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Parasitoids of the silkmoth *Borocera cajani* Vinson or "Landibe" (Lepidoptera: Lasiocampidae) in the Arivonimamo Tapia forest: Diversity and abundance

Parasitoïdes du papillon séricigène *Borocera cajani* Vinson ou "Landibe" (Lepidoptera : Lasiocampidae) dans la forêt de Tapia d'Arivonimamo : Diversité et abondance

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Résumé : *Borocera cajani* Vinson, le fameux Landibe, un papillon séricigène sauvage de la forêt de Tapia est le plus exploité en matière de soie et possède la plus large distribution à Madagascar. Sa population ne cesse de régresser dans son habitat naturel suite à différentes pressions. Cependant, aucune étude n'a mentionné si les parasitoïdes contribuent aux menaces de l'espèce. Ainsi, une étude sur le parasitisme de cette espèce a été conduite pour sa première génération (Fin novembre – Mi-mars) dans la forêt de Tapia d'Arivonimamo. Tous les stades du cycle de développement de Landibe ont été étudiés. L'échantillonnage des parasitoïdes a été réalisé à partir des observations sur des surfaces rectangulaires préétablies, l'exposition des appâts d'œufs sur les troncs d'arbres, l'utilisation des pièges Malaise et des assiettes jaunes et la collecte des cocons du Landibe. Le travail a montré que l'espèce est parasitée par 5 familles d'Hymenoptères (Scelionidae et Eurytomidae pour le stade œuf, Braconidae pour les chenilles, Ichneumonidae et Tachinidae pour les chrysalides). *Enicospilus evanescens* (Ichneumonidae), parasite nymphal de Landibe se trouve être l'espèce la plus abondante et la plus fréquente des parasitoïdes du Landibe à Arivonimamo.

Mots clefs : Papillons séricigènes, Parasitoïdes hyménoptères, Fréquences, Taux de parasitisme, Saison humide.

Abstract: *Borocera cajani* Vinson, the famous Landibe, a wild silk moth frequents the Tapia forest is the most exploited in silk production and wide-spread of the Madagascar. Its population continues to decline in its natural habitat due to various pressures. However, no studies have mentioned whether parasitoids contribute to the threats of the species. Thus, a study on the parasitism of this species was undertaken for its first generation (End of November – Mid-March) in the Tapia forest of Arivonimamo. All stages of Landibe's development cycle have been studied. Sampling of parasitoids was carried out from observations on pre-established rectangular areas, the exposition of egg baits on tree trunks, the use of Malaise traps and yellow plates and the collect of Landibe cocoons. This work showed that the species is parasitized by five families of Hymenoptera (Scelionidae and Eurytomidae for the egg stage, Braconidae for the caterpillars, Ichneumonidae and Tachinidae for the chrysalises). *Enicospilus evanescens* (Ichneumonidae), a nymphal parasite of Landibe is the most abundant and frequent species of Landibe parasitoids at Arivonimamo.

Key words : Silk moth, Hymenoptera parasitoids, Frequencies, Parasitism rate, Rainy season.

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INTRODUCTION

The wild silk moth *Borocera cajani* or Landibe is among the wood products of the sclerophyllous Tapia forest of Madagascar (GADE, 1985; KULL et al., 2005; RAKOTONIAINA, 2010). This species spreads and abundant in the Tapia forest which provides a shelter, a habitat for developing and foods. *Borocera cajani* is bivoltine, i.e it has two life cycles per year (RAZAFIMANANTSOA et al., 2012). Each life cycle cover the two seasons of the year of which the beginning and the duration differ on localities and seasons. Previous study reported that the cycle average duration is around 108 days and 199 days during the rainy and dry seasons respectively. Adults can be found in the field from November to December and from the end of February to April. The female oviposits on the leaves, branches, trunks or grasses (RAZAFIMANANTSOA et al., 2013). After about 9 to 10 days, the larvae hatch and feed on their host plant. Then, they developed through 4 continuous molting for having 5 instars in 64 days in average. The last instar is the longest compared to the other. Chrysalis needs 47 days for completing its development but it can go up until 90 days. Species moths have a short life span, only 2 to 4 days (RAZAFIMANANTSOA et al., 2012).

The landibe plays an important role in Malagasy culture, economy and culinary art as source of protein in some rural areas. The silk from the cocoons is used in clothing and in the manufacture of shrouds for the Malagasy people in the highlands (GADE, 1985; PEIGLER, 2004; RAZAFIMANANTSOA, 2012). Several actors are also involved in the transformation of cocoons into silk as cocoon's collectors in the forest, spinners, weavers and traders (DIEZ, 2013a). The economic gain is not negligible in this sector (GADE, 1985; DIEZ, 2013b). During the colonial period, national production of this bivoltine species is above 100 tons (BERGERAT, 1925). But Landibe pupae have long been consumed in and around cocoon collection areas (DECARY, 1937; GADE, 1985; KULL et al., 2005; BARSIC et al. 2013a; DIEZ, 2013a). They are also sold in rural markets during pupation periods. Consequently, the population in nature records an important decrease year by year due to anthropogenic activities (RAZAFIMANANTSOA, 2013; RAZAFIMANANTSOA et al., 2013a), the production drops to 43 tons in 2009 (CITE/BOSS Corporation, 2009). RAZAFIMANANTSOA et al. (2013a) recorded very low production in Arivonimamo, about 0.045 kg/ha. Several threats caused this drastic decrease: habitat loss and habitat degradation due to wildfire, invasion of exotic plant species such as pines, overexploitation of pupae and poor management of the Tapia forest which is the main niche of this species (RAZAFIMANANTOSOA et al., 2006; RAZAFIMANANTSOA, 2012). No study mentioned yet the parasitism phenomenon that contributes also to this abundance reduction in its natural habitat. But SMILANICH et al. (2009) reported that parasitoids are one of the highest biotic sources of mortality for insect herbivores, particularly lepidopteran larvae. Many works already confirmed this finding (GRANGEON, 1907; PAULIAN, 1950; PAULIAN, 1953; RAZAFIMANANTSOA et al., 2012; DIEZ, 2013b; RAZAFIMANANTSOA, 2013). The identified parasitoids of Landibe are mostly nymphal and larval parasites which break its life cycle. They are mostly Hymenoptera and Diptera of different sizes (GRANGEON, 1907; PAULIAN, 1950; RAZAFIMANANTSOA, 2013). This manuscript shows the relationship between parasites and the remaining population of Landibe through the identification of parasitoids and their ecological requirement in different stages of development as well as its parasitism rate in nature.

MATERIALS AND METHODS

Study sites

This study was carried out during rainy and hot season (from November 21st 2017 to March 23rd 2018) inside the Tapia forest of Arivonimamo II, which is located in Itasy Region. The study period coincides with the first generation of the Landibe silkmoth.

Two sites (Tsaramasoandro and Ambatomirainty) spaced of 1 km (Fig. 1) were selected and visited regularly during the study period. They are including between the following geographic coordinates 47°11'E 18°58'S and between 1200 m and 1400 m of elevation (BARSICS et al., 2013b). Two distinct seasons were recorded: cold and dry season from April to October, and hot and rainy season from November to March. The annual rainfall and the mean average temperature recorded were 1,470 mm and 17.7°C, respectively. The habitat type inside the study sites is composed of wooded savannah dominated by *Uapaca bojeri* (Phyllanthaceae) tree called locally "*Tapia*" (MALAISSE et al., 2013).

Plots establishment

Two rectangular areas (plots) of 0.1 ha (50 m length and 20 m width) each and spaced of 100 m were established per site for the Landibe sampling and theirs parasitoids. Each rectangular area was divided in 10 squares of 10 m x 10 m to facilitate the observation. The places of each plot were chosen randomly but all of them respected the following criteria: each area presents at least several Tapia trees and the variation of the elevation did not exceeded 100 m in the whole areas.

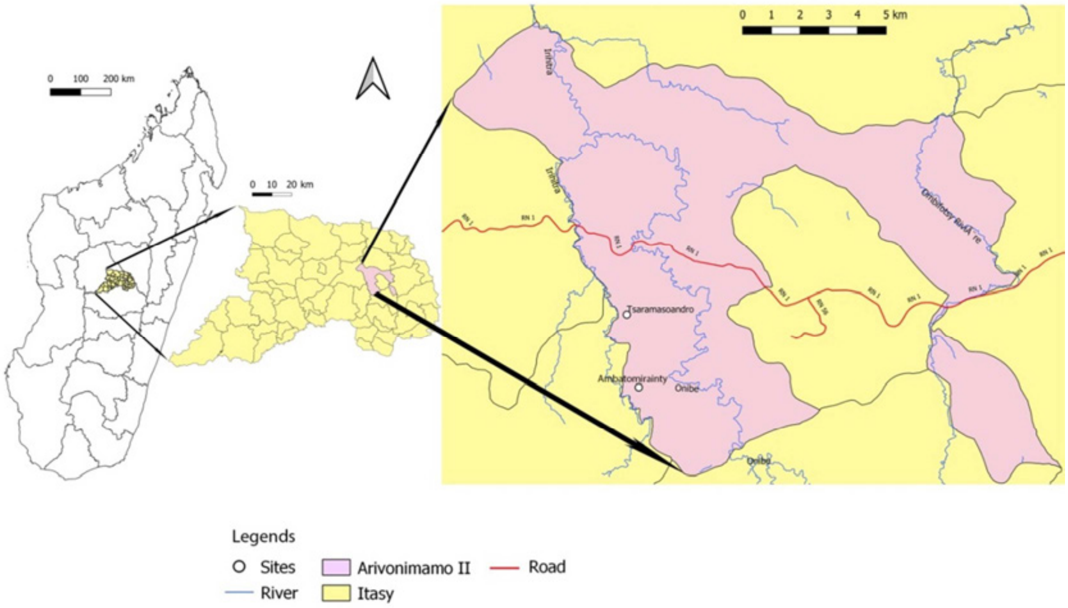

Figure 1: Map of Arivonimamo indicating the two study sites.

Identification of the parasitoids at each stage of Landibe

Egg and caterpillar stages

Previous studies already identified two host plants: *Uapaca bojeri* and *Aphloia theiformis* (Voafotsy) of Landibe (RAZAFIMANANTSOA et al., 2013b). Thus, clusters eggs were put and exposed on host plants for serving bait outside the study plots. Three batches composed of more than 100 eggs and three batches with only 20 eggs were placed on branches of Tapia and Voafotsy trees. All of the eggs were monitored regularly during nine days. The embryogenesis for the Landibe lasts about nine to ten days (RAZAFIMANANTSOA et al., 2012; RAZAFIMANANTSOA, 2013). All parasitized eggs and those with holes were removed and put inside ventilated boxes to wait for the parasitoids emergence.

All parasitized caterpillars in the study plots during the investigation were collected and put inside ventilated boxes with lids to obtain adult individuals as well.

Chrysalis stage

The parasitoids of the chrysalis of the Landibe were identified through collecting remaining cocoons of the previous generation and those which formed during the study period inside the study plots at the end of November (i.e. the left cocoons of the second generation of the cold and dry season) and in March (i.e the cocoons of first generation of hot and rainy season) respectively. These cocoons were kept individually in labeled and ventilated boxes until adult moth or parasitoid emerges.

Abundance of the Landibe and their parasitoids in the study site

Abundance of the parasitoids

<u>Parasitoids collection methods</u>

Two trapping methods were used simultaneously for counting parasitoids: colored plates (yellow) and the Malaise trap. These technics are the best method for capturing good-flying insects such as Hymenoptera and Diptera (BONNEIL, 2009), especially wasps parasitoid (SAUNDERS & WARD, 2018). Both traps (nine yellow plates and one Malaise trap) were placed inside each plot during three consecutive days. A solution of soapy water combined with little alcohol was put inside each yellow plate and in each small bottle of the malaise trap. After each sampling session, all trapped insects were collected, kept on boxes and identified into a laboratory

(TUO et al., 2020). All traps were removed and reinstalled the next week. The same operation was applied once a week during the study period.

The Malaise traps were installed on the edge of the plots. RAZAFIMANANTSOA (2013) stated that *Borocera cajani* always frequents different vegetation stratum and height in its natural environment. The majority of Landibe are found in height below 2 m. Then, three Tapia trees were selected to put yellow plates: one on the middle and two on extremes of each plot. Three yellow plates were put on each selected Tapia tree: one was placed on the ground, and two were attached each with a rope and suspended on branches between 1 m and 2 m above the ground (Fig. 2).

Figure 2: Arrangement of yellow plate traps on *Uapaca bojeri* tree.
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Parasitoid census

All trapped parasitoids with malaise trap and yellow plates were counted and specimens are numbered and classified.

Abundance* of *Borocera cajani

The abundance of *Borocera cajani* was estimated through the census using the technic developed by RAZAFIMANANTSOA et al. (2013a). Each plot was visited twice a month during the study period and all trees and vegetation inside were thoroughly checked for verifying the presence of Landibe. Two observers encountered and recorded all individuals observed inside each square of 10m² during 30 minutes. They spent one day to verify each plot. The following information was recorded: eggs, larvae and cocoons with their respective number, and parasitized or not.

Specimens identification method

All collected parasitoids were identified using magnifying glass and microscope. The species were identified after checking two field guides: « Mémoire de l'Académie Malgache sur les Ichneumonidae » (HEINRICH, 1938) and « Mémoire de l'Institut Scientifique de Madagascar sur les Braconidae» (GRANGER, 1949). Specimens from the « Parc Botanique et Zoologique de Tsimbazaza » were also examined for species determination.

Data analysis

Parasitism rate of Landibe

The parasitism rate of the Landibe eggs and cocoons were calculated from the ratio of the number of parasitized eggs and cocoons to their total numbers.

Frequency and abundance of the parasitoids

The relative abundance of the parasitoids is calculated from the ratios of the parasitoids trapped number and the individual's total trapped number and/or the individual's total number of the families of each parasitoid. Indeed, the relative abundance shows the importance of each species compared to all the species present in the area (DAJOZ, 1985).

The frequency is defined as the number of weeks a parasitoid was trapped during the inventories inside the plots at each site. In total, 17 weeks of observation were carried out during this research.

RESULTS AND DISCUSSION

Landibe parasitoids

Eleven species of parasitoids of the Landibe were recorded and identified during the study period. All of them are belonging to the Hymenopteran order which contains the majority of the insect parasitoid. The results showed that the species of parasitoids vary from one stage to another during the immature stage of the Landibe. Adults were not parasitized. Previous study already reported that Hymenopteran parasitoids overall exhibit many life history strategies and behaviors to exploit their various hosts, but as far as Lepidoptera are concerned the host is attacked in its egg, larval or pupal stage, never as adults (MIFSUD et al., 2019). Three species of two families: Scelionidae (*Scelio* sp.) and Eurytomidae (2 unidentified species) attacked eggs (Fig. 3).

Figure 3.- *Scelio* sp. ovipositing on *B. cajani* egg (left), Eurytomidae sp.1 ovispositing on *B. cajani* egg (middle), Eurytomidae sp. 2 under binoculaire magnifying glass (right).
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The Braconidae family represented by two species: *Apanteles decaryi* Granger and *Apanteles borocerae* Granger (Fig. 4), was recorded inside the larval stage. Both families, Ichneumonidae (*Enicospilus evanescens* Gauld & Mitchell, *Pimpla madecassa* Saussure, *Theronia hildebrandti* Krieg, *Xanthopimpla hova* Saussure) and the Tachinidae (*Brachymeria podagrica* Fabricius and *Brachymeria* sp.) are nymphal parasitoids (Fig. 5).

Mechanism and parasitism rate

Eggs

The microhymenoptera such as *Scelio* sp. and two species of Eurytomidae, pierced the eggs with their ovipositor and deposit their eggs inside. The adults of *Scelio* sp. emerge after 17 days inside their host. This duration is a little being similar as BORGES FILHO et al. (2017) reported on *Telenomus pachycoris*, a scelionid eggs parasitoids of a hemipterious insects which the duration of the egg-to-adult period was close to 15 days. One female of *Scelio* sp., with 3 mm size, is able to parasitize more than 150 eggs of the Landibe. It is a wasp solitary parasitoid, i.e. at most one offspring is able to complete development to adult on or in a host (BONET, 2009). Thus, only one individual emerges from each parasitized egg. Wasps' parasitoid of the genus *Scelio* is solitary. Females always lay their eggs inside the eggs of other species of insects or spiders. The hatched wasp larva consumed the contents of the host egg and pupates within it. A wide range of taxa serves as hosts butterflies and moths (Lepidoptera) (AUSTIN et al., 2005; GHAHARI et al., 2015; AFISSA et al., 2022).

Eurytomidae sp. 1 and sp. 2 are also solitary. The two species are morphologically different; they distinguish by the color of their legs. Sp. 1 has white legs while the legs of sp. 2 are black with white tarsi.

During the observation, both parasitoids attacked eggs in small quantities on leaves or trunks while *Scelio* sp. parasitized eggs whatever the quantity.

The parasitism rate (by the identified three species) of the Landibe eggs used as bait is about 52.5% in our two study sites. This parasitism rate is a little being similar as HARTLAND-ROWE (1992) reported on African silkworm *Gonometa rufobrunnea*. His work stated that parasitoids species of eggs of *G. rufobrunnea* silkworm caused 50% mortality of its eggs.

Caterpillar

Apanteles borocerae and *A. decaryi* prepupal larvae appeared before they pupate. They pierced the skin of the caterpillar during the last or penultimate larval stage (4^{th} and 5^{th} instar). All of them are gregarious parasitoids (more than one offspring can successfully complete development on or in a host) (BONET, 2009) and have different characters. For *A. decaryi*, after emerging the caterpillar, their prepupal larvae weave together a common white silky cocoon, and then each individual before pupating weaves its own cocoon once inside. So, the cocoons are gathered in a common envelope, i.e formation of small cocoons inside a large one. Some masses of cocoons produced by gregarious species are wonders of cooperation, as the emerging larvae spin first the overall structure of the cocoon mass, then their individual cocoons (WHITFIELD et al., 2018). As far was concerned *A. borocerae*, each individual prepupal larva produced each white own cocoon after emerging from their host. All produced cocoons are attached in cluster to each other and form a brood. Their number can reach 200 individuals for *A. decaryi* while it is only around 40 individuals or less for *A. borocerea*. The host caterpillars parasitized by these Braconidae species seem to be healthy. But they became weak and still alive for 4-7 days after parasitoid emergence. They did not move anymore and did not eat as well and the brood cocoons of the parasitoids were always attached on the under part of their body until the host death. Another parasitized caterpillar within another families (*Pieris brassicae*, Pieridae family) parasitized by another genus of braconid microgastrinae (Genus *Cotesia*, gregarious parasitoid) survived for an average of almost 7 days after parasitoid egression and pupation (HARVEY et al., 2008). This behavior of the parasitized caterpillar can play an important role for guarding the parasitoid cocoons against their own natural enemies such as hyperparasitoids.

Only 3 Landibe caterpillars were parasitized by these parasitoids inside the study plots, one in 4^{th} instar for *A. decaryi* and two (4^{th} and 5^{th} instar) for *A. borocerae. Apanteles* is one of the gregarious braconid wasps parasitizing the caterpillars (immature stage) of Lepidoptera. The number of individuals hatched from the same host can be considerable, reaching several hundred and even nearly a thousand (GRANGER, 1949). Caterpillar wasps recorded in this study, i.e. *A. borocerae* and *A. decaryi*, were also reported by other authors (BRENIÈRE, 1965; GRANGER, 1949; PAULIAN, 1950; PAULIAN, 1953) as parasitoids of *Borocera madagascariensis* and *B. marginepunctata* silkworms. Indeed, *Apanteles* is a microgastrinae which exclusively parasitize Lepidoptera caterpillars. The genus may attack one or a few taxonomically related species. The adult female lays eggs on the early instar caterpillars. Larvae spend their larval lives as koinobiont endoparasitoids of larval Lepidoptera and emerge from the host caterpillars in their last larval stage. After, the wasp larvae spin their characteristic cocoons on, under or near their host, which often survives for a short period after the emergence of the parasitoids (WHITFIELD et al., 2018).

Few host caterpillars were parasitized by these parasitic wasps during the investigation. This situation may be due to the color of *B. cajani* caterpillars. According to BARBOSA & CALDAS (2007), green larvae were the most susceptible to parasitism than other larval trait. *B. cajani* has different color varying from gray to russet. Also, Landibe caterpillars were not collected and reared to have more information about their parasitoids in field. Nevertheless, rearing technics is very used for identifying caterpillar parasitoids (GERARD et al., 2011; BOUGHTON et al. 2012; ÖZBEK & ÇOTUH (2012)). However, previous works on lepidopteran caterpillar parasitoids reported other caterpillar parasitoid families such as the Tachinid Dipteran (VELDTMAN et al., 2004).

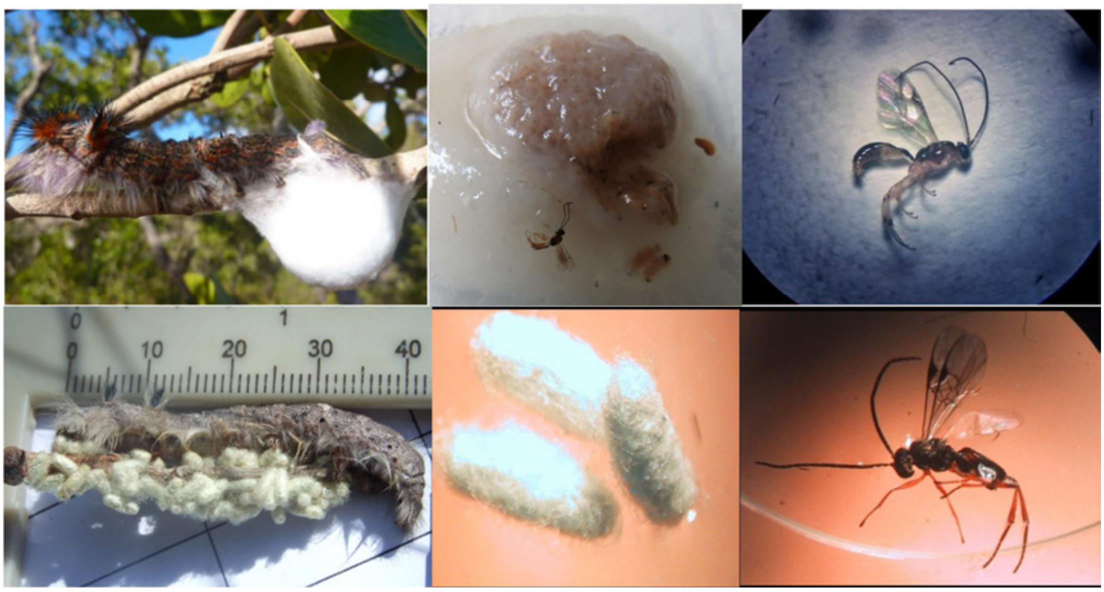

Figure 4 : *A. decaryi* (above): Common cocoons on Landibe caterpillar in 4th instar (left), Individual cocoons (middle), Adult (right).
A. borocerae (below): Larvae exiting through the body of the host in 4th instar on the back and cocoons on the ventral face (left), individual cocoons (middle), Adult (right).
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Chrysalis

A parasitized cocoon of *B. cajani* is easily recognizable by its lightness compared to the healthy cocoon. After shaking, the cocoon seems to be empty and without sound. Six wasp species including Ichneumonidae and chalcididae families were emerged inside the Landibe's cocoons. They killed the Landibe prepupae caterpillars or pupae host inside the cocoon. Four species of the Ichneumonidae family (*Xanthopimpla hova*, *Pimpla madecassa*, *Theronia hildebrandti*, *Enicospilus evanescens*), of which their size varied from 1.2 to 2.7cm, transform the inner layer of the cocoon of the host chrysalis and produce a rigid ovoid shell brown dark color to black. These parasitoids are solitary. For the Chalcididae family, *Brachymeria* sp. is also solitary while *Brachymeria podagrica* is gregarious. One Landibe cocoon contains up to 44 individuals of this species.

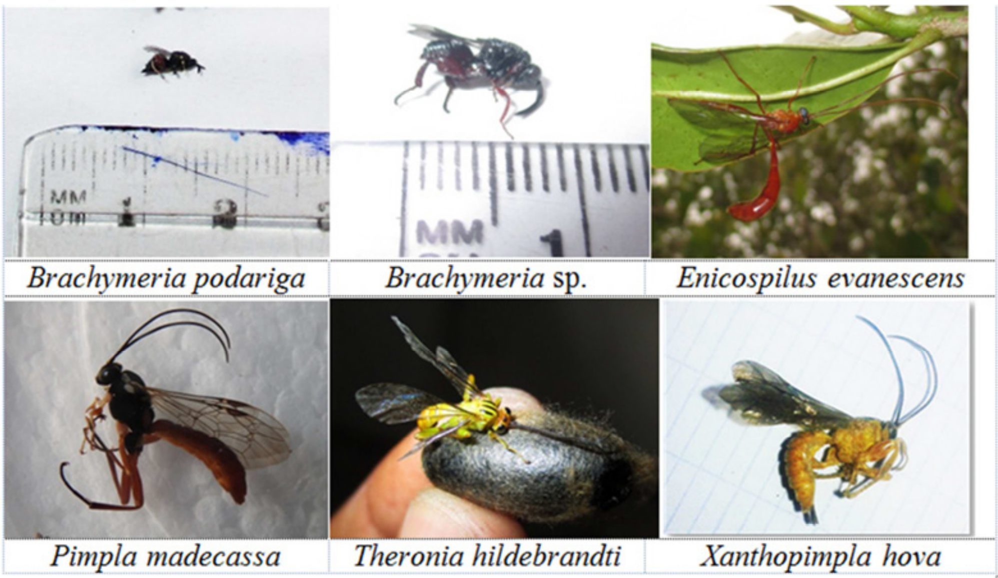

Figure 5: Nymphal wasps of *B. cajani* © Tsiresy Maminiaina RAZAFIMANANTSOA & Mahefatiana Sitraka RAZAFIMANANTSOA.

Cocoons collected in the study plots at the end of November and on March showed an overall parasitism rate of 23.08% (n = 54/234 cocoons) and 18.56% (n = 36/194 cocoons) respectively (Table 1). In November, almost half of the collected parasitized cocoons (42.1%) were already hatched before the collection date. The emergence rate of all parasitoids is about 86.84%. Three hymenopterious species were emerged from the host cocoons of the second generation: *B. podagrica* with 44 individuals from one cocoon and a parasitism rate about 0.43%; *P. madecassa* of one individual only and a parasitism rate around 0.43%; and *E. evanescens* with 15 individuals and a parasitism rate up to 6.41%. For the March harvest, three wasp species were also emerged from the Landibe cocoons of the first generation: *Brachymeria* sp (one individual, parasitism rate 0.51%), *Xanthopimpla hova* (one individual, parasitism rate 0.51%) and *E. evanescens* (25 individuals, parasitism rate 12.89%). The emergence rate of all of these first generation parasites is 77.77%. According to the results, *E. evanescens* is always a predominant species parasite in terms of abundance during the two generation of the Landibe. This species plays probably an important role in regulating the natural population of *B. cajani* in the Tapia forest.

Pimpla madecassa was reported by HEINRICH (1938) and PAULIAN (1953) as a parasitoid of Malagasy silkworm's *B. madagascariensis*. And by analogy with neighboring species, the author confirmed that this species lays eggs inside the pupae, has a rapid development and it is very polyphagous. It was also reported as a parasitoid of *Deborrea malagassa* Heyl (Psychidae) while *Xanthopimpla hova* was recorded by PAULIAN (1950, 1953) as a parasitoid of *B. madagascariensis*. However, the author indicated that this wasp parasite larval and pupal stages of its host. GRANGEON (1907) mentioned that *X. hova* lays eggs within the body of the Landibe caterpillar. But each parasitized caterpillar always weaves its cocoon and transforms in chrysalis. Nevertheless, each chrysalis host died and the parasite becomes a nymph and then adult insect. Concerning *E. evanescens*, RANAIVOSOLO (2015) and VAN NOORT (2022) already mentioned that this species parasitized *B. cajani* as well.

During the study period, parasitized cocoons record the highest number compared to the attacked larvae. Three main reasons may explain this situation: (1) The parasitoid of cocoon is more diverse in the study area than the parasitoid of larvae; (2) All observed cocoons inside each plot were collected but not all larvae; and (3) Most of the family Ichneumonidae are larval-nymphal koinobiont endoparasitoid this is why it is very difficult to detect their presence during the larval stage.

The current study recorded an overall parasitism rate between 0.43 and 12.89% for both sites. FENING et al. (2008) confirmed a larval pupal parasitism ranging from 0.3–32.7% for the African wild silkmoth *Gonometa postica* in South Africa.

Table 1: Parasitism rate of Landibe cocoons for the two generation

Collecting period	End of November	Mid-march
Number of cocoons collected	234	194
Parasitism rate (%)	23,08	18,56

Composition, abundance and frequency of Landibe parasitoids in the plots of the Tapia forest

Parasitoid composition

Both traps (the malaise trap and yellow plates) captured 1,091 individuals of Hymenoptera. Among them, 12% (n=131 individuals) were the Landibe parasitoids. Among the identified parasitoids, the family Ichneumonidae (*Enicospilus evanescens*, *Theronia hildebrandti*, *Xanthopimpla hova*) recorded 47.33% (n=79 individuals) of the whole trapped individuals. The remaining identified families represent each the following proportion: Scelionidae (*Scelio* sp.: 13.74%), Braconidae (*Apanteles borocerae* and *A. decaryi*: 12.97%), Eurytomidae (sp. 1 and sp. 2: 12.97%) and Chalcididae (*Brachymeria podariga* and *Brachymeria* sp.: 12.97%). Among the species of the Ichneumonidae family, *E. evanescens* has the highest relative abundance with a proportion about 87.1% (Table 2).

The presence of *Pimpla madecassa* was confirmed but zero captured individual. The species could be rare in the site. So, this study does not allow yet determining its place inside the Hymenopteran group. HEINRICH (1938) stated that this species is easily observed during October, December, January and July. Our study period was included between these months.

The Ichneumonids collected present the highest number compared to other families. This taxon is the most abundant and species richness of the parasitoid wasp superfamilies (BONET, 2009; MIFSUD et al., 2019). Only *Scelio* sp. (18 individuals) and *E. evanescens* (54 individuals) were more represented compared to other species.

Table 2: Percentage distribution of the traped Ichneumonidae parasitoids

Species	Relative abondance (%)
Enicospilus evanescens	87,10
Theronia hildebrandti	11,29
Xanthopimpla hova	1,61

Frequency and relative abundance of parasitoids

About the observation frequency, 10 out of 17 (58.82%) observations (Table 3), *E. evanescens* always observed from the 6th week (December 26th 2017) to the 12th week of observation (February 5th 2018). During these periods, Landibe caterpillars are in the penultimate and last instar of its larval life. The highest abundance (n= 25 individuals) was recorded during the 8th week (January 09th 2018). So, it is currently the most frequent and the most abundant species. *A. borocerae*, *A. decaryi*, and *Brachymeria* sp are moderately frequent with a frequency over 40% but their relative abundances seem to be low, between 5 and 7% (Table 3). However, these three species are gregarious parasitoids. *X. hova* is the least frequent species and recorded the lowest relative abundance.

Table 3: Frequency and relative abundance of trapped Landibe parasitoids.

Life stage parasitized	Species	Frequency (%)	Relative abundance (%)
Egg	*Scelio* sp.	29.41	13.74
	Eurytomidae sp. 1	29.41	6.11
	Eurytomidae sp. 2	11.76	6.87
Larva	*Apanteles borocerae*	47.06	6.11
	Apanteles decaryi	41	6.87
Cocoon	*Enicospilus evanescens*	58.82	38.93
	Xanthompimpla hova	5.88	0.76
	Theronia hildebrandti	29.41	7.63
	Brachymeria podariga	35.29	7.63
	Brachymeria sp.	41.18	5.34

This study allowed identifying 11 parasitoid species of the Landibe within the Arivonimamo Tapia forest. The family Ichneumonidae is the most abundant and the most frequent. In addition, these wasps are parasitoids of caterpillars and cocoons which are the longest stages in the life cycle of *B. cajani*.

The results showed that parasitism rate depends on the parasitoid species and parasitoids vary according generation particularly for the chrysalis stage.

This study also inventoried and quantified for the first time the composition of *B. cajani* parasitoids in their natural environment during the study period of its first generation (October – March). We estimate that *E. evanescens* seems to be a specific parasitoid of the Landibe or a relative parasitoid silkworm bivoltine species. It is therefore a common species and could present a shorter life cycle compared to the others in order to be able to parasitize the next generation more quickly.

Based on the parasitism rate observed in our study, we can conclude that parasitoids have an influence on Landibe population in Arivonimamo especially for the eggs and chrysalis stage. We suggest a study of Landibe parasitoid on the second generation to provide more information and a research on another factors causing mortality of the host which can be substantial as predation and disease.

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