 1).

The main species of phytophagous insects considered as pests vary according to the geographical region (Nielsen, 2010). In Africa, specifically in Mozambique, *Aphthona dilutipes* Jacoby (Coleoptera: Chrysomelidae) prevails; the adults of this species defoliate the crop and its larvae feed on the roots (Gagnaux, 2009). In India (Asia) *Scutellera nobilis* Fabricius (Hemiptera: Scutelleridae) stands out, causing the fall of the flowers that form the inflorescence, as well as the abortion of fruits and the malformation of the seeds, according to Shanker and Dhyani (2006). In Oceania (Australia), these last authors cite other species of the same family, *Agonosoma trilineatum* (Fabricius), which causes severe damage to the seed. Also, in the Asian and African continents, the cited authors make emphasis on the presence of *Stomphastis* (=*Acrocercops*) *thraustica* (Meyrick) (Lepidoptera: Gracillariidae), that feeds on the inflorescences.

On the other hand, in Central and South America (particularly in Nicaragua and Honduras) the existence of the hemipterans *Pachycoris klugii* Burmeister (Scutelleridae) and *Leptoglossus zonatus* (Dallas) (Coreidae), which remarkably damage developing fruits, is reported (Alfonso, 2008; Grimm and Maes, 2008). Besides, in Brazil, Saturnino *et al*. (2005) report the presence of the hemipterans *Empoasca* spp. (Cicadellidae) (from which some species are vectors or virus-transmitters), that affect considerably the leaves, and *Pachycoris torridus* (Scopoli) (Scutelleridae), that damages fruits.

Regarding phytophagous mites, four species that belong to the order Trombidiformes, suborder Prostigmata were related: 1) *Polyphagotarsonemus latus* (Baks) (Tarsonemidae), 2) *Tetranychus* sp., 3) *Tetranychus bastosi* Tuttle, Baker & Sales, and 4) *Panonychus citri* McGregor, which are found in Australia, Brazil, United States, Republic of Cape Verde and Italy, and affect the leaf shoots and flower buds. The last three ones (from the family Tetranychidae) damage the leaves, mainly on the underside, in Brazil (Grimm and Maes, 1997; De Arruda *et al*., 2005; Vedana, 2006; Dos Santos *et al*., 2007; Carels, 2009; Sarmento *et al*., 2011; Erazo (s.f.) and Contran *et al*., 2013); and it should be emphasized that *P. latus* causes remarkable economic loses in that country (Saturnino *et al*., 2005).

With regards to beneficial arthropods, they were grouped into 103 species: 90 of insects –separated into 37 predators, 21 parasitoids and 32 pollinators, taking into consideration that the predator *Polistes* sp. (Hymenoptera: Vespide) is also a pollinator (table 2)– and 13 of spiders (predators), number that exceeds the 65 species -40 of insectivores and spiders, and 25 pollinators– found in Chiapas (Mexico) by Quiroga *et al*. (2010).

On the other hand, as another result of this compilation (table 2) it could be observed that there is a prevalence of insect species belonging to the orders Hymenoptera (18 parasitoids, 11 predators and four pollinators), Coleoptera (11 pollinators and 5 predators), Lepidoptera (represented by 16 pollinators) and Hemiptera (including 13 predators). Within that group of insects, according to the criteria expressed by Grimm and Maes (1997), Gagnaux (2009), Quiroga *et al*. (2010) and Contran *et al*. (2013), a remarkable group of insectivores to which reference is made below, stands out.

The hemipterans of the family Reduviidae *Apiomerus pictipes* Herrich-Schaeffer and *Rocconota* sp., as well as the stink bug *Euthyrhynchus floridanus* (Linnaeus), constitute predators of nymphs and adults of the shield-backed bug *P. klugii*. In addition, *Procheiloneurus* sp. (Encyrtidae) and *Telenomus* (=*Pseudotelenomus*) *pachycoris* (Costa-Lima) (Scelionidae) are hymenopterans which parasite the eggs of such pest, and the latter is also a pest of *P. torridus*.

Likewise, an unidentified dipteran species –hymenopteran *Brancon hebetor* Say (Braconidae)– and undetermined species from the family

Table 1. List of the main phytophagous insects associated to *J. curcas* in the different zones where it is cultivated worldwide.

ORDER Family	Species	Organ or growth stage it damages	Distribution
COLEOPTERA			
Anthribidae	*Araecerus coffeae* (Fabricius)	Leaf	Mozambique
Apionidae	*Piezotrachelus* sp.	Leaf	Mozambique
Bostrichidae	*Bostrichus capucinus* L.	Leaf	Germany, Australia, Brazil, France, Italy, United Kingdom
	Bostrichus sp.	Wood	Cape Verde Islands
Bruchidae	*Megacerus* sp.	Foliage and seed	Mexico
Buprestidae	Especie sin determinar	Branch and stems	Mexico
Cerambycidae	*Coptops aedificator* (Fabricius)	Foliage	Mozambique
	Crossotus stypticus (Pascoe)	Foliage	Mozambique
	Lagocheirus undatus Voet	Bark, branch and stem (wood)	Brazil, Mexico, Nicaragua, North and Central America, Oceania
Chrysomelidae	*Aphthona dilutipes* Jacoby	Leaf (adults) and root (larvae)	Africa, Malawi, Mozambique
	Aphthona sp.	Leaf	Mexico
	Aphthona sp. n (near *dilutipes*) Jacoby	Leaf (adults) and root (larvae)	Mozambique
	Aphthona sp. (*hargreavesi*) Bryant	Leaf (adults) and root (larvae)	Mozambique
	Phyllotreta sp. n (near *hargreavesi*) Jacoby	Leaf	Mozambique
	Altica sp.	Leaf	Mozambique
	Asbecesta sp. n (near *cyanipennis*) Harold	Leaf	Mozambique
	Podagrica maculata Weise	Leaf	Mozambique
	Sternocolaspis quatuordecimcostata (Lefèvre)	Leaf (foliage) and immature fruit	Brazil
	Ootheca mutabilis (Sahlberg)	Leaf	Mozambique
	Alagoala sp.	Leaf	Honduras
Curculionidae	*Alceis* sp.	Foliage	Honduras
	Anypoctatus jansoni (Sharp)	Leaf	Nicaragua
	Coelostemus notariaceps Marshall	Leaf	Brazil
	Pantomorus femoratus Sharp	Leaf	Mexico, Nicaragua
	Systates sp.	Foliage	Mozambique
Dermestidae	Unidentified species	Seed	Netherlands
	Trogoderma sp.	Seed	Nicaragua
Elateridae	*Cardiotarsus* sp.	Foliage	Mozambique
	Conoderus rodriguezi (Candéze)	Root	Honduras
Eucnemidae	Unidentified species	Leaf	Mozambique
Scarabaeidae	*Oxycetonia versicolor* (Fabricius)	Inflorescence	Brazil, India
	Phyllophaga sp.	Root	Central America, Mexico
	Tephraea dichroa (Schaum)	Leaf (adults) and root (larvae)	Mozambique

Table 1. (*Continuation*)

ORDER Family	Species	Organ or growth stage it damages	Distribution
COLEOPTERA			
Scarabaeidae	*Oxycetonia versicolor* (Fabricius)	Inflorescence	Brazil, India
	Phyllophaga sp.	Root	Central America, Mexico
	Tephraea dichroa (Schaum)	Leaf (adults) and root (larvae)	Mozambique
Tenebrionidae	*Lobometopon guatemalenses* Champion	Trunk, branch and dead material	Honduras
	Tribolium castaneum Herbst	Seed	Netherlands
	Tribolium sp.	Seed	Nicaragua
DIPTERA			
Lonchaeidae	Undetermined species	Fruit	Mexico
Tephritidae	*Anastrepha* sp.	Leaf and fruit	Mexico
HEMIPTERA			
Aleyrodidae	*Trialeurodes vaporiariorum* Westw.	Leaf	Germany
	Bemisia tabaci (Gennadius)*	Leaf	Africa, Asia, Barbados, Cuba, Dominica, United States, El Salvador, Europe, Guatemala, Hawaii, Honduras, Jamaica, Mexico, Nicaragua, Puerto Rico
	Bemisia argentifolii (Bellows & Perring)*	Leaf	Africa, Asia, Barbados, Cuba, Dominica, El Salvador, United States, Europe, Guatemala, Hawaii, Honduras, Jamaica, Mexico, Nicaragua, Puerto Rico
AIydidae	*Hyalymenus tarsatus* (Fabricius)	Fruit	Nicaragua
	Stenocoris tipuloides (De Geer)	Inflorescence	Nicaragua
Aphididae	Undetermined species	Foliage	Mexico
Cercopidae	*Aeneolamia* sp.	Branch and stem	Mexico
	Prosapia sp.	Branch and stem	Mexico
Cicadellidae	*Agrosoma placetis* Medler	Leaf underside	Mexico
	Empoasca kraemeri (Ross &Moore)	Leaf	Nicaragua
	Empoasca spp.	Leaf and inflorescence	Brazil
	Erythrogonia aerolata Signoret	Leaf underside	Mexico
	Unidentified species 1	Leaf and inflorescence	Mozambique
	Unidentified species 2	Leaf and inflorescence	Mozambique
	Macunolla ventralis (Sign.)	Leaf	Nicaragua
	Oncometopia clarior (Walker)**	Leaf	Nicaragua
Cicadidae	*Diceroprocta* sp.	Leaf	Nicaragua
Cixiidae	Undetermined species	Root (the nymphs)	Mexico
Coreidae	*Acanthocephala femorata* Fabricius	Fruit	Mexico
	Anasa scorbutica Fabricius	Fruit	Mexico, Nicaragua
	Chariesterus albiventris Burmeister	Fruit	Mexico

Table 1. (*Continuation*)

ORDER Family	Species	Organ or growth stage it damages	Distribution
HEMIPTERA			
Coreidae	*Acanthocephala femorata* Fabricius	Fruit	Mexico
	Anasa scorbutica Fabricius	Fruit	Mexico, Nicaragua
	Chariesterus albiventris Burmeister	Fruit	Mexico
	Chariesterus moestus Burmeister	Fruit	Mexico
	Hypselonotus concinnus concinnus Dallas	Fruit	Mexico
	Hypselonotus intermedius Distant***	Inflorescence and fruit	Mexico, Nicaragua
	Hypselonotus lineatus detersus Horvath***	Inflorescence and fruit	Mexico, Nicaragua
	Leptoglossus gonagra Fabricius	Fruit	Mexico, Nicaragua
	Leptoglossus zonatus (Dallas)	Inflorescence, fruit and seed	Brazil, Bolivia, Central and South America, Colombia, Ecuador, United States, Honduras, India, Mexico, Nicaragua, northern Africa, Peru, Venezuela
	Mozena lunata Burmeister	Fruit	Mexico
	Mozena ventralis Mayr	Fruit	Mexico
	Salamancaniella alternata Dallas	Fruit	Mexico
Dactylopiidae	*Dactylopius coccus* Costa	Leaf, branch, trunk and fruit	Brazil
Diaspididae	*Pinnaspis strachani* (Cooley)	Leaf shoot	Cape Verde islands
Flatidae	*Dworena hyacintha* (Kirkaldy)	Foliage	Honduras
	Undetermined species	Leaf, petiole, peduncle and fruit	Mexico
Largidae	*Largus cinctus* Herrich-Schaeffer	Flower bud and inflorescence	Nicaragua
Margarodidae	*Llaveia axin axin* Llave	Leaves, mainly	Mexico
	Llaveia mexicanorum Morrison	Leaves, mainly	Mexico
	Coccus axin Llave	Leaves, mainly	Mexico
Membracidae	Undetermined species	Leaf underside and petiole	Mexico
Miridae	*Lygus* sp.	Leaf	Nicaragua
Pentatomidae	*Acrosternum marginatum* (Palisot de Beauvois)	Fruit	Nicaragua
	Edessa rufomarginata (De Geer)	Fruit	Mexico
	Euschistus sp.	Inflorescence	Nicaragua
	Nezara viridula (Linnaeus)	Forming fruit and seed	Argentina, Brazil, Chile, Colombia, Costa Rica, El Salvador, Guatemala, French Guiana, Honduras, Nicaragua, paleotropical and neotropical regions, Paraguay, Uruguay, Venezuela
	Piezodorus guildinii West.	Fruit	Mexico

Table 1. (*Continuation*)

ORDER Family	Species	Organ or growth stage it damages	Distribution
HEMIPTERA			
Pentatomidae	*Acrosternum marginatum* (Palisot de Beauvois)	Fruit	Nicaragua
	Edessa rufomarginata (De Geer)	Fruit	Mexico
	Euschistus sp.	Inflorescence	Nicaragua
	Nezara viridula (Linnaeus)	Forming fruit and seed	Argentina, Brazil, Chile, Colombia, Costa Rica, El Salvador, Guatemala, French Guiana, Honduras, Nicaragua, paleotropical and neotropical regions, Paraguay, Uruguay, Venezuela
	Piezodorus guildinii West.	Fruit	Mexico
	Proxis punctulatus (Palisot de Beauvois)	Leaf, stem, inflorescence and forming fruit	Nicaragua
	Rhyssocephala infuscata Rider	Fruit	Mexico
	Rhyssocephala rufonotata (Stål)	Fruit	Mexico
Pseudococcidae	*Ferrisia virgata* (Cockerell)	Branch and trunk	Cape Verde islands
	Planococcus sp.	Leaf, branch and fruit	Honduras
	Paracoccus marginatus Williams & Granara de Willink	Leaves, mainly	Mexico
	Pseudococcus sp.	Leaf, branch, flower bud and fruit	Honduras
Pyrrhocoridea	*Disdercus bimacutatus* Stål	Leaf underside, inflorescence	Mexico
	Disdercus sp.	Leaf and inflorescence	Mozambique
Rhopalidae	*Niesthrea sidae* (Fabricius)	Dry fruit	Nicaragua
Scutelleridae	*Agonosoma trilineatum* (Fabricius)	Seed	Australia
	Calidea dregei (LePelley)	Forming fruit and seed	Paleotropical region, Senegal
	Calidea stigmata Fabricius	Fruit	Cape Verde islands, paleotropical region
	Chelisoma sp.	Fruit	Mexico
	Chelisomidea variabilis (Herrich-Schaffer)	Inflorescence and fruit	Mexico, Nicaragua
	Eurygaster sp.	Fruit	Mexico
	Pachycoris klugii Burmeister	Inflorescence, fruit and seed	Africa, Brazil, Central and South America, Honduras, India, Mexico, Nicaragua
	Pachycoris spp.	Immature fruit, seed	Brazil
	Pachycoris torridus (Scopoli)	Inflorescence, fruit and seed	Brazil, United States, Nicaragua, North, Central and South America
	Scutellera nobilis Fabricius	Inflorescence, fruit and seed	Asia, Brazil, India

Table 1. (*Continuation*)

ORDER Family	Species	Organ or growth stage it damages	Distribution
HEMIPTERA			
Scutelleridae	*Sphirocoris punctellus* (Stal)	Fruit	Nicaragua
Thyphlocybinae	Unidentified species	Leaf	Mozambique
Tingidae	Unidentified species	Leaf	Mexico
HYMENOPTERA			
Formicidae	*Atta sexdens rubropilosa* Forel	Seedling leaf, mainly	Brazil, central Argentina, southern United States
	Atta spp.	Leaf	Central America, Honduras, Mexico
	Acromyrmex landolti Forel	Stem bark	Brazil
	Solenopsis geminata (Fabricius)	Seed	Nicaragua
ISOPTERA			
Termitidae	*Cornitermes* spp.	Root, stem inside and branch	South Africa, Argentina, Brazil, Canary Islands, Italy, Madagascar, Mozambique, Peru
	Armitermes spp.	Root	Brazil
	Procornitermes spp.	Root	Brazil
	Syntermes spp.	Root	Brazil
Rhinotermitidae	*Coptotermes formosanus* Shiraki	Trunk and branch	North and South America
	Heterotermes spp.	Root	Brazil
LEPIDOPTERA			
Arctiidae	Unidentified species	Leaf	Mozambique
	Estigmene acrea (Drury)	Leaf	Central America
	Phaloecia saucia Walker	Leaf	Nicaragua
Geometridae	Undetermined species	Leaf	Mexico
Gracillariidae	*Stomphastis* (=*Acrocercops*) *thraustica* (Meyrick)	Leaf	Africa, Brazil, India, Mexico, Mozambique, Nigeria
Metarbelidae	*Indarbela* spp.	Bark	India
	Indarbela quadrinotata Walker	Bark	India
Noctuidae	*Achaea janata* Linnaeus	Leaf	Africa, Brazil, India, Nigeria
	Spodoptera litura (Fabricius)	Leaf	Austria, India
	Spodoptera sp.	Foliage	México
Pieridae	*Ascia monuste* Linnaeus	Leaf	Mexico
Pyralidae	*Pempelia morosalis* (Saalm Ũller)	Inflorescence and immature fruit	Brazil, India
	Plodia interpunctella (Hubner)	Seed	Nicaragua
Saturniidae	Undetermined species	Leaf	Mexico
	Rothschildia hesperus Linnaeus	Leaf	Mexico
	Rothschildia lebeau lebeau (Guerin-Meneville)	Leaf	Nicaragua
Tineidae	*Tinea pellionella* Linnaeus	Trunk (wood)	Central America, Netherlands

Table 1. (*Continuation*)

ORDER Family	Species	Organ or growth stage it damages	Distribution
ORTHOPTERA			
Acrididae	Undetermined species	Leaf	Mexico
	Oedaleus senegalensis Krauss	Leaf	Africa
	Shistocarca nitens Thunberg	Whole plant (leaf, mainly, and immature fruit)	El Salvador, Honduras, Nicaragua
Eumastacidae	*Lophothericles* sp.	Leaf	Mozambique
	Pieltainidia sp.	Leaf	Mozambique
	Sphenarium purpurascens Charpentier	Leaf	Mexico
Pyrgomorphidae	*Pyrgomorpha* sp.	Leaf	Mozambique
	Stenoscepa sp.	Leaf	Mozambique
	Zonocerus elegans Thunberg	Leaf	Mozambique
Tettigoniidae	Unidentified species	Leaf	Mozambique
	Idiarthron sp.	Leaf and immature fruit	Nicaragua
	Stilpnochlora sp.	Fresh leaf	Mexico
Proscopiidae	*Corynorhynchus radula* (Klug)	Leaf and inflorescence	Brazil, Mozambique
THYSANOPTERA			
Phaelothripidae	Unidentified species	Foliage	Mexico
Unidentified	Unidentified species	Leaf and inflorescence	Mozambique
Thripidae	*Retithrips syriacus* Mayet (=*Stylothrips bondari* Bondar)	Leaf underside, inflorescence and fruit	Brazil, Costa Rica, Africa, southern Asia
	Thrips sp.	Foliage	Mexico
	Heliothrips sp.	Foliage	Mexico
	Frankliniella sp.	Foliage	Mexico
	Selenothrips rubrocinctus (Giard)	Leaf, inflorescence and fruit	Brazil, Australia and Nigeria

Source: Grimm and Maes (1997); Grimm (1999); De Arruda *et al.* (2005); Saturnino *et al.* (2005); Shanker and Dhyani (2006); Vedana (2006); Alfonso (2008); Dos Santos *et al.* (2007); Grimm and Maes (2008); Carels (2009); Gagnaux (2009); Morales *et al.* (2009); Brittaine and Lutaladio (2010); Nielsen (2010); Quiroga *et al.* (2010); Rengifo (2010); Erazo (s.f.); Contran *et al.* (2013)

* It is a virus-transmitter; ** It transmits the bacteria *Xanthomonas campestris* Pammel & Dowson pv. Jatrophicola, *** It is also a pollinator

Table 2. List of the main beneficial insects associated to *J. curcas* in the different zones where it is cultivated worldwide.

ORDER Family	Species	Distribution
COLEOPTERA		
Cantharidae	Undetermined species (Po)	Mexico
Cerambycidae	Undetermined species (Po)	Mexico
	Stenygra histrio Serville (Po)	Nicaragua
Coccinelidae	*Hippodamia* sp. (Pr)	Mexico
	Platynaspis sp. (Pr)	Mozambique
	Scymnus sp. (Pr)	Mozambique
Lampyridae	*Aspidosoma* sp. (Pr) (larval state) and plant-eater (adult state)	Nicaragua

Table 2. (*Continuation*)

ORDER Family	Species	Distribution
COLEOPTERA		
Lycidae	Undetermined species (Po)	Mexico
Meloidae	*Epicauta* sp. (Pr) [1] (larval state) and plant-eater (adult state)	Nicaragua
Scarabaeidae	*Apeltastes chiapasensis* Howden (Po)	Mexico
	Euphoria geminata Chevrolat (Po)	Mexico, Guatemala
	Euphoria leucographa (Gory & Percheron) (Po)	Mexico, Nicaragua
	Euphoria pulchella Gory & Percheson (Po)	Mexico
	Guatemalaica hueti Chevrolat (Po)	Mexico, Guatemala, Panama
	Strigoderma sp. (Po)	Mexico
Tenebrionidae	*Epitragus sallei* Champ. (Po)	Nicaragua
DERMAPTERA		
Forficulidae	*Doru taeniatum* (Dohrn) (Pr) [2]	Nicaragua
DIPTERA		
Asilidae	*Efferia* sp. (Pr) [2]	Nicaragua
	Undetermined species (Pr)	Mexico
Dolichopodidae	Undetermined species (Pr)	Mexico
Unidentified	Unidentified species (Pa)	India
Syrphidae	Unidentified species (Po)	Mexico
Tachinidae	Undetermined species 1 (Pa)	Mexico
	Undetermined species 2 (Pa)	India
HEMIPTERA		
Pentatomidae	*Euthyrhynchus floridanus* (Linnaeus) (Pr)	Nicaragua
	Euschistus sp. (Pr) [3]	Nicaragua
	Heterocelis lepida (Stål) (Pr)	Costa Rica, Panama, Mexico
	Oplomus pulcher (Dallas) (Pr)	Costa Rica, Panama, Mexico
	Stiretrus anchorago (Fabricius) (Pr) [2]	Nicaragua
Phymatidae	*Phymata* sp. (Pr) [4]	Mexico
Reduviidae	*Apiomerus pictipes* Herrich-Schaeffer (Pr)	Nicaragua
	Apiomerus sp. (Pr)	Mexico
	Repipta sp. (Pr) [2]	Nicaragua
	Rocconota sp. (Pr)	Nicaragua
	Rocconota tuberculigera Stal (Pr) [2]	Nicaragua
	Sinea sp. (Pr) [2]	Nicaragua
	Zelus sp. (Pr) [2]	Nicaragua
HYMENOPTERA		
Apidae	*Apis mellifera* Linnaeus (Po)	Nicaragua
Aulicidae	Unidentified species(Pa) [5]	Mexico
Braconidae	*Brancon hebetor* Say (Pa)	India
	Undetermined species (Pa) [6]	Mexico

Table 2. (*Continuation*)

ORDER Family	Species	Distribution
HYMENOPTERA		
Chalcididae	*Brachymeria* sp. (Pa)	Mexico, Cuba, United States, Nicaragua, Puerto Rico, Haiti, Dominican Republic, Costa Rica, Panama, Colombia, Trinidad and Tobago, Venezuela, Guiana, Brazil, Ecuador, Peru, Paraguay, Uruguay, Argentina
Encyrtidae	*Procheiloneurus* sp. (Pa)	Nicaragua
Eucharitidae	Undetermined species (Pa)	Mexico
Eucoilidae	Undetermined species (Pa) [6]	Mexico
Eulophidae	Undetermined species (Pa) [7, 8]	Mexico
Eupelmidae	Undetermined species (Pa)	Mexico
Eurytomidae	Undetermined species (Pa)	Mexico
Formicidae	*Camponotus* sp. 1 (Pr)	Mozambique
	Camponotus sp. 2 (Pr)	Mozambique
	Cataulacus intrudens Smith (Pr)	Mozambique
	Conomyrma sp. (Po)	Nicaragua
	Oecophylla longinoda Latreille (Pr)	Mozambique
Formicidae	*Pachycondyla tarsata* (Fabricius) (Pr)	Mozambique
	Solenopsis geminata (Fabricius) (Pr)	Nicaragua
Halictidae	*Ceylalictus* sp. (Po)	Mozambique
	Undetermined species (Po)	Mexico
Ichneumonidae	Unidentified species (Pa)	Mexico
Mymaridae	Unidentified species (Pa) [7, 9]	Mexico
Platygasteridae	Unidentified species (Pa) [7]	Mexico
Pteromalidae	Unidentified species (Pa) [7, 10]	Mexico
Scelionidae	*Gryon* sp. (Pa)	Nicaragua
	Undetermined species (Pa)	Mexico
	Telenomus (=*Pseudotelenomus*) *pachycoris* (Costa-Lima) (Pa)	Nicaragua, Brazil
Tiphiidae	Undetermined species (Pr)	Mexico
Trichogrammatidae	*Megaphragma* sp. (Pa)	Mexico
Vespidae	Undetermined species (Pr) [3]	Mexico
	Polistes sp. (Pr) [3] (Po)	Nicaragua
	Polybia sp. (Pr) [3] (possible Po)	Nicaragua
LEPIDOPTERA		
Ctenuchidae	Undetermined species (Po)	Mexico
	Correbidia elegans Druce (Po)	Nicaragua
	Correbia undulata Druce (Po)	Nicaragua
	Dycladia correbioides Felder (Po)	Nicaragua

Table 2. (*Continuation*)

ORDER Family	Species	Distribution
LEPIDOPTERA		
Ctenuchidae	Undetermined species (Po)	Mexico
	Correbidia elegans Druce (Po)	Nicaragua
	Correbia undulata Druce (Po)	Nicaragua
	Dycladia correbioides Felder (Po)	Nicaragua
Nymphalidae	*Adelpha fessonia* Hewitson (Po)	Mexico
	Euptoieta hegesia hoffmanni Comstock (Po)	Mexico
	Pyrrhogyra hypsenor Godman & Salvin (Po)	Mexico
Papilionidae	*Protesilaus epidaus epidaus* Doubleday (Po)	Mexico
Pieridae	*Aphrissa statira jada* Butler (Po)	Mexico
	Eurema daria Godart (Po)	Mexico
	Glutophrissa drusilla tenuis Lamas (Po)	Mexico
	Melete lycymnia isandra Boisduval (Po)	Mexico
	Phoebis agarithe Boisdual (Po)	Mexico
	Phoebis argante argante Fabricius (Po)	Mexico
	Phoebis sennae marcellina Cramer (Po)	Mexico
	Pyrisitia proterpia proterpia Fabricius (Po)	Mexico
MANTODEA		
Mantidae	*Mantis* sp. (Pr) [4]	Mexico
	Stagmomantis carolina (Johansson) (Pr) [2]	Nicaragua
NEUROPTERA		
Chrysopidae	*Chrysopa* (=*Chrysoperla*) sp. (Pr)	Mexico
Mantispidae	*Mantispa* sp. (Pr)	Mexico

Fuente: Grimm and Maes (1997); Gagnaux (2009); Quiroga *et al.* (2010); Contran *et al.* (2013)

(Pr): Predator; (Pa): Parasitoid; (Po): Pollinator

[1] Of grasshopper eggs; [2] Polyphagous; [3] Of lepidopteran larvae; [4] Generalist; [5] Of hymenopterans and coleopterans; [6] Of hemipterans; [7] Of hemipterans, coleopterans and dipterans; [8] Of thrips, lepidopterans and hymenopterans; [9] Of ortopterans; [10] Of hymenopterans

Tachinidae are cited, as parasitoids of the snout moth *P. morosalis*. In addition, reference is made to: the parasitoid of eggs from the leaf-footed bug *L. zonatus*, the hymenopteran *Gryon* sp. (Scelionidae); the parasitoid of different thrip species, *Megaphragma* sp. (Hymenoptera: Trichogrammatidae); and the aphid predator, the coleopteran *Hippodamia* sp.

Other examples are the predator *Oplomus pulcher* (Dallas) (Hemiptera: Pentatomidae) and the parasitoid *Brachymeria* sp. (Hymenoptera: Chalcididae), which control the populations of *A. monuste*; although this last insectivore also feeds on the owlet moths *Remigia latipes* Gueneé and *Spodoptera frugiperda* (Smith). On the other hand and undetermined species is cited (Hymenoptera: Scelionidae) which, in addition to being a parasitoid of *S. frugiperda*, equally controls the hemipteran *N. viridula* and the acridic orthopterans.

Meanwhile, five species of the family Phytoseiidae, present in Brazil, were compiled as predator mites: *Amblyseis herbicolus* (Chant), *Euseius concordis* Chant, *Iphiseiodes zuluagai* Denmark & Muma, *Neoseiulus californicus* (McGregor) and *N. idaeus* Denmark & Muma. They are predators of the thread-footed mite *P. latus*, but the second and third species are also predators of the spider mite *T. bastosi* (Dos Santos *et al*., 2007; Sarmento *et al*., 2011).

Likewise, the 13 species of predator spiders found are included in seven families: Araneidae

(*Gasteracantha cancriformis* (L.) and *Micrathena* sp.); Eresidae (*Stegodyphus* sp., predator of the jewel bug *S. nobilis*); Oxyopidae (*Peucetia viridans* (Hentz), predator of the stink bug *N. viridula*; *P. longipalpis* F. O. P.-Cambridge and *Hamataliwa flebilis* F. O. P.-Cambridge); Philodromidae (*Apollophanes* sp.); Salticidae (unidentified species, predator of nymphs of the shield-backed bug *P. klugii*; *Lyssomanes diversus* Galinao and *Thiodina* sp.); Tetragnathidae (*Leucage* sp., predator of the jewel bug *C. variabilis*) and Thomisidae (unidentified species, predator of nymphs of the leaf-footed bug *L. zonatus*; and *Misumenoides* sp.). The third species is distributed in India; while the first, second, fourth, eighth, eleventh and twelfth are found in Nicaragua; and the others in Mexico (Grimm and Maes, 1997; Shanker and Dhyani, 2006; Quiroga *et al*., 2010).

Potential strategies for phytosanitary pest management in J. curcas

The main strategy for the phytosanitary pest management in *J. curcas* is integrated pest management –IPM– (Gagnaux, 2009). Several examples are shown below.

In the case of the leaf beetle *A. dilutipes*, the first element that should be taken into consideration is the management of the planting date (in order to evade the initial emergence of adults); then, the performance of deep plowing, taking into consideration the dormancy of the larval state at remarkable depths in the soil, to expose larvae to predators, sun rays and the physical damage with agricultural tools. On the other hand, the use of biopesticides of botanical origin, available in the different localities, is possible, specifically those obtained from plants of the family *Meliaceae* which are very effective for the control of chewing insects –such as lepidopterans and coleopterans–; as well as those of microbial origin based on *Beauveria bassiana* (Bals.-Criv.) Vuill. Finally, the use of synthetic (conventional) pesticides is recommended: Carbaryl pH 80 % (at 2 g/l^{-1} or 0,7 kg ha^{-1}), Cymbush CE 25 % (at 0,5 mL L^{-1} or 0,2 L ha^{-1}), Basudine CE 60 % (at 2 mL L^{-1} or 0,7 L ha^{-1}), among others.

For the control of the leaf miner of *J. curcas* the lepidopteran *S. thraustica*, as main measure, and the chemical pesticides Mospilan PS 20 % (at 40 g 100 L of water^{-1}), Disyston GR 5 % (at 30 g 100 L of water^{-1} m^{-1} of the tree height), are recommended, among others. Nevertheless, Quiroga *et al*. (2010) report that there are diverse natural enemies of this pest that can regulate its populations, for example: seven-spotted ladybug (Coccinelidae), green lacewings (Chrysopidae), assassin bugs (Reduviidae), tiny wasps (Encyrtidae), spiders and predator ants.

Likewise, for the hemipterans *P. klugii* and *L. zonatus* the use of chemicals is suggested as main control measure, among them: the insecticides Monarca SE 11,25 % and Karate CE 2,5 % in doses of 360-500 mL ha^{-1} (Alfonso, 2008). However, it is possible to use insectivores as an effective biological measure, as it was mentioned above when the beneficial insects (predators and parasitoids) and the predator spiders found in this compilation were addressed.

Nevertheless, it is evident that taking phytosanitary measures in a preventive way, such as the ones proposed by Nielsen (2010), would be an important contribution for the management of *J. curcas* plantations; among these measures are:

The use of resistant varieties or, at least, the utilization of plants as "mother plants" for seed and cutting production.

J. curcas should not be planted when the pest incidence is intense, especially at the end of the rainy season, when the temperature and relative humidity are high; because the infestation rates can be higher years after the plant has been sown.

To avoid dense *J. curcas* plantations and massive pest outbreaks it is necessary to widen the planting frame; to cultivate in small fields separated and isolated from each other in the landscape; to sow on the edges, instead of in the plots; and to cultivate *J. curcas* associated to other species.

To use the biopesticides obtained from *J. curcas* to be applied to young plants, because it is then that they have a lower toxin concentration.

In addition, it is necessary to take into consideration that in the sites of *J. curcas* plantations, the most important element is the agroecological management of the farm, because it means to act on the causes for which organisms that are noxious for plants become pests and affect the crops present in it, every time they are sown. Hence it is necessary to understand that the farm must be managed as a system, precisely to reduce the causes of pest appearance. This is basic and constitutes an important part of the success in pest suppression, which, regrettably, is not considered in intensive production systems and much less in monocrops (Vázquez, 2011).

CONCLUSIONS

According to the compiled information to elaborate this review, it can be concluded that there

is a large number of arthropods associated to the *J. curcas* crop. Among the plant-eating organisms considered as potential pests, the insects of the order Hemiptera and four mite species stand out. Among the beneficial ones (mainly predators, parasitoids and pollinators), the insects of the order Hymenoptera stand out, in addition to five species of predator mites and the predators spiders of the families Oxyopidae and Salticidae –with three species each.

Regarding the pest management strategies, higher emphasis is made on the chemical control measures and some cultural-type actions, which indicates the importance of establishing programs of selection of local lines (accessions) and breeding, in accordance with their performance and adaptation in the regions that produce *J. curcas*; the use of certified seeds; the timely determination of the economic threshold level; as well as the agroecological management of the farm: from the organic and innocuous nutrition (through compost, organic manures, and others of this kind) to the phytosanitary protection based on biological products; the physical, mechanical, cultural control and with the minimum use of conventional chemicals, for example, using herbicides only at the beginning of the establishment of the plantation, if it is necessary.

For such reasons, and taking into consideration these antecedents, in Cuba it is essential to know the main organisms associated to this recently-introduced plant for the production of oil and its conversion into biodiesel; and, based on these experiences, to incorporate more accurately the agroecological component in pest management, and thus achieve sustainable land management, related to the socioeconomic development of the country, with the maintenance of the productive capacities of agroecosystems and their resilience.

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