



Limestone quarry moths

Quarry of Huellerie in Saint-Germain-d'Arcé (72)

Marek Banasiak and Raphaël Bourigault

September 2018

1. Contestant profile

▪ Contestant name :	BANASIAK Marek
▪ Contestant occupation:	Volunteer
▪ University / Organisation	/
▪ Number of people in your team:	2

2. Project overview

Title:	Moths of a limestone quarry
Contest: (Research/Community)	Research
Quarry name:	Quarry of Huellerie in Saint-Germain-d'Arcé (France)

Abstract

At a time when **participatory science** is on the rise, we have tried to extend an already long tradition of **amateur work** for a group of insects, the study of which is sometimes difficult. When we learned about Ciments Calcia's call for projects, we immediately thought that an **inventory of moths (Heterocera)** would be very appropriate. Whereas the study of a majority of groups is concentrated over a short period, that of a moth population is spread over a whole year. In fact, the flight period of **incredibly diverse** species is staggered, the only interruptions being at nights when the temperature falls below 0 °C.

The idea was therefore quite obvious **to inventory as exhaustively as possible the macro-Heterocera over the entire period allowed by the study**. As other groups have been studied on this site, the known exceptional biodiversity made us want to take advantage of this wonderful opportunity **to enrich in a definite way all the knowledge of the moths of the Sarthe** and thereby **contribute to their protection**.

This participatory inventory mobilized 4 people from the collective "Papillons72" but also moved about fifteen naturalists. Thus, more than 300 species of moths frequent the site including 6 of them new for the department of Sarthe and many heritage species.



Barred Umber (Plagodis pulveraria), covered with dew, among the first species inventoried on a fresh April night.

Acknowledgements

To our respective companions who undergo our strange nocturnal activities!

We would like to thank the numerous amateur and even professional early risers who have contributed from time to time, voluntarily but professionally, to the success of this study: **Cornelius Van Den Ham**, who did not hesitate to cross the regional administrative area as soon as possible to place his light traps on the site and extend the list of inventoried species. **Marc Nicolle**, who brought his immense knowledge from Maine-et-Loire, lent his expert regard to the difficult to identify species and surveyed the site in search of the nocturnal moths flying by day. We also owe some great discoveries to his meticulous examination of genitalia. **Frédéric Vaidie**, indispensable friend and valuable naturalist whose light trap has also harvested beautiful finds on several occasions.

We extend our sympathy to **Elodie Russier-Decoster** of the IUCN (International Union for the Conservation of Nature) for monitoring the project and providing her valuable re-reading of the document.

Finally, this project would not have taken place without the information of the competition sent by the **CPIE72**, we thank them warmly for their confidence throughout the implementation of the project.

Introduction

The limestone quarry of Saint-Germain-d'Arcé was already known by naturalists, but only by botanists. Fournier (2003) indicated that, in the "Zone naturelle d'intérêt écologique, faunistique et floristique" (ZNIEFF) (Natural area of ecological interest, fauna and flora) "Coteau du Moulin de Coulongé" of 21 hectares included in the perimeter of the quarry, entomological inventories would be carried out. Since then, some botanical surveys have been carried out mainly by the "Conservatoire botanique national du Bassin parisien" (National botanical conservatory of the Paris basin) revealing rare and endangered plants on a regional scale (Hunault and Moret, 2009).

It was during the inventories of a consulting firm (MICA Environmental) as part of the extension project of the quarry that the first entomological surveys were performed. These inventories concern groups where protected species are found. Thus, the consulting firms focus on the Rhopalocera (moths), Odonata (dragonflies) and Orthoptera (locusts, crickets and grasshoppers). The authors took note of this inventory at the "Conseil scientifique régional du patrimoine naturel" (CSRPN) (Regional scientific council on natural heritage), which included countervailing measures in a file requesting exemption from destruction for protected species.

Via the Ciments Calcia call for projects, we wanted to go further by proposing an inventory on the macro-Heterocera (moths) and occasionally associate other naturalists to inventory this quarry in more detail.

The erosion of biodiversity requires no further proof and the conservation of nature must be a national cause. There are countless studies showing this decline. We salute the initiative of Gaudet and Devictor (2018) summarising nearly 13,000 publications on the subject of conservation biology. Politicians must therefore take a stand on the subject. We welcome the launch last July of the biodiversity plan, but economic players must also integrate biodiversity into the heart of their system.

We clarify that this project was conceived and realised entirely by volunteer time. In fact, Heterocera are rarely taken into account by environmental professionals, who prefer to use as a standard other groups whose study is more obvious (see section Materials and methods).

The study of Heterocera is the most often and for a long time now carried out by passionate amateurs. It is of little concern to professional naturalistic studies, which usually focus more on the

"unifying" groups (ornithology, chiropterology etc.) Marek Banasiak is a botanist, entomologist and mammalogist, and usually works for these groups in a professional capacity. Raphael Bourigault is a farm worker and generalist naturalist, passionate about Lepidoptera. We both saw, in this call for projects, the rare opportunity to make a strong contribution to the knowledge and hopefully the protection of the moths of the Sarthe.

Materials and methods

Most Heterocera are attracted by light, which disorients them. This means they can be actively or passively observed; both methods using ultraviolet light whose spectrum is more efficient. For active observation, the observer stands in front of a white lit-up sheet and takes note of the species that land upon it. Each one flies at a quite specific time of night. Many come out late at night and the arrivals are spread out until daybreak. A method that is very time-consuming... We prefer passive observation:

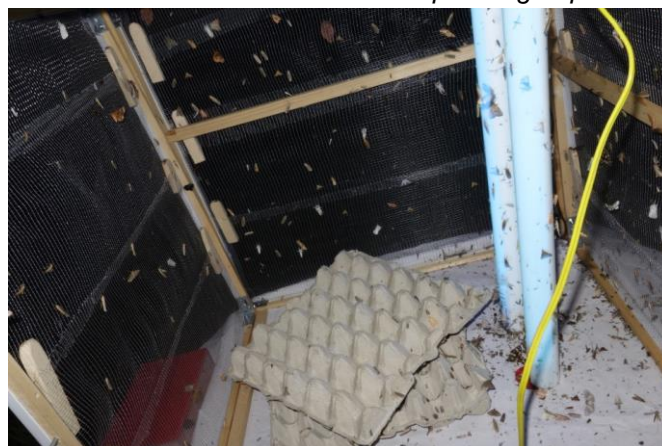
This involves an autonomous net-based moth trap. A cubic hoop net whose sides are covered and with fine netting to hold in the smallest species of moth. A light source is placed inside it. The moths enter through thin slots but struggle to get through the net from the opposite direction. This device is set up before nightfall and left in position. Last detail to ensure an abundant "harvest"; egg boxes are placed at the bottom of the trap, where the moths take refuge, motionless away from the disturbing light. This mainly limits the frenzied flight of individuals inside the trap, which erases the tenuous patterns that identify them. Without this, a larger portion of the harvest would not be able to be determined.



Willow Beauty (Peribatodes rhomboidaria)

On the left: "rubbed" individual who has lost the microscopic scales forming the species-specific patterns, up to the bare exposure of the chitin of the thorax. A few more wing beats and the individual was impossible to identify ...

Right: fresher individual. The delicate identification of this species group is facilitated.



View of the interior of a trap before sunrise. We can see the multitude of moths attracted during the night.

The next day, one hour before dawn, we perform the inventory. Once the trap is open, we have to work quickly and methodically. The species fleeing the light of day must not escape us and predators (insectivorous birds) can take advantage of this captive manna very quickly. The vegetation around the trap is routinely inspected before opening because many individuals settle there. Each of them is photographed and released (except the species to be dissected or permanently captured). This is used as both an aide-memoire and for discussion or submission to more experienced "colleagues" in some complex cases.



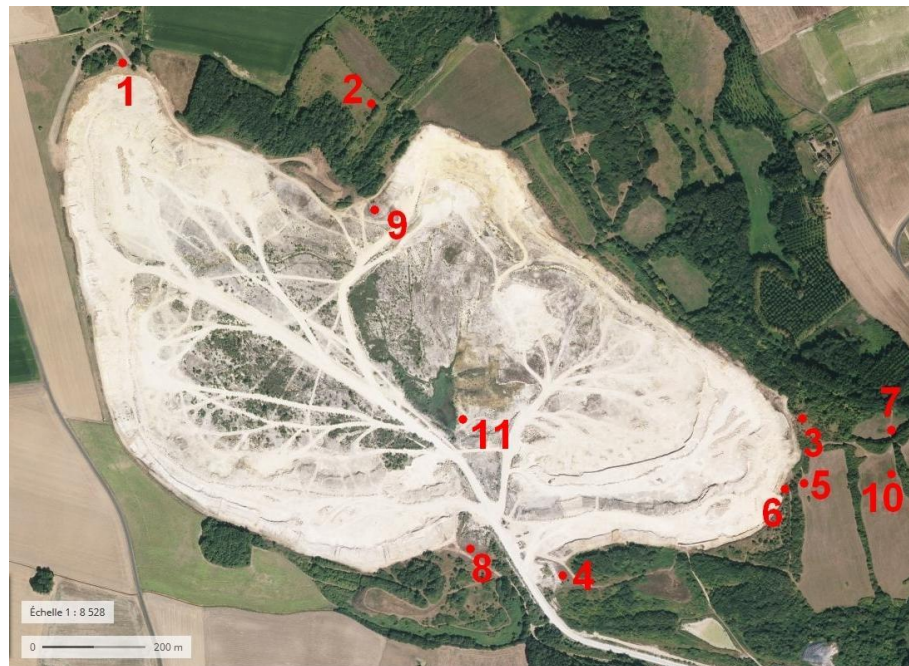
Trap at sunrise, after examination of the species attracted during the night. Note the favourable situation in meadow, overlooking an old afforestation and its rim of shrubs.

A place is chosen to set the trap that for us is accessible, clear and visible from the most favourable areas. To this end, an identification visit upstream, during the winter and in the company of Calcia employees, was able to identify, on the one hand, the precise limits and different accesses of the site to be inventoried and, on the other hand, the precise points where the traps would be laid. Marek Banasiak is also a botanist. He quickly came up with some interesting plant communities (phytosociology) that would have to be trapped. For practical reasons of access to the site and volunteer availability, not all points received the same inventory pressure. Nevertheless, the observation of the vegetation and in particular the phenology of the host plants (spawning) or nectariferous plants (feeding of the adults) guided us towards certain points rather than others. As some plots are subject to mowing management, we had to model our interventions on this agricultural calendar, leaving the freshly exploited plots in favour of sites at the right vegetative stage.

The trapping calendar is modelled on that of the moon. Our lamps are not very effective against its powerful illumination. It is said that it competes too much with the light traps, making them less attractive. So, each month, a night before or after the new moon was chosen. We defined this rhythm as a minimum to reconcile good feasibility and obtain interesting results. But as we will see in the discussion section, this temporality was necessary but not really sufficient.

The weather was also a factor limiting or at least directing our activities. The month of February and its rare periods of mild weather did not allow us to be present during the rare nights favourable to the

flight of the few species. Also in March, concordance between moon, weather and volunteer availability was hard to find... Only a dozen species could be detected that month. On the other hand, some months, mild or even stormy nights (the most favourable!) pushed us to make outings outside of the scheduled dates of the favourable moons. This was the case in May for example where the minimum of one outing per month was largely exceeded ($n = 5$). In the end, 35 traps were made.



Map of the trapping points

Regarding the light sources, the personal traps of each naturalist involved were used. This is self-built material. Each uses a type of lamp that they favour (actinic neon, actinic fluorescent tube, ultraviolet LED and mercury vapour bulb). The power and the light spectrum therefore differs considerably for each of the traps used simultaneously on the different points. The first three types of lamp can be powered by 12V batteries. Special GEL batteries that support the alternation of slow and deep charges and discharges are used. This type of equipment has the immense advantage of being able to be transported everywhere and operated autonomously. The mercury vapour bulb must be powered on 220V. It is more powerful. As the type of trap is not standardised a bias also exists here. Nevertheless, some points that are quite similar and/or having similar environments (e.g. No. 3/No. 6 and No. 6/No. 5), which were trapped the same night with these differences in material, often revealed the attraction of a list of species that was significantly different. We have therefore discovered that this diversity of material has probably contributed to the comprehensiveness of our inventory. Finally, the mercury vapour lamp, the most powerful one, used several times, presented hope for greater attractiveness for a wider range of species. Unfortunately, the only access to an electrical outlet is at the bottom of the quarry and samples very pioneering environments. The use of this equipment was less satisfactory than expected and brought results similar to lower power lamps.

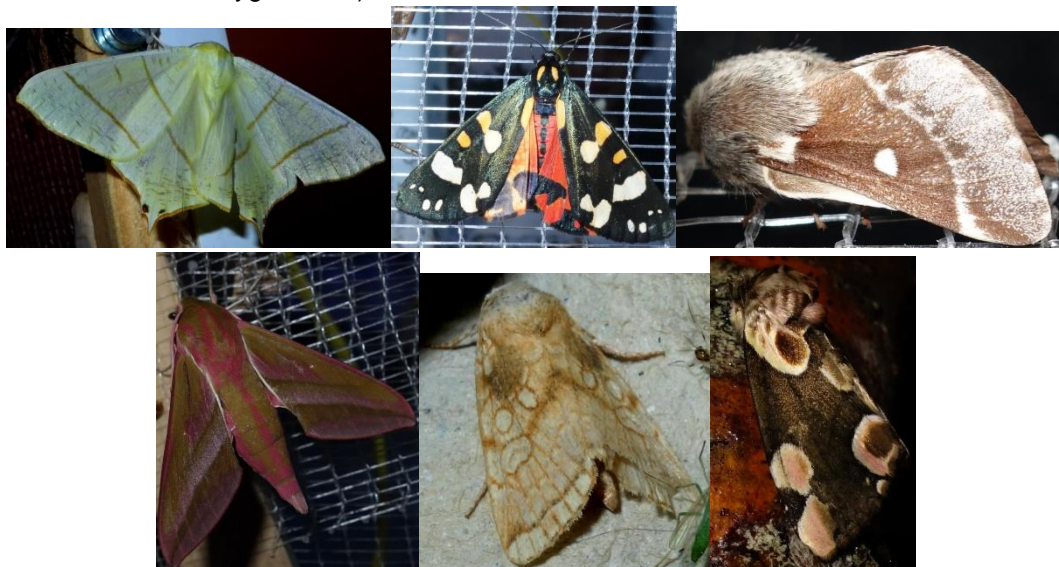
Certain species of moth can only be identified through the examination of their genitalia. These were therefore collected for dissection and identification by Marc Nicolle, a non-professional specialist in order to have the most exhaustive list possible for macro-Heterocera (see list of families concerned in the results section).

It should be noted that these species, very rare in relation to the group as a whole, usually make up groups of two, or rarely three, species, which are physiologically too similar to be specifically distinguished by sight. The schedule of this study is not compatible with the long time required for this voluntary work in "laboratory". Although some beautiful discoveries have already been revealed by this means, we were expecting that a small part would not be able to be definitively identified. These species appear in the study as a binomial (example: *Sphinx pinastri/maurorum*). The same is true for small moths, of which an even greater number require an in-depth examination. This subgroup of moths, better known to the general public through families such as budworms, corn borers, having an influence human activities (crops, food storage etc.) presents a much greater diversity of species, mostly small or very small (just a few millimetres of wingspan!) Their consideration was initially excluded from this study. But we will see below that surprises awaited us, which we could not refrain from citing in the results.

Finally, some moths having diurnal habits; a few punctual daily outings complete the nocturnal inventories.

Results

As we anticipated, the diversity highlighted on this site is exceptional. 318 macro-Heterocera belonging to about a dozen large families have been identified (Hepialidae, Cossidae, Limacodidae, Lasiocampidae, Endromidae, Sphingidae, Drepanidae, Geometridae, Notodontidae, Erebiidae, Noctuidae, Nolidae and Zygaenidae)!

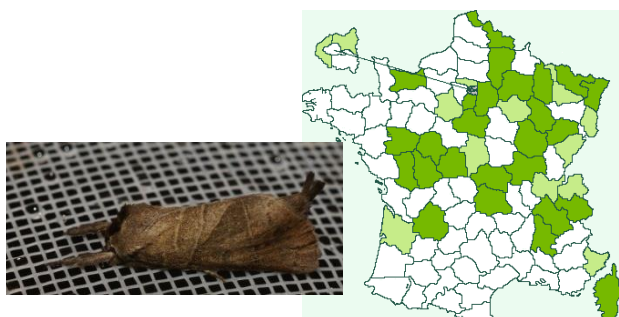


Examples of families of macro-Heterocera. In the direction of reading: a Geometridae, Swallow-tailed Moth (*Ourapteryx sambucaria*), an Erebiidae, Scarlet Tiger (*Callimorpha dominula*), a Lasiocampidae, Small Eggar (*Eriogaster lanestris*) a Sphingidae, Elephant Hawk-moth (*Deilephila elpenor*), a Noctuidae, Heart Moth (*Dicycla oo*) finally a Drepanidae, Peach Blossom (*Thyatira batis*).

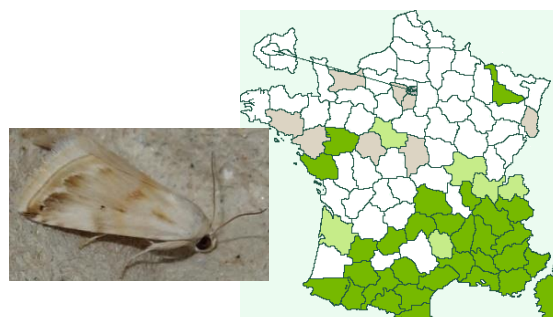
Symbolic figure since it represents more than half of the number of species present throughout the regional administrative area listed on the same site. At the same time, the list of moths of the Sarthe thus crosses the bar of 600 species. Among them, six had never been noted in Sarthe despite an exploration effort that was significantly lengthy and conducted elsewhere in the area. We take as reference the inventory made in the early 80's by Louis Faillie and Robert Passin. In addition to these new features, the consultation of online maps Lepinet.fr site shows that a significant number had probably never been reviewed since that date. Proof of their rarity? A lack of exploration or updating of knowledge?

This contribution of species discovered in less than a year in the department has all the more value as the Sarthe is ranked in this website among the 22 French departments for which the synthesis is considered correctly completed to date for the moths.

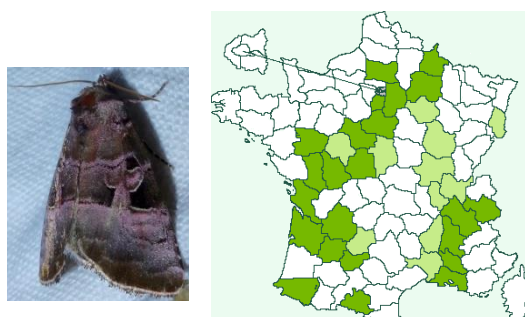
Here are in pictures, the six new species accompanied by their map of national distribution known to date (source: Lepinet.fr, contemporary data in dark green, old data in light green, and erratic data, often related to the migratory character of certain moths, in grey):



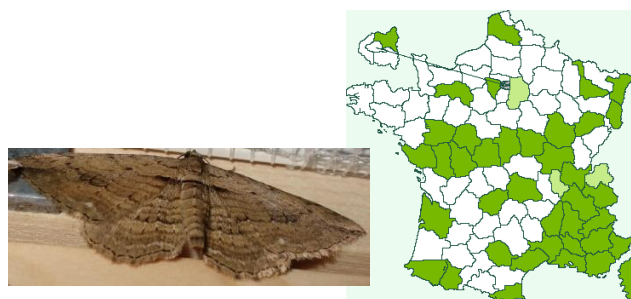
Clostera anastomosis



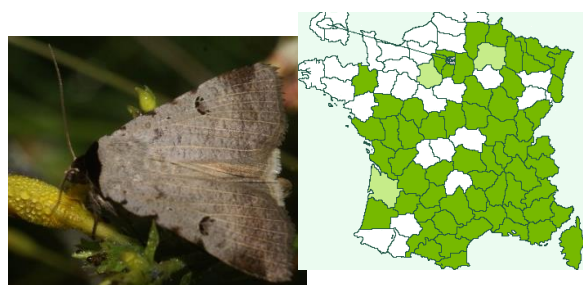
Purple Marbled (Eublemma ostrina)



Cumberland Gem (Eucarta amethystina)



Horisme radicularia



Scarce Blackneck (Lygephila cracca)



Bordered Gothic (Sideridis reticulata)

The presence of naturalists mastering various disciplines on the site throughout the study, but especially during a period of strong weather gathering twenty participants on the weekend of 8 to 10 June, has shown that the Huellerie site is the last refuge of many other species:

- Botany: Winged broom (last and only station in Pays de la Loire, in danger of extinction in Pays de la Loire)/Dwarf black olive and Angled pea (critically endangered in Pays de la Loire),

- Longicorn: *Phytoecia virgula* (1st datum in Sarthe),
- Cicada: *Cicadetta cantilatrix* (1st datum in Pays de la Loire, identification Thomas Cherpitel),
- And the three new moths (microlepidoptera) for Sarthe: *Eurhodope cirrigerella* (also new for the Pays de la Loire), *Eurhodope rosella* and *Pyrausta sanguinalis* (these three species are linked to dryland plants).



On the left *Eurhodope cirrigerella*, on the right *Eurhodope rosella* and their respective maps of distribution. Note the rarity of the stations known in France for these two species and their fragmented distribution with southern tendency, typical of the procession of Heterocera detected on the quarry.

Discussion

A remarkable inventory

As described in the results, the presence of six new species for the Sarthe and 23 ZNIEFF defining species (only heritage list in existence) makes this inventory a remarkable and original procession for the Sarthe (and the Pays de la Loire).

Most of the inventories of Heterocera are done by volunteers in their garden (with unpublished inventories). Only two "Réserves naturelles régionales" (RNR) (Regional nature reserves) in Sarthe have inventories of moths: this is the RNR of the Marshes of Cré/La Flèche (2017) and the hillside of Tessé (in progress). The Cré marsh, as the name suggests, is composed of wet habitats; the comparison with our site is therefore irrelevant. As for the RNR of Tessé, it is located north of Sarthe, so too great of a distance separates them and this affects the presence of southern species.

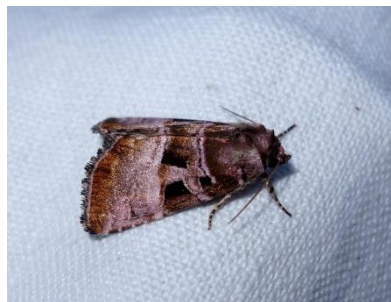
Thus, only the inventory made at Thoiré sur Dinan by Denis Foussard (2015) seems comparable to us. This inventory was made in an old grove on a limestone plateau. The habitats are therefore more "evolved" than the pioneer habitats of the quarry. The inventory of Thoiré was much longer, from 2010 to 2013, for more than 150 nights of mercury lamp hunting (by trapping). 400 macro-Heterocera were therefore inventoried with 23 ZNIEFF determining species. Thus, we find the same number of critical species but only three species are on both sites.

The site of Calcia is original in presenting:

- hermophilic and southern species (6% of species) such as Cumberland Gem (*Eucarta amethystina*) or Purple Marbled (*Eublemma ostrina*); the site constituting their northern limit of distribution,



Purple Marbled (Eublemma ostrina)



Cumberland Gem (Eucarta amethystina)

- species of wetlands (15% of species) and more particularly plain reed beds such as Twin-spotted Wainscot (*Lenisa geminipuncta*) or Bulrush Wainscot (*Nonagria typhae*)

This makes it a real reservoir of biodiversity that must serve as a springboard for these species for the colonisation of other areas of the Loir Valley where we find limestone lawns and marshes (classified Natura 2000 zone). Moreover, to find a comparable fauna of the thermophilic calcicolous environments, it is necessary to make a leap of about 50 km further south in the Saumurois or the Puys du Chinonais (pers. comm. Alain Cama).



Twin-spotted Wainscot (Lenisa geminipuncta)



Bulrush Wainscot (Nonagria typhae)

Note that this inventory is all the more remarkable as it is largely incomplete given that the species succeed each other at a rhythm that is too fast to be present on the ground as often. We certainly trapped on average a little more than once a month. But from one catch to another, how many species with very short flight period escaped us? For proof, almost 1/3 of them showed themselves only once, the trapping night having taken place at the right moment. And how many of them, scarce one year, go unnoticed, but then would have been detected the following year? Next, the time of the study does not quite correspond to the time of the biodiversity. At the time of writing, dozens of end-of-summer and autumnal species are flying or planning to do so! Next, it will be the winter species that will follow until the strong frosts of February. So much data that will not appear in this document. We are also hoping that this autumn we will be able to continue the capture sessions outside the formal challenge of this study, or even reiterate the experience for years to come. As we have seen above, a truly comprehensive inventory of moths should be spread over several years. Other surprises await us on this place, now become mythical in our eyes!

An essential consideration

Faced with such a hard challenge for the reception of biodiversity, it seems clear to us that the Calcia group must continue to take into consideration the protection of nature without us calling into question the company's extractive activity. This responsibility is all the stronger because the quarry is home to many species within the boundaries of its range; hence the desire to keep the site in the best state of conservation possible.

Moreover, it is thanks to the land control of nearly 200 hectares in the municipality of Saint-Germain-d'Arcé that the heritage habitats at the margin of the site (including limestone lawns) have been preserved from the intensive agriculture of the 1960s.

Beyond the reduction or compensation measures that will be implemented during the next 30 years (as part of the prefectural order for the extension of the quarry obtained this year), we propose that the quarry set up accompanying measures:

- 1) Continue to open its doors to the naturalistic environment; beautiful discoveries still await us
- 2) Make contact with a structure specialised in the management of natural areas to maintain the maximum number of fauna and flora species; this structure will link up with the amateur naturalists to provide the best guide for the explorations to come
- 3) Extend and update the ZNIEFF "Coteau du Moulin de Coulongé" to the limestone lawns south of the quarry (where preservation issues are the strongest)
- 4) Cede back the lands at the end of the operation to a natural areas manager
- 5) Organise outings for the general public and schoolchildren

A promotion campaign is to be carried out

We will promote this project in different ways via:

- a publication in specialised journals (Oreina, newsletter of the Entomology Tourangelle Ligérienne, Lettre des Naturalistes Sarthois) in order to formalise this inventory with the scientific community but also to show the role of the quarry in receiving such biodiversity.
- a conference in a symposium (we will intervene at the next regional naturalist meetings in November in Loire-Atlantique).
- Work with the employees. A first activity has already taken place, bringing together half a dozen of these same and their children. It consisted of opening a trap and inventorying the harvest in the early morning with them.

Conclusion

From the observation of 318 macro-Heterocera, by the installation of 35 "Tavoillot" type light traps from March to September 2018, the site of the Huellerie quarry in Saint-Germain-d'Arcé is exceptional for the hosting of moths and diversity more generally. In fact, in half a season of inventorying, it is rare to observe such convincing results; this site hosts more than half of the Sarthois moths including many patrimonial species.

The quarry therefore has a responsibility in maintaining this biodiversity. With the acquisition in the 1960s of nearly 200 hectares of land for the gradual exploitation of limestone, patrimonial areas were made into sanctuaries. We thus find calcicolous grasslands with a floristic composition quite original for the Sarthe but also a network of hedges and groves favourable to the development of many species of insects including Heterocera.

It is in this logic of preservation of the mosaic of habitats that the quarry must maintain the greatest possible biological richness and thus allow species to colonise new environments in the Loir Valley.

Project tags

<p>Project focus:</p> <p><input type="checkbox"/> Beyond quarry borders</p> <p><input type="checkbox"/> Biodiversity management</p> <p><input type="checkbox"/> Cooperation programmes</p> <p><input type="checkbox"/> Connecting with local communities</p> <p><input type="checkbox"/> Education and Raising awareness</p> <p><input type="checkbox"/> Invasive species</p> <p><input type="checkbox"/> Landscape management</p> <p><input type="checkbox"/> Pollination</p> <p><input type="checkbox"/> Rehabilitation & habitat research</p> <p>X Scientific research</p> <p><input type="checkbox"/> Soil management</p> <p><input type="checkbox"/> Species research</p> <p><input type="checkbox"/> Student class project</p> <p><input type="checkbox"/> Urban ecology</p> <p><input type="checkbox"/> Water management</p> <p>Flora:</p> <p>X Trees & shrubs</p> <p><input type="checkbox"/> Ferns</p> <p>X Flowering plants</p> <p><input type="checkbox"/> Fungi</p> <p><input type="checkbox"/> Mosses and liverworts</p> <p>Fauna:</p> <p><input type="checkbox"/> Amphibians</p> <p><input type="checkbox"/> Birds</p> <p>X Insects</p> <p><input type="checkbox"/> Fish</p> <p><input type="checkbox"/> Mammals</p> <p><input type="checkbox"/> Reptiles</p> <p><input type="checkbox"/> Other invertebrates</p> <p><input type="checkbox"/> Other insects</p> <p><input type="checkbox"/> Other species</p>	<p>Habitat:</p> <p><input type="checkbox"/> Artificial / cultivated land</p> <p><input type="checkbox"/> Cave</p> <p><input type="checkbox"/> Coastal</p> <p><input type="checkbox"/> Grassland</p> <p><input type="checkbox"/> Human settlement</p> <p><input type="checkbox"/> Open areas of rocky grounds</p> <p><input type="checkbox"/> Recreational areas</p> <p>X Sandy and rocky habitat</p> <p><input type="checkbox"/> Screes</p> <p><input type="checkbox"/> Shrub & groves</p> <p><input type="checkbox"/> Soil</p> <p><input type="checkbox"/> Wander biotopes</p> <p><input type="checkbox"/> Water bodies (flowing, standing)</p> <p>X Wetland</p> <p>X Woodland</p> <p>Stakeholders:</p> <p><input type="checkbox"/> Authorities</p> <p><input type="checkbox"/> Local community</p> <p>X NGOs</p> <p><input type="checkbox"/> Schools</p> <p><input type="checkbox"/> Universities</p>
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Annexe 1 : References

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