Some bio-ecological aspects of *Haplozana nigrolineata* Aurivillius (Lepidoptera; Notodontidae): an edible insect in the Republic of Congo

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1 SUMMARY

Called "Batsini or Atsiere" in the Téké language and "Bitsina" in the Lari language, *Haplozana nigrolineata* is a protein-rich insect, consumed in its larval stage. It is of considerable socio-economic interest in the Republic of Congo. The aim of this study was to determine the insect's development cycle and ecology with in view of its domestication. In the Odziba area, near Brazzaville, ovipositing female imagos were spotted on the underside of the leaves of *Eriosema glomeratum* and *Eriosema psoraleoides* plants. For 19 days, the eggs were counted and monitored regularly until they hatched. After hatching, the larval development of the neonates was monitored in semi-captivity before the caterpillars buried themselves to pupate. In order to determine the other host plants of *H. nigrolineata*, 100 m² plots were delimited and a floristic inventory was carried out. Oviposition took place only on the leaves of *Eriosema glomeratum* and *Eriosema psoraleoides* plants. A female laid an average of 343±63.68 eggs with a hatching rate of 85.33%. The average incubation period was 19 days. Larval development lasts 58.48 days, with a long hypogeal phase lasting around 10 months. After the 3rd moult, the caterpillars leave the feeder legumes to migrate to grasses. In terms of other host plants, 16 families and 41 species have been identified in dicotyledons, compared with 8 families and 26 species in monocotyledons. This knowledge of the bioecology of *H. nigrolineata* will enable it to be conserved for sustainable use of the resource and facilitate its domestication.

2 INTRODUCTION

The consumption of insects by humans, or entomophagy, has been practised since the dawn of time. Around 2,000 species of insect are consumed worldwide, mainly in tropical countries (Van Huis, 2015). Several studies on edible insects have been carried out by different authors around the world (Mabossy-Mobouna & Malaisse, 2020; Lin et *al.*, 2023). These insects, which have a high nutritional value (Van Huis, 2020), provide an alternative solution to animal protein deficiencies in order to meet the major challenge of global food security. Currently, the consumption of around 28 caterpillar species has been noted based on thorough and rigorous identification (Mabossy-Mobouna et *al*. 2017). The Congo people are overall entomophagous. Values of 40g per person per day of smoked caterpillars consumed in November, December and January were reported by Bascoulergues Bergot, (1959). In Brazzaville, the annual consumption of caterpillars is estimated at around 30 tonnes, representing a turnover of 70 million CFA francs. Much of this production (around 25 tonnes, or 85%) comes from the Likouala region, particularly the sub-prefectures of Bétou, Dongou, Enyellé and Impfondo. In Impfondo alone, annual household consumption of caterpillars is estimated at 7 tonnes (Kounkou et *al*, 2000). An endemic and polyphagous species, *H. nigrolineata* Aurivillius (Lepidoptera; Notodontidae), synonymised with *Hypophiala melanogramma* Janse, regularly appears on the Teke plateaux. Called "Batsini or Atsiere" in the Téké language, "Bitsina" in the Lari language and "crâneur" in French, *H. nigrolineata* Aurivillius is very similar to a caterpillar called "lusambwa" in Bemba territory in the Democratic Republic of Congo. It is distributed geographically from Transvaal, Mashonaland, Angola, Malawi, Zambia, the Democratic Republic of Congo, the Republic of Congo and East Africa (Malaisse, 1997). Unfortunately, this resource is threatened by the sowing of cassava plantations using agricultural tractors. This practice destroys plants of *E. glomeratum* (Guill. and Perr.) Hook. F. and *E. psoraleoides* (Lam.) G. Don without which oviposition does not take place, but also the nymphs buried about 5 cm in the soil. In addition, the anthropic pressure exerted on the insect by excessive harvesting for food, such is the demand, does not allow complete regeneration of the species. These practices threaten to wipe out this much-appreciated resource, which is a source of substantial income for the local population and those involved in the industry. A number of insect species remain unknown to the scientific world due to a lack of studies into their biology and ecology. It is therefore imperative to know their development cycle and ecology, to manage harvests sustainably and protect the species from extinction. The aim of this study was to enhance the value of *H. nigrolineata*, an insect consumed by humans in its larval stage, by analysing its development cycle and ecology.

3 MATERIALS AND METHODS

3.1 Study site and plant material: The study was conducted in the northern part of the Pool department, on the Batéké plateaux (Plateau de Mbé), more specifically in the Odziba area, Ngabé district (Figure 1). The Mbé Plateau stretches from latitude 3°30 south to latitude 5° south, longitude 15°15. The vegetation is tall in the lowlands and steppe-like on the slopes and hills, where the shrub layer may be sparse. The dominant species is *Loudetia demeusei* (Makany, 1976).

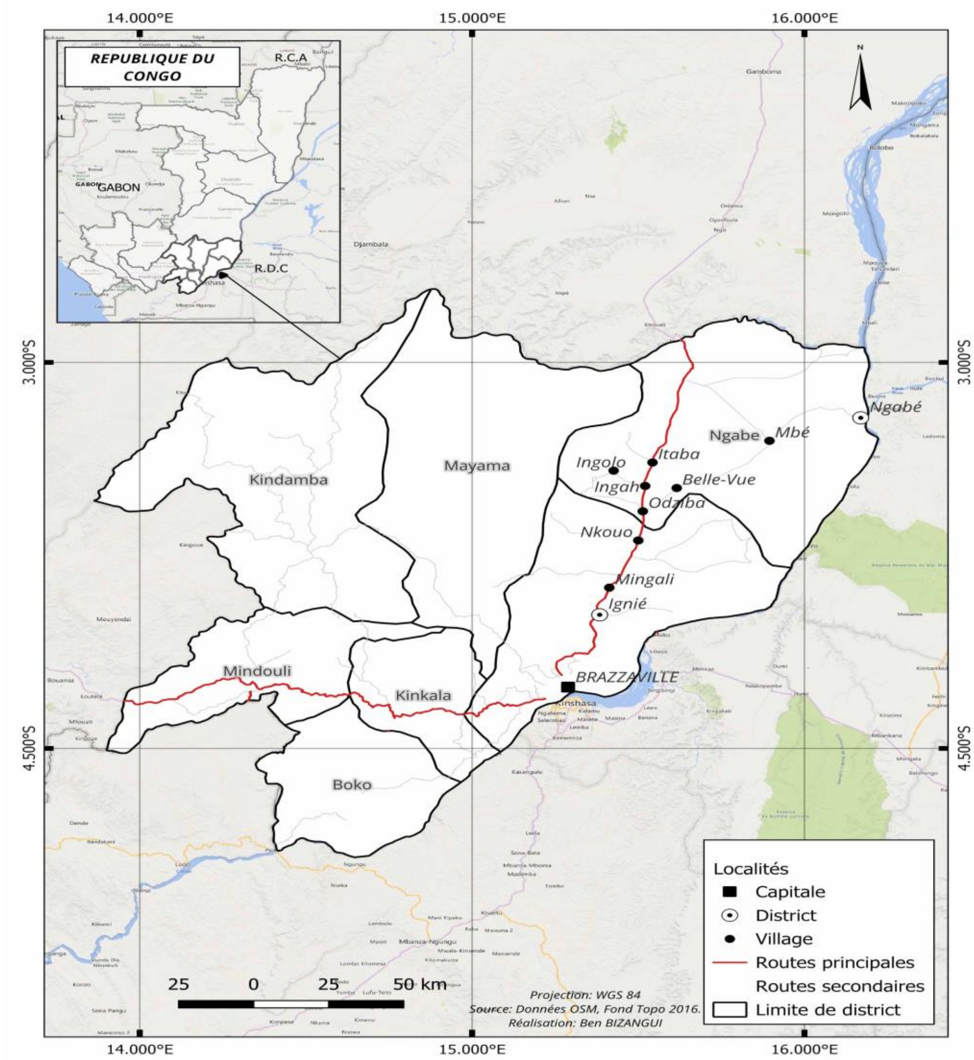

Figure 1: Location of the study site

The floristic analysis of the study area was carried out in the locality of Odziba, approximately 81.77 km from Brazzaville in the Ngabé district, Pool department. Twelve 100-m² surveys were carried out in equal numbers at the Belle Vie and Imbama sites, located around 16 km from Odziba. The Zurich-Montpellier study method developed by Braun-blanquet (1952) was used. The plant material consisted of the plant species consumed by the caterpillars of *H. nigrolineata* Aurivillius found on the above-mentioned study site. The animal material consisted of *H. nigrolineata* Aurivillius, a lepidopteran of the family Notodontidae (Figure 2). The species *H. nigrolineata* Aurivillius was chosen for its importance as a food and socio-economic resource in Congo.

Figure 2: Caterpillar of H. nigrolineata

3.2 Methods

3.2.1 Development cycle of *H. nigrolineata:* The development cycle of *H. nigrolineata* was determined by counting the number of eggs laid and assessing the hatching rate, incubation period and duration of larval development. The ooplacae were located by observing the underside of the leaves of *E. glomeratum* and *E. psoraleoides*. Eggs laid by *H. nigrolineata* females were counted on these grey-brown ooplaques. The date of laying was noted on the record sheets and followed until hatching in order to determine the incubation period. Once the eggs had hatched, the larvae or caterpillars were followed systematically until they entered the soil to pupate. The geographical coordinates of the pupation area were recorded using a Garmin etrex 32X GPS.

3.2.2 . Assessment of the food preference of *H. nigrolineata:* Concerning the assessment of the food preference of *H. nigrolineata*, during monitoring of larval development up to pupation, all plant species consumed by *H. nigrolineata* caterpillars were identified and marked. The level of damage to the leaves consumed by the caterpillars was then classified in the range from 0 to 100% using the Trouvelot and Raucourt (1936) scale. This scale defines four ranges of damage as follows: From 0 to 25 %, for slightly consumed leaves having lost less than 25 % of their surface area; from 26 to 50%, for moderately consumed leaves with a proportion of the leaf surface area loss of between 26 and 50 %; from 51 to 75 %, for heavily consumed leaves having lost 51 to 75 % of their surface area; from 76 to 100 %, for totally consumed leaves.

3.3 Estimation of leaf area consumed by *H. nigrolineata* caterpillars maintained on *Eriosema glomeratum* and *Eriosema psoraleoides*: In semi-captivity, 9 sites were selected, each receiving 60 caterpillars, in order to estimate the leaf area consumed by *H. nigrolineata* caterpillars on the leaves of *E. glomeratum* and *E. psoraleoides* species. Thus, 540 *H. nigrolineata* caterpillars from the 3rd moult were raised on the leaves of E. *glomeratum* and *E. psoraleoides*. The 9 sites, divided into 3, were chosen according to the presence of *E. glomeratum*, *E. psoraleoides* and control grasses. All sites were covered with mosquito netting to prevent the caterpillars from escaping. The behaviour of *H. nigrolineata* caterpillars was observed at each site.

3.4 Estimation of leaf area of *Eriosema glomeratum* and *Eriosema psoraleoides* consumed after caterpillar migration on grasses: Six sites were identified to estimate the leaf area of *E. glomeratum* and *E. psoraleoides* consumed after caterpillar migration on grasses. Three hundred and thirty (360) caterpillars that had already migrated on grasses and cyperaceae were collected and put back on *E. glomeratum* and *E. psoraleoides*. Each site received 60 caterpillars. The 6 sites were divided in two: three sites with *E. glomeratum* and three other sites with *E. psoraleoides*. All sites were covered with mosquito netting to prevent the caterpillars from escaping. The behaviour of

H. nigrolineata caterpillars was observed at each site.

3.5 Estimation of the leaf area of Poaceae and Cyperaceae consumed by *H. nigrolineata* Aurivillius caterpillars: In the laboratory, the leaf area of the Poaceae and Cyperaceae consumed by the caterpillars of *H. nigrolineata* Aurivillius was estimated. The leaves of the Poaceae and Cyperaceae plant species most consumed in the field were collected and identified. For each plant species, the leaves were cut into 3 cm long pieces and placed in 9 cm Petri dishes. A caterpillar was placed in each dish. After 3 hours, the damage to the leaves was observed and noted. Food preferences were also tested in binary and triple choice situations.

3.6 Inventory of natural enemies of caterpillars and floristic inventory of the study site: Careful observations were made on several organisms belonging to different taxonomic groups, hindering the evolutionary dynamics of *H. nigrolineata* Aurivillius at different stages of its development. In the laboratory, 1000 caterpillars of *H. nigrolineata* Aurivillius were placed in 90° alcohol. The abdominal parts of the caterpillars were dissected using a small knife to identify their intestinal parasites. For the floristic inventory, the survey sites were chosen according to where the caterpillars of *H. nigrolineata* had appeared the previous season. A 100 m² plot was marked out using a rope, 4 stakes, a sledgehammer and a double metre. The stakes were threaded through loops, the first and last around the same stake. They were then driven into the ground by stretching the ropes and giving the perimeter a square shape. The analysis began by drawing up a list of species on a well-defined area of 1 m² placed at the corner of the perimeter. This area was doubled (2 m²); the next was doubled until the plot area was completely delimited (4 m²) and so on until the entire delimited area had been analysed. New species that have appeared because of successive duplications are added to the first list of plants. Finally, a herbarium was compiled for possible inclusion in the national herbarium of the Institut national de Recherche en Sciences Exactes et Naturelles (IRSEN).

3.7 Data analysis: Collected data were processed by using the Statistical Package for Social Sciences (SPSS) 26.0. The non-parametric methods, namely, the Pearson's Chi-Square test, at the 5 % likelihood, were applied.

4 RESULTS

4.1 Life cycle of *H. nigrolineata* in the study site: *H. nigrolineata* is a univoltine species with larval diapause. Its life cycle comprises an epigeal phase that begins with the appearance of the imagos until the caterpillars enter the soil, and a hypogeal phase that corresponds to the pupal phase in the cocoon in the soil (Figure 2).

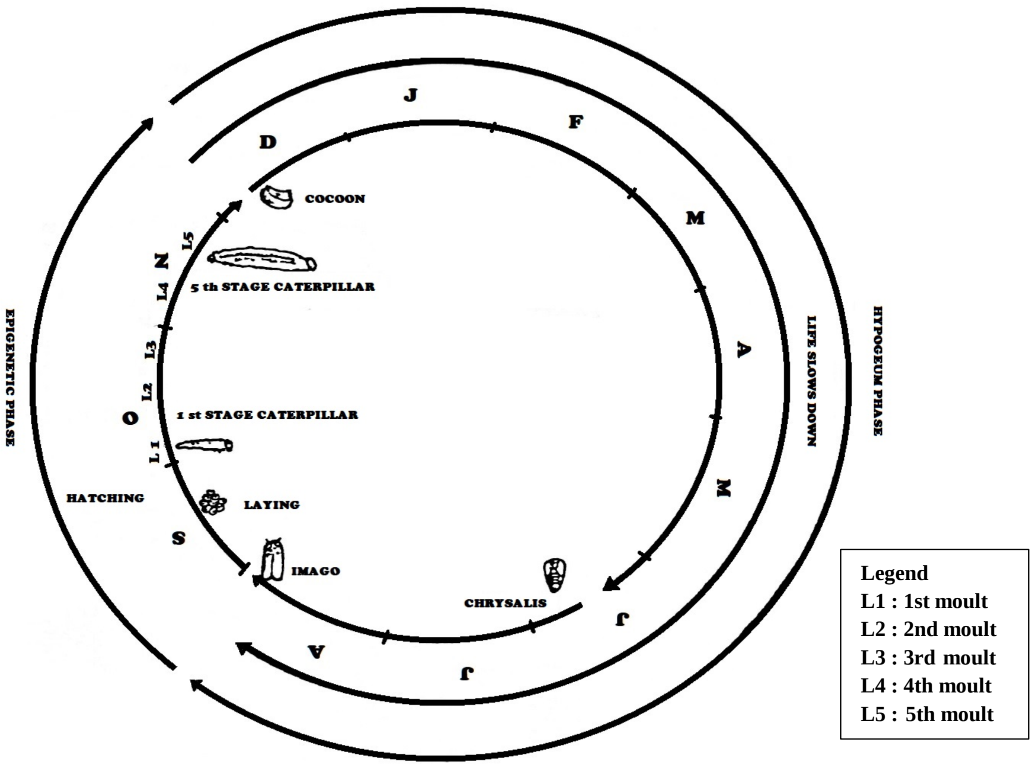

Figure 3: Development cycle of *H. nigrolineata* Aurivillius in the wild

Oviposition takes place at the time of emergence of the imagos, which occurs in a staggered fashion between August and October. The imagos lay their eggs on the underside of the tender leaves of *Eriosema glomeratum* and *Eriosema psoraleoides* (figure 4). Out of 36 ooplaques monitored for a total of 12,352 eggs, it was determined that a female laid an average of 343±63.68 eggs. The eggs laid were small and white in colour. A few ooplaci were found on *Landolphia lanceolata*, *Anisophyllea congoensis* and on the leaves of grasses very close to the two *Eriosema*. However, out of 574 *E. glomeratum* plants observed, 87 (15.15%) had ooplaci. Of 241 *E. psoraleoides* plants observed, 28 (11.61%) had ooplaci. Hatching took place on average 19 days after oviposition. Out of 5619 eggs laid, 4795 hatched with a hatching rate of 85.33 %.

Figure 4: Eggs laid by *H. nigrolineata* imagos on the underside of *E. glomeratum*

From the 18th day onwards, on average, after the eggs hatch, in some cases and from the 28th day onwards, on average, in others, the latter being more frequent, the caterpillars of *H. nigrolineata* change their diet. From a forbivorous diet (consisting exclusively of the leaves of *E. glomeratum* and *E. psoraleoides*), the caterpillars become graminivorous and feed on Cyperaceae. In *E. glomeratum*, the change from the 18th day occurs when all the leaves on the shrub are used up. At one site on *E. glomeratum*, caterpillars were observed migrating to feed 6 days after the second moult, following the exhaustion of the leaves of the second moult. In *E. psoraleoides*, on the other hand, the caterpillars migrated even though the leaves were still on the shrub. The change that occurs from the 28th day after hatching concerns both *Eriosema*. Indeed, after the third moult, more precisely 2 days after the third moult, the caterpillars of *H. nigrolineata*, whether they are on *E. glomeratum* or *E. psoraleoides*, migrate to grasses and cyperaceae. After the 5th moult, *H. nigrolineata* caterpillars reduce their food intake and mobility. They adopt a significant position (head downwards, generally at the bottom of tufts of grasses and sedges). Eleven days on average after the fifth moult (i.e. 58.48 days after hatching), *H. nigrolineata* caterpillars measuring around 5 cm leave the grasses and cyperaceae and descend to the ground. They hastily look for safe places to bury themselves in order to build cocoons inside which the caterpillars will lead a slow life at a depth of around 4 cm. These caterpillars transform into chrysalises and then into butterflies, which emerge 10 months later to perpetuate the species (figures 5 and 6). The average weight of a cocoon is 0.54g; this cocoon has 7 buttons similar to false legs at each end; a grey-orange colour and 3 buttons at the poles.

Figure 5: Cocoon and chrysalis of *H. nigrolineata*

Figure 6: Imago of *H. nigrolineata*

4.2 Food preference of *H. nigrolineata*

4.2.1 Observation of Poaceae and Cyperaceae consumed by *H. nigrolineata* caterpillars in the field: Field observations show that all the grasses present in the field are eaten by *H. nigrolineata* caterpillars. However, the palatability index varied from one species to another. Thus, 5 out of 14 plant species of Poaceae and 1 out of 4 species of Cyperaceae, the most consumed, were observed and listed. These are:

Andropogon schirensis A. Rich, *Digitaria brazzae* (Franck.) Stapf, *Digitaria diagonalis* (Nées) Stapf, *Loudetia demeusei* (De Wild.) C.E. Hubbard, *Ctenium newtonii* Hack, *Bulbostylis laniceps* C.B Clarke.

4.2.2 Leaf area of Poaceae and Cyperaceae consumed by *H. nigrolineata* caterpillars: The observations made on the extent of damage caused by *H. nigrolineata* caterpillars on the 5 grasses and one cyperaceae are presented in Table 1. Examination of Table 1 reveals that the proportion of leaves having lost their entire leaf surface varies from 70.7 % in the case of *Ctenium newtonii* to 85 % in the case of *Andropogon schirensis*. In all cases, more than 80 % of leaves had more than 50 % of their surface area consumed.

Table 1: Damage caused by *H. nigrolineata* on the leaves of 4 grasses and one cyperaceae.

Species	Total number of sheets	Number of leaves consumed and severity of damage		
		100%	50%	<25%
Andropogon schirensis	703	598(85%)	34(5%)	71(10%)
Digitaria brazzae	485	400(82%)	85(18%)	
Digitaria diagonalis	691	557(81%)	72(10%)	63(9%)
Loudetia demeusei	553	437(79%)	116(21%)	
Bulbostylis laniceps	650	516(80%)	84(12%)	50(8%)
Ctenium newtonii	537	380(70.7%)		157(29.3%)

To support the above descriptive analysis, the statistical analyses were applied. It emerged from them that there are statistical differences among the observed countings and the expected ones at the 5 % threshold. Thus, the species were effectively different relatively to their countings (Table 2).

Table 2: Homogeneity among the observed countings and the expected ones via the Pearson's homogeneity Chi-Square

Cod species*	Countings observed	Countings expected	Resid ual*	Source	Statistic s
0	703	603.2	99.8	Chi-Square	67.532
1	485	603.2	-118.2	df	5
2	691	603.2	87.8	p-value	0.000
3	553	603.2	-50.2		
4	650	603.2	46.8		
5	537	603.2	-66.2		
Total	3619				

Legend Cod species*: Numeric code assigned to species seen in nature. **Residual*:** Difference between the observed countings and the expected ones.

4.2.3 Leaf area consumed by *H. nigrolineata* caterpillars kept and returned after migration on grasses on *Eriosema glomeratum* and *Eriosema psoraleoides* :The experiment consisting of keeping or returning *H. nigrolineata* caterpillars that had migrated to grasses on *E. glomeratum* and *E. psoraleoides* showed that the caterpillars evolved normally, consuming all the leaves of these two species. These caterpillars underwent their fourth and fifth moults in the same time intervals as control *H. nigrolineata* caterpillars kept on grasses and covered with mosquito netting. *H. nigrolineata* caterpillars are collected by the local population at the 5th stage of larval development. Pupation always takes place in the soil.

4.3 Floristic analysis of the study site: An inventory of the flora of the Odziba savannahs revealed 64 species. These species are divided into 52 genera belonging to 26 families. These families are mainly represented in the group of monocotyledons, followed by dicotyledons and pteridophytes (Table 3). *Hyparrhenia diplandra* and *Bridelia ferruginea* predominate. Of the 64 species recorded, 60 species belong to the grassy stratum and 4 species to the shrub stratum. The grassy formation represents 93.75% while the shrub layer represents 6.25%. The Poaceae family is the most represented with 13 species, followed by Fabaceae with 12 species and Asteraceae with 7 species. There are 11 genera in the Poaceae family, 6 genera in the Fabaceae family and 6 genera in the Asteraceae family.

Table 3: List of species collected at Odziba

Species	Family
Aframomum alboviolaceum (Ridl.) K. Schum.	Zingibéraceae
Albizzia adianthifolia (Schum.) W. F. Wight	Mimosaceae
Anisophyllea quangensis (Engl.) ex Henriq.	Rhizophoraceae
Annona senegalensis (pers) subsp oulotricha	Annonaceae
Antherotoma phaerotricha (Hochst.) jacq. Fel	Melastomataceae
Aspilia kotschyi (Sch. Bip.) Oliv.	Asteraceae
Brachiaria brizantha (Hochst.ex A. Rich.) Stapf.	Poaceae
Bridelia ferruginea Benth.	Euphorbiaceae
Bulbostylis laniceps (C. B.) Clarke	Cyperaceae
Chamaecrista pratensis (R. Vig) Du Puy	Caesalpiniaceae
Cissus guerkeana (Buttn.) Th. Dur. Schinz	Vitaceae
Commelina diffusa Burm. f.	Commelinaceae
Ctenium newtonii Hack.	Poaceae
Cyanotis longifolia Benth.	Commelinaceae
Desmodium adscendens (Sw.) DC.	Fabaceae
Desmodium triflorum (L.) DC	Fabaceae
Digitaria diagonalis var hirsita (De willd. Et T. Durand) traupin	Poaceae
Drimia altissima (L. f.) Ker Gawl.	Liliaceae
Englerastrum schweinfurthii Briquet	Lamiaceae
Eriosema glomeratum (Guill. and Perr.) Hook. f.	Fabaceae
Eriosema psoraleoides (Lam.) G. Don	Fabaceae
Eriosema schirense (Bak.) F.	Fabaceae
Fimbristylis hispidula (Vahl) Kunth.	Cyperaceae
Fimbristylis pilosa (Poir.) Vahl	Cyperaceae
Gladiolus unguiculatus Bak.	Iridaceae
Haumaniastrum caerulem (Oliv.) P. A. Duvign. and Planche	Lamiaceae
Helichrysum keillii Moeser	Asteraceae
Helichrysum mechowianum klatt	Asteraceae
Hymenocardia acida Tul.	Euphorbiaceae

Hyparrhenia diplandra (Hack.) stapf.	Poaceae
Hyparrhenia familiaris (Steud.) stapf.	Poaceae
Indigofera capitata Kotchy	Fabaceae
Indigofera hirsuta L.	Fabaceae
Ipomea pyrophila (A.) Chev.	Convolvulaceae
Lactuca schulzeana Buttn.	Asteraceae
Landolphia lanceolata (K. Schum.) pichon	Apocynaceae
Loudetia demeusei De Wild.	Poaceae
Loudetia simplex (Nées) (C.E.) Hubbard	Poaceae
Murdannia simplex (Vahl) Brenan	Commelinaceae
Ochna afzelii (R. Br.) Ex. Oliv.	Ochnaceae
Ochna gilletiana Gilg.	Ochnaceae
Pandiaka angustifolia (Vahl) Hepper	Amaranthaceae
Panicum brevifolium L.	Poaceae
Panicum repens L.	Poaceae
Parinari pumila Mildbr.	Chrysobalanaceae
Paspalum conjugatum (Schult.) Berg.	Poaceae
Pennisetum polystachyon (L.) Schult.	Poaceae
Psorospermum febrifugum Spach.	Hypericaceae
Pteridium aquilinum (L.) Kuhn	Dennstaedtiaceae
Pycreus flavescents (L.) P. Beauv. Ex. Rechb.	Cypéraceae
Rottboellia cochinchinensis (Lour.) clayton	Poaceae
Setaria sphacelata var sericea (Stapf) Clayton	Poaceae
Smilax anceps Willd.	Smilacaceae
Stomatanthes africanus (Oliv.et Hiern)	Asteraceae
Strychnos pungens Solered.	Loganiaceae
Tephrosia nana kotschy ex schweinf.	Fabaceae
Uraria picta (Jacq.) Desv	Fabaceae
Vernonia guineensis Benth.	Asteraceae
Vernonia smithiana less.	Asteraceae
Vigna heterophylla A. rich.	Fabaceae
Vigna radicans (Welw.) ex. Baker	Fabaceae
Vigna unguiculata (L.) Walp.	Fabaceae
Vitex doniana Sweet	Verbenaceae
Vitex madiensis Oliv.	Verbenaceae

Figure 7 shows the number of species inventoried at the six stations in the Odziba locality. The result shows an increase in the number of species counted according to the surface area of the area surveyed. Surveys at station No. 4 revealed 41 species over an area of 128 m². This number rose from 29 to 33 species counted at station N°2 and station N°5 respectively. At 32 m², 38 species were recorded at station N°1 and station N°3. This number is higher at 30 and 33 species recorded at stations 2 and 4 respectively. At station 5 and station 6, 25 and 26 species were recorded at the 32 m² surface area. An area of 32 m² is the minimum area for savannahs in the Odziba zone, since more than 80% of herbaceous species are recorded there.

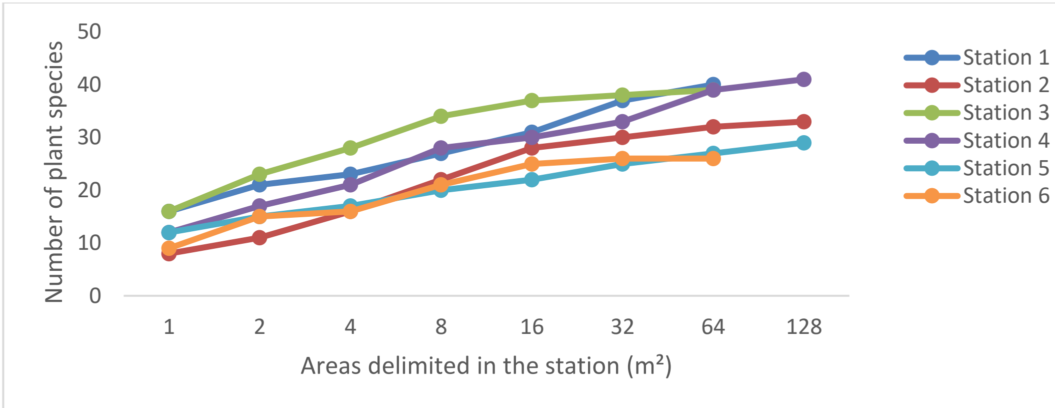

Figure 7: Species recorded according to station in the Odziba savannah

5 DISCUSSION

This study determined the development cycle and ecology of *H. nigrolineata* with a view to its domestication. The species *H. nigrolineata* is a univoltine with larval diapause. This result is contrary to the results obtained by Numbi Muya et *al.,* (2020) on 'Mikombidila', a multivoltine caterpillar with larval diapause consumed in the west of the Democratic Republic of Congo. *H. nigrolineata* caterpillars bury themselves in the soil and lead a slow life of 10 months before transforming into chrysalises and imagos, confirming the results obtained by Madamo Malasi et *al.,* (2024). There may be a direct relationship between annual ambient and soil temperatures in the transformation of caterpillars into chrysalises and imagos in July, August and September. Of the several species in the genus *Eriosema*, oviposition in *H. nigrolineata* only occurs on *E. glomeratum* and *E. psoraleoides*. A few exceptions have been observed on *Landolphia lanceolata*, *Anisophyllea quangensis* and on grass leaves very close to two *Eriosema*. These exceptions are attributed to precipitation on the part of the butterfly during oviposition. This implies a particular chemical constitution for the two species on which the eggs are laid. It could be that the meticulous choice made by the imagos at night on the two legumes is both visual and/or motivated by emanations of chemical substances emitted by *E. glomeratum* and *E. psoraleoides*. These chemical substances would be emitted at a certain time of year and at a certain stage in the physiological development of the legumes. However, it has been observed that imagos prefer to oviposit on *E. glomeratum* than on *E. psoraleoides*. This can be explained by the abundance of *E. glomeratum* in the study area. In fact, *E. glomeratum* is present in all 6 areas where surveys were carried out, unlike *E. psoraleoides*, which prefers forest edges and roadsides. The eggs hatch 19 days after laying. Neonates are gregarious at the start of their larval development. The caterpillars then become solitary as their larval development progresses. *H. nigrolineata* caterpillars are monophagous at first and become polyphagous during their larval development. These results are contrary to those obtained by Drouin, (2007) and Razafimanantsoa et *al*., (2013a). Larval development in *H. nigrolineata* takes place in 5 stages and lasts 58.48 days. When the leaves of the legume come to an end, they change to *Eriosema* plants. Two days after the 3rd moult, corresponding to the 3rd instar, i.e. 28 days on average, the caterpillars leave the legume and migrate to grasses and cyperaceae, even if the *Eriosema* leaves are not exhausted. The caterpillars that were maintained or returned to the two legumes gave the same results as the control caterpillars that migrated to the grasses and sedges. The explanation for this phenomenon may be chemical or simply the caterpillars' desire to change food. This behaviour is not so common. In fact, studies have shown that in the order Lepidoptera, around 55% of species feed on just one plant genus, 30% feed on just one plant family and 15% feed on more than one family (Bernays and Chapman, 1994). On grasses and sedges, caterpillars are very mobile in the early morning and late afternoon in their search for food. This behaviour exposes the caterpillars to numerous predators such as birds, ants, spiders and wasps. These results are similar to those obtained by Bernays, (1997) and Razafimanantsoa et *al.,* (2013a). The 5th instar caterpillars of *H. nigrolineata* greatly reduce their food intake and position themselves upside down before pupation, which takes place in the soil. These results confirm those obtained by Malaisse et *al.,* (1974). At all stages of its development, *H. nigrolineata* is attacked by several as yet undetermined natural enemies. This result is similar to that obtained by Paritsis et *al*., (2012) in north-west Patagonia in Argentina on Ormiscodes amphimone (Lepidoptera: Saturniidae). The caterpillars of *H. nigrolineata* are parasitized by as yet undetermined intestinal parasitoids. This intestinal parasitoid depends on the larval development zone of *H. nigrolineata*. The hypothesis is that they ingest the parasite when they feed. These results are similar to those found by Tarasco et *al*., (2016). No poisoning or contamination due to the consumption of *H. nigrolineata* caterpillars has yet been reported in the Congo. Apart from parasites, there are also predators and other harmful organisms such as wasps, spiders, ants, birds, insects with their rostrum and even humans, which attack the insect.

The grouping of *Hyparrhenia diplandra* and *Bridelia ferruginea* gave an indication of the floristic composition of the savannahs in the Odziba zone. Of a total of 26 families, 17 families (65.38%) and 38 species (59.37%) were recorded among the dicotyledons. Among monocots, 8 families (30.76%) and 25 species (39.06%) were recorded, while among pteridophytes, 1 family (3.84%) and 1 species (1.56%) were recorded. The poaceae families were predominant. This suggests that, compared with other families, these species are highly adaptable to the climatic and edaphic conditions of the Batéké plateaux. Poaceae species have the ability to regrow after human intervention, such as bush fires or planting of fields. These results corroborate those obtained by Makany, (1976) and Gontso et *al*., (2019). There are several methods for carrying out floristic inventories, including the aligned quadrat points method and the Braun-blanqueto-tüxenian phytosociological method. The Zuricho-montpelierrienne method was chosen to define the plant groupings and to calculate the area-species curve. However, as with all floristic analysis methods, many authors have criticised the technique used to calculate the minimum area (Gillet, 2000; Bouxin, 2008). The use of the Zuricho-Montpelierrienne method is easily applicable to temperate ecosystems because of the limited number of species observed within them. However, its use in the study of tropical ecosystems is very delicate, if not inappropriate, given the high number of plant species (Masens Da-musa, 1997). The minimum area is 32 m², with more than 80% of the herbaceous species recorded in the savannahs of the Odziba zone. These results are similar to those obtained by Kambale et *al*., (2016).

6 CONCLUSION

The increase in the world's population is rekindling concerns about the sustainable food and nutritional security of the poorest populations in developing countries. Insect domestication offers a palliative solution to reduce the animal protein deficit and the harmful effects of conventional livestock farming, which consumes water, space and agricultural products and contributes to global warming. This chapter has determined the development cycle of *H. nigrolineata* Aurivillius, which is essential for domestication and reintroduction in areas where it no longer occurs. Floristic analyses of the study area then gave us an insight into the nature of the plant species consumed by the caterpillars. All this data will enable policy-makers to create protected areas aimed at sustainably managing this income-generating resource, which is under threat from human activities.

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