Colonization pattern by vegetation and relationships with faunal inventory in an old sand quarry

by Thierry HANCE, Jean-Marie DUMONT, Luc HANCE, Luc RENIER & Philippe GOFFART

Summary

Colonization of bare soil by plants corresponds to a dynamic process involving a gradual transformation of the soil substrate through humus formation. Changes in vegetation structure and in soil organic matter content both induce a succession of peculiar soil fauna assemblages. The Champ'taine site at Chaumont-Gistoux (Belgium) is ideal for analysing such relationships. It is an old sand quarry (12 ha) which exploitation was stopped in 1976. Subsequently, vegetation has progressively but not uniformely colonized the sandy soil. At the present day, the different colonization stages are still present on relatively large areas. This succession is: 1) bare sand, 2) tuffets of *Corynephorus canescens*, 3) grassland with *Deschampsia flexuosa*, 3) clumps of *Calluna vulgaris* and *Sarothamnus scoparius*, 4) birch grove, 5) oak-beech grove. Carabids were chosen as indicators of soil fauna succession according to those five vegetal formations. Fifteen stations were sampled during two weeks.

On the whole, 40 species (192 individuals) of Carabidae were caught. At each colonization stage corresponds a group of species. For example, *Cicindela hybrida* and *Microlestes maurus* were found on the unsettled sandy soil of the well exposed excavation slopes, while *Cychrus caraboides* and *Carabus problematicus* were only present in the oak-beech grove. This obvious relationship between the succession of plant assemblages, soil formation and fauna gives a great scientific and didactic interest to the site, and the creation of a nature reserve is planned. To assess the biological quality of the site, insect of other families were sampled. Twenty species of Lepidoptera and 6 species of Orthoptera were identified, indicating the great diversity in habitats of the Champ'taine quarry site.

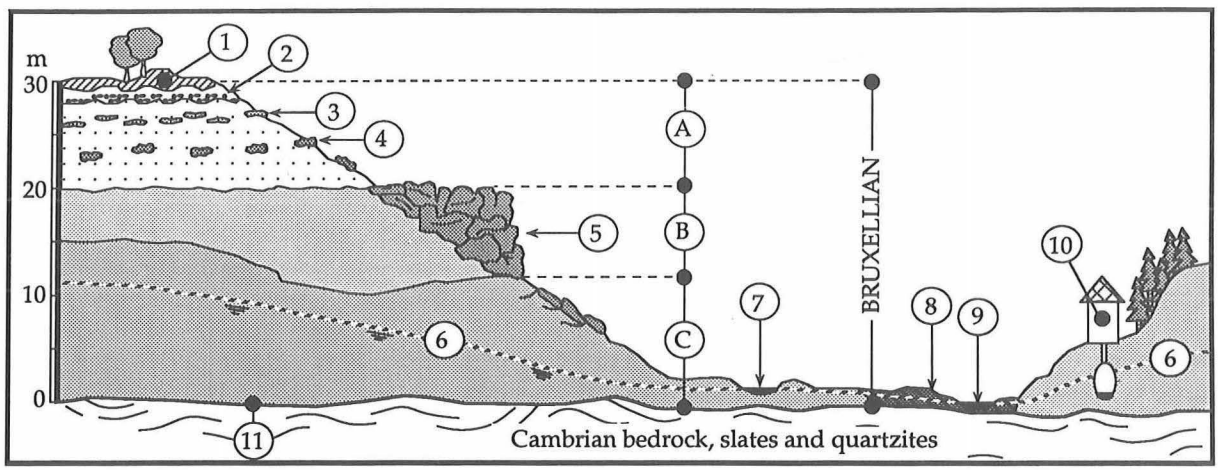
Introduction

Champ'taine quarry at Chaumont-Gistoux is an old sand quarry which exploitation was stopped in 1976. Since then, the reconversion of the site has become the subject of a large debate between the neighbours, the municipality and potential users such as sport clubs. Numerous propositions were made such as motocross circuit, permanent clay shooting field, dog training area, recreation site or nature reserve.

Such diversity of interest and the consequently conflicting situation require to realize a global evaluation of the biological quality of the site prior any decision. This was the purpose of the present study. As an exhaustive evaluation of the site would be too time-spending, we have limited our analysis to a functional description of the site, with emphasis on indicatory groups: Carabidae, Lepidoptera and Orthoptera. Thus, the following description is not only a list of species, but it takes into account the relationships between flora and fauna in a dynamic point of view.

Description of the site

The 12 ha sand quarry is situated at Chaumont-Gistoux (45 km S.-E. from Brussels) in the Bruxellian (Tertiary: Eoceen) decalcified sands. Its geological description has been realized by HANCE *et al.* (1989). Figure 1 shows a transversal section illustrating the geological setting of the quarry. The soil substrate is not uniformous in constitution, moisture and sun exposition. Three main layers (A, B, C) can be distinguished regarding granulometry and development of sandstone beds or concretions. The bottom of the quarry is situated at 95 m above sea level and the top at 125 m.



A. Fine sand
B. Ferrugineous sandstone
C. Medium sand
1. Quaternary silt with Silex pebbles
2. Tongrian sands with fossiliferous gravels at the base
3. Discontinuous thin sandstone layer locally vacuolated
4. Sandstones concretions
5. Ferrugineous sandstone
6. Piezometric level
7. Pool
8. Alluvion
9. Ry du pré Delcourt
10. Water harnessing
11. 95 m above sea level

Fig. 1. Transverse section of the quarry.

Since the exploitation stopped, vegetation has progressively colonized the bare sandy soil and has thus led to a progressive constitution of the pedological horizons. The more striking appearance is given by the slopes which covers 3.50 ha and where some parts are not yet stabilized (Fig. 2). In consequence, the different stages of plant recolonization may still be observed. This succession is represented by: 1) bare sand, 2) tuffets of *Corynephorus canescens*, 3) grassland of *Corynephorus canescens* with some species like *Hypochoeris radicata* and *Polytrichum piliferum*, 4) grassland with *Deschampsia flexuosa*, 5) clumps of *Calluna vulgaris* and *Sarothamnus scoparius*, 6) birch-grove, 7) oak-beech grove. This is the typical succession usually met on sandy decalcified soil. In fact, the possibility to observe all these stages in a quite limited area is exceptional in Belgium and thus reveals an outstanding scientific and didactic interest.

Such colonization of bare soil by vegetation corresponds to a dynamic process involving a gradual transformation of soil substrate through humus formation (Tab. 3). The succession of soil transformations may be described as following: 1) bare and moving sand, 2) fixed sand, 3) settled organic layers, 4) progressively thickening and differentiating pedological layers.

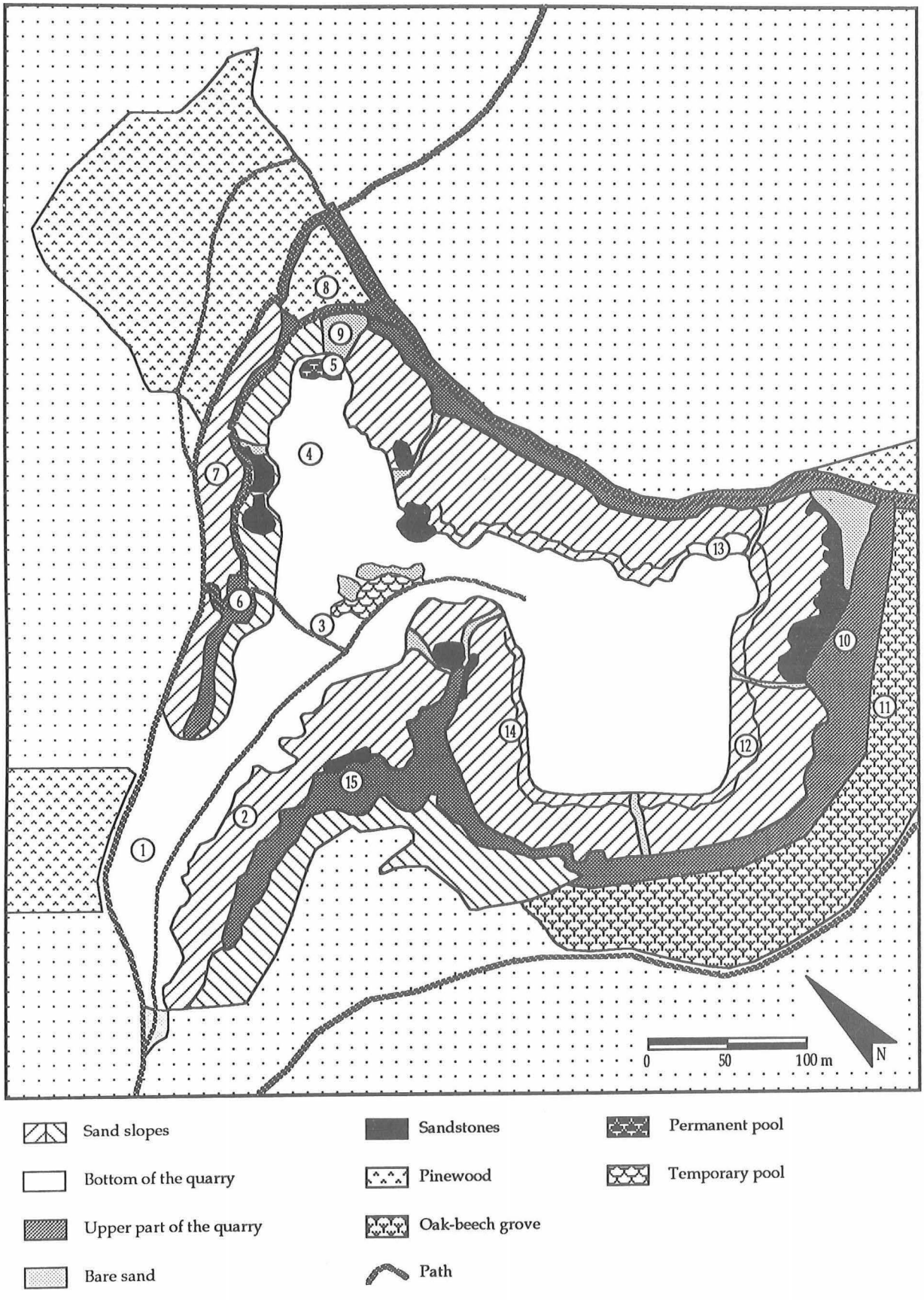


Fig. 2. Map of the quarry. The numbers indicate the position of the Carabid sampling stations.

Exploitation was stopped when it has reached the underground water level. A permanent but not very deep pool has been created in this way and is presently surrounded by some alders (*Alnus glutinosa*) and willows (*Salix sp.*). Typical plants of such milieu have also appeared; for instance, *Glyceria notata, Typha latifolia, Juncus effusus* and *Veronica beccabunga*. Another pool is present in the middle of the quarry but this one dries up in summer. It is partially colonized by big tuffets of *Juncus effusus* and in some places by *Glyceria notata*; besides, some muddy areas remain free of vegetation. Finally, the laying out of the quarry presents a ruderal vegetation as it is constituted by spoil and has been partially filled by agricultural soil.

Faunistical inventory

Both phenomena, i.e. changing in vegetation structure and in soil organic matter content, should induce a succession of peculiar soil fauna assemblages. Moreover, the great diversity in habitats should involve an important faunistic diversity. In order to analyse these hypotheses, three insect groups were chosen as indicators: Carabids and Orthoptera for soil fauna, and Lepidoptera for vegetation diversity.

Material and methods

Carabid sampling

Fifteen stations were selected among the different vegetation stages and near the pools. The stations are described in Annex 1 and located in Figure 2. In each station, two pitfall traps were placed. They consist in plastic jars (8.5 cm diameter and 14 cm deep) that are filled to 1/3 with a 5 % formaldehyde aqueous solution. The distance between each trap was approximately 2.5 m. The traps were placed on 25.05.1988 and were collected on 02 and 10.06.1988. The sampling was limited in time in order to avoid possible disturbance of the site.

Other insect samplings

Orthoptera were hand caught on 17.08.1988 and they were identified in the field using the systematic keys of DUIJM & KRUSEMAN (1983) and BELLMAN (1985). External morphology as well as song patterns were used. The Tetrigidae were not considered in this work.

Lepidoptera were caught alive with a butterfly net, twice a month from early May until last October. They were identified in the field and then released.

Results

Characterization of the Carabid fauna

Although the short period of trapping, 40 species and 192 individuals of Carabidae were caught (cf. Annex 3). This reflects the ecological diversity of habitats in the quarry. But, in consequences of the short period of trapping, the relationships found between fauna and vegetation will only be indicative and based on the beetle presences. Table 1 shows those relationships between soil formation, succession of vegetation and carabid presence. First appear carabid species with strong ecological requirements (stenotopic species) such as dry sand and scarse vegetation. This species assemblage is constituted by *Cicindela hybrida, Calathus erratus, Harpalus smaragdinus* and *Microlestes maurus*. They are followed by species bound to dry grasslands such as *Harpalus tardus* and *Bembidion lampros*. Then, in the birch grove appear species commonly found in woodland: *Abax parallelepipedus* and *Pterostichus oblongopunctatus*. Finally, some taller species are found in the oak-beech grove such as *Cychrus caraboides* and *Carabus problematicus*. The damped zone possess also a well characterized carabid population with riparian species; the most trapped were *Elaphrus riparius, Agonum viduum, Bembidion varium* and *Bembidion dentellum* (Tab. 2). In Table 3, species are listed according to their main habitats requirements, as described by DESENDER (1986a, b, c, d).

Grasshopper and cricket fauna

Orthoptera are influenced by microclimatic conditions which are linked to the vegetation structure of their habitat and on soil composition. Six species were identified, 2 crickets (Ensifera) and 4 grasshoppers (Caelifera) (Tab. 4). Each of them are related to defined habitats present in the quarry. *Chorthippus mollis* is clearly associated with dry *Corynephorus canescens* grassland well exposed to sun light and more generally to scattered herbaceous vegetation and heath. In Belgium, this species has only been recorded in similar habitats in the Campine region (DEVRIESE, 1988). In the Champ'taine quarry, *Chorthippus mollis* lives close to three other species, *Chorthippus biguttulus, Chorthippus brunneus* and *Chorthippus parallelus*. The two species of Ensifera found are linked to dense vegetation. *Tettigonia viridissima* lives on threes and bushes (*Sarothamnus scoparius* clumps or the young birch grove) as well as in ruderal vegetation. *Pholidoptera griseoaptera* was more confined to shrubs showing undercover with dense vegetation (especially *Rubus sp.*).

Lepidoptera

Although 20 species of Rhopalocera were caught (Annex 2), the Lepidoptera fauna is constituted by widespread species. Indeed, it is mainly composed by eurytopic, mesophilic or nemoral species and by species characterizing ruderal environments, such as most common Nymphalidae. Nevertheless, the diversity of habitats is pointed out by the presence of woodland species (*Pararge aegeria*), close to grassland species (*Maniola jurtina*). *Aphantopus hyperanthus* requires shaded grassland while *Thymelicus lineolus* is common on rough and well drained grassland on every type of soil. The most interesting observation was the presence of *Callophrys rubi*, a relatively scarce Lycaenidae in Brabant which caterpillars feed notably on *Sarothamnus*, *Rubus* and *Lotus* species.

Conclusions

Generally, botanical inventory, including scarce plant species is the main criterion used to evaluate the biological quality of a site, and indeed, it has brought numerous information in this case, particularly on the dynamic process of vegetation colonization. This constitutes the main interest of the quarry. But floral inventories may be notably completed by pointing out the relationships between fauna, vegetation structure and pedological constitution. The three groups chosen as indicators for this study (Carabidae, Orthoptera, Lepidoptera) appear to be suitable for completing botanical information. They show the importance of each vegetation assemblage regarding the biological quality of the site. For instance, the ruderal vegetation found in the bottom of the quarry, despite it has a quite limited botanical interest, is favourable for Lepidoptera fauna. Even the bare sands show their own typical fauna with species as *Cicindela hybrida*.

One of the main characteristics of quarries is that they usually show a wide spectrum of environmental conditions and particularly combination of extreme physical features. So, they could provide ideal habitats for a large number of plants and animals endangered by the agricultural intensification, industrial and housing development (RANSON & DOODY, 1982). In this context, the Champ'taine quarry presents many interesting aspects of strong associations between insect fauna, vegetation and soil substrate. The general ecological quality of the site revealed by this study has led the municipal authorities to take the protection of the site into account, planning the constitution of a nature reserve. Presently, a local association has been constituted with the goal of carrying on the full description of the site and of planning its future management.

Acknowledgements

The authors are gratefully to the municipal authorities of Chaumont-Gistoux and particularly to M. A. DOCQUIER, Mayor, for the information they provided and for their willingness. They are also indebted to Professor Ph. LEBRUN, head of the "Unité d'Écologie et de Biogéographie". They greatfully acknowledge Dr. G. VAN IMPE for helpful review of the manuscript.

References

BELLMAN, H., 1985. A field guide to the grasshoppers and crickets of Britain and Northern Europe. Collins, London, 213 pp.

DESENDER, K., 1986a. Distribution and ecology of Carabid beetles in Belgium (Coleoptera, Carabidae), Part 1. *Documents de travail de l'Institut royal des Sciences naturelles de Belgique, Bruxelles*, 26: 1-30.

DESENDER, K., 1986b. Distribution and ecology of Carabid beetles in Belgium (Coleoptera, Carabidae), Part 2. *Documents de travail de l'Institut royal des Sciences naturelles de Belgique, Bruxelles*, 27: 1-24.

DESENDER, K., 1986c. Distribution and ecology of Carabid beetles in Belgium (Coleoptera, Carabidae), Part 3. *Documents de travail de l'Institut royal des Sciences naturelles de Belgique, Bruxelles*, 30: 1-23.

DESENDER, K., 1986d. Distribution and ecology of Carabid beetles in Belgium (Coleoptera, Carabidae), Part 4. *Documents de travail de l'Institut royal des Sciences naturelles de Belgique, Bruxelles*, 34: 1-48.

DEVRIESE, H., 1988. Saltatoria Belgica. Voorlopige verspreidingsatlas van de sprinkhanen en krekels van België. Institut royal des Sciences naturelles de Belgique, Bruxelles, 85 pp.

DUIJM, M. & KRUSEMAN, G. 1983. De Krekels en Sprinkhanen in de Benelux. Koninklijke Nederlandse Natuurhistorische Vereniging. Amsterdam, The Netherlands, 186 pp.

HANCE, Th., DUMONT, J.-M. & HANCE, L., 1989. La carrière Champt'aine à Chaumont-Gistoux, une site exceptionnelle à protéger. *Parcs Nationaux*, XLIV (2): 36-48.

RANSON, C.E. & DOODY, J.P., 1982. Quarries and nature conservation - Objectives and management. *In*: DAVIS, N.P.K (ed), Ecology of Quarries. The importance of natural vegetation, pp. 20-26. Institute of Terrestrial Ecology, Huntingdon, United Kingdom.

Thierry HANCE, Jean-Marie DUMONT,
Luc RENIER & Philippe GOFFART
Unité d'Écologie et de Biogéographie
Place Croix du Sud 5
B-1348 LOUVAIN-LA-NEUVE

Luc HANCE
Service Géologique de Belgique
Rue Jenner 13
B-1040 BRUXELLES

Table 1. Relationship between soil formation, plant successions and Carabid fauna.

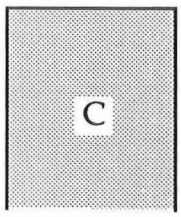
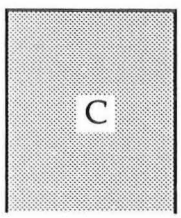
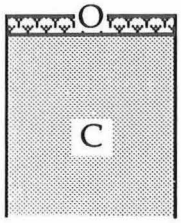
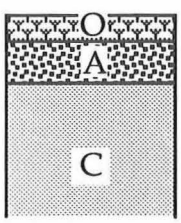
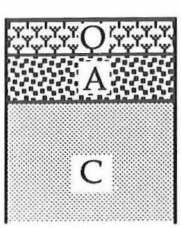
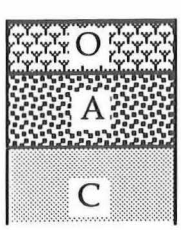
SOIL		STATION	VEGETATION	CARABID FAUNA
bare and unstable sand		9	tuffets of *Corynephorus canescens*	*Harpalus tardus* *Cicindela hybrida* *Microlestes maurus*
stable sand		6 13	grassland with *Corynephorus canescens*	*Cicindela hybrida* *Calathus erratus* *Harpalus tardus* *Harpalus griseus* *Harpalus rupicola* *Microlestes maurus* *Harpalus smaragdinus*
layer of organic matter		14	grassland with *Deschampsia flexuosa*	*Harpalus tardus* *Amara consularis* *Microlestes maurus* *Bembidion lampros*
differentiation and thickening of the pedologic layers		15	clumps of *Calluna vulgaris* and *Sarothamnus scoparius*	*Harpalus tardus* *Amara consularis* *Microlestes maurus* *Bradycellus harpalinus*
		2	Birch grove	*Abax parallelepipedus* *Leistus rufomarginatus* *Pterostichus oblongopunctatus*
		7 10 11	Oak-beech grove	*Calathus piceus* *Notiophilus rufipes* *Cychrus caraboides* *Leistus ferrugineus* *Abax parallelepipedus* *Carabus problematicus* *Pterostichus oblongopunctatus*

Table 2. Relation between habitat and the Carabid fauna found in the quarry.

SOIL	STATION	VEGETATION	CARABID FAUNA
Damped areas			
1) mud soil	3	*Glyceria notota* *Juncus effusus* *Rumex crispus*	*Agonum viduum* *Elaphrus riparius* *Bembidion dentellum* *Panagaeus crux-major*
2) damp soil	5	damped grassland	*Pterostichus minor* *Agonum gracile* *Harpalus anxius*
Areas with anthropic impact			
1) bottom of the quarry	1 & 4	grassland	*Harpalus tardus* *Pterostichus niger* *Bembidion lampros* *Harpalus autumnalis*
2) layer filled with agricultural soil	12	grassland with lupin	*Harpalus tardus* *Harpalus rubripes* *Calathus erratus* *Bembidion lampros*
3) pine forest	8	pine	*Harpalus rufipes* *Carabus problematicus* *Pterostichus oblongopunctatus*

Table 3. **Habitat preferences of the Carabid species caught in the Champ'taine site.**

Habitat preferences according to DESENDER (1986 a,b,c,d)	Species
dry sandy soil	*Cicindela hybrida* *Calathus erratus* *Harpalus griseus* *Harpalus rupicola* *Microlestes maurus* *Harpalus smaragdinus*
dry habitat, eurytopics	*Harpalus tardus* *Leistus ferrugineus* *Bembidion lampros*
woodland	*Cychrus caraboides* *Abax parallelepipedus* *Leistus rufomarginatus* *Pterostichus oblongopunctatus*
riparian and humid habitat	*Agonum viduum* *Elaphrus riparius* *Bembidion varium* *Bembidion dentellum*
humid grassland	*Panagaeus crux-major*

Table 4. **Habitats of the six species of Orthoptera caught in the quarry.**
Index of abundances:
+ scarcely present
++ present but in small number
+++ abundant
++++ very abundant

Location of observations	Index of abundance	Species
dry grass land of *Corynephorus canescens* and stable slopes with sarce vegetation	+++ +++	*Chorthippus mollis* *Chorthippus brunneus*
Stable slopes with herbaceous vegetation	++	*Chorthippus biguttulus*
Trees, bushes and dense ruderal vegetation	+++	*Tettigonia viridissima*
Bushes and dense vegetation cover (*Rubus sp., ...*)	++++	*Pholidoptera griseoaptera*
open habitats	++++	*Chorthippus parallelus*

Annex 1. Description of sampled stations for Carabid fauna.

Station 1 : Bottom of the quarry with ruderal grassland
Station 2 : Birch-grove associated *Deschampsia flexuosa*, North exposition
Station 3 : Temporary pool with *Glyceria notata* and *Rumex acetosella*
Station 4 : Bottom of the quarry with ruderal grassland
Station 5 : Border of the permanent pool
Station 6 : Dry grassland with *Corynephorus canescens*
Station 7 : Oak-beech grove underwood with *Calamagrostis epigejos* and *Epipactis helleborine*
Station 8 : Pine forest
Station 9 : unstable sand cliff with tuffets of *Corynephorus canescens*
Station 10: Oak-Beech grove, border with *Corynephorus canescens* grasland
Station 11: Underwood, oak-beech grove
Station 12: Ruderal grassland with lupins
Station 13: Dry grassland with *Corynephorus canescens*, stable sands
Station 14: Grassland with *Deschampsia flexuosa* and *Holcus mollis*
Station 15: Heath

Annex 2. List of Rhopalocera observed in the quarry; the last column gives common names.

Papilionidae	*Papilio machaon* (L.)	Swallowtail
Hesperiidae	*Thymelicus lineolus* (Och.)	Essex Skipper
	Ochlodes venata (Bremer)	Large Skipper
Pieridae	*Pieris brassicae* (L.)	Large White
	Pieris rapae (L.)	Small White
	Pieris napi (L.)	Green-veined White
	Anthocharis cardamines (L.)	Orange Tip
	Gonepteryx rhamni (L.)	Brimstone
Nymphalidae	*Aglais urticae* (L.)	Small Tortoiseshell
	Polygonia c-album (L.)	The Comma
	Araschnia levana (L.)	European Map
	Cynthia cardui (L.)	Painted Lady
	Vanessa atalanta (L.)	Red Admiral
	Inachis io (L.)	The Peacock
Satyrinae	*Maniola jurtina* (L.)	Meadow Brown
	Aphantopus hyperantus (L.)	The Ringlet
	Coenonympha pamphilus (L.)	Small Heath
	Pararge aegeria (L.)	Speckled Wood
	Lasiommata megera (L.)	The Wall
Lycaenidae	*Callophrys rubi* (L.)	Green Hairstreak
	Lycaena phlaeas (L.)	Small Copper
	Polyommatus icarus (ROOT.)	Common Blue
	Quercusia quercus (L.)	Purple Hairstreak

Annex 3. List of Carabidae and number of individuals trapped in each station.

Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	tot
Cicindela hybrida LINNAEUS						5			1							6
Carabus problematicus HERBST								1			3					4
Cychrus caraboides (LINNAEUS)										3						3
Leistus ferrugineus (LINNAEUS)							4									4
Leistus rufomarginatus DUFTSCHMIDT		1						1								2
Notiophilus rufipes CURTIS							1	1								2
Elaphrus riparius (LINNAEUS)			9													9
Dyschirius angustatus (AHRENS)													1			1
Bembidion dentellum (THUNBERG)			6													6
Bembidion guttula (FABRICIUS)			1													1
Bembidion lampros (HERBST)				2								2	2	2		9
Bembidion tetracolum SAY			1		1											2
Bembidion varium (OLIVIER)			5													5
Pterostichus minor (GYLLENHAL)					1								2			3
Pterostichus niger (SCHALLER)	1															1
Pterostichus oblongopunctatus (FABRICIUS)		3						2		1						6
Abax parallelepipedus (PILLER & MITTERPACHER)		11					4			1	7		1			24
Calathus erratus (SAHLBERG)						12			6	1		3				22
Calathus piceus (MARSHAM)					1		2									3
Agonum dorsale (PONTOPPIDAN)					1											1
Agnonum gracile (GYLLENHAL)					1											1
Agnonum muelleri (HERBST)			1													1
Agonum viduum (PANZER)			9													9
Amara aenea (DE GEER)				1												1
Amara aulica (PANZER)			1													1
Amara consularis (DUFTSCHMIDT)												1		1	1	3
Amara plebeja (GYLLENHAL)				1												1
Bradycellus harpalinus (SERVILLE)															1	1
Acupalpus meridianus (LINNAEUS)			1													1
Harpalus anxius (DUFTSCHMIDT)					1											1
Harpalus autumnalis (DUFTSCHMID)	1															1
Harpalus griseus (PANZER)						1										1
Harpalus latus (LINNAEUS)			1													1
Harpalus rubripes (DUFTSCHMIDT)				1								2				3
Harpalus rufipes (DE GEER)								1								1
Harpalus rupicola STURM													1			1
Harpalus smaradginus (DUFTSCHMIDT)						4										4
Harpalus tardus (PANZER)	3					1			1			1	2	4	1	13
Panagaeus crux-major (LINNAUES)			3													3
Microlestes maurus (STURM)						16				1		4	1	3	7	32
Total																192