Bioecological study of white grubs in the Constantine region

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In order to combat these pests and minimize their negative effects, it is necessary to obtain information on their biological aspects in the regions of interest.

Madaci Brahim: Doctor in biological sciences.
Chennouf Fadila: Doctoral student in biophysics.

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Use of anal patch bristles to identify inventoried species

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INTRODUCTION

While adult beetles play an identical role in recycling organic matter or structuring the soil (so-called "soil engineer" species), their larvae are known as crop pests, mainly of cereals.White grubs, the term given to beetle larvae, frequently feed on the roots of various plants, but mainly those of grasses and pastures. Damage caused by grubs initially resembles drought stress. As feeding continues, the attacked parts of the host plant begin to wilt and turn brown. The plant (cereal) that has been damaged by the grubs detaches itself from the soil easily because the roots have been eaten away and they are no longer anchoring the plant to the ground.In Algeria, Melolonthini, and more particularly Geotrogus deserticola (Blanch.) in the south-west, cause considerable damage to the roots of a wide variety of plants, particularly cereals **(Mesbah. A and Boufersaoui. A, 2002)**. It is a fearsome pest that attacks all vegetable crop species, and especially all cereal species, which are considered preferential plants.In order to control these pests and minimize their negative effects, it is necessary to obtain information on their biological aspects in the regions of interest. Consequently, it is first necessary to identify the species and determine fundamental biological parameters.We are interested in the Rhizotrogini group (Coleoptera, Scarabaeidae), which is not yet well known. In Algeria, most entomological studies have been carried out with the Rhizotrogini group, referring to the description of adults, where there are .... species, most of these species belong to the Melolonthinae family and the Rhizotrogini group, but little is known about the taxonomy of the immature and mature stages of the many species that inhabit them, despite the frequency of reported damage to the root system of several staple crops for the national economy.The Rhizotrogini are widely represented in North Africa, with 64 different species or forms, or around 1/3 of the world's total. Their study was the subject of a fundamental work by Peyerimhoff (1945), who specified the morphological characters of the different species grouped into four genera: Amphimallon Serv, Geotrogus Guer, Pseudoapterogyna Escal and Rhizotrogini Serv (**Balachowsky.A.S,1962)**.

The aims of the present work are to describe the immature and mature larval forms of the Rhizotrogini group found in North Africa (Algeria), and to provide a key for updating the third stage of the five genera of the Rhizotrogini group according to the latest literature on this group **(Montreuil. O, 2003)** (chapter I). Species have been identified by the so-called "raster key" and more precisely the "palidium or palidia", and comparison with specimens either found in (the literature), and presented in Appendix II and Appendix III.

According to (**Azem .A et Madaci .I, 2011**) among the species of Rhizotrogini (in the Constantine region), there are those that have the setae of the anal escutcheon arranged in the form of a "parenthesis" and those that have the setae of the anal escutcheon in the form of a "U".

This work allows us to contribute to the study of the systematics of the Rhizotrogini group. In Chapter I, we presented a general bibliography on white grubs, both as beetle larvae and as pests. We presented the systematics, external morphology, biology, damage and control methods of these worms. We have also collected dozens of images of the anal patch of several species mentioned in the literature (Appendix II).

In Chapter II, we present: the study region (Constantine), its geographical location, relief, general climate (temperature, precipitation, relative air humidity, wind, insolation), vegetation, soils, distribution and land use in the region and an inventory of cereal crops.)

In Chapter III, which deals with materials and methods, we present: the stations and methods used in the field and laboratory.
In Chapter IV, we present: study results in the form of an inventory of the number of larvae collected from different stations, inventory of the different larval stages in the 7 study stations, the maximum, mean and minimum value of each morphometric parameter, the relationship between the different morphometric parameters, number of setae, comparison of the number of Rhizotrogini setae with the different species mentioned in appendices II and III, principal component analysis, systematic analysis, description of the raster, comparison of the rasters of the larvae collected with those presented in appendices II and III. Finally, we present a conclusion concerning the raster of beetle larvae of the Rhizotrogini group from the Constantine region (Algeria).

CHAPTER I
BIBLIOGRAPHICAL DATA

White grubs are the larvae of beetles, most of which do not cause significant economic damage to crops or horticultural plantations. A few species, however, do cause damage to cultivated plants.

I. General information on white grubs (larvae of scarabéidés)

I.1. Worm systematics white

White grubs belong to the insect class, a super-branch of Arthropods, the Mandibulate phylum, the order Coleoptera, of which this order is the most species-rich, comprising around 360,000 described species (**Sipek. P, 2012).**

The white worm belongs to the Scarabaeidea family, part of the vast Scarabaeoidea superfamily, which has over 30,000 described species worldwide, probably even close to 35,000 (**Randriamanantsoa.R et al ,2010)**, whose final antennae articles are "club-shaped", made up of articles modified into more or less mobile leaflets.

The Scarabaeidae family is one of the most intensively studied groups of beetles in terms of biology, taxonomy and phylogeny. The Scarabaeidae family is one of the most intensively studied groups of beetles in terms of biology, taxonomy and phylogeny, with around 4,000 described species in some 200 genera (**Ahrens. D, 2005)**.the most varied of these pest species are represented in the subfamily Melolonthinae, which worldwide represents nearly 2,705 species included in 122 genera and 11tribes (**Neita-Moreno. J C et al ,2012**).

The Melolonthinae are an example of a species-rich lineage of phytophagous beetles. They constitute an ecologically diverse taxonomic group within the Scarabidae. The Melolonthinae are characterized, among other things, by the white worm.The Rhizotrogina group comprises some 1400 species from the Palearctic, Nearctic, Neotropical and Oriental regions (**Montreuil.O, 2003 and 2008**). The following diagram presents the hypothesis of phylogenetic relationships in the Rhizotrogina subgroup (**Montreuil.O, 2003)**. The Rhizotrogina subgroup includes around 200 species from the Western Mediterranean region (**Montreuil.O,2003)**. These species are divided into five (5) genera (**Montreuil.O, 2003**):

- ✓ Amadotrogus Reitter, 1902,
- ✓ Amphimallon Berthold, 1827
- ✓ Geotrogus Guérin, 1842 [senior synonym of Pseudoapterogyna Escalera1914]
- ✓ Monotropus Erichson 1848,
- ✓ Rhizotrogus Berthold, 1827 and the scuttelaris group

The Amphimallon genus comprises some 60 species that inhabit the West Palearctic region, distributed across Europe (except in northern regions), the Middle East, from Central Asia to Siberia, and **North Africa** (Morocco, northern **Algeria**). According to recent phylogenetic and taxonomic data focusing on Rhizotrogini, our understanding of the diversity and evolution of this group is very limited (**Montreuil.O, 2008**).

Thehypotheses of phylogenetic relationships in the Rhizotrogina subgroup

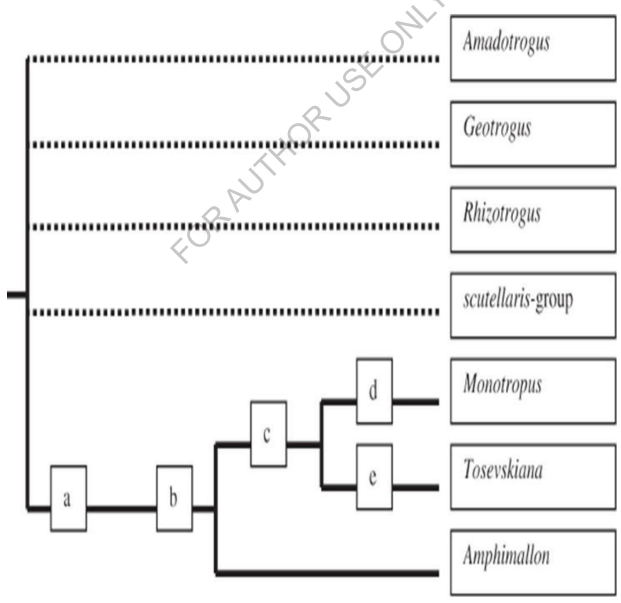


Fig. I.1: The hypothesis of phylogenetic relationships in the Rhizotrogina group is :

a) antennomera. - b): reduction of sclerotized apophyses in endophallus; C) antennomera club; weak elongation; -D): antennomera; basal part of phallobase strongly enlarged; sclerotized apophyses in endophallus completely reduced;-e)antennomera club strongly elongated (**Montreuil.O, 2003**).

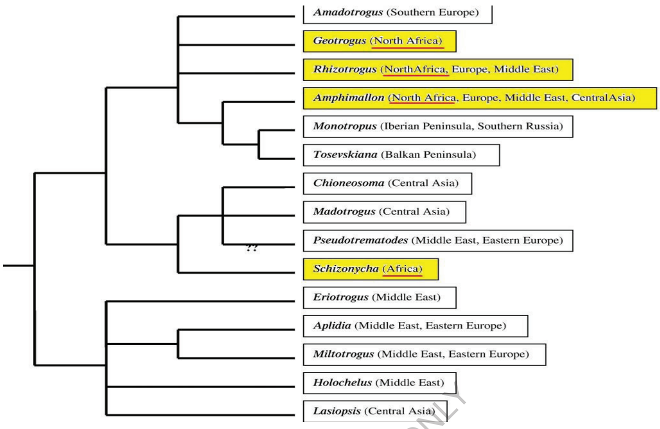


Fig.I.2: Phylogeny and distribution of Rhizotrogini in the Eastern Palearctic (**Montreuil. O, 2008**).

I.2. Worm morphology white

I.2.1 the larva

White grubs can be found in the soil. All species have a soft, white, C-shaped body. Length varies according to species, larval stage and region, from small when they hatch (3- 4 mm long), to mature larvae ranging from 2 cm (Japanese beetle larva) to 4 cm (common chafer larva) (**Charbonneau.P, 2010**). A healthy larva is milky white, with the dark contents of its digestive tract visible through the cuticle at the posterior end of its abdomen.

The head: the white worm's head is ochre or brown, well developed, equipped with sense organs and mouthparts (Fig.I.3).

Thorax: As in holometabolous insects, the thorax is weakly sclerotized, making it difficult to distinguish between segments. It consists of 3 segments: the prothorax, mesothorax and metathorax. Each thoracic segment carries a pair of locomotor legs six prominent spiny legs They are similar and each consists of coxa, trochanter, femur, tibia, tarsus, and a single tarsal claw. A pair of stigmata is present laterally on the prothorax (Fig.I.4).

Abdomen: The abdomen is usually made up of 10 segments, with a space between the abdominal muscles.darker gray at the abdominal end, soft and usually without distinct sclerites. Abdominal segments 1-8 each have a pair of stigmata, but stigmata are not present on segments 9 and 10. The anus is a horizontal transverse slit, extending across the posterior end of the 10^{eme} segment. The ventral region of the anal slit on the 10^{eme} abdominal segment is known as the "raster", and bears a species-specific pattern of short to medium spines (Fig. I.4).

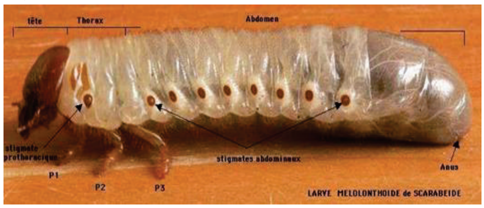


Fig.I.3: Beetle larva (white worm) (**Anonymous, 2012a**)

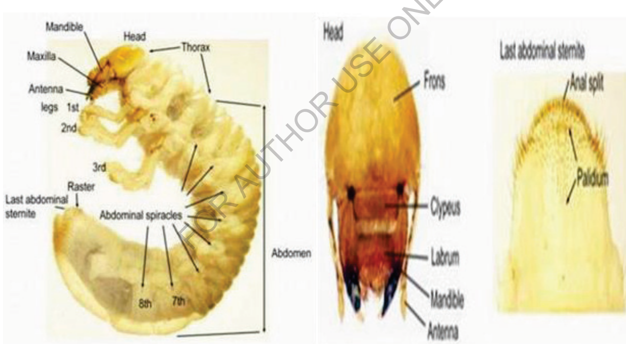


Fig. I.4: External morphology of white grubs (beetle larvae)

It's important to learn how to identify these parasites accurately. The adults (beetles) of these species are dissimilar in many respects and easy to identify. However, their larvae (grubs) are almost identical. The general shape of the larva varies slightly according to genus, species and region (Fig.I.5).

Fig.I.5 shows the different forms of scarab beetle white worm from different geographical regions: May/June Beetle, green June beetle, European chafer, Japanese beetle, Masked chafer, Oriental beetle and Asiatic garden beetle respectively from left to right (**Shetlar.D J**,**2004**).

Fig.I.5

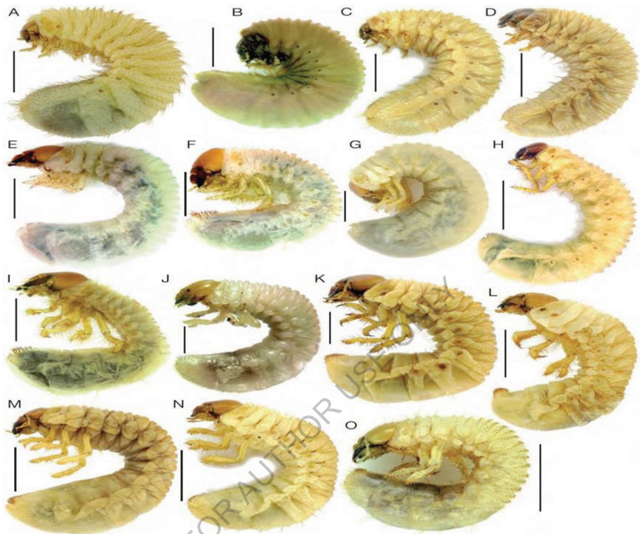


Fig. I.6 Different forms of Scarabaeoidea larvae from **Madagascar** (same region) for different species: A, Bricoptis variolosa; B, Celidota parvula; C, Anochilia bifida; D, Euryomia argentea; E, Heteronychus arator rugifrons; F, Heteronychus bituberculatus; G, Heteronychus plebeius; H, Hexodon unicolor; I, Heteroconus paradoxus; J, Paramorphochelus cornutus; K, Encya sikorai; L, Apicencya waterloti; M, Empecta scutata; N, Hoplochelus betanimena; O, Triodontus nitidulus . Scales: A-I, K, L, N, 5 mm; J, O, 2 mm; M, 3 mm (**Randriamanantsoa.R et al, 2010**).

I.2.2 The nymph

It resembles a small mummy, with its legs, wings and antennae folded tightly over its body. It does not feed and remains motionless (Fig.I.7). They are yellowish or brownish in color. The insect overwinters in the lodge built by the white worm a few days before pupation, at depths of up to 60-80 cm and even 1 metre (**Kehal.A and Benseddik .R, 2003**).

Fig.I.7 : External morphology of the nymph Nymph (**Fraval.A, 1997**)

I.2.3 Adult

Adult beetles have rigid, more or less cube-shaped shells and long, spiny legs. These medium-sized beetles feed on a wide variety of trees and shrubs. The adult is a tawny-ochre beetle that is attracted to light at night. The European chafer adult is smaller than the European chafer.

Common (**Vittum.PJ,1986**). The adult of the genus Rhizotrogus differs from that of the genus Amphimallon in the number of antennal articles: 10 in Rhizotrogus, 9 in Amphimallon (**Montreuil.O, 1997)**. Their external morphologies are shown in (Fig. I.8),(Fig. I.9).

The main pest species recognized in Algeria belong to the genera Geotrogus and Pseudoopterogyna (**Hadji.K et al, 1994)**, both of which belong to the Rhizotrogini. The species most frequently observed in the country are: Geotrogus inflatus buq, reddish brown, widespread in Oranie, and Geotrogus deserticola, white, dark brown, widespread throughout Algeria, and abundant in the high plateaus, where a density of 100 larvae or more per square metre is not uncommon (**Boulahlib.L et al,2001)**.

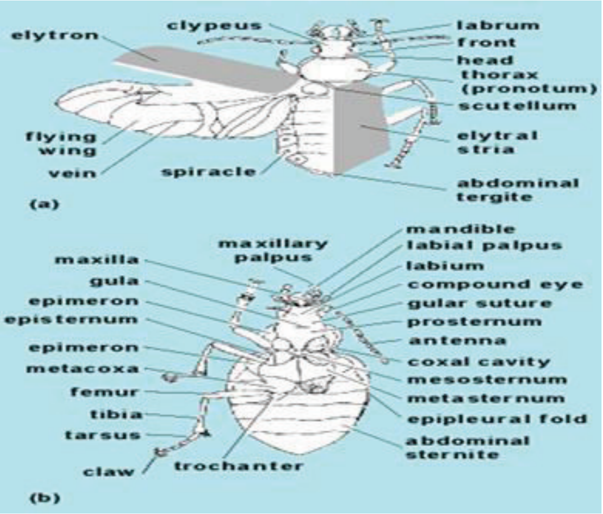


Fig.I.8: External morphology of adult beetles

Adult color and size vary according to genus, species and region, e.g. the Japanese beetle is metallic green with brown elytra. May beetles are solid brown. The green chafer is emerald green except for a tan margin on the sides of their elytra (Fig.I.9).

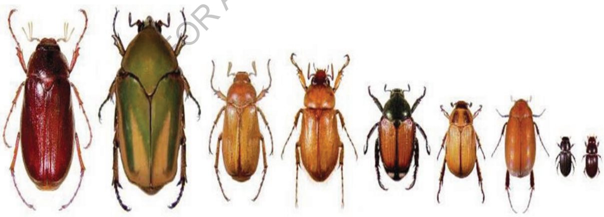


Fig. I.9: Morphology of adult Scarabéidés **(different species)** (**Shetlar.D J**, **2004)**: May/June Beetle green June beetle European chafer, masked chafer, Japanese beetle, Oriental beetle and Asiatic garden beetle respectively.

Fig.I.10: Melolontha melolontha (L.) adult male (left) and adult female (right) (**Fraval. A, 1997**)

I.3. The biological cycle

It's important to understand the white grub (pest) cycle in order to protect yourself from potential damage. The adult female lays her eggs in the soil at a depth of 2 to 10 cm, in clusters under grass cover, on weeds and under the soil. Once the eggs have hatched, and during the first and second larval instars, the larva wreaks the greatest havoc on plants. It feeds heavily on roots, as it is still growing. (Fig.I.11), (Fig.I.12).

I.3.1 The life cycle of the chafer

Life cycle research has shown that you need to know which types of grubs you're dealing with, as they have different life cycles and will feed at different times. The length of the evolutionary cycle is highly climate-dependent, depending on the number and duration of developmental arrest phases during larval life, and on temperature and humidity during periods of activity. (**Houadeg.K, 1996**).

✓ The **European chafer** larva has a **one-year** life cycle (Fig. I.13):

- The larvae hibernate buried in the soil.
- Early in the spring, the larvae rise close to the surface and feed on grass roots.
- Towards the end of May, the larvae transform into pupae. At this stage, they

no longer cause damage to plants.

- Adult beetles emerge from the ground and breed in trees.
- The females dig a hole about 10 cm deep in the ground, and in it

lay their eggs. They prefer short plants.

• 2 to 3 weeks after laying, the eggs hatch and the **tiny larvae** begin to feed. This is when the larvae are most vulnerable.
• The larvae increase in size and strength a s they grow.

nourish.

• With the arrival of cold weather, the larvae burrow into the soil to overwinter.

✓ **Common chafer** larvae live for **three years** in the soil (Fig.I.14), **two of** which are spent as grubs that feed on the crop all year round. Common chafer larvae seem to cause more damage in soybeans (and sometimes forage crops) because the crop is still young and in the process of establishing itself.
✓ **Japanese beetle** larvae have a life cycle similar to that of the European chafer, which lasts **one year**, but they feed longer during the summer before pupating. Adult beetles emerge, mate and lay eggs in midsummer, mainly from late **June** to early **August**.

✓ Eggs are laid a few centimetres below the surface and hatch in about two weeks. The young (3.2 mm long) first instar larvae (those emerging from the egg) develop rapidly, feeding on fine roots and organic matter.

Damage caused by feeding Japanese beetle grubs continues until **early June**, before pupation when they become adults. These one-year-cycle larvae start feeding again in late summer, after the adults have laid their eggs, and the young larvae hatch and begin feeding.

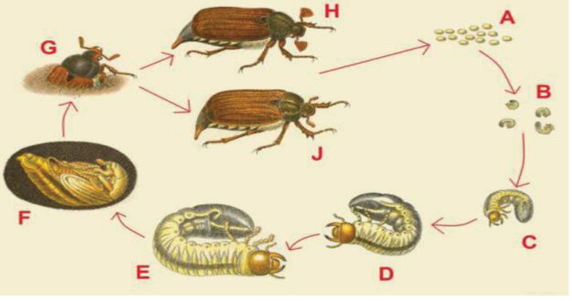


Fig.I.11 : The life cycle of a chafer, whatever the species (**Anonymous, 2012b**)

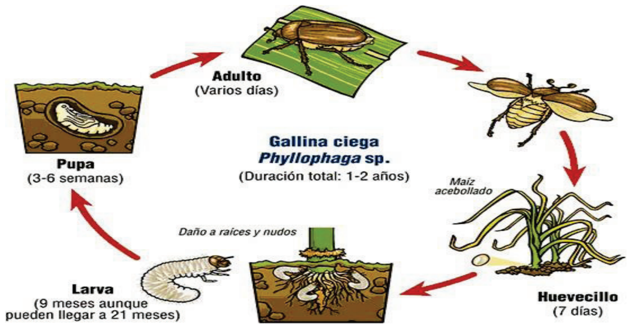


Fig.I.12 : Life cycle of Phyllophaga sp (common chafer) (**Anonymous, 2010**)

The life cycles of various cockchafer species are presented in **Appendix II**.
In **Algeria**, life cycle research has shown that grubs maintained in these temperature and humidity conditions have a **two-year** cycle, with adult emergence in spring. Mating takes place on the surface of the soil. Egg-laying begins **two to three weeks** after mating, and takes place in **three** to **four** days. After **three** weeks, the L1 larva appears. The first molt occurs in September of the first year. The longevity of L2 can exceed one year. The second molt takes place in September of the second year. L3 lasts six months. Pupation, which lasts one month, takes place in March. The new imagos emerge in spring (April) (**Mesbah. A et al, 2002**).

I.3.2 Period of activity of l'hanneton

The period of activity varies according to gender and region. next diagram **:**

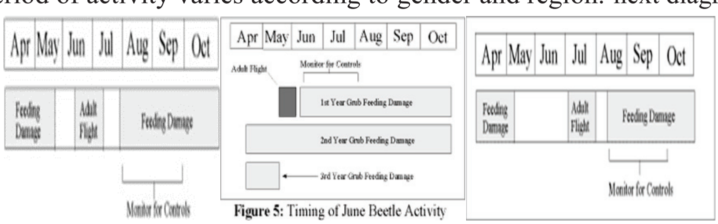


Diagram: Period of activity of the European chafer, June chafer and chafer respectively (**Stewart.J.B, 2010**).

Scarab beetles live in a wide range of biotopes, from the sands of Saharan oases to the heavy soils of the Siberian forest. In North Africa, the Melolonthinae and Rutelinae seem to adapt to quite different climatic conditions, with the most common frequenting Mediterranean shores (**Boufenara.B, 1995**).

II. Characteristics of different types of chafer

Table I.1: a comparison between the different types of chafer (**Betsy.A et al, 2011**)

The common name	The name scientific	Size of the adult L × W (mm)	mature larva	activity time of the adult	Power supply adult	Oviposition
Ground beetle European	Rhizotrogus majalis	1.52 × 0.76	3	in the evening	no	sandy soil - silty
Ground beetle Japanese	Popilia japonica	0.76 - 1.27 × 0.64	2.54	day	nursery	sandy soil - silty
Ground beetle oriental	Anomala orientalis	0.91-1.04 × 0.64	2.49	day/evening	no	wide range floor
Ground beetle Asian garden	Maladera castanea	0.76 -1.02 × 0.51	1.90	night	garden	sandy loam soil
Northeren masked chafer	Cyclocaphala borealis	1.14 × 0.66	2.54	night	no	sandy loam soil
Rose chafer	Macrodactylus subspinosa	1.02 L	1.80	day	green plant	sandy
Ground beetle of June	Phyllophaga spp	0.76 - 6.35 × 0.38 - 3.17	2.54 - 6.35	night	green plant	sandy soil - silty
Bumble flower beetle	Euphoria inda	1.27 - 1.52 × 0.76 - 1.01	5.08	the day	fruit	soil rich in material organic

III. Damage

White grubs feed on root systems, and seem to be more damaging than other types of grubs.on cereals, whose entire root systems can be consumed by these larvae.Attacks in the field can be recognized by the presence of large dark patches, which can widen and spread in the absence of specific treatment. Large areas of vegetation are often destroyed, and the soil remains bare for as long as the larvae are present. The damage caused by white grubs is shown in Fig. I.14: Strong damage caused by white grubs several figures illustrate the damage (Fig. I.13), (Fig. I.14), (**INPV, 2010**), (Fig. I.15) and (Fig. I.16).

Fig.I.13 Fig.I.14

Fig.I.15: Damage caused by white grubs on maize

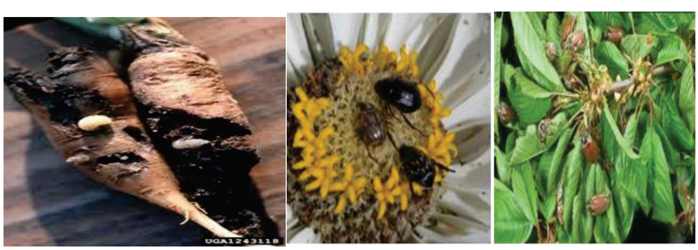


Fig.I.16: White grub attacking market garden crops, grouping of adults on a cherry shoot (**Richmond.D, 2010**).

IV. Control methods

An average of eight or more larvae per sample may indicate a need for treatment, particularly when cereals are in hot, dry conditions. To control white grubs, there are 2 periods to remember:

✓ **1ère period: Autumn**

In autumn, cultivation methods are the best way to limit the damage these predators can cause. The first step is deep ploughing in summer, just after the harvest. This ploughing turns the buried horizon towards the ground, exposing the grubs to the sun and the birds (up to 50% reduction in larval populations).

✓ **2ème period: Spring**

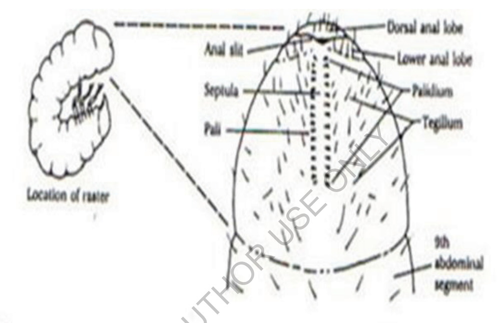
Next, apply the insecticide product, followed by a cover cropping operation to bury the product.Another method of control is to coat the cereal seed with a suitable insecticide. This operation keeps grubs away from the root system after the cereal has emerged.In spring: the treatment is localized in cereal plots (around the edge of the field).stains).However, treatments must be maintained for a period of at least 2 successive years in order to break the insect's biological cycle and control the population level.

Natural enemies

✓ In some regions, natural controls such as predators, parasites (wasps Tiphia vernalis Rohwer 1924 (Hymenoptera: Tiphiidae) and Tiphia pygidialis Allen 1966 (Hymenoptera: Tiphiidae) (**Rogers.M E and Potter.D A,2004)**, can help keep grubs at bay.Several pathogens have been isolated from T. subtropicus larvae, including Bacillus popilliae, Metarhizium anisopliae, Beauveria bassiana, and Verticillium lecontei, however, infection rates are generally low (< 10%). The application of nematodes (microscopic parasites), such as Steinernema glaseri (Steiner),Melolonthinimermis hagmeieri (**Jacky.F et Couturier.A,1970**) can also attack T. subtropicus larvae, nymphs and adults.

V.Worm species identification

The number of palidia spines is given for information only, as it is subject to some variability. Raster morphology can be used to separate species (**Randriamanantsoa.R, 2010**). The distribution of spines on the raster is a key chosen to identify species and groups. White grubs can also be identified by examining the raster's arrangement of small spines on the ventral side of the last abdominal segment.Each species has a different-shaped anal patch. Different grub anal shields for different species are shown in the following diagram, which illustrates the different shapes of anal shields. raster situation (Fig.I.17), (Fig.I.18). The rasters of several species are presented in **Appendix II**.



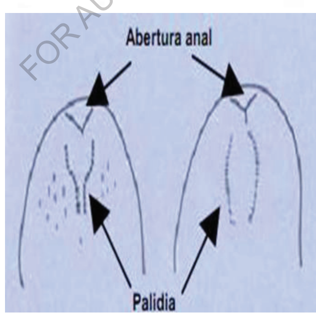


Fig.I.17Fig.I.18: (**Pardo Locarno. LC,2002**)

Fig.I.17: Ventral view of last posterior abdominal segment showing random characteristic of raster setae of different species of Colorado Scarabaeidae larva (**Krischik.V,2012**).

Fig.I.18: Raster of Plectris con palidia with semitrapezoidal "V"-shaped anal opening (Izquierda). Raster Phyllophaga con palidia in the shape of a "parenthesis" anal opening y in the form of "Y" (derecha).Among the anal escutcheons of species existing in North Africa and more precisely in Algeria (in the Constantine region) are the following: Fig.I.19, Fig.I.20 and Fig.I.21 (**Azem. A and Madaci.I ,2011**).

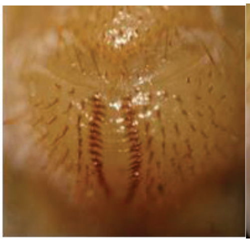
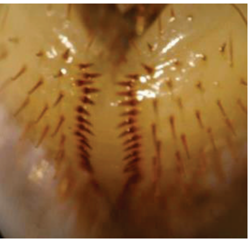




Fig.I.19 Fig.I.20 Fig.I.21

CHAPTER II
PRESENTATION OF THE STUDY REGION (CONSTANTINE)

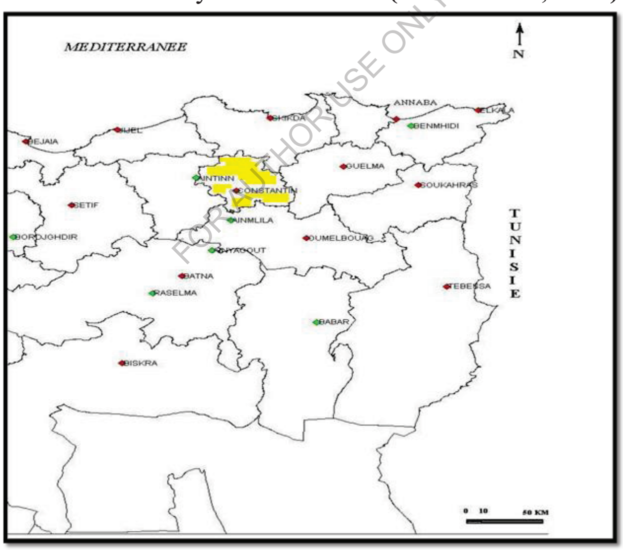
I. Presentation of the study region (Constantine)

I.1. Geographical location of the Constantine region

The Constantine region is located in eastern Algeria, with a latitude (North) of 36°17, longitude (East) of 06° 37, and an altitude of 660 meters **(Tir. K, 2009)**. It covers an area of 2287 km². It is bounded by :

- to the north, by the wilaya of Skikda ;to the east, by the wilaya of Guelma ;
- to the south, by the wilaya of Oum El Bouaghi ;to the west, by the wilaya of Mila

Map N°1 shows : North-east Algeria (Constantine in yellow), geographical location in the city of Constantine **(Boussouf. R, 2008)**.



Map 1: Geographical location of the Constantine region (**Tir.K, 2009**).

I.2. The reliefs

Due to its geographical position, the Constantine region is a transition zone between north and south. The North is characterized by a rugged relief, and the South by a flatness of space that constitutes the high plains. These different and very distinct physical environments are defined by :

a. Mountainous areas

The north of the wilaya is made up of a rugged mountainous terrain formed essentially by the Numidian chain, which extends to the northeast by the Djebel El Ouahch massif, straddling the territory of several of the wilaya's communes and covering an area of 500 km^2 .

b. Inland depressions and valleys

Orographically, this region is made up of the pseudo-massifs of Chettaba in the south-west, Oum Settas in the south-east, Djebel Ouahch in the north-east and Djebel Driss in the north-west. Altitudes range from 300 m in the Rhumel valley to 1,350 m at Djabel Ouahch. The inland fringe of the wilaya is characterized by the extension of the inland Mila basin around the commune of Messaoud Boudjeriou, in continuity with the Hamma Bouziane basin, the Didouche Mourad depression and Béni Hamidène.

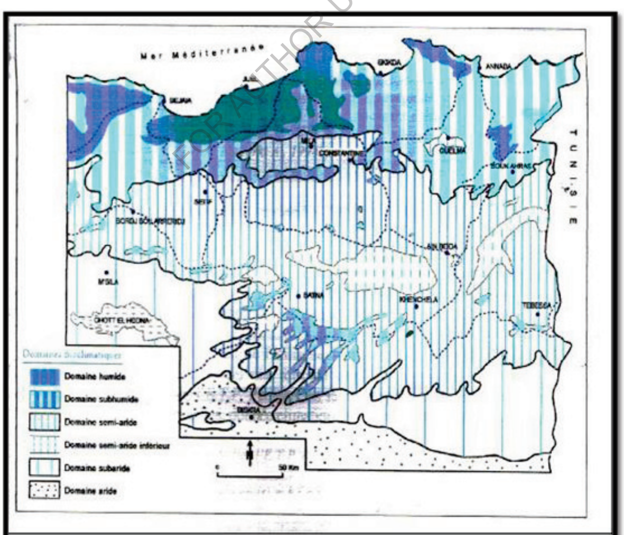
C. The valleys

The valleys are the natural corridors of contact with the Tell and the high plains of the southern lands; there are four of them:

- The upper Rhumel valley at Ain Smara.
- Boumerzoug valley, El Khroub.
- The lower Rhumel valley: Ibn Ziad - Hamma Bouziane.
- The Oued Smendou valley, which converges with the lower Rhumel valley in the Béni Hamidène commune.

I.3. The general climate

Climate through its components such as temperature, precipitation, wind, pressure and relative humidity controls many biological and physiological phenomena (**Harrat .A and Moussi .A, 2007**). In turn, climatic elements are influenced by climatic factors, which include geographical features local. The Constantine study area is subject to the dual influence of a temperate Mediterranean climate in the north and, to a lesser extent, a subtropical climate in the south. The distance from the sea (around one hundred kilometers) and the high relief of the Numidian chain to the north, forming a barrier, cause air masses from the north to dry out progressively. Temperature is the most decisive element in the characterization of vegetation. Constantine's climate is characterized by cold winters and hot summers (Mediterranean climate).The relatively cool but wet winters in 3/4 of its surface area are located in the north, while the southern part of the region (communes of Ain-Smara and El-Khroub) lies at the boundary between sub-humid and semi-arid, as it receives the tropical air that escapes and descends towards the Mediterranean. This air is characterized by dry, warm winds.



Map 2: bioclimatic map of eastern Algeria (**Benkenana.N, 2006**)

I.3.1. Temperature

Temperature plays a key role in white grub biology. It modulates the general activity and speed of larval development, and influences mortality rates and distribution.In the Constantine region, low temperatures are recorded in December, January and February with 7.79, 6.64 and 7.66 respectively for the period 1984 to 2004. High temperatures occur in June, July and August, when they reach 22.34, 25.30 and 25.90 respectively for the same period (Table.II.1) (**Benkenana. N, 2006**).

Table II.1: Average monthly temperatures in degrees Celsius (C°) during the decade 1984-2004 in the Constantine region.

period 1984-2004	month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aou	Sep	Oct	Nov	Dec
	T average	9791	.799	7719	9371 .	9.73 1	3172 1	3172 2	3177 2	3971 2	9.79 1	9977 1	.7.7

T: Temperature in degrees Celsius, Moy: average monthly temperature in (C°)

Fig.II.1: shows the average monthly temperatures at the Ain Bey station.- Constantine (1971-2007) (**Zekri. Dj et al,2011**).

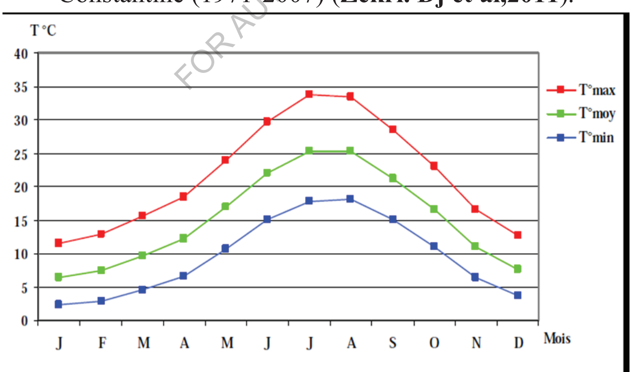


Fig.II.1 (**Zekri.Dj et al,2011**)

Table II.2 represents the absolute monthly maximum temperatures for the period (1978-2004) (**Zekri. Djet al, 2011**) :

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aou	Sep	Oct	Nov	Dec
Constantine	23.3	26.7	32.1	34..3	38.6	41.9	43.5	42.7	41.0	37.0	31.9	24.5

Table II.3: Monthly variation in mean maximum temperatures. Period (1978- 2004) (**Tir. K, 2009**) in the Constantine region:

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aou	Sep	Oct	Nov	Dec
Constantine	-5.5	-10.2	-2.6	-2.1	1	5.5	8.4	10.2	5	2.2	4.6	4.9

Table II.4: Average annual temperatures in Constantine. Period (1978-2004). (**Tir.K, 2009**) :

Year	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
T(C°)	14,21	14,64	14,05	15,05	15,17	15,31	13,58	15,21	14,95	15,68	15,63	15,59	15,75	14,29	14,38	15,12	16,28	15,44	14,97	16,01	15,23	16,3	16,13	16,32	16,24	16,24	15,48

Table II.5: Average monthly temperature at **50 cm** below ground (1981-1995). (**Tir.K, 2009**) for the Constantine region:

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aou	Sep	Oct	Nov	Dec
Constantine	6.49	6.93	8.99	10.48	13.69	17.5	20.69	21.57	19.72	16.05	12.06	8.33

Table II.6 shows that the variation in temperature at 50 cm below ground is very marked between winter and summer. The lowest values are recorded in January. The highest values were recorded in August.

Table II.6

Month	Dec	Nov	Oct	Sep	Aou	Jul	Jun	May	Apr	Mar	Feb	Jan
T	9717	9772	1777	92711	92797	9.712	32797	3971.	977.3	99721	93729	1722

The first **beetles** appear when the soil warms up in spring. They emerge at the end of April and beginning of May, when the soil temperature has reached 10°C at 25 cm (**Anonymous, 2011c**).

Fig. II 5: Variation in average monthly soil temperature at **50 cm** depth.

Period (1981-1995) (**Tir.K, 2009**).

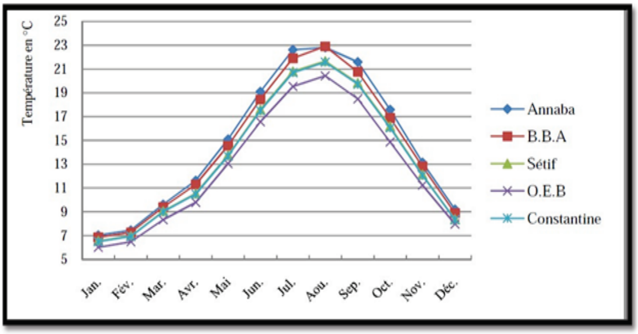


Fig.II 5

Fig. II.6: Variation in maximum and mean annual temperatures over a 10-year period (1998-2007) in the Constantine region. Figure (left) shows the seasonal variation in maximum temperatures over a 10-year period (1998-2007) in the Constantine region (**Tir. K, 2009**).

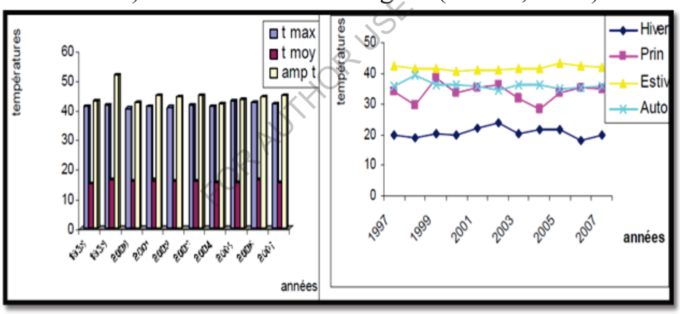


Fig.II 6

I.2.1. Precipitation

Precipitation refers to any type of water that falls from the sky, in liquid or solid form. This includes rain, snow, hail, etc. Rainfall is a fundamental ecological factor in terrestrial ecosystems, as it conditions, along with temperature, their structure and primary productivity (**Ferhati .M, 2007**). For most countries, it is characterized by three main parameters: volume, intensity and duration (months, years). Precipitation plays a very important role in the Mediterranean region. It is characterized by its irregular pattern and uneven distribution (summer drought) **(Tir. K, 2009)**. The evolution of these three characteristics is essential for planning the use of precipitation for agriculture.Average rainfall varies from 400 mm to 600 mm depending on the year, and is highly variable from north to south. It has a major influence on the regeneration of water reserves. Average annual rainfall is between 40 and 60 days.On the one hand, rainfall has an impact on flora, particularly on the development of plants.and on fauna, in particular on the evolution of the **white grub**'s life cycle.A summer with little rainfall can reduce the grub population. In fact, drought can cause **chafer eggs** to die from lack of the water they need to grow and hatch into grubs.In general, when rainfall is sufficient, grubs cause less damage. A healthy, growing cereal field has more roots and can better withstand the ravages caused by grubs. On the other hand, a less healthy field with less stamina will be more affected by **grubs**.The mountainous environment and the depressed environment of the high plains of Constantine. Rainfall hierarchies are determined by altitude, exposure and, to a lesser degree, latitude. In the central part of Constantine, rainfall reaches **600 mm/year**, gradually decreasing towards lower altitudes, to **532 mm/year** in **Ain Abid,** for example **(Gherbi.W, 2006)**.

Table II.7: Probability of a rainy day in the Constantine region. Period (1978-2004) (**Tir.K, 2009**):

Month	J	Feb	Mar	Apr	May	Jun	Jul	Aou	Sep	Oct	Nov	Dec	Average
Constantine	0.44	0.42	0.39	0.37	0.30	0.18	0.10	0.14	0.25	0.27	0.41	0.44	0.309

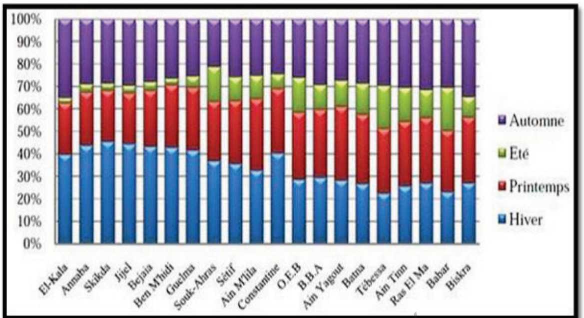
Table II.8: Monthly rainfall variability in the Constantine region period (1978-2004) (**Tir.K, 2009)** :

Month	Jan	Feb	Mar	Apr	May	Ju	Jul	Aou	Sep	Oct	Nov	Dec	Avg
M	73.61	58.03	55.54	56.6	41.62	18.86	6.36	10.19	36.1	39.1	57.01	84.8	537.8
S	53.12	43.11	32.26	40.62	26.99	16.49	8.472	7.594	25.14	26.17	42.44	71.81	137.5
C.V	0.722	0.743	0.581	0.718	0.648	0.875	1.332	0.745	0.696	0.669	0.745	0.847	0.256

Table II.9: represents the seasonal precipitation regime of the Constantine region, for the period (1978-2004) (**Tir.K, 2009**) :

Station	Winter	Spring	Summer	Autumn	Regime
constantine	216.42	153.76	35.40	132.22	HPAE

Fig.II.6: shows the seasonal rainfall pattern in eastern Algeria (and the region Constantine). Period (1978-2004) (**Tir.K, 2009**):



I.3.3 Air relative humidity

Average relative humidity is the ratio in % of the partial pressure of water vapour in the air (Pa) to the pressure of saturated vapour (Pr) (under the same conditions of T° measurement read with a dry bulb thermometer) (Seltzer. P).Humidity is the amount of water vapor in the air. Relative humidity is an important factor in characterizing a climate. Its variation depends in part on air temperature and the hygrometric characteristics of air masses (**Tir. K, 2009**). This acts on the density of grub populations, increasing their numbers.

Table II.10: shows relative air humidity in %.

Month	Jan	Feb	Mas	Apr	May	Ju	Jul	Aou	Sep	Oct	Nov	Dec
HR %	78.80	.9727	.2721	.2771	99771	11711	117.9	17799	93799	9.71.	.17.9	.7731

RH: Relative humidity expressed in %. The Constantine region receives very few northerly winds carrying humid masses. It is the westerly winds that drain these humid masses. Relative humidity averages 70% in winter and 50% in summer.

Table II.11: Average monthly humidity in the Constantine region (2004-2005) (**Benkenana. N, 2006**) :

Month Year	Jan	Feb	Mar	Apr	May	Ju	Jul	Aou	Sep	Oct	Nov	Dec
2004	82	75	.1	.7	..	9.	19	12	91	92	11	11
2005	11	13	.2	.9	99	12	12	11	9.	.2	.2	12

RH: Relative humidity expressed in percent.

Table II.12: represents the average monthly humidity in the Constantine region. Period (1984-2004) (**Tir. K, 2009**) :

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aou	Sep	Oct	Nov	Dec	Avg
Constantine	77.77	75.96	73.15	71.12	66.92	57.15	47.62	50.73	62.88	68.15	74.77	78.27	67.04

I.3.4. The wind

Wind is one of the most characteristic elements of climate. It activates evaporation, which can lead to drought. The winds that benefit the Constantine region are those from the west, which move moisture-laden air masses that are transformed into precipitation, especially in February and March.Dominant winds from the north (cold and dry) and secondarily from the south are observed particularly during summer periods. The number of windy days from 1984 to 2004 is shown in Table II.13.

Table II.13: Average monthly wind during the period: 1984-2004 (**Benkenana. N, 2006**) :

Month	Jan	Feb	Mas	Apr	May	Ju	Jul	Aou	Sp	Oct	Nov	Dec
V(m/s)	3797	3713	37.9	3711	3711	3713	3729	3731	3791	3791	3791	37.3

For 2004 and 2005, the average wind speed (V(m/s)) ranged from 1.4 to 2.9. Average wind speeds for 2004-2005 are shown in Table II.14 (**Benkenana. N, 2006**):

month year	Jan	Feb	Mas	Apr	May	Jun	Jul	Aou	Sp	Oct	Nov	Dec
4002	379	371	372	377	377	379	379	379	971	971	372	372
4002	373	279	373	371	971	379	379	379	979	979	379	3.0

I.3.5 Insolation

Possible insolation is the period during which the sun will be able to shine, assuming a cloudless sky, while effective insolation is the period during which the sun has shone. Light is an essential factor in maintaining our biological rhythm. It acts through its intensity, wavelength, degree of polarization, direction and duration Constantine 2781.54 (h/year) (**Tir.K, 2009**).

Table II.15: Average annual sunshine duration (LS) in eastern Algeria.

Month	Jan	Feb	Mar	Apr	May	Ju	Jul	Aou	Sep	Oct	Nov	Dec
LS	155.30	174.80	212.80	238.23	278.80	311.28	337.61	306.19	247.90	212.33	164.42	150.47

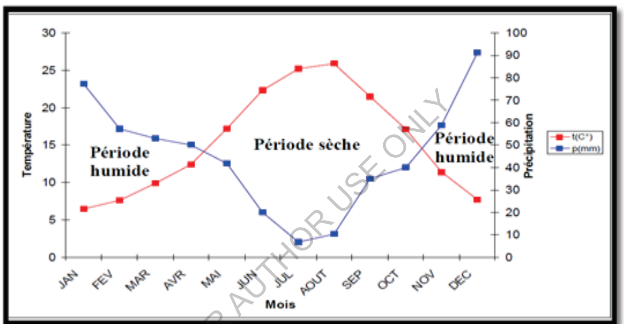


Fig.II.7: GAUSSEN umbrothermal diagram of the region Constantine (1984-2004) (**Benkenana. N, 2006**).

II. The vegetation

The vegetation of the Constantine region is made up of forests and scrubland, which make up 9% of the region's total agricultural area. Forests occupy almost 8% of the total area, i.e. 17,858 ha. The Chettabah state forest, located in the south of the region, is made up of holm oak and Aleppo pine (Pinus halpensis). The Draâ-Nagah state forest: covers 19 hectares at an altitude of 950 meters. The microclimate is subhumid to cool. The dominant species are eucalyptus, pine (Pinus sp) and oak (Quercus sp).

III. Soils in the wilaya of Constantine

According to all the studies carried out in the wilaya, there are 5 categories of soil in the region wilaya of Constantine, each one defined by its own characteristics, aptitudes distribution and spatial importance. A clear dominance of the agricultural vocation, represented in land categories I, II and III and totaling an area of 137,643 Ha. This value is close to the current extent of the UAA (131,096 Ha). Agro-sylvopastoral land covers a significant area of 75,296 Ha (**Boulahia L, 2008**).A detailed soil classification for the wilaya of Constantine is provided in **Appendix III.**
There are 3,962 cereal farms in the wilaya of Constantine. They are distributed according to the two types of cereal crops:

✓ Dry cereals: with 3954 farms occupying a surface area of 65223Ha.

✓ Irrigated cereals: representing 8 farms on 27 Ha.

Climatic conditions make the wilaya a cereal-growing region. That's why the region's CRMA is mainly responsible for agricultural insurance, with the aim of protecting farmers against any atmospheric calamities that may arise (**Boulahia.L, 2008**).

V. Grain harvests in the wilaya of Constantine

Cereals predominate in terms of UAA (almost 50%) in the wilaya of Constantine. Among cereals, soft wheat alone occupies around 60% of the area, or 40,000 hectares. The remainder is taken up by durum wheat and barley, with 20,000 Ha and 5,000 Ha respectively. Grain oats occupy a mere 350 Ha. (**Boulahia .L, 2008)**.The useful agricultural area (S.A.U.) in the Wilaya of Constantine covers 127400 ha of which 1274 ha (Boussouf. R, 2008). The main activity of the agricultural sector in the wilaya of Constantine is cereal production. Every year, 50% of the usable surface area is used for cereal production. **(Benkenana. N, 2006)**.

Some details concerning temperature, precipitation, soil, soil classification, land distribution and occupation, cereal farms, cereal harvest trends, and all the forests in the Constantine willaya ... in **appendix IV**.

CHAPTER III
MATERIALS AND METHODS

Several agricultural stations in the Constantine region have reported white grubs infesting their cereal plots, so we have chosen to collect white grubs from these infested plots.

I. Choice of study stations

The study stations were chosen according to the nature of the crops (cereals).

II. Presentation of the study stations

II.1. Aïn Smara station

Aïn Smara is a commune in the wilaya of Constantine (Algeria), located to the west of the latter at an altitude of 629 m (**Anonymous, 2012f**). Our specimens were collected from a cereal field located in this commune. The profits were made on a field located near INATA.

The following map shows the communes of the Constantine willaya (**Anonymous, 2012e**).

Map N° 3: shows the communes of the Constantine willaya

Station Wed Atmania

It's a commune in the Mila willaya. It is very close to the commune of Ain Smara. The crops we harvested were grown in an area between Ain-Smara and Wed-Atmania, for this reason, it was considered that the climate and the same Ain-Smara. This station very special in cereals, mainly wheat. The harvest in this plot was done on 14 - 03- 2012.

II.3. Benmadani station

This station belongs to the commune of Benbadis (El-Haria), one of the communes of the Willaya de Constantine, and more precisely to the place known as Douar El-okba. The grubs were harvested on 25-03-2012 at a temperature of 6°C at a depth of 25 cm.

II.4. Station Baarawia

The El-Baaraouia station (Commune d'El-Khroub: 36° 16' N; 06°40' E), located 12 km south-west of the Constantine willaya, at an altitude of 622 m. The El-Baaraouia station is a plain. The climate is sub-humid in the northern part and semi-arid in the south. The soil is calcareous, with the presence of calcic or petro-calcareous elements, of medium texture and good permeability (**Hamra Kroua .S et al, 2009**).

We harvested our grubs on a pilot farm in El-Baaraouia, more precisely in the plot known as 84.85. The harvest in this plot was done on 18-03- 2012, whose temperature was 06 C°, infested soil is wet the prospection was at a depth of 18 cm.The soil texture of this station is clay-loam. The farm on this station covers an area of 25 ha, 15 ha of which is utilized agricultural area (UAA), with the remaining 10 ha in need of development. It specializes exclusively in cereal growing. Cereal crops are grown on fallow land, with yields as follows: - durum wheat: 30 quintals per hectare, - soft wheat: 35 quintals per hectare.

II.5. The station: S.P Sahnoun Walid

This station is located near INATA (Ain Smara), whose soil is infested with white grubs. The larvae (grubs) were harvested on 25-03-2012, at a depth of 25 cm, in moist soil with a clay-loam texture (ONAMA).

II.6. F.P. station: Kadri Brahim

This station is called INATA. It is located in Ain-Smara, where the soil is infested with white grubs. The larvae (white grubs) were harvested on 22-03-2012, at a depth of 20 cm, in slightly damp soil with a clay-loam texture.

III. Materials and Methods

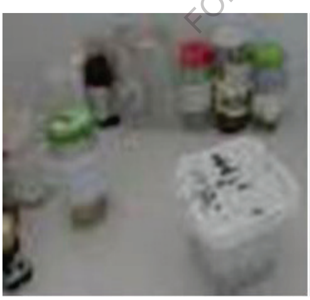
III.1 Materials used

III.1.1 Visit

The field work consists of the equipment used for sampling: a shovel for digging the soil; 9×9×7.5 cm plastic cube boxes (Fig.III.1),(Fig.III.2**)** for storing the larvae (grubs) during the survey, a marker to record the date and place of harvest on the boxes, a notebook to record all observations and information concerning the grubs in their environment, black bags with holes to collect the soil from each station for analysis. The larvae are placed in cubic boxes with soil and roots to recover them alive.

III.2 In the laboratory

The larvae, recovered alive, are placed in 70° alcohol for storage in vials, the purpose of which is to keep them white in order to obtain clear images (Fig.III.3).To identify the larvae, we used a binocular magnifying glass (Fig.III.4), to observe and count the anal escutcheon bristles, and a camera to take images of the anal escutcheons of each specimen. We used a high-precision balance (0.01g) (model: Scout pro SPU 202) (Fig.III.5), to weigh the larvae. Before weighing the larvae, they were blotted dry to obtain clear images (without light reflection).




We used millimeter paper to measure morphometric parameters.

Fig.III.1 Fig.III.2

Fig.III.3 Fig.III.4

Fig.III.5: Ohaus Scout pro SPU 202 scale

III.2. work methods

III.2.1 at

Grub harvesting begins with locating the spot where we're going to dig the soil, looking for signs of grubs in the subsoil (non-herbaceous spots). We dug the soil randomly over the spots, to a depth of 20-25 cm, using a shovel. profiles. After recovering the larvae, we made a light morphological observation to confirm that this was the type of worm we were looking for. In each study station, we placed the larvae in cubic plastic containers, or in black bags with holes, in both cases containing a large quantity of soil (for analysis) and roots (larval food until they returned to the laboratory, when they were placed in alcohol).Each bag or box is marked with: harvest date, station name, type of host plant, depth of survey, soil moisture....The present work is done in the months of March, April and June.larvae from the El-Harrach station with the help of ONAMA.

(Fig.III.6): Rhizotrogini larvae (from the Constantine region)

III.2.2. At laboratory

In the laboratory, the harvested larvae were identified: each larva was carefully examined with a binocular magnifying glass, based mainly on the shape and distribution of the setae, the shape and size of the setae, the color of the setae and, above all, the number of setae on the palidium (palidia) of the larvae at different stages (L_1 ,L_2 ,L_3), then preserved in 70% ethyl alcohol. The morpho-metric parameters of each specimen were taken: the length of the setae, the number of setae and the number of setae. length and width of head, mouthparts, thorax (Th), mandibles (Md), length of entire larva (L), length of last abdominal segment (Last) and weight (P).

Principal Component Analysis (PCA)

We will use the separative method for parameter analysis, i.e. to present the different morphometric parameter curves for each stage and station, then we will use PCA: Principal Component Analysis (PCA). PCA: is a method of data analysis, and more generally of multivariate statistics, which consists in transforming related variables (called "correlated" in statistics) into new variables that are decorrelated from one another. These new variables are called "principal components", or axes. It enables the practitioner to reduce information to a smaller number of components than the initial number of variables.PCA seeks to synthesize information in a table crossing individuals and quantitative variables (**Ali Kouani, S. et al. 2007**). We collected all the morpho-metric parameters (8 numerical random variables) describing 35 individuals, in a table. In other words, we're looking to define k new variables, a combination of 8 that would result in less information being lost, and we've drawn the diagram that will give us the new "possible information". These k variables will be called: principal components and the axes they determine called: principal axes on all the larvae collected from the different stations.To compare our results, we have :

✓ Collected the various raster images of species mentioned in the literature (see Appendix II);

✓ counted the number of bristles (Ns) on each anal patch shown on the images collected from literature;

✓ commented on the shape and size of the bristles on these anal shields,

✓ present these results in Appendix III.

Counting technique

The technique for counting bristles on raster images of species collected from the literature: we copied the image and pasted it onto a Word page, then enlarged it as much as possible so that the bristles appeared large and very clear to count.

Variance

The variance is always positive or zero. When the variance is zero, this means that the random variable corresponds to a constant (all realizations are identical). The variance is equal to the expectation of the square of X minus the square of the expectation of X, of which the

$$\mathrm{Var}(X) = \mathbb{E}\left[X^2\right] - \mathbb{E}[X]^2$$

In statistics and probability theory is the value of the standard deviation between the most commonly used measures dispersion statistics to measure statistical dispersion, ie it shows how areas along the values in the group of statistical Albeannat.

CHAPTER IV
RESULTS AND DISCUSSION

I. Inventory

I.1. Numbers of larvae in different stages larvae

The individuals shared in 7 study stations are shown in the following Table IV.1 :

Station	BM	S	Kh	H	A.S	Ba	K	W.A
Number of larvae	4	7	2	7	5	4	4	2

Ben-Madani (**BM**), Khroub (**Kh**); Sahnoun Walid (**S**) ; El-harrach (**H**) ; Ain Smara (**A.S**) ; Baaraouia (**Ba**); Kadri Brahim (**K**) and Wed-Atmania (**WA**). These symbols are used in the following.

I.2 Inventory of the various larval stages at the 7 stations studied

According to the results presented in Table IV.2, the larval stages are not always present in the harvesting site, but this does not indicate that the absent stage is always absent in the station (35 specimens are totally insufficient to deduce the existence of one stage or another).

Table IV.2

stadium station	BM	S	Kh	H	A.S	Ba	K	W.A
L1	1	0	0	4	1	4	4	0
L2	0	2	1	3	2	0	0	0
L3	3	5	1	0	2	0	0	2

I.2 Morphometric parameters

Morphometric parameters for each larva are presented in Table IV.3, in millimeters (mm) (L, Last, Mb) or without units (Rth, Rcl, RTe). The symbols in the following table are :

Lv: larva, **Stt**: station where larva was harvested, **Stage**: larval stage; **P**: weight of larva in grams; **L**: total length of larva; **R_{th}** : ratio between width and length of thorax; **RTe** : the **ratio** between the width and length of the head; **Last**: the length of the last abdominal segment; **R_{cl}** : the **ratio** between the width and length of the whole Clypeus + labrum; **Mb**: the length of the mandible; **N_s** : the number of bristles making up the palidium of the raster.

Table IV.3: Measurements (mm) and weights (g) of fresh samples of Rhizotrogini larvae

Lv	Stt	Stadium	P	L	Rth	RTe	Last	Rcl	Mb	Ns
1	BM	L3	2,38	40	0,6	0,66	10	0,75	4	102
2	BM	L3	2,12	45	0,54	0,50	9	1,00	4	85
3	BM	L3	2,18	40	0,46	0,50	7	0,75	5	84
4	BM	L1	0,36	21	0,66	0,50	5	1,00	2	75
5	S	L2	1,10	40	0,5	0,50	9	1,00	4	90
6	S	L3	2,20	30	0,62	0,50	8	0,75	4	132
7	S	L2	1,10	30	0,50	0,50	6	1,00	3	63
8	S	L3	1,86	40	0,50	0,50	9	1,00	4	126
9	S	L3	2,68	44	0,62	0,38	10	1,00	4	85
10	S	L3	2,54	45	0,62	0,50	10	1,00	4	107
11	S	L3	2,01	42	0,58	0,50	9	1,00	4	73
12	Kh	L3	1,67	41	0,54	0,50	7	1,00	5	58
13	Kh	L2	0,55	28	0,37	0,40	6	1,00	2	94
14	A.S	L2	1,16	30	0,55	0,50	6	0,66	3	93
15	A.S	L3	1,50	38	0,58	0,50	8	1,00	4	90
16	A.S	L2	0,74	31	0,55	0,50	6	1,00	3	75
17	A.S	L1	0,36	23	0,66	0,66	5	1,00	2	43
18	A.S	L3	1,85	40	0,42	0,66	9	1,00	4	73
19	H	L1	0,11	14	0,75	0,66	3	0,50	2	39
20	H	L1	0,42	23	0,71	0,60	5	1,00	2	45
21	H	L2	0,99	32	0,55	0,66	6	0,75	4	72
22	H	L1	0,16	16	0,50	0,66	4	1,00	2	38
23	H	L2	1,05	34	0,60	0,50	6	1,00	3	71
24	H	L1	0,12	17	0,60	0,66	5	0,50	2	55
25	H	L2	1,16	33	0,55	0,43	8	1,00	4	73
26	Ba	L1	0,53	23	0,57	0,50	5	1,00	2	59
27	Ba	L1	0,33	19	0,50	0,50	5	1,00	2	64
28	Ba	L1	0,49	22	0,50	1,00	4	1,00	2	57
29	Ba	L1	0,46	22	0,57	0,50	6	1,00	2	56
30	K	L1	0,10	19	0,50	0,50	5	1,00	2	74
31	K	L1	0,49	14	0,75	0,66	4	1,00	1	92
32	K	L1	0,53	23	0,55	0,60	5	0,75	2	49
33	K	L1	0,30	17	0,57	0,66	4	0,66	1	28
34	W.A	L3	1,22	44	0,58	0,66	6	1,00	4	85
35	W.A	L3	1,26	33	0,42	0,71	6	1,00	4	83

I.3. Maximum, mean and minimum values for each parameter morphometric

The maximum, mean and minimum value of each **morphometric** parameter is very important for distinguishing between larval stages and for determining the range of variation of each stage. They are calculated and shown in Table IV.4. The minimum value of each parameter is quite small compared with the maximum value, while the latter is very important.in front of the average value, this indicates that the larva consumes a quantity of roots over a long period of time to reach mature size.

Table IV.4: Maximum, average and minimum values of Rhizotrogini morphometric parameters of harvested larvae

	P	L	Rth	RTe	Last	Rcl	Mb	Ns
Min	0,1	14	0,37	0,38	3	0,5	1	28
Avg	1.10	30.10	0,56	0.56	6.46	0.93	3.03	74
Max	2,68	45	0,75	1	10	1	5	132
V(x)	0.62	100.20	7.16	0.01	3.90	0.02	1.26	554.11
Standard deviation	0,79	10,01	0,09	0,12	1,98	0,15	1,12	23,53

There was a strong correlation between the maximum, average and minimum values for: mandibles, thorax, whole (clypeus **+labrum**) and head. This gives us an idea of the L_2 stage larva, which has intermediate values between L_1 and L_3, , and thus allows us to deduce that the L_1 larva, in order to reach the L_3 stage, consumes a significant quantity of roots, so the larva is at its most active in the L_2 stage, during which it begins to increase in size, and this development continues in the L_3 stage to prepare for pupation.

II. The relationship between morphometric parameters

• The order of the parameters and stations in Table IV.3 and the tables in Appendix V is closely followed in the following figures, and is very useful for understanding the figures and findings.

• Morphometric parameter symbols are well defined in **I.2**.

• The numbers on the X axis represent the order of the larvae in Tables 1, 2 and 3 of Appendix V, corresponding to each larval stage. For example, larva 3 (L_1) on the X axis is larva 19 (L_1) in Table 1 of Appendix V,) larva 3 (L_2) on the X axis is larva 14 (L_2) in table 2 appendix V, larva 3 (L_3) on the X axis is larva 3 (L_3) in table 3 appendix V.

The correlation between Last and Mb is relatively strong for most larvae at different stations, but weak for others, so the correlation between L and Last is not always achieved whatever the larval stage. The correlation between L and Mb is valid in L_1 , L_2 and L_3, but is not achieved for very few larvae whose mandible length Mb is almost constant in L_3 , a little variable in L_2 and very little variable in L_1 , on the other hand the length L is very variable in L_1 , L_2 and L_3 (**Fig.IV.1**),(Fig.**IV.2**),(**Fig.IV.3**).The correlation between the two parameters $\mathbf{R_{cl}}$ and **Last** in the L_1 , L_2 and L_3 stages is always achieved for some larvae at the different stations, but not for others (**Fig.IV.4**), (**Fig.IV.5**) and (**Fig.IV.6**).The correlation between **Last** and **L** is strong in L_1 and L_3 , but relatively weak in L_2 .

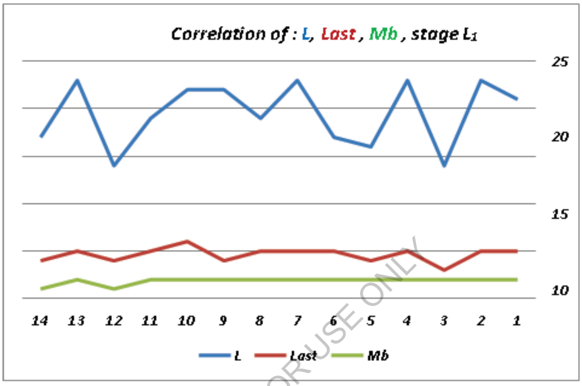


Fig.IV.1

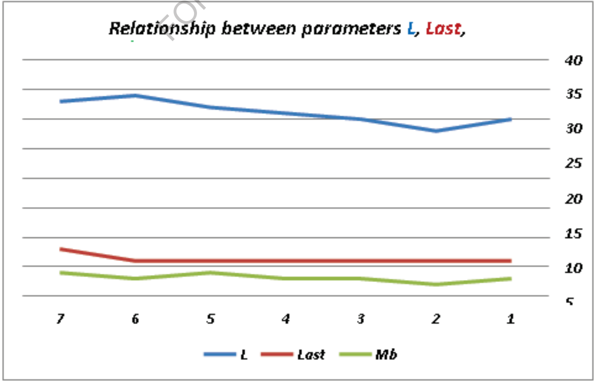


Fig.IV.2

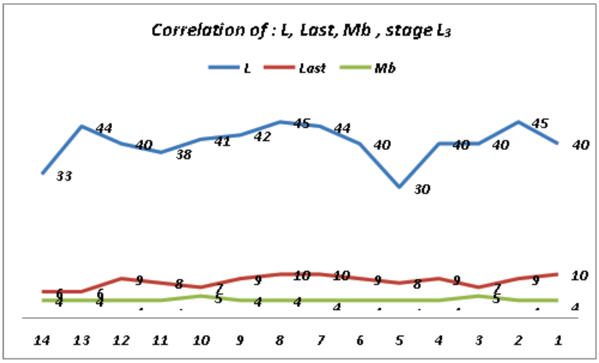


Fig.IV.3

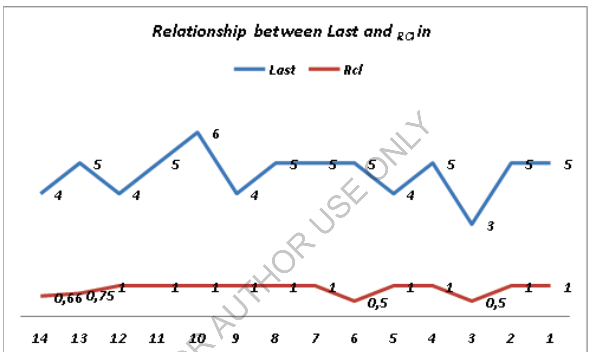


Fig.IV.4

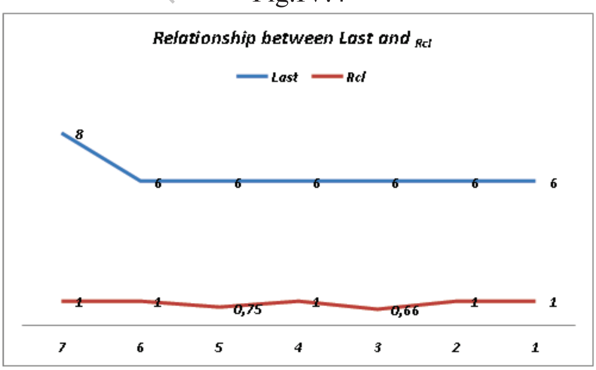


Fig.IV.5

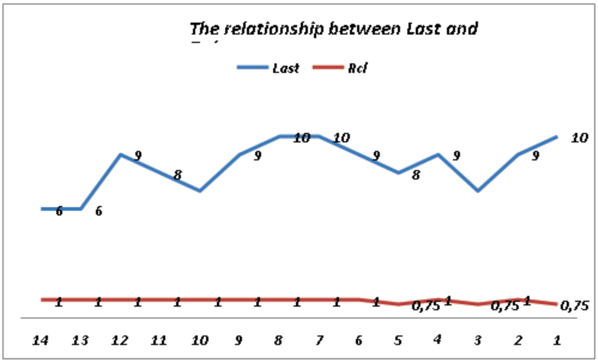


Fig.IV.6

Random variation in R_{th} ,R_{te} , R_{cl} , and no correlation between these morphometric parameters at **different** stations in the **L_1 , L_2** and **L_3** larval stages. Intersections of the Rth and R_{Te} curves, e.g. larva 8 on the L_1 stage X axis (Fig.IV.7), i.e. larva 27 in table 1 appendix V stage L_1 , this larva has the same ratio between width and length of thorax and head. The same applies to larva 11 on the X axis, which is larva 30 in table 1 appendix V stage L_1 , these two larvae are from the same Kadri station (K), so they may be the same species, and the same applies to other larvae (**Fig.IV.7**), (**Fig.IV.8**) and (**Fig.IV.9**).

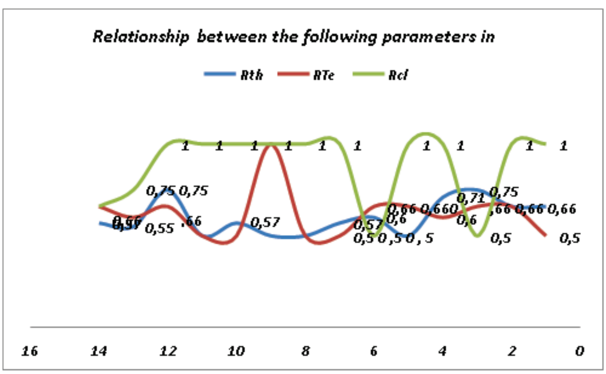


Fig.IV.7

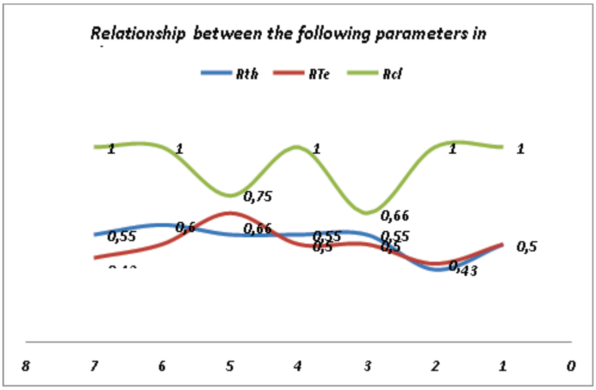


Fig.IV.8

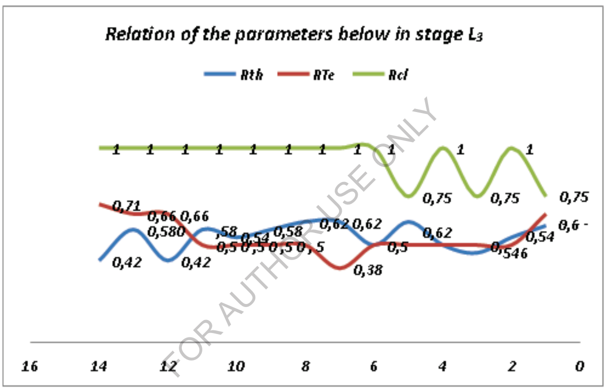


Fig.IV.9

Several larvae coincide in R parameter$_{th}$ for example larva 6 (L_1) and larva 6 (L_2) on the X axis (24 in table 1 (L_1) and 23 in table 2 (L_2) appendix V) (same study station El-harrach) have the same R_{th}, this can inform us that these larvae can be of the same species and as can be of different species, Idem for other larvae **Fig.IV.10**).

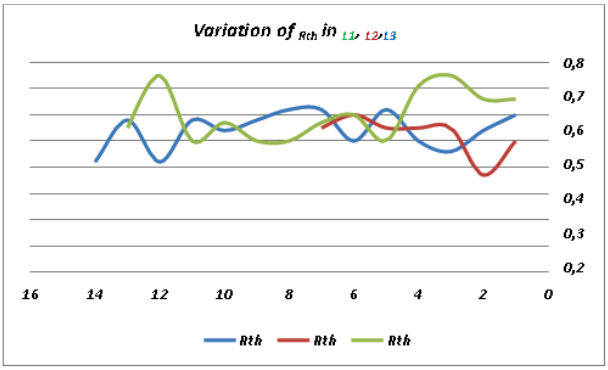


Fig.IV.10

Larvae 1(L_1 , L_3), 3 (L_2 , L_3) ,4 (L_2 , L_3), 6 (L_2 , L_3),8 (L_1 , L_3), 11(L_1 ,L_3) on the X axis that are **respectively** the larvae: (4,1)(table 1 and 3), (14,3)(table 2 and 3), (16, 5) (table 2 and 3), (23,8) (table 2 and 3), (27,10) (table 1 and 3), (30,15)(table 1 and 3) (appendix V). coincide in R_{Te} (**Fig.IV.11**). The same finding of several larvae that are coincident in R_{th} , R_{Te} and R_{cl} (**Fig.IV.10**), (**Fig.IV.11**) and (**Fig.IV.12**).

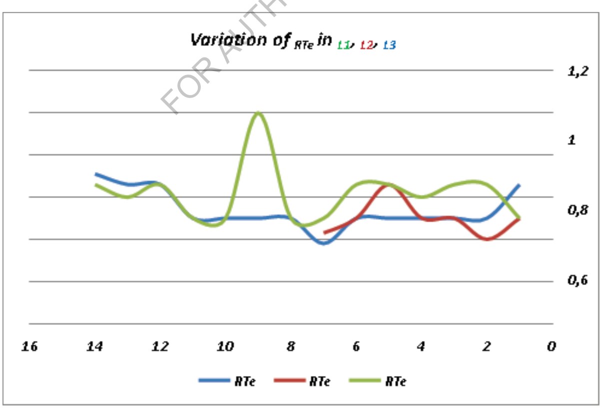


Fig.IV.11

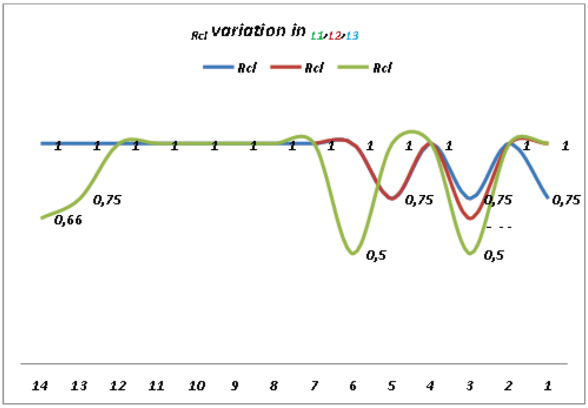


Fig.IV.12

Larval length is a random variable at L_1 , L_2 , L_3 and at the different study stations (**Fig.IV.13**).

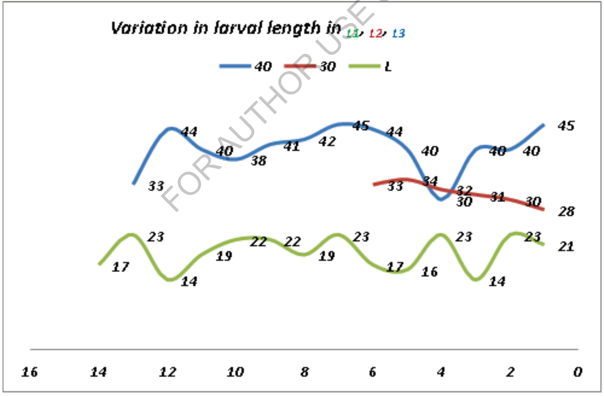


Fig.IV.13

Generally, mandibular length (Mb) is constant at L_1 (2 mm) and L_3 (4 mm), but may deviate slightly from these values. At the L_2 stage, Mb varies between 2 and 3 mm (**Fig.IV.14**).

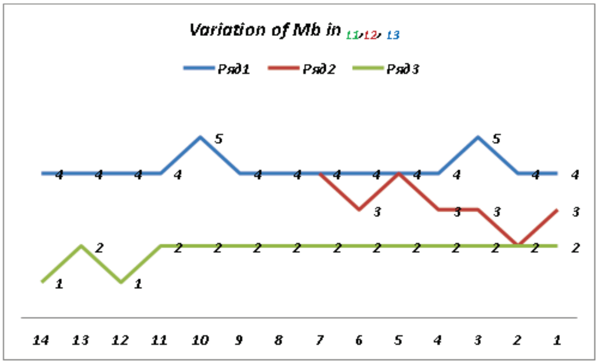


Fig.IV.14

In each larval stage and in each study station, the weight of the larva is a random variable. **Fig. IV.15** shows this variation. The colors green, red and blue correspond to the L_3 , L_2 and L_1 stages respectively. The larvae of each stage are those shown in the order of table 1, table 2 and table 3 in appendix V. This may depend on the type of soil or even the type of wheat (roots) (**Fig.IV.15**).

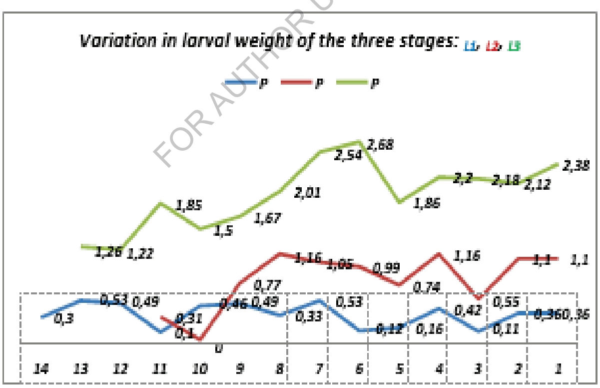


Fig.IV.15

The weak correlation between the number of setae (Ns) and the length of the larva in the $\mathbf{L_1}$ stage at the different stations (Table 1, Appendix V) allows us to deduce that the number of setae is the mark of the larva as early as the $\mathbf{L_1}$ stage. Thus the correlation appears weak in the $\mathbf{L_2}$ and $\mathbf{L_3}$ stages, which confirms the specificity of the number of setae in the $\mathbf{L_1}$ stage (**Fig.IV.16, 17, 18**).

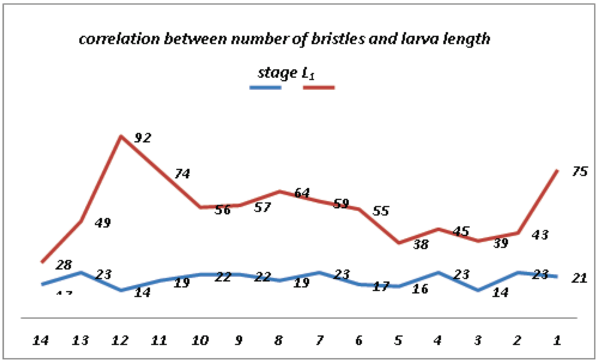


Fig.IV.16

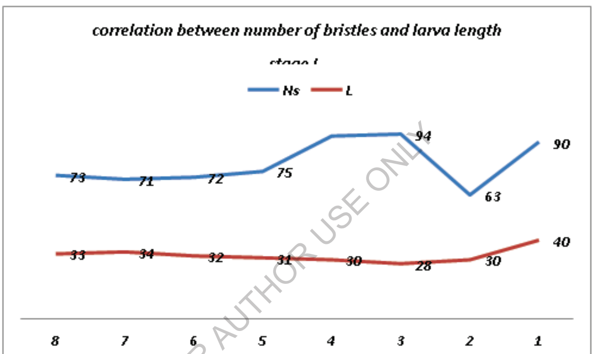


Fig.IV.17

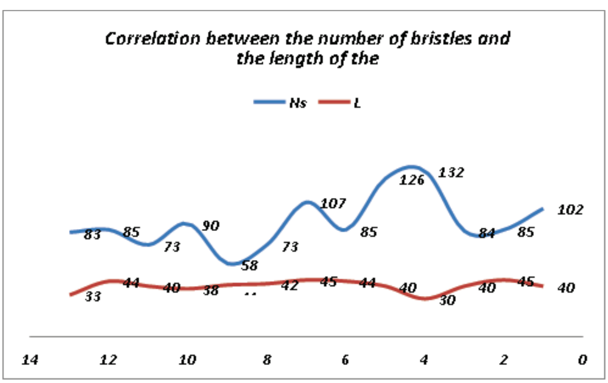


Fig.IV.18

II.2 Variation in the number of bristles

The number of bristles on all larvae collected from different stations varies randomly. in the same larval stage, this can be due to 2 possibilities:
1- The existence of several species in these stations

2- Variation in the number of silks of the same stage on the same station
According to the data, the attractive thing about different stations and different larval stages is that the number of bristles varies individually, because it is specific to each species. species from hatching. There is no variation for a given species, but it does vary within the same stage, at the same station, between different species (values in Tables 1, 2 and 3 in Appendix V). For example, larva N°12 (L_1) from the Kadri station has 92 tan setae, while larva N°14 (L_1) from the same station has 28 setae **(Fig.IV.19)**, **(Fig.IV.20)**.

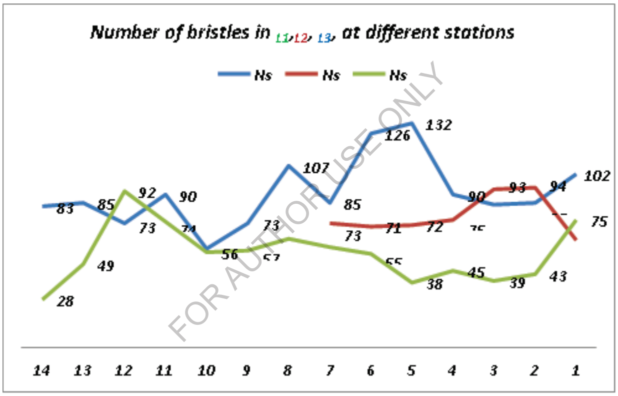


Fig.IV.19

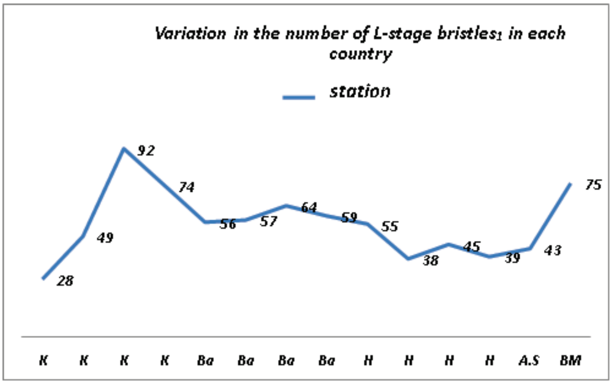


Fig.IV.20

Fig.IV.21, **Fig.IV.22** show the variation in the number of setae at different stations, at the same station and in the same larval stage. The first three values are from the same larval stage and are very close to each other; they may be from three different species, or from the same species (Fig. IV.13).

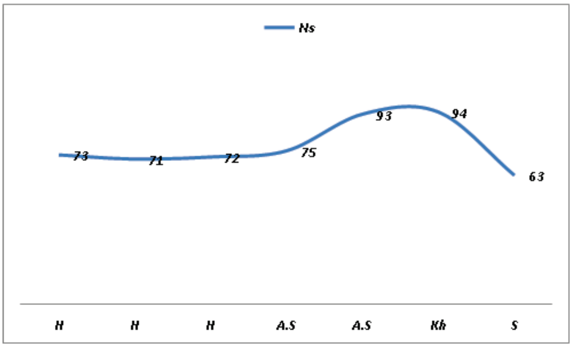


Fig. IV.21 (L $stage_2$) at each station

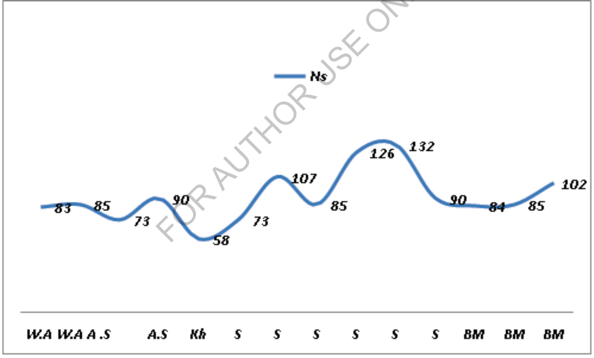


Fig. IV.22 (L $stage_3$) at each station

The number of setae does not depend on the larval stage, i.e. it does not depend on larval maturation (see Table IV.3). For example, larvae N° 25 (L_2) and N°18 (L_3) have the same number of setae = 73, but are different in larval stage and harvested from different stations (Appendix V), while larva N° 31 from station Kadri (K) (L_1) has 92 setae.The number of setae is independent of developmental stage or station, and is species-specific from the first larval stage, as illustrated in the tables in Appendix V.

III. Comparison of the number of Rhizotrogini bristles with different species

The number of bristles (Ns) of Rhizotrogini is a random variable belonging to [28-132], and this range is included in that of the number of bristles of the species listed in Appendix II, Table 1, which is [10-144]. We can deduce that the Rhizotrogini group has a wide range of bristle numbers, indicating the existence of several species, which can be determined with morphometric parameters and confirmed by adding the number of bristles and the shape of the palidium.

IV. Component analysis

The PCA results are shown in **Fig. IV.23**. It can be seen from this figure that:

✓ The set of 35 larvae is grouped into three subgroups (subsets), these subsets are correlated into five morphometric parameters which are : L, Last, Mb, P, Ns among the eight previously mentioned in **(I.2)**;
✓ This correlation is very strong between Mb, Last and Ns. It is relatively strong between P and

Ns, a little weak between weight and length L;

✓ no correlation between parameters R_{th} and R_{ca} and R_{Te} ;

✓ The sub-set (in blue) includes the L larval stage$_3$;

✓ The centered subset (in yellow) contains lava from the three larval stages L_1 , L_2 , L_3 ;

✓ The sub-group on the left (in red) is made up of larvae from the L stage$_1$;

✓ The ranges of variation of the main parameters are shown in the table below. IV.5 next :

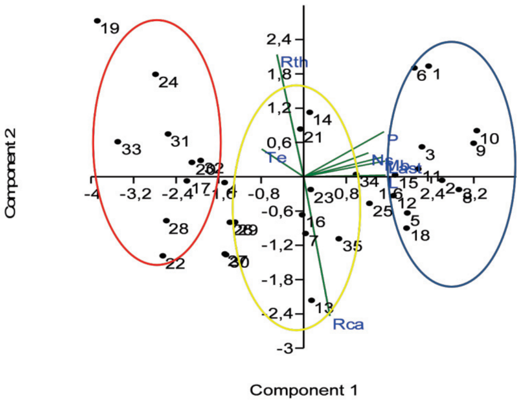


Fig.IV.23: Projection of variables (morphometric parameters) on the Component plane (1 x 2).

Table IV.5

Parameter	P	L	Mb	Last	Ns
S-G1 (left)	[0.10 -1.26]	[14 - 44]	[1, 2, 3,4]	[3, 6]	[38 - 94]
S-G2 (center)	[0.11- 0.53]	[14-23]	[1, 2]	[3, 4,5,6]	[28 - 92]
S-G3 (right)	[1.10 - 2.68]	[30 - 45]	[4, 5]	[7, 8, 9, 10]	[58 -132]

S-G: sub-group (sub-set)

The superimposed points (20 and 32), (26 and 29), (27 and 30) are identical, they are common in more than 05 parameters, they are highly correlated, they belong to the same subset. These larvae are in the same larval stage L_1 , they can be of the same species by a probability (see Table **IV.3**), (**Fig.IV.23**).

V.Analysis

V.1 Presentation of the different anal ecusson images of each larva harvested and raster analysis

VI.2.1. Description of the group raster

For all the larvae rasters collected, these points are common:

✓ The size of the palidium varies slightly in the same larval stage, and varies completely in the same larval stage.

between the L_1 and L_3 stages;

✓ During raster analysis, we found palidiums made up of a mixture of palis varying between medium, short and very short, in others there are only medium pali (spines);
✓ the septula is generally wide and naked, and varies from one individual to another, even in the same station and location.
✓ The Palidium (Palidia) consists of two or three slightly concave longitudinal rows of spines. The spines (setae) incline towards the septula and forwards, converging at the anterior end and diverging at the posterior end;
✓ the tegillum is made up of medium-sized, very long, dense spines, the tips of which are very rich in very long, dense bristles;
✓ The transverse anal cleft is slightly arched, close to the trapezoid shape, and the anterior and posterior ends of the anal lip are edged with medium-sized, long, fine bristles.
✓ In the L_1 larval stage, the palidium is slightly bent at the anterior end;

✓ The color of the setae is Caramel, and the number of setae on the left side is very close to or equal to the number of setae on the right side. If the larva is immature (L_1 or L_2 stage), the shape is the same as that of the mature larva, and the number of setae is the same or slightly different;
✓ Some of the spines on the palidium of certain specimens are very strong, with a black base and circular cross-section.
✓ These larvae are mature; they are in the **L** stage$_3$;

In the following images, each raster is different from the other. To give names to the raster, we've adopted the shape of the septula and/or the shape of the palidia and the symmetry.

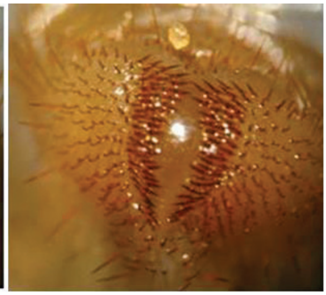



Fig.IV.1

Fig.IV.2

Fig.IV.1 : Each palidia is made up of three rows of spines, and undergoes a degradation in the number of rows, from the posterior end, there are three rows, then two rows and ends with a single row at the anterior end. The distribution of the "pali" gives the septula a shape resembling an "**elongated long-necked vase**".

Fig.IV.2: the distribution of the "pali" gives the palidium a shape resembling a pair of "pali".The "**angel wings**" converge at the anterior end and diverge at the posterior end.The septula is elongated, as in **Fig.IV.3** and **Fig.IV.5.**

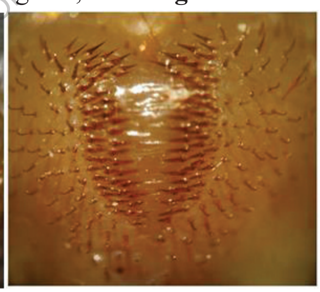



Fig.IV.3

Fig.IV.4

Fig.IV.4: a specific distribution of palidium setae at the posterior end, this end is in the form of a triangle so that the septula forms a trapezium at the posterior end, the total area of the septula forming a sort of "**trapezoid-headed nail**".

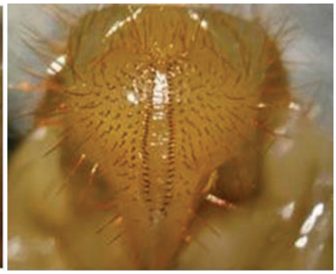
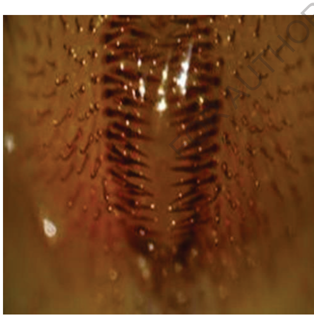


Fig.IV.5

Fig.IV.6

Fig.IV.6: the palidium is in the form of two parallel lines, slightly divergent at the center, or a "**very elongated avoide**" shape. This is a specific shape characterizing a certain species, found at the Sahnoun Walid station. The tegillum is very rich in very long bristles.



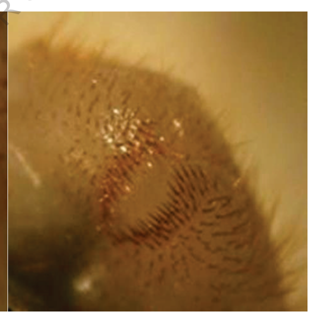
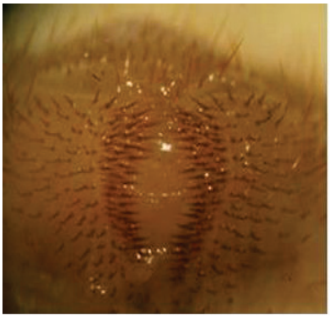


Fig.IV.7

Fig.IV.8

Fig.IV.7: Raster with "**avoide alongé**" septula and "**angel wing**" palidia. Setae cover most of the septula.

Fig.IV.8: Wide septula with "**avoide"** shape, "**angel wing**" palidia



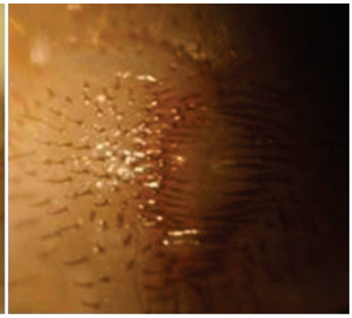


Fig.IV.9

Fig.IV.10

Fig.IV.9 raster with septula in the form of an **avoid vase** with thickened neck **and angel-wing** palidia whose total raster shape is "**wide avoide**

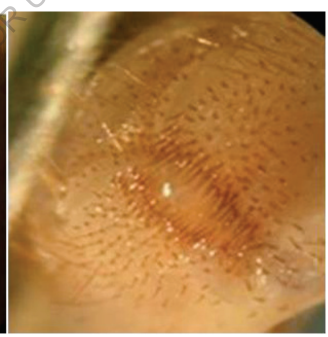
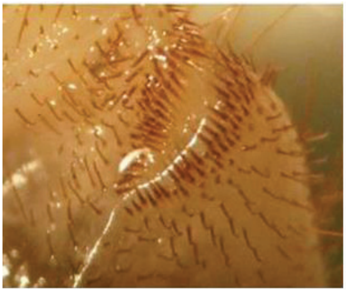


Fig.IV.11

Fig.IV.**12**

Fig.IV.11, Fig.IV.12, Fig.IV.13, Fig.IV.14: the sepula avoide raster, with 2 or 3 rows of palidia whose total shape is an "**avoide vase**".



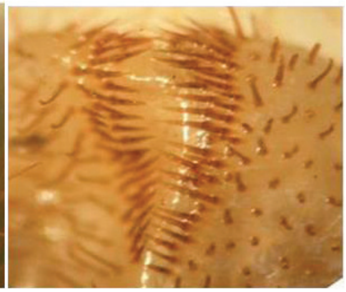


Fig.IV.13

Fig.IV.14

Fig.IV.14: the same shape as the general form, but this time the palidium is longer than others.

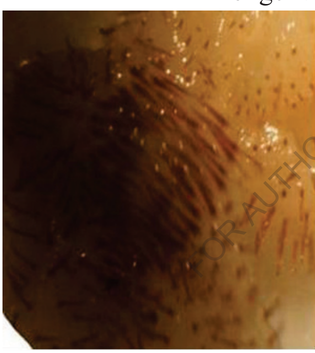
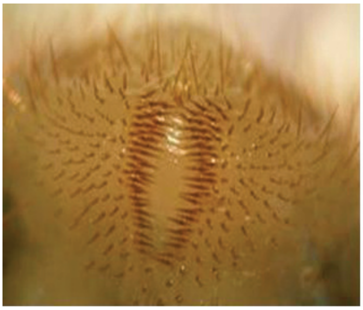


Fig.IV.15

Fig.IV.16

Fig.IV.15 : The spines are very inclined towards the septula, they cover the latter, they give an **avoide** form to the palidia: "**avoide form**".

Fig.IV.16 : The septula is "**avoide"** shaped, surrounded by intense palidia, ending in two well-bonded spines at the anterior end. The general shape of the palidium is symmetrical. septula shaped like an **"avoide vase".**



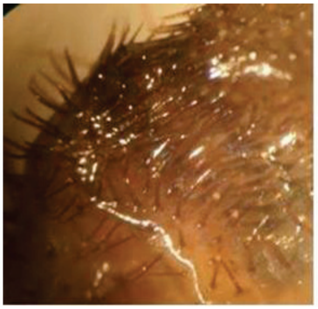


Fig.IV.17

Fig.IV.18

Fig.IV.17 : the septula is symmetrical, oval and elongated, the palidia resembles that of fig.IV.9 larva stage **L_3** , collected from Wed -Atmania station, the spines are very hard, medium length, number of spines 85, palidium symmetrical.

Fig IV.18 and **Fig.IV.19**: **L** stage**$_1$** collected from the Kadri Brahim station, a single row of spines on each side. This characteristic is not specific to the larva in the L stage$_1$, it will be the same in the L stage$_3$, with slightly more solid spines. The number of bristles counted (**Fig IV.18**) is very precise and is 14 on each side, of which all are 28.

Fig.IV.19 : The number of setae counted is very precise and is 29 on each side, including all 58, without forgetting the continuation of the ecusson on the dorsal part, which has 8+ 8 spines, the total number of setae being 74. The (septula+ palidium) resembles a "**leaf**".

Fig.IV.20: looks like "**2 long parallel lines**" or "**zipper**".
Fig.IV.22: looks like a "**wide parenthesis**" converging at the anterior end.
Fig.IV.23: Raster with wide septula, single-row palidia, short spines. The (septula+ palidium) resembles a "**leaf".**

Fig.IV.24: Raster with wide septula, palidia with a single row of pali. Total shape resembles to a "**narrow parenthesis**" or "**oval shape**".

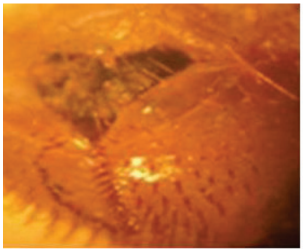
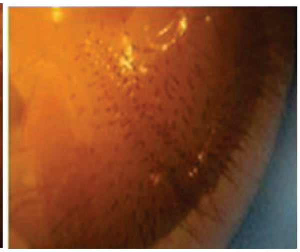



Fig.IV.19

Fig.IV.20

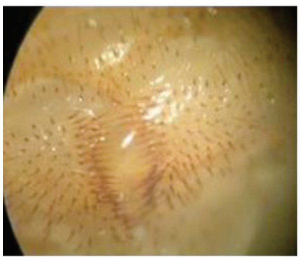



Fig.IV.21
Fig. IV.22

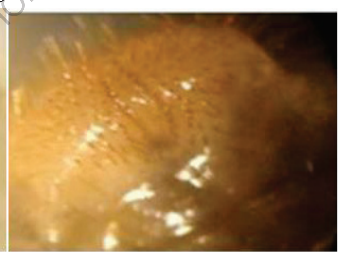



Fig.IV.23

Fig.IV.24

VI.2.2 Comparison of results (raster) with literature

According to our results, the raster of Fig.IV.2, Fig.IV.3, Fig.IV.1, Fig.I.1 , Fig.IV.., FigIV78 Fig.I 7, Fig.IV.99 resenblent to : Antitrogus parvulus Britton, Lepidiota negatoria lackburn 1912, Lepidiota noxia Britton, Lepidiota frenchi Blackburn 1912, Lepidiota consobrina Girault, Hoplochelus betanimena (Künckel, 1887), sp. M3

GENERAL CONCLUSION

From all the data consulted, it seems that :

✓ larval stages are not always present at the survey site; this does not mean that they do not exist at the harvesting station;
✓ The correlation is high for some parameters and relatively low for others, across the different stations and larval stages;
✓ The larval stage can be deduced from morphometric parameters;

✓ The number of bristles on all larvae collected from different stations varies randomly within the same larval stage;
✓ The number of bristles on different larvae from different stations and stages varies individually, and is specific to each species;

✓ The number of bristles does not depend on the larval stage, i.e. does not depend on maturation. of the larva;

✓ The number of Rhizotrogini setae Ns is a random variable belonging to the interval [28-132], it is included in the interval [10 -144] number of setae of the species mentioned in appendix III;
✓ The Rhizotrogini group has a wide range in the number of bristles.

allows us to deduce that it comprises several species;

✓ The Rhizotrogini raster has septula, palidia, tegillum and uniform setae.

✓ The Rhizotrogini palidium has different "setae" distributions

✓ The Rhizotrogini "raster" is a specific pattern that, in most of our harvest, resembles a **"pair of angel wings" with medium-sized spines.** If it is specific to a species, it exists as early as the L stage$_1$;
✓ The presence of a "**wide parenthesis**", a "**narrow parenthesis**" and a **"leaf"**, **nails**

with **trapezoid head**, **zipper, oval shape, wide avoide**;

✓ The number of bristles in L_1 will be the same in L_3 ,

✓ The color of the bristles varies very slightly from the L_1 to L_3 stage; it is Caramel (L_1 , L_2) and very dark for the mature larva (L_3) ;
✓ The number of bristles does not vary between the L_1 , L_2 and L_3 stages of a given species;

✓ The number of setae varies from one species to another within the same larval stage;

✓ the raster (palidium) can have: very long, long, medium, short spines or

They can be thick or thin;

✓ the shape of the septula varies in the same stage, in the same station;

✓ In some harvested and mature larvae, only medium-length bristles are present;

✓ The bristles forming the palidium are always inclined towards the axis of pseudo-symmetry (oy);

✓ The bristles forming the palidium are different from the surrounding bristles;

✓ The bristles forming the palidium are sharp and straight;

✓ Nature has endowed each beetle species with a type of escutcheon adapted to its way of life. The general shape of the anal escutcheon of the "Rhizotrogini" beetle larva in Constantine (the shape of a "pair of wings") is the most common in the harvest;

✓ the 24 raster images are different for Palidium, septula and tegidium.

✓ The orientation of the raster's bristles is very important, distinguishing between the bristles of the palidium and those of the tegillum, so the size of the bristles (setae) varies between those of the palidium, and those of the tegillum and the tip of the raster itself, which are always very few and very long.

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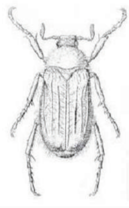
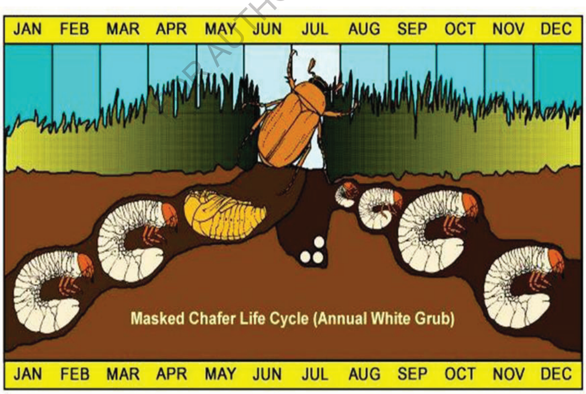
APPENDIXES

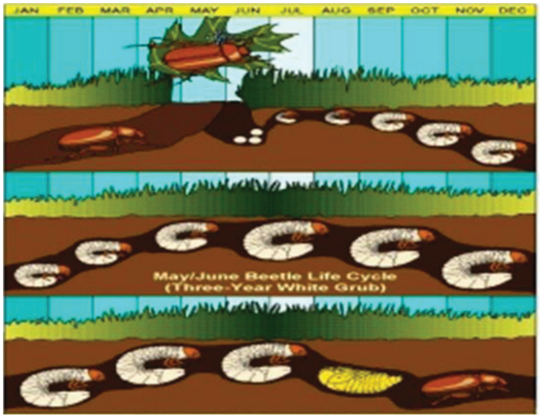
Appendix I
Table: Recognition of adult species (Anonymous, 2010b)

Nom en français *Nom en latin* Nom en allemand	**Hanneton commun** *Melolontha melolontha* Feld-Maikäfer	**Hanneton de la St. Jean** *Amphimallon solstitialis* Junikäfer / Brachkäfer	**Hanneton horticole** *Phyllopertha horticola* Gartenlaubkäfer
Dessin de l'insecte adulte			
Longueur adulte	**25 - 30 mm**	**15 - 19 mm**	**8 - 10 mm**
Longueur larves - été, 1ère année - automne, 2ème année - printemps, 3ème an.	 10 - 20 mm 30 - 35 mm 40 - 50 mm	 10 - 30 mm - - - - - - - - - -	 10 - 20 mm - - - - - - - - - -
Cycle de développement	**3 ans**	**2 ans**	**1 an**
Vol	mi avril à début mai vol du soir	juin à août vol du soir	début mai à début juin vol de jour

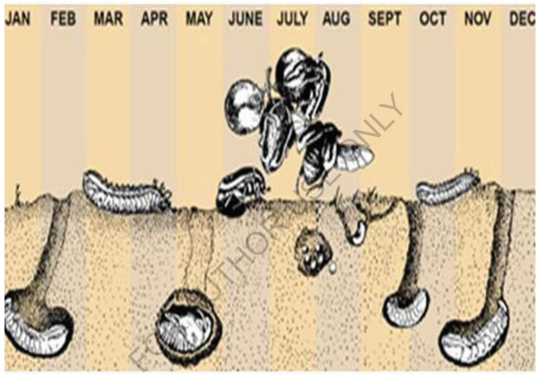
Life cycle of various cockchafer species :



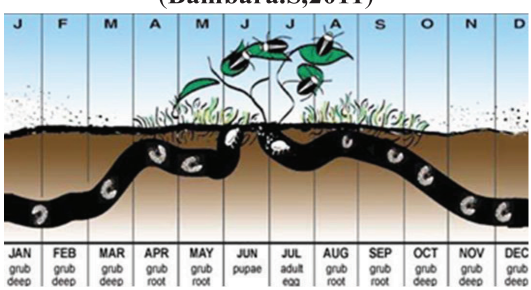
Life cycle of the masked chafer (one year) (**Anonymous,2009a**)



Beetle life cycle: **May - June** beetle (03 years) (**Anonymous, 2011a**)



Life cycle of the **Green-June beetle** (**Patricia. P C et al, 2000**) (**Bambara.S,2011**)



Life cycle of the Japanese beetle (**Anonymous,2011b**)

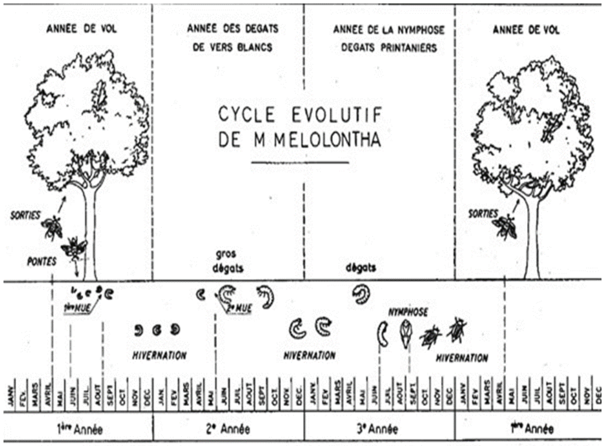
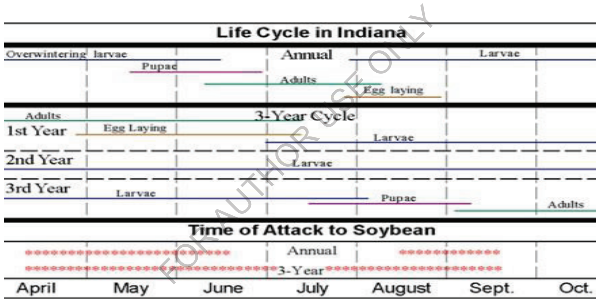


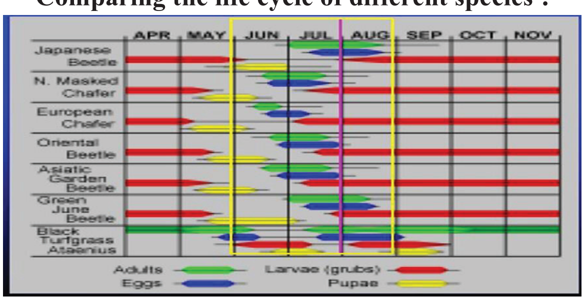
FIG. 46. — Schéma du cycle évolutif triennal de *Melolontha melolontha* L.

European chafer life cycles (triennial) (Anonymous, 2010b)



Life cycle of the **Indian** chafer (03 years) (**Anonymous, 2009b**)

Comparing the life cycle of different species :



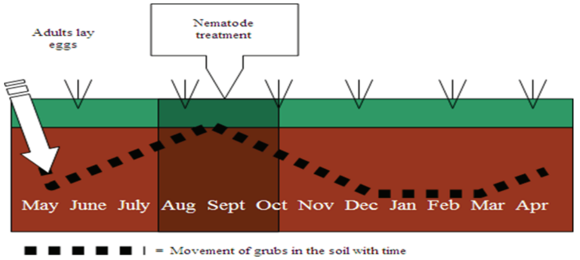


Figure of the movement of larvae in the soil during the year when nematodes are best placed (**Anonymous,2012c**).