



Orchids in quarries and gravel pits

Colourful queens of the plant kingdom

HEIDELBERGCEMENT

Orchids in quarries and gravel pits

Colourful queens of the plant kingdom

Editor

Dr. Michael Rademacher,
Global Manager Biodiversity & Natural Resources, HeidelbergCement

Written by

INULA – Institut für Naturschutz und Landschaftsanalyse, Freiburg i. Br.

ISBN 978-3-9815050-2-3

1st edition, 2012

Table of contents

Preface.....	4
Greetings.....	6
Colourful queens of the plant kingdom.....	8
Enchanting orchids	10
Orchids – an evolutionary success story.....	12
The blueprint of beauty	14
Every orchid's ornament: the flower.....	16
The guile and wile of reproduction – Trick or treat in the orchid world	18
Small seeds with high hopes	24
Pale vampires of the plant kingdom.....	28
Protection of orchids.....	30
Orchid determination can be difficult.....	32
Orchids in Europe.....	33
Secondary habitats – protection of nature in quarries and gravel pits.....	34
Zero hour as an opportunity.....	36
Always something happening: dynamics in mineral extraction sites.....	38
Grasslands full of life.....	44
Gravel pits as surrogates for floodplains and diverse cultural landscapes	46
Soil-site conditions and plant occurrence	56
Orchids species in quarries & gravel pits.....	62
Orchid habitats	64
Warm forests and edges of woodlands.....	64
Sparsely-stocked forests	66
Wet meadows	70
Dry semi-natural grasslands	72
Moonscapes to orchid habitats: Guidelines for managers of mineral extraction sites.....	78
Responsible use of resources	80
In case of emergency: save what can be saved	82
The poorer the better.....	84
Near-natural forests instead of commercially managed forests	86
Preserving the exceptional	87
Invasive plants – they came, they established, they conquered	88
Grazing for nature conservation.....	92
Literature.....	94



Preface

During the last years the interest of many nature lovers of plants and animals living in quarries and gravel pits has markedly increased. When I and my colleagues lead excursions through our mineral extraction sites orchids are always the centre of attention of the participants. Because of the often exotic appeal of their flowers orchids are one of the most popular plant families, the Orchidaceae. Many people feel reminded of their adventurous trips to far away tropical places. Some have big collections of exotic orchids in their living rooms or greenhouses.

But few people know that Europe is home to a great variety of native orchid species as well. Therefore, amazement prevails whenever we come upon a bunch of helleborines or fly orchids at the foot of a rockface or on a dry meadow.

Orchids are not only beautiful; they also have a fascinating way of life. Many species are highly specialised with regard to the quality of the site and the insects serving as pollinators. The places where orchids grow have been subject to a strong decline in the past, and they still are. For this reason, all orchids are protected by law, and it is strictly prohibited to destroy the plants, pick their flowers, or even dig them up. In the past, mineral extraction has played a role in the disappearance of individual orchid sites. An important reason is that rural communities often encouraged the exploitation of their waste and fallow lands because in this way they could increase their revenue. The fallow lands were often dry meadows intermixed with groves and sparsely-stocked forests and of low agricultural and silvicultural value. Thus mineral extraction was welcome as a new source of income. Owing to this, valuable orchid sites were in fact destroyed in former times. Today, modern approval procedures resolve environmental issues, including biodiversity and species protection. Thereby, the destruction of significant orchid sites can be avoided. If orchid populations are affected, legislation strictly demands compensatory measures such as the creation of new orchid sites close to the quarries or the transplantation of individuals into newly created physical sites or habitats - specific environments with favourable light irradiance, microclimate, soil, hydrology, and within extraction areas.

In past years, surveys have contributed to a much better knowledge of occurrences of orchids in quarries and gravel pits. In quarries that have been re-

stored, a great variety of rare orchid species have re-established spontaneously. Some old quarries today harbour the most important orchid occurrences of a region. Surveys of the occurrences and the analysis of site factors allow us to stimulate the natural re-establishment of orchids by creating suitable habitats in the course of restoration of a mineral extraction site. This process encompasses the creation and implementation of management plans for dry meadows, groves, and sparsely-stocked forests as a prerequisite for the permanent preservation of orchids in former mineral extraction sites. An important task for the years to come is to continue data acquisition and develop new management concepts in cooperation with environmental protection agencies, non-governmental organisations, and universities.

In 2011, HeidelbergCement has entered into a partnership with the internationally acknowledged nature conservation organisation BirdLife International. Projects will be initiated for nature protection in company-owned mineral extraction sites throughout Europe. Protection and management of new orchid habitats will certainly play an important role in this concept.

I would now like to invite you cordially to enjoy this book. Like the first volume of this series that deals with dragonflies, it gives fascinating insights into the habitats within quarries and gravel pits. Photos, drawings and texts were made by biologists for citizens interested in nature. Besides applied topics such as how to design and manage orchid habitats, there is a strong focus on fascinating aspects of the biology and ecology of orchids. One final remark: Almost all photos and a big part of the results in this book come from excursions of the authors in HeidelbergCement mineral extraction sites throughout Europe.

Enjoy your reading!

Dr. Michael Rademacher
Manager Biodiversity & Natural Resources,
Global Environmental Sustainability
HeidelbergCement

Greetings

Orchids, quarries, gravel, and waters: what do these things have in common? You will find the answer in this richly illustrated second volume of the book series “Biodiversity in mineral extraction sites.” Attention is drawn to an unusual field of work that deserves more future consideration: the protection of species in their near-natural plant-animal-communities – embedded in landscape parts, which are features of industry but not completely built over. The book is about the attempt to trigger and stimulate the development of new and not just short-lived habitats under diverse soil and climate conditions, directed by habitat management actions. This initiative is demonstrated featuring the example of a highly valued and highly threatened plant family: the orchids (Orchidaceae). Orchids are globally distributed, with distinct core areas in the tropics and strongly declining towards the poles. They are one of the most species rich of all plant families, boasting between 15 and 20,000 species. This wide range in the number of scientifically acknowledged species shows how incomplete our knowledge about tropical plants and vegetation still is. Many Central Europeans know only cultivated orchid varieties – usually hybrids – in the form of potted plants or cut flowers with their showy, elegant blossoms. Most of their wild forms grow as epiphytic plants in the tops of rainforest trees where they get enough light but are adapted to temporary drought and heat – good prerequisites for resilience and longevity under indoor conditions of the

temperate zones. The “queen of flowers” was already cultivated and bred in the ancient Chinese empire (500 BC). Today, vegetative propagation plays an important role in maintaining the desired features of the hybrids. The architecture of the flowers can be studied much more easily in large flowers of tropical potted plants than in the much smaller flowers of our native orchid species. Doing this, one can recognize – maybe marveling – how similar, even identical, the architecture of the tropical and non-tropical specimens are. They all possess a flower part called a column, which is formed by one or two stamens and the stigma. The stamens produce packs of glued-together pollen grains, which cannot be transported by the wind but need the assistance of animals in order to reach other flowers of the same species. The seeds of all species, including the only crop plant within this plant family, the vanilla orchid, are produced inside capsules. A critical developmental phase is the germination of the tiny dust-like seeds. These are easily transported by the wind, but for germination they have to encounter a specific fungus supplying the young seedling with nutrients. Before germination, the seeds seem to be able to persist for some time in the soil. However, it is not well known for which species and for how long. Fungi stay important “room-mates” by living in the outer layers of the orchid’s root. The fungus delivers water and mineral nutrients to its host plant which, in turn, supplies the fungus with energy-rich, photosynthesized carbohy-

drates. Our knowledge about this fungal-root association, called mycorrhiza, and the specific fungal species involved is still fragmentary. The lack of fungal partners might account for the almost complete absence of orchids in home and botanical gardens. The vegetative profile of orchids, including morphological parts, is rather uniform. There are no woody orchids and no water orchids, the leaves are simple, and the flowers are either solitary or, in tropical species, aggregated in loose panicles. The small flowers of our native species form dense racemes, which look like flamboyant “candles” in species such as the western marsh orchid (*Dactylorhiza majalis*). With orchid habitats and site conditions being very diverse, the evolution of orchids must have produced a great variety of physiological adaptations. The ecological requirements of a given species play important roles when trying to protect the species. This book gives insights into orchid ecology and at the same time cautions against the misbelief that orchids – even if only the about 60 Central European species – could easily be supported using one method of regeneration.

The questions are: Where can orchids be introduced and conserved given the diverse regional and local environmental conditions of mineral extraction sites in Central Europe? Which habitats are suitable with regard to climate and soil conditions? Now let us scan the wide array of our plant communities where orchids occur. There are very many different orchid sites comprising such extreme ones as

storm-prone rock faces of the Alps where the alpine dwarf orchid (*Chamorchis alpina*) grows. However, calcareous semi-natural dry grasslands, i.e. grasslands that are hardly ever fertilized and mowed once a year or less, are the most important orchid habitats. They host several orchid species that occur in abundance. These grasslands are often interspersed with small copses, which increase the diversity of site conditions for both animals and plants. The tall lizard orchid (*Himantoglossum hircinum*) prefers such transition zones – called ecotones. A number of orchids grow in sparsely-stocked forests where the soil and especially the quality of the humus are very different in type and development. It can be assumed, for instance, that the lady's-slipper (*Cypripedium calceolus*) occurs most often within forests on former semi-natural dry grasslands sites because the specific root fungi needed by the orchid are still present in the soil. Certain types of pine forests can be valuable as well! Swamps, fens, and temporarily inundated areas are ecologically different habitat types, which support few but sometimes very rare and threatened orchid species. Such small habitats could easily be removed, for instance by farmers who considered them unwanted in meadows and along creeks. Among their sensitive and threatened inhabitants there were, and still are in rare cases, a small number of species that are today in urgent need of protection, e.g., the fen orchid (*Liparis loeselii*). At such sites, successful habitat management can be accomplished simultaneously for dragonflies, orchids, and other

target species for nature conservation.

Threatened plants are generally poor competitors for resources such as light, water, and nutrients. They cannot exist where dominant plants are present. Therefore, they do not occur among dense, tall, oftentimes strongly fertilized, intensively used, or otherwise disturbed vegetation. They are also absent where stinging nettles, shrub willows, and tall herbs occur in dense, uniform stands that are not threatened. Nevertheless, such stands may play an important role, especially for some animals.

Scientific findings and considerations about the history of vegetation in Central Europe have revealed that our orchids, like probably most of our native plant species, have migrated back from warmer refuges following the last ice age. In most cases, human beings were unwittingly involved. Already as hunters and gatherers they had begun to roam the light birch and pine forests and later the mixed deciduous, oak-rich forests. Along hunter's paths and trade routes the forests became more open. Later, some forest areas were impacted and sometimes destroyed by livestock pasturing. In this way, new sites were created where herbaceous species and plant communities could establish. Along with settlements – at first in loess, later in limestone regions, and finally also in mountain ranges made up of silicate rock – more and more open habitats became suitable for orchids and for different types of land use. At present, landscape fragmentation and the rarity of suitable extensively used sites keep many

species from establishing a denser network of populations. Some species may profit from the current environmental situation. For instance, some readers may have noticed the bands of yellow flowers extending along highways for many kilometres. This phenomenon is caused by an opportunistic ragwort species from South Africa which resists salt, drought, and mowing. Orchids, however, do not have such a constitution.

So, the environment of mineral extraction sites should be mapped in order to assess where potential surrogate habitats for orchids are present or where their future development could be initiated.

Still rare are well documented long-term monitoring programmes which investigate and evaluate the effectiveness of different restoration techniques of creating favourable establishment conditions. Should soil material be applied? Should the development of vegetation be initiated by planting or direct seeding? In any event, we should not forget that even if the “target orchid species” do not thrive and prosper as hoped for, chances are high that other rare plant and animal species will benefit from the new sites. Following concrete habitat management actions, surprises are to be expected. For this challenging enterprise, I wish everyone involved great success!

Prof. em. Dr. Otti Wilmanns
Universität Freiburg,
Faculty of Biology,
Department of Geobotany



Colourful queens of the plant kingdom



Enchanting orchids

Have you ever seen a flowering orchid in the wild? Some tropical representatives of this unique plant family, such as *Phalaenopsis*, have made careers as popular house plants and are a familiar sight in many living rooms. Most people, however, know little about the 300 orchid species that occur naturally in Europe. Few people have ever marveled at a “red helleborine” or a “lady’s-slipper”. But our native “queens of flowers”, distinguished by colourfulness and great variety of shapes as well as by sophisticated adaptations to their pollinators, are fascinating and beautiful study objects for botanists, naturalists, and nature enthusiasts as well.





Origin of the name

The name "**orchid**" is derived from the Greek noun "orchis" meaning testicles. This noun refers to the root tubers of the genus *Orchis* that resemble testicles. In earlier times, the upright inflorescences were also associated with phallic symbols. This led to the myth that orchids could be used as aphrodisiacs – an erroneous belief that still exists in some parts of the world.

01 A colourful rarity: the bee orchid (*Ophrys apifera*).

02 The beautiful flowers of the spotted orchid (*Dactylorhiza maculata*).

Orchids – an evolutionary success story



The orchid family, Orchidaceae, is one of the most species-rich plant families on Earth. With more than 20,000 known species globally, up to 10% of all flowering plant species are orchids. They occur on all continents except for Antarctica, and in all ecozones except for deserts.



01

01 A familiar sight: a hybrid of the popular potted plant orchid *Phalaenopsis*.

02 There are no limits to the variety of shapes in tropical orchids. This is a specimen from a botanical garden in Singapore.

Orchids are mainly distributed in the tropics, where they thrive most abundantly in rain forests. Here, they often live as epiphytes, i.e. they root on the bark of trees without harming them. They use trees as supports to reach the sunny treetops where conditions for photosynthesis are much more

favourable than on the shady forest understory and ground cover. Up to 50 orchid species have been found on one single giant rainforest tree.

Photosynthesis

Photosynthesis is the most important biochemical process on Earth. Using sunlight, plants including algae, as well as some bacteria, transform energy-poor inorganic compounds into energy-rich organic substances. In the leaf green of the plant cells, the chloroplasts, sugar, starch, and other carbohydrates are produced from water (H₂O) and carbon dioxide (CO₂), allowing plants to grow, flower, and fruit. This plant biomass is the basic food resource for animals, and thus for human beings as well. Oxygen (O₂) needed for breathing is generated as a by-product. Thus, photosynthesis is the basic prerequisite for life on Earth. Coal, petroleum, and natural gas originated from algae and plants of primeval times. The wealth of the industrial countries is mainly based on energy extraction from these fossil fuels as well as on the production of all kinds of plastics by the petrochemical industry.

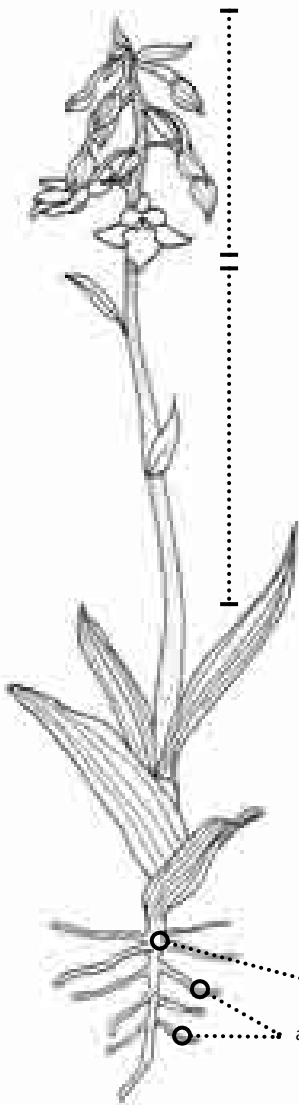
Ecozones

Global zones that are characterised by similarities in diurnal und annual climatic regime, soil composition, and vegetation are called **ecozones**. In Europe, the Mediterranean belongs to the **winter humid subtropical zone**. In Scandinavia, the **boreal zone** begins in the northernmost region, which passes into the polar zone. Central Europe belongs to the **humid temperate zone**.

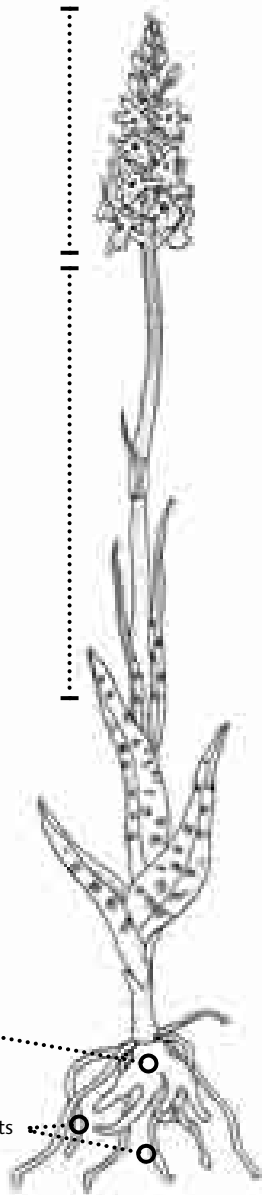


Architecture of orchids

marsh helleborine
(*Epipactis palustris*)



spotted orchid
(*Dactylorhiza maculata*)



inflorescence

flower stem

leaves

root tuber

rhizome

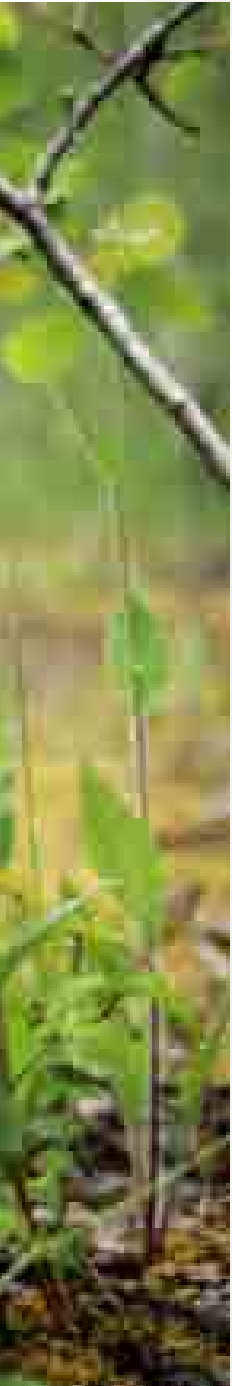
adventitious roots



The blueprint of beauty

In the temperate zones of Europe all orchids are terrestrial, i.e. rooting in the soil. Their roots lie protected in the soil and endure the winter. In orchids, the initial radicle (true root) aborts at an early stage, and rhizomes, root tubers, and adventitious roots are formed. The leaf veins, used for transportation of nutrients and water, are almost always parallel and not branched.

The inflorescence (i.e., a cluster of flowers) that makes orchids unique, is usually a panicle or raceme with the single flowers typically opening from the bottom up. Some species have solitary flowers.

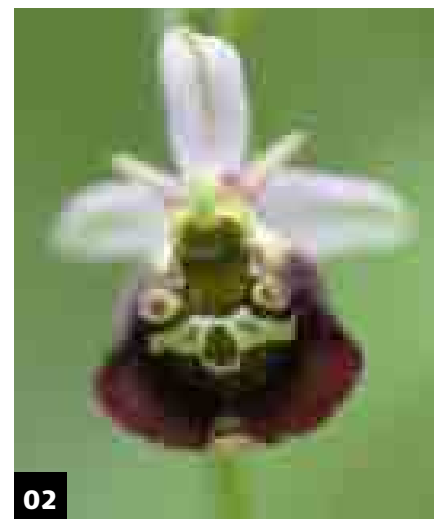


02

01 The upright flower stems of a spotted orchid (*Dactylorhiza maculata*).

02 The thick, basal root tuber and the long adventitious roots of the early marsh orchid (*Dactylorhiza incarnata*) were photographed during the process of transplanting.

Every orchid's ornament: the flower



The flowers of orchids look extravagant not only because of their often very colourful patterns but also because of their intricate shape.

The sepals and petals have completely different shapes. The lip of the flower is often divided into three or more lobes. In some orchid species, the back part of the lip forms a hose- or sacklike spur that is either filled with nectar or empty. Stamens, bearing pollen, and carpels, where the seeds will be produced, are grown together forming the so-called

column. At its tip, there are packets of pollen grains, the pollen mass or pollinia. The pollen grains are held together by a glue-like substance. These sticky pollinia become attached to insects visiting the flowers. When visiting the flowers of different individuals of the same species, pollination takes place.

Depending on the genus, orchid flowers can be very showy or relatively inconspicuous. The main flowering time of most native orchids is early in the season, May and June.

01 Each flower of the fragrant orchid (*Gymnadenia conopsea*) is borne singly compared to multiple flowers on a raceme of some other orchids.

02 The flower lip of the late spider orchid (*Ophrys holoserica*) bears a characteristic design.

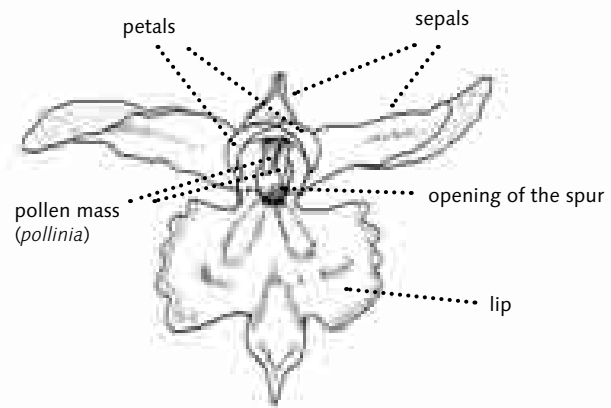
03 The flower lip of the broad-leaved helleborine (*Epipactis helleborine*) forms a "nectar dish".



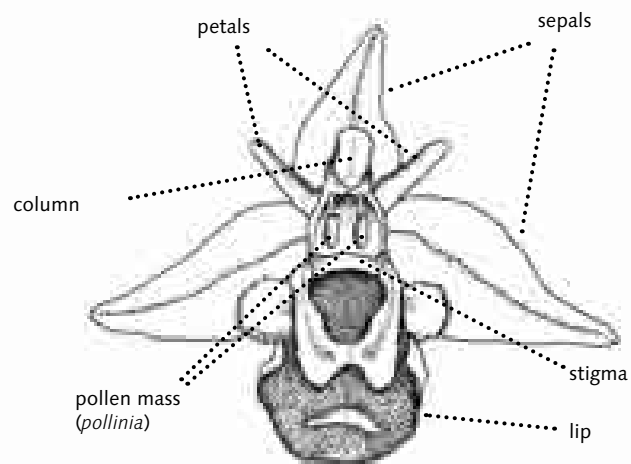
03

Architecture of orchid flowers

Dactylorhiza



Ophrys



The guile and wile of reproduction

In order to achieve fertilisation, the ultimate goal of pollination, all kinds of mechanisms have developed in different orchid species. Some species can simply pollinate themselves. In general, however, a permanent mixing of the gene pool by means of cross-pollination is mandatory for the long-term survival of any species. For this purpose, orchids have developed an array of amazing “tricks”.

Trick or treat in the orchid world

01 The flowers of the fragrant orchid (*Gymnadenia conopsea*) have long spurs filled with nectar. They are pollinated by butterflies.

02 The marsh helleborine (*Epipactis palustris*). At upper right is a hoverfly ready to land and feed on the nectar.

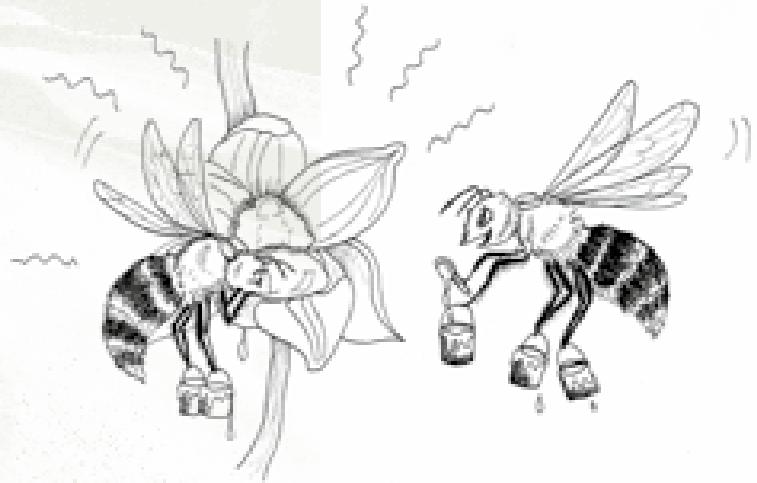


01

Pheromones and kairomones

In the animal kingdom olfactory stimuli, e.g., scents, play an important role in communication. The substances produced for this purpose, e.g., for mate selection, are called **pheromones**. They are especially widespread among insects. Usually females exude pheromones in order to attract males.

Kairomones on the other hand are substances used for interspecific communication, i.e., between members of different species. Specific fragrances emitted by plants in order to attract pollinators are a typical example.

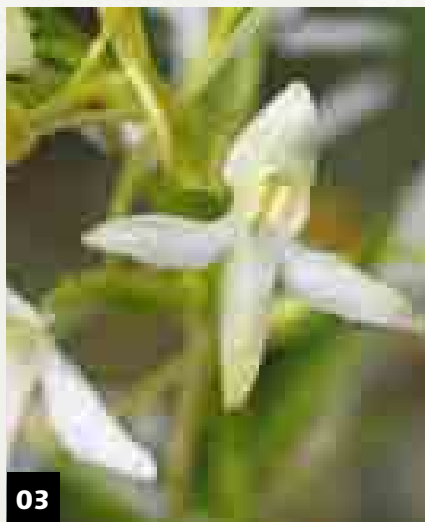


The generous ones

Helleborines (genus: *Epipactis*) are decent business partners: As a reward for insects pollinating their flowers, their lip is filled with nectar.

The night owls

The butterfly orchids (*Platanthera*), with flowers in shades of white and pale green, are comparatively inconspicuous. However, they do not depend on pretty colours at all. They put all their eggs in one basket – their captivating scent that attracts moths. They also supply the pollinators with nectar which is stored in a very elongate, thin spur.



03 The lesser butterfly orchid (*Platanthera bifolia*).

The thrifty ones

Some species, for example in the genus *Orchis*, woo pollinators with bright colours and seducing fragrances but do not offer any nectar at all. This fraud is brought to perfection by optical illusions on the petals that imitate nectar droplets.

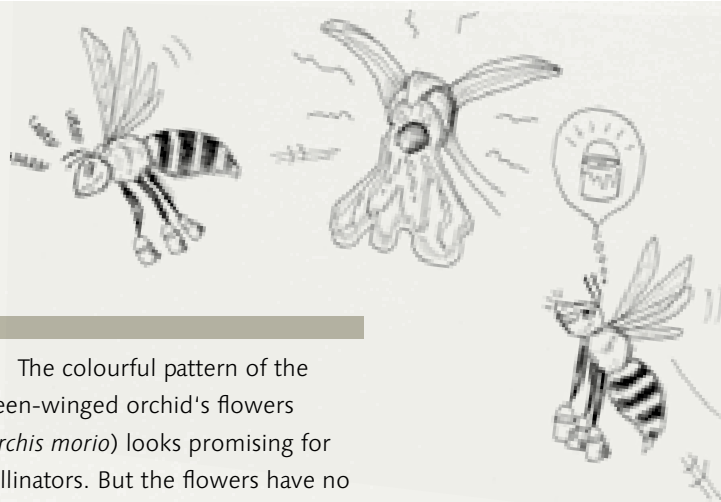


Talking plants?

The cunning broad-leaved helleborine

Hard to believe. There are plants that "call predatory insects for help" when they are infested by vermin. However, the call is not audible, and the plants emit a scent (kairomone) to attract predators of the vermin. The predators find a reliable food source, remove the vermin, and both plant and predatory insects profit by this strategy.

To insure pollination, the broad-leaved helleborine (*Epipactis helleborine*) employs a unique strategy: By imitating the biochemical "distress call" of a plant infested with caterpillars the helleborine lures parasitic wasps to itself for assistance. Usually, these wasps deposit their eggs inside the caterpillars, and their larvae feed on them. In this case, however, instead of caterpillars the wasps find the flowers of the broad-leaved helleborine. While feeding on its nectar they pollinate the orchid, and using this mutualistic strategy both partners derive benefit.



01 The colourful pattern of the green-winged orchid's flowers (*Orchis morio*) looks promising for pollinators. But the flowers have no nectar!



The possessive ones

The flowers of the lady's-slipper orchid (*Cypripedium calceolus*) act as traps. Pollinators are lured into the hollow, slipper-shaped flower lip by scents and the bright yellow colouring. As the walls inside the trap are slick and bulgy, the insects have only one escape route. It is an opening at the base of the lip where, upon passing, the insect inevitably touches stamens or stigmata of the orchid. An amazing extra feature along this route is a transparent window in the flower lip leading the insects outside. And what about nectar? No way, José!

02

02 Each flower a trap: the endangered lady's-slipper (*Cypripedium calceolus*).



01 What a cosy bed: The flowers of the red helleborine (*Cephalanthera rubra*) make ideal sleeping places for insects.

The hospitable ones

A similar effect is achieved by flowers that offer sleeping quarters, for instance helleborines of the genus *Cephalanthera*. In this case, however, the insects do not get “tricked into pollination duty” by the flowers but are offered a safe place to sleep during the night and in bad weather in return for their pollination services.

01



The marriage swindlers

Some orchids have developed a somewhat sneaky method to secure pollination. Species of the genus *Ophrys* attract male insects by imitating their females. This mutualism is accomplished in a very convincing manner. The flowers do not only mimic the insect females in shape, colour, and texture, they are also capable of emitting the pheromones of certain insect genera – a perfect illusion!

02



Orchids of the genus *Ophrys* in attracting pollinators have evolved substances with an amazing bio-chemical resemblance to sexual pheromones of certain hymenopterous insects (bees, wasps, bumble bees). They imitate the pheromones of the pollinators, thus the scents act as kairomones (see sidebar p. 19). The bee orchid (*Ophrys apifera*) is an exception, because no pollinator has ever been observed and the flowers self-pollinate.



02 This late spider orchid (*Ophrys holoserica*) is being pollinated by a bee (*Eucera nigrescens*) (photo: Hannes Paulus).

03 The fly orchid (*Ophrys insectifera*).

04 The fly orchid's flowers look just like a female wasp – at least in the eyes of this male wasp (*Gorytes spec.*) (photo: Claudia Gack).



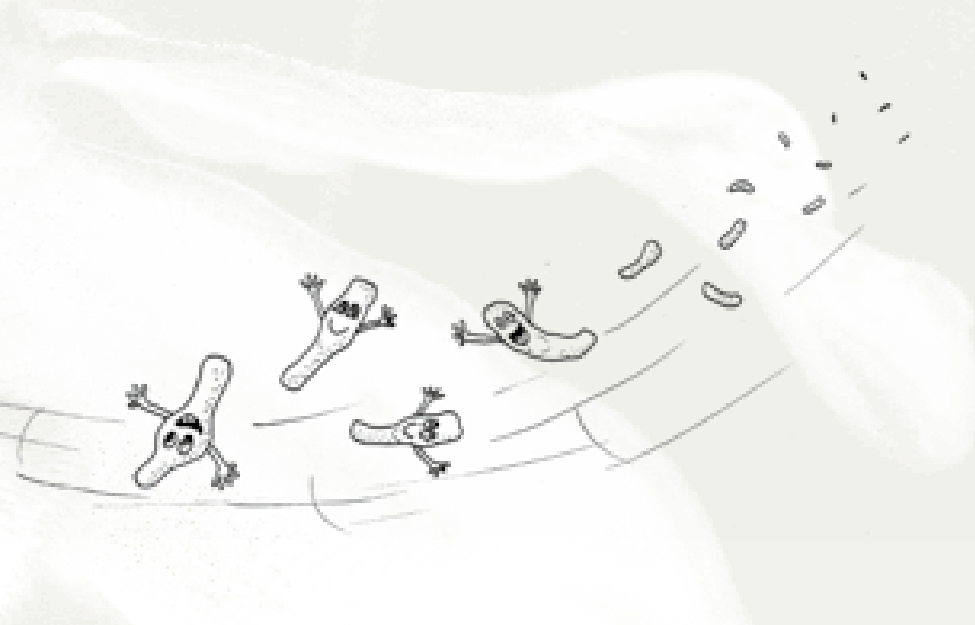
Because the flowers open shortly before the occurrence of the insect females, the deceit is even more effective. The male insects confuse the orchid flowers with females of their own species and a pseudocopulation occurs during which the pollinia get attached to the insect. The flowers of the next individual visited are pollinated.

Small seeds with high hopes

Following pollination, orchids produce huge amounts of tiny, distinctly shaped seeds, which are very light and can be transported by wind over far distances. In this way orchids can easily reach potential establishment sites. As the small seeds lack nutritive tissue, germination cannot be accomplished without external help: The seeds depend on a specific root fungus with which they enter into a symbiosis (mycorrhiza, see sidebar p. 29).

Only if this fungus is present at the establishment site, can seeds produce roots for the uptake of water and nutrients and leaves for photosynthesis. As only very few seeds happen to encounter this fungus, most seeds “starve to death”.





Orchids for dessert?

Vanilla (*Vanilla planifolia*) is an orchid species from Mexico and Central America, which today is cultivated in plantations in vast regions of the tropics. Vanilla pods have been highly esteemed since the time of the Aztecs. Embedded in the scraped-out vanilla pulp, which is used in baking, are thousands of seeds of the vanilla orchid. When these tiny black dots are visible in the dishes, you can tell that real vanilla has been used. These seeds and the vanilla pods themselves contain vanillin but also many other flavours. The synthetically produced vanilla flavourings can never replace the complex taste of the real vanilla.

Only in its original range are vanilla orchids pollinated in a natural way – by specific humming birds and bees. Everywhere else on Earth the pollen has to be transferred manually from flower to flower using a cactus needle.



02 An open capsule of the marsh helleborine (*Epipactis palustris*) with seeds, which are easily dispersed by wind.

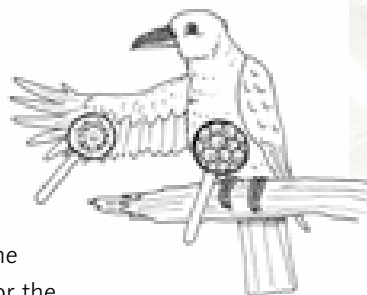
01 Following pollination orchids form seed capsules, shown here the spotted orchid (*Dactylorhiza maculata*).



Dispersal of seeds

Plants have evolved many different strategies in order to disperse their seeds to new suitable establishment sites.

The seeds of some species are transported by wind (**anemochory**). Well known examples are the seeds of dandelions resembling tiny parachutes, or the tiny orchid seeds – 100,000 orchid seeds weigh just about one gram! Some swamp and water plants use water for seed and fruit dispersal (**hydrochory**). Their seeds act like flotation devices – the coconut (*Cocos nucifera*) is a famous example.



In many cases, plants use animals as involuntary assistants for the dispersal of their fruits and seeds. Many plants wrap their seeds in tasty and energy-rich fruits. Animals feed on the fruits and transport the seeds in their gastrointestinal tract (**endozoochory**). The dung containing the seeds is deposited elsewhere and serves as a fine fertiliser when the seeds germinate. The seeds of other species are covered with bristles, small hooks or glutinous mucous substances so that the seeds stick to fur or feathers of animals and are transported to other places before they fall off or are brushed off (**epizoochory**). These holdfasts are very effective. Moreover, epizoochory is an especially "cost-effective" strategy compared to the much more energy-consuming production of fruits.

Last but not least, some plant species spread their seeds in a self-propelling style (**autochory**) – a popular representative is touch-me-not or jewelweed (*Impatiens* spp.).



**01**

01 Lizard orchids (*Himantoglossum hircinum*).

No flowers visible? There still may be orchids!

If you are a mushroom hunter you know that in some years your basket is full within minutes, whereas in other years you scramble through the woods for hours without finding a single mushroom. With orchids, it's the same story: There are good and bad "orchid years". Some orchid species do not flower every year but pause for one or even several years. The reasons for this are not completely known; damages to the roots during the winter by animals or frost may play a role. In years when an orchid does not flower it can be easily overlooked.

Therefore, several survey years are always necessary in order to achieve a reasonable overview of the orchid populations of an area.

Species notorious for not flowering each year are, among others, lizard orchid (*Himantoglossum hircinum*), late spider orchid (*Ophrys holoserica*), and bee orchid (*Ophrys apifera*).

Pale vampires of the plant kingdom

The bird's nest orchid (*Neottia nidus-avis*) has no chlorophyll and does not photosynthesise.

For this reason it has neither green leaves nor flower colours. Instead, it remains dependent on its mycorrhizal root fungus all of its life. Because the host root fungus does not profit from this relationship but is “exploited” by the orchid, it is parasitism not symbiosis.

A parasitic way of life occurs in other plant families as well. The equally colourless, brownish broomrape species (*Orobanche* spp.) resemble the bird's nest orchid. They do not parasitize fungi, however, but flowering plants, and are very host-specific.

The dainty hellweed or strangle-tare (*Cuscuta epithymum*) is also a parasite. It has no roots and has no contact with the soil. Instead it entangles the host plant and taps its sap.



Parasitism, symbiosis, and mycorrhiza

Exploitation is a common concept in nature. Every relationship between organisms that serves one side and harms the other can be called **parasitism**. Some orchid genera, such as the bird's nest orchids (*Neottia*) do not produce chlorophyll after germination but exploit their root fungus permanently without giving it anything in reward.

Some organisms enter relationships that are of mutual benefit; this is called **symbiosis**. A famous example from the animal kingdom is the clownfish living in the shelter of a sea anemone, which is poisonous for other animals. In return, the anemone is defended from its predators by the clownfish.

Symbiosis occurs in the plant kingdom as well. A good example is the so-called **mycorrhiza**, an obligate partnership between plants and root fungi. The fungus lives on or within the roots and supplies them with water and nutrients while the plant "feeds" its fungus with carbohydrates and other compounds. Plants with mycorrhizae have better access to nitrogen and phosphate. Their drought resistance is also improved owing to the mycorrhizal fungus' better capability of extracting water from the soil.



02

01 The bedstraw broomrape (*Orobanche caryophyllacea*).

02 The bird's nest orchid (*Neottia nidus-avis*).

03 The dainty hellweed (*Cuscuta epithimum*) has pretty pink flowers.



03

Protection of orchids

Orchids need protection. Not only most of the tropical species are critically endangered or on the verge of extinction. The greater part of the roughly 300 European orchid species is threatened as well. Humans are responsible for this. Destruction and deterioration of terrestrial landscapes and plant communities, intense agricultural and forestry use, and uncontrolled collecting have decimated the populations.

Because of this dramatic loss, the whole orchid family is listed in annexes I and II of CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora, also known as the Washington Convention). Import and export of orchids are, at least within the European Union, strictly regulated.





02

Natura 2000 is an ecological network of protected areas in the territory of the European Union. Its purpose is the conservation of natural habitats and of wild fauna and flora of European interest. The legal framework encompasses the **Habitats Directive** and the **Birds Directive**. The former requires the establishment of **Special Areas of Conservation (SACs)** for habitat types listed in Annex I. In Annex I are, for example, calcareous fens, semi-natural dry grasslands, or certain natural or near-natural forest types. In Annex II are individual species, among them the lady's-slipper orchid (*Cypripedium calceolus*) and the fen orchid (*Liparis loeselii*). Annex IV is devoted to species in need of strict protection outside the SACs.

01 The military orchid (*Orchis militaris*).

02 The lip of the bee orchid (*Ophrys apifera*) bears a distinctive design.

Orchid determination can be difficult

The scientific attribution of orchids to different genera or species, called taxonomy, is often difficult. Over and over again genetic studies reveal new facts leading to marked changes in taxonomy. In addition, many orchid species or even genera can produce hybrids that are sometimes fertile. This makes determination of some orchid taxa a complicated task.



01

01 When military orchid (*Orchis militaris*) and monkey orchid (*Orchis simia*) interbreed, this beautiful hybrid results: *Orchis xbeyrichii*.

02 This orchid (*Orchiaceras*) is a hybrid between man orchid (*Aceras anthroporum*) and military orchid (*Orchis militaris*).



02

Orchids in Europe



03

Orchid habitats in Europe often exhibit extremes of insolation and availability of nutrients and water. Many orchids are indicators of warm, calcareous, and nutrient-poor sites. In post-glacial landscapes of Central Europe, orchids undoubtedly first grew on unconsolidated parent material, rocky sites, and then with the development of vegetation in dry meadows, sparsely-stocked forests, which developed on inland dunes and in floodplains.

Today, such primary habitats have become extremely rare, and many orchid species depend on secondary habitats in quarries and gravel pits.




04

03 The lady orchid (*Orchis purpurea*).

04 Many orchid species require calcareous soil, which is present in this quarry.





**Secondary habitats –
protection of nature in
quarries and gravel pits**

Zero hour as an opportunity

Quarrying glacial deposits of unconsolidated materials (sand, gravel, cobbles, stones, and dense sediments of moraines) means an irreversible impact to the landscape. The soil horizons that developed over millennia in the unconsolidated glacial material

(i.e., parent material of soil) are removed, and plants and animals are expelled or killed. Existing landscapes are forever changed. However, quarries and gravel pits may develop into valuable secondary habitats for rare and endangered species within a relatively short period of time.





- 01** The little ringed plover (*Charadrius dubius*) has become rare. It can be encountered in some mineral extraction sites.
- 02** Rock face in a quarry.
- 03** The attractive field cow-wheat (*Melampyrum arvense*) grows exclusively on nutrient-poor, dry sites.

Always something happening: dynamics in mineral extraction sites



With their rock faces, gravel plains, and open, unconsolidated mineral surfaces, quarries and gravel pits have much in common with shore and inundation zones of near-natural rivers. In the unaffected, vast alluvial

plains of the post-glacial and pre-human settlement landscapes, floods created and periodically recreated a variety of different pristine habitats. High-waters uprooted trees, eroded high banks and shores, and deposited gravel and sand banks. Once waters

receded, exposed soils, ponds, and shallow-water zones remained. Pioneer species and water-dwelling organisms profited from this permanent recreation of habitats.



01 Here's looking at you, kid!
The midwife toad (*Alytes obstetricans*) has golden eyes with cat- or snake-like vertical pupils.

02 A pond with clear spring water in a quarry.

03 The males of the midwife toad carry the fertilised eggs with them until the tadpoles hatch.

04 The large thyme (*Thymus pulegioides*) has roots that go down more than one meter.



But creatures confined to dry and warm pristine habitats also found living spaces in floodplains. Gravel islands piled up during the floods often developed into dry and hot microsites on permeable substrates. When the river changed its course, these “submediterranean islands” lay above the ground water table and were extremely dry. The surrounding forest restricted air circulation and the sites could reach very high temperatures (up to more than 50°C). Site conditions were ideal for dry meadows and heaths – perfect habitats for orchids, especially over calcareous substrate. Because of the extreme conditions these sites remained open, but even when forest took over after some time similar sites were recreated in other places.





-
- 01** The Chiltern gentian (*Gentianella germanica*) grows in dry calcareous grasslands.
- 02** The rattle grasshopper (*Psophus stridulus*) lives in dry, stony areas.
- 03** The globe daisy (*Globularia punctata*) is a typical species of gravel islands in river floodplains.

**01**

01 Steep faces, reed zones, and inundated zones. All these are habitats of floodplains that have become rare. In some mineral extraction sites they are created anew.

02 The white stonecrop (*Sedum album*) thrives on unconsolidated materials.



Pioneer species

Pioneer species are plant and animal species that are capable of quickly reaching and colonising newly created habitats. **Pioneer plants** are the first to appear on disturbed soil or unconsolidated parent material. They produce huge amounts of lightweight seeds that are transported over long distance by wind, or sticky seeds that travel by waterfowl. The seeds of some species are very resistant, and buried in the soil they may remain viable for centuries. In natural landscapes **pioneer habitats** are created during floods in floodplains, or during catastrophic events such as avalanches and landslides. These habitats are not permanent so that pioneer species depend on their periodic recreation.

Today, almost all rivers and streams in Europe are straightened and regulated; shoreline stabilisation, water-retaining structures, and barrages reduce dynamic processes almost to zero. Important orchid habitats of floodplains such as temporary waters, gravel islands, and steep slopes were reduced greatly. Such sites and their inhabitants are threatened severely and need to be protected.

Grasslands full of life

In former times pasturing was much more widespread than today. It created and maintained open landscapes that bore many secondary habitats for orchids, other plants, and animals. Especially calcareous grasslands were created by pasturing livestock, particularly grazing by sheep. Where grazed pastures still exist, they offer ideal conditions for orchids, which are weak competitors and need low and sparse grass vegetation.

Intensification of agricultural land use and decreasing numbers of grazers have been leading to an ongoing decline in grasslands on poor soils and thus fewer habitats for orchids. The “amelioration” of such grasslands by fertilisation and plowing destroy many valuable habitats even today. Airborne nitrogen immissions, caused by vehicles and industry, have a negative impact on orchids as well. Nitrogen in the form of nitrate acts as a fertiliser and leads to greater growth of competing plant species.



01

They can overgrow and finally eliminate the orchids which thrive well on poor sites but are weak competitors when nutrient availability is high. When calcareous grasslands become

fallow, shrub encroachment and the shade cast by woody plants threaten orchids and cause their disappearance in the long run.



02

Grasslands are plant communities that are dominated by grasses but also contain many herbs, which enhance the typical aspect of a species-rich flower meadow. Grasslands depend on mowing or grazing for their permanent existence. Pastures and meadows are valuable habitats for many plants and animals. If they have not been plowed for at least five years, they are called **permanent grasslands**.

When grasslands in Central Europe become fallow, they are subject to succession and finally turn to forest.



03

- 01** Meadows and pastures are valuable habitats for a great variety of plants and animals. Nutrient-poor meadows can shelter orchids such as these lady orchids (*Orchis purpurea*). In order to stay open, they have to be mowed or grazed regularly.
- 02** Sheep grazing is suitable for the management of vast calcareous grasslands.
- 03** The fringed gentian (*Gentianella ciliata*) occurs most frequently in sheep pastures.

Gravel pits as surrogates for floodplains and diverse cultural landscapes

In modern times, highly dynamic conditions comparable to natural floodplains are found exclusively within extraction sites. Gravel pits, especially, with vast gravel plains that are permeable to water, resemble natural floodplains. Following exploitation, exposed mineral surfaces that serve as im-

portant pioneer sites for specialist plants are left behind. In addition, small water bodies are created which are important habitats for dragonflies, amphibians, and many other

organisms depending on water. But moist shore lines, inundated zones, and wet meadows near ponds and lakes are important habitats as well, especially for some orchid species.

01 Some areas in mineral extraction sites resemble gravel plains of pristine rivers. In this quarry, narrow-leaved flax (*Linum tenuifolium*) covers the unconsolidated materials.





02



03

02 Water bodies in mineral extraction sites are highly valuable for amphibians, dragonflies, and other animals.

03 The small bluetail (*Ischnura pumilio*) is a characteristic damselfly species of waters lacking vegetation.



02



01 Many mineral extraction sites have a dry and warm local climate because the unconsolidated materials heat up strongly, and because they are sheltered from the wind owing to their kettle-like setting.

02 A male of the chalkhill blue (*Polyommatus coridon*).

03 The goldmoss stonecrop (*Sedum acre*) on top of a steep rock face.

04 The early spider orchid (*Ophrys sphegodes*) occurs exclusively at extraordinarily warm sites.



01



04



03

Gravel pits and quarries provide important secondary habitats for both aquatic organisms and for species of hot and dry sites, including many orchids.

Generalist species and specialist species

Among plants and animals there are generalist and specialist species. **Generalist species** are comparatively undemanding and get by with a wide amplitude of light, water, soil, and nutrient conditions. On average sites, generalist plants dominate the vegetation and do not give way to specialists. The **specialist species** are not assertive at all and get the short end of the stick when forced to compete with generalist species. Therefore, they are confined to extreme sites where they grow and reproduce with very limited resources of, e.g., water and nutrients, where generalist species cannot survive. Almost all orchids are specialist species.

01





01 A large quarry in use – maybe a future El Dorado for nature?

02 The corn poppy (*Papaver rhoeas*) is known as a plant of grain fields with organic production. It also occurs on fallows or ruderal sites.



If nutrient-poor pioneer sites are well-managed, they can develop into valuable, species-rich grasslands. Particularly in limestone quarries species richness is often overwhelming. It must not be denied, however, that sometimes quarry-

ing destroys sparsely-stocked forests or calcareous grasslands that are of high value from a nature conservation perspective. In such cases it is even more important to carefully select the extraction sites. In the worst case, adequate compensatory

measures are required. Following exploitation carefully planned and executed renaturation measures are always mandatory.

01



01 Dittany, gas plant, and burning bush are some of the many common names of this beautiful, strongly fragrant plant growing in the transition zone between forests and dry meadows (*Dictamnus albus*).

02



02 The Carthusian pink (*Dianthus carthusianorum*) is a poor-site indicator.

03 The small gold grasshopper (*Euthystira brachyptera*) is another typical species of dry grasslands.

03



Succession and woody plant encroachment

Succession is the sequence of different plant or animal communities naturally occurring on a site over time. The different successional stages from the species-poor pioneer stage (see sidebar p. 43) all the way to the late-successional stage fade into one another. The mid-successional stages are particularly species rich, because species of early- and of late-successional stages blend into one another. Almost everywhere in Central Europe, forest is the late-successional stage. Valuable orchid habitats of the open landscape, such as near-natural dry grasslands that are not used or managed regularly, are always threatened by **woody plant encroachment**. Shade is detrimental to orchids that germinate and thrive in full sunlight. To reduce shade and retain, periodically, the unconsolidated materials left in the extraction process or patches of bare soil in grasslands, plant succession must be set back at regular intervals by removing woody plants or by pasturing prime habitats with goats.

Mineral extraction sites heat up during the day and stay relatively warm at night because of their wind protected shape and the high heat storage capacity of the unconsolidated material. This makes them attractive for thermophile, often Mediterranean plants and animals. In the neighbourhood of these warm and dry sites there can be shady, north exposed steep faces or humid areas. This small-scale microclimatic variety also contributes to species richness in mineral extraction sites.

In addition, in mineral extraction sites there are often different stages of vegetation succession. They range from scarce scree vegetation over ruderal vegetation to pioneer forests that can be important habitats of orchid species.



01

01 Abandoned mineral extraction sites may develop into mosaics of trees, shrubs, and herbs. In order to keep the sites from becoming overgrown, careful habitat management is necessary.

02 Diversity: a steep rock face with unconsolidated material, piles of rocks, woody plants, and pioneer vegetation.

03 This small snail (*Xerolenta obvia*) endures the heat of summer in a state of inactivity (estivation).



02



Strategies to avoid heat stress – adaptions to extreme temperature

Intense solar irradiance stresses many organisms. Extremely high temperatures at the ground surface, which may exceed 50°C, occur on sand and gravel islands of river floodplains and on the similar secondary habitats in quarries and gravel pits. Under such conditions, most plants suffer desiccation or scorching of leaves, and wilting due to excessive water loss (i.e., transpiration) may become lethal. At extremely hot and dry sites, only plants and animals with special adaptations can survive.

Plants adapted to great heat and drought are called **xerophytes**. Some of them have a waxy coating on the outside of their leaves, the cuticle. Moreover, the pores in the leaf and stem epidermis used for gas exchange, the stomata, are deeply embedded in leaf tissue to minimise water losses by transpiration. Water is stored in fleshy (succulent) leaves, the stem, or the roots. Examples include stonecrop (*Sedum* spp.) and blueweed (*Echium* spp.). Another adaptation is dense leaf pubescence, which serves as direct protection against intense solar irradiance and to reduce transpiration.

Orchids have an important advantage when competing for water with other plants on hot and dry sites because their mycorrhizal fungi allow for an improved water uptake.

Animals, too, have adapted to extreme heat. Elephants, fennecs, and many other animals have large ears used like radiators, thereby giving off heat. Apart from such physiological adaptations, many species avoid the hottest hours of the day in the protection of caves or rock crevices.

Some snails, for instance the small species *Xerolenta obvia*, endure the hottest periods of the summer in a state of inactivity (estivation, as compared to the more familiar hibernation). Thus they escape the maximum temperatures at the soil surface by climbing up plants and by sealing the opening of the shell with a calcareous lid (epiphragm).

Soil-site conditions and plant occurrence

Many plant species have well-defined soil requirements, and vegetation growing on different substrates differs greatly.

Especially in limestone quarries species richness, generally, and the abundance of orchids, specifically, are often overwhelming. Calcareous grasslands are some of the most diverse and species-rich plant communities in Europe!

01 Colourful calcareous grassland with meadow sage (*Salvia pratensis*).





02



04



03

02 The horseshoe vetch (*Hippocrepis comosa*).

03 The tufted milkwort (*Polygala comosa*).

04 The Carthusian pink (*Dianthus carthusianorum*).

In mineral extraction sites with sandstone or other low-lime substrates and acidic soils of low nutrient availability, sandy grasslands may develop. They also carry very special vegetation that is highly valuable for nature conservation.



02



01



03

01 A sandy grassland within a gravel pit.

02 The blue bonnet (*Jasione montana*) belongs to the bellflower family (Campanulacea).

03 The dwarf everlast or immortelle (*Helichrysum arenarium*).



If waters with shoal inundation zones are created in mineral extraction sites on acidic substrates, plants that are confined to bogs and fens in natural landscapes may establish, such as round-leaved sundew (*Drosera rotundifolia*) and inundated club moss (*Lycopodiella inundata*).



04 Landscape with acidic lakes – some plant species are specific for acidic soils.

05 The round-leaved sundew (*Drosera rotundifolia*) is a carnivorous plant. It catches insects with a sticky secretion that is also capable of "digesting" its prey.

Wet meadows are another type of valuable and threatened habitats harbouring several orchid species and many other plants and animals.

01 The broad-leaved cottongrass (*Eriophorum latifolium*) grows in bogs, fens, and wet meadows.

01





02

Shallow, temporarily drying-up water bodies, inundation zones, and tailings ponds within gravel pits may support specific and rare types of vegetation. These include, especially, amphibious or submersed shoreweed communities and/or annual dwarf rush communities. In the European Union, these sites are also protected as Natura 2000 habitat types (see sidebar p. 31)




03

02 Inundation zones like this one often harbour rare plants in need of protection.

03 The water mudwort (*Limosella aquatica*) is a species of inundation zones which has become rare.



A photograph of a field of purple orchids in bloom. The orchids are tall and slender, with multiple small flowers clustered along their stems. They are surrounded by green grass and other vegetation. The background is slightly blurred, emphasizing the orchids in the foreground.

Orchids in quarries and gravel pits

Orchids of Europe occur in diverse landscapes and settings, ranging from semi-natural dry grasslands and wet meadows to warm and temperate forests, and especially on calcareous loam and clay soils. Depending on the habitats that are present in a given mineral extraction site, different orchid species can be expected.

Warm forests and edges of woodlands

The lady's-slipper (*Cypripedium calceolus*) occurs together with white and red helleborines (*Cephalanthera damasonium*, *C. rubra*) in forests, warm edges of woodlands and copses. These three species typically grow in the moderate shade.

Orchid habitats





02



04



03

01 The white helleborine
(*Cephalanthera damasonium*).

02 Orchids may occur in deciduous
forests with sun spots and openings.

03 The unique flowers of the
lady's-slipper (*Cypripedium calceolus*).

04 The red helleborine
(*Cephalanthera rubra*).

Sparsely-stocked forests

Broad-leaved helleborine (*Epipactis helleborine*) and bird's nest orchid (*Neottia nidus-avis*) occur mostly in beech or hornbeam forests on loamy calcareous soils. The greater butterfly orchid (*Platanthera chlorantha*) thrives in sparsely-stocked, thermophile forests as well as in semi-natural grasslands. It indicates periodically changing availability of soil water.

The lady orchid (*Orchis purpurea*) is a thermophytic plant of moderately-shaded sites such as sun-exposed edges of woodlands.



01

01 The parasitic bird's nest orchid (*Neottia nidus-avis*).

02 The lady orchid (*Orchis purpurea*).

03 The broad-leaved helleborine (*Epipactis helleborine*).



02



03



04 In sparsely-stocked, warm beech or oak forests over limestone, orchids may be part of the ground-cover vegetation.

05 The greater butterfly orchid (*Platanthera bifolia*).



01



02



03

The spotted orchid (*Dactylorhiza maculata*) usually grows on moist sites. The twayblade (*Listera ovata*) is relatively undemanding and lives in different types of meadows, more seldom in sparsely-stocked forests as well.



04



05



06

01 A tall specimen of the spotted orchid (*Dactylorhiza maculata*) with last year's flowering stems and seed capsules.

02 The inflorescence of the spotted orchid (*Dactylorhiza maculata*).

03 The twayblade (*Listera ovata*) is a very inconspicuous orchid...

04 ...and it has tiny, delicate flowers.

05 The "nectar pots" of the dark red helleborine (*Epipactis atrorubens*)...

06 ... and the whole plant.

The dark red helleborine (*Epipactis atrorubens*) prefers sunny, calcareous, dry and warm sites at the edges of thickets and forests, various types of semi-natural dry grasslands, and rocky sites. It is one of the few pioneer species among orchids, as it is capable of colonising unconsolidated material and sparsely vegetated fallows.

Wet meadows

The early marsh orchid (*Dactylorhiza incarnata*) grows in fens and wet meadows. It is sensitive against changes in the site's water regime.



02



03



01

01 Bullrushes and shrubs interspersed throughout a wet meadow in an abandoned mineral extraction site.

02 The early marsh orchid (*Dactylorhiza incarnata*) has a yellow variety...

03 ...and, more commonly, a purple variety.



The marsh helleborine (*Epipactis palustris*) grows on usually calcareous, marshy ground. It can be found in different types of wet meadows.

04 The graceful flowers of the marsh helleborine (*Epipactis palustris*).



01

Dry semi-natural grasslands

The pyramidal orchid (*Anacamptis pyramidalis*) and the man orchid (*Aceras anthropophorum*) are typical species of dry semi-natural grasslands with high orchid diversity. Both may find suitable habitats in mineral extraction sites.

02



01 In abandoned mineral extraction sites, good habitat management may foster the development of valuable dry grasslands.

02 The pyramidal orchid (*Anacamptis pyramidalis*).

03 From a distance the flowers of the man orchid (*Aceras anthropophorum*) look unspectacular...

04 ...but at close range they resemble little manikins.

05 The lizard orchid (*Himantoglossum hircinum*) can reach a height of up to one meter.

06 The central lobe of the flower lip is formed like a tongue.



03



05



04



06

The lizard orchid (*Himantoglossum hircinum*) can be found in semi-natural grasslands, on sunny slopes, or at the edges of sparsely-stocked copses on limestone and loess soils. The flowers smell of goats. This is reflected in the plant's common name in France (orchis bouc) or Germany (Bocks-Riemenzunge).

02



The fragrant orchid (*Gymnadenia conopsea*) grows both in moist and dry sites. In mineral extraction sites, it may occur in semi-natural grasslands, for instance. It is pollinated by butterflies and moths.

01 Inflorescences of the fragrant orchid (*Gymnadenia conopsea*).

02 The long spurs are filled with nectar and adapted to butterflies as pollinators.



01



03 The "scorched" appearance of the flower buds gives the burnt orchid (*Orchis ustulata*) its name.



04 The military orchid (*Orchis militaris*) is named after the helmet-like upper parts of its flowers.

05 The late spider orchid (*Ophrys holoserica*).

06 A nutrient-poor meadow with brown knapweed (*Centaurea jacea*) and field scabious (*Knautia arvensis*).



The burnt orchid (*Orchis ustulata*) occurs in calcareous semi-natural dry grasslands. It is often accompanied by the lizard orchid and diverse *Ophrys* species. The military orchid (*Orchis militaris*) and the late spider orchid (*Ophrys holoserica*) are mostly found in semi-natural dry grasslands on calcareous loam and clay soils as well. The latter is a Mediterranean species that prefers the warmest sites.

01



The early spider orchid (*Ophrys sphegodes*) requires much light and warmth and grows mostly in calcareous dry meadows. It is susceptible to spring frost and therefore restricted to micro-

climatically especially favoured sites such as gravel islands within natural floodplains. Therefore, it also profits by the wind-protected, kettle-like settings found in many quarries.

01 The early spider orchid (*Ophrys sphegodes*), in contrast to its name, is pollinated by bees of the genus *Andrena*.

02 The name of the bee orchid (*Ophrys apifera*) implies that it is pollinated by bees. However, no pollinator has been found so far, instead, the bee orchid is self-pollinating.

03 The fly orchid (*Ophrys insectifera*) is restricted to very dry sites.



02

The bee orchid (*Ophrys apifera*) prefers calcareous dry meadows over loess and limestone. Due to its later flowering time it is less sensitive to spring frost than other *Ophrys* species.

The fly orchid (*Ophrys insectifera*) occurs most often in sparsely-stocked pine forests on calcareous soils or in montane semi-natural grasslands.




04

04 A species-rich dry grassland with adjacent copse.



03



**Moonscapes to orchid
habitats: Guidelines
for managers of mineral
extraction sites**



Responsible use of resources

Intensification of agriculture and the resulting loss of nutrient-poor grasslands, the enormous land consumption that hardly spares any unploughed field boundaries or fallow strip, and the massive use of fertilisers and biocides have brought many formerly common species of cultural landscapes to the edge of extinction. In monotonous and poorly structured landscapes, mineral extraction sites may play an important role as refuges for species of forest edges, field margins, meadows, and pastures.

However, quite a few things have to be considered in order that mineral extraction sites can fulfil this function. The primary objective has to be to

create and permanently maintain a mosaic of different habitats in existing and new quarries and gravel pits that is as diverse as possible.

01 The common flax (*Linum usitatissimum*) and bird's-foot trefoil (*Lotus corniculatus*) in a quarry.



**02****03**

02 A restored natural zone with newly established greenland in a quarry.

03 The chalkhill blue (*Polyommatus coridon*).

In case of emergency: save what can be saved



If the destruction of valuable habitats for mineral extraction purposes is inevitable, topsoil and vegetation can be transplanted to suitable compensatory sites nearby. First, specialists have to select a permanently secured site as close as possible to the mineral extraction site which is fit for the habitat transplantation and successful regeneration with regard to soil conditions, water and light availability. The carefully

peeled-off topsoil and vegetation are applied onto this site and subsequently managed in such a way that the species can regenerate optimally and establish permanently.





Surveys for valuable plant populations in areas subject to exploitation have to be carried out for several years, because some orchid species do not flower every year (see sidebar p. 27).

As shown in the following section, some other plant species can also be transferred to compensatory sites via their seeds.

01 Orchids are being transplanted from their original site and taken to a new habitat. They are carefully removed, intact with soil, and transported to the new site in the caterpillar's shovel.

02 Early marsh orchids (*Dactylorhiza incarnata*). The hood-like leaf-tips are characteristic for this species.

The poorer the better

As a matter of principle, the unconsolidated material and rocks in quarries and gravel pits must not be covered with humus-rich topsoil or other material, because nutrient-poor grasslands serve as habitats for many endangered plant and animal species and are therefore highly valuable for nature conservancy issues.

Unfortunately, sites with marginal agricultural yields keep disappearing from our agricultural landscapes where the focus is on profit maximisation – either by abandonment of use or, more often, by intensification, i.e., heavy fertilisation or even ploughing of grasslands.

When establishing new semi-natural dry grasslands, the best results are achieved by “inoculation” with grass clippings taken from sites nearby if possible. The freshly mowed grass is removed from its original site and distributed at the prepared new site. Upon drying, the seeds are shed and germinate at the new site. The de-

composing plant material serves as an ideal seedbed and provides organic matter that conserves water.

Any management action for orchids has positive effects on other plants and thereby on animal species as well.





01 South-facing forest edges, especially in limestone zones, have a high potential for orchids, here military orchids (*Orchis militaris*).

02 Unconsolidated materials are being "inoculated" with seeds of grassland species by disseminating grass clippings.



03

03 The conspicuous caterpillars of the puss moth (*Cerura spec.*) are most often to be found near forest edges.

04 A mosaic of mowed and unmowed zones is favourable for many species, including butterflies and grasshoppers.



04

Near-natural forests instead of commercially managed forests



In most cases, open country is of higher value for rare plants and thermophile animals than woodlands. However, as pointed out earlier in this book (see pages 64 to 69), some orchid species thrive in

sparsely-stocked forests, and woodlands can also be extremely valuable for mammals, including bats, as well as birds and many other animals.

When reforesting areas where woodland has fallen victim to extraction

activities, commercial aspects should be restrained. Instead, natural woodland types adapted to the site and characteristic for the region and the natural landscape should be established.

Preserving the exceptional

Rare or special sites with high nature conservation value that should by all means be managed carefully and maintained permanently are, among others:

- Shallow, seasonally drying-up water bodies; inundation zones and tailing ponds; and incipient calcareous fens with orchids and rare annual species of wet sites. Permanent management of these sites usually requires dredging or the use of bulldozers, cutting of woody plants, or extensive grazing.
- Dry, sandy and gravelly fields within gravel pits. They may often host a high diversity of wildflowers, which were once typical for arable fields but have become very rare because the fields have been treated with fertilizers, pesticides, and herbicides. In some cases, the above mentioned open gravel fields should be tilled periodically to permanently preserve the specialised plants and animals occurring there.
- Rock faces in quarries where pioneer vegetation can establish for relatively long periods of time.



02

01 An early stage of forest succession in a quarry.

02 Unconsolidated materials, piles of rocks, and sun-exposed slopes can be very valuable habitats.

Invasive plants – they came, they established, they conquered

Many plant species are not native in certain regions but have been introduced by humans either on purpose or accidentally. In many cases, these newcomers, called neophytes, exotics, aliens, or invasives, were not able to establish stable and reproducing populations owing to an unsuitable climate and other factors. However, some of these have spread rapidly since their introduction and now pose a serious threat to native species and affect certain habitat factors. The Himalayan balsam (*Impatiens glandulifera*), for example, spreads readily along different types of standing waters and water courses. It grows very tall and may shade and finally replace the original vegetation. Canada goldenrod and giant goldenrod (*Solidago canadensis*, *S. gigantea*) can invade dry semi-natural grasslands, form dense stands, and subsequently outcompete the native plant species. Japanese knotweed and giant knotweed (*Fallopia japonica*, *F. sachalinensis*) are extremely competitive species on moist sites. They do not produce seeds but display exclusively vegetative reproduction, i.e.,

the plants can regenerate easily even from small root parts. Once established, the knotweed fans out quickly with belowground rhizomes and is very resistant against most methods of weed control. The black cherry (*Prunus serotina*), a North American

species, spreads rapidly and has become a problem, especially in areas with sandy soils. Following cutting, the black cherries regenerate quickly from root suckers. Therefore, it takes much effort to eradicate this invasive species.



Bad aliens may threaten your health

Giant hogweed (*Heracleum mantegazzianum*) is a dangerous special case among invasive plants as it produces a toxic milky sap that reduces our skin's UV protection. If you come into contact with this sap, sunlight can trigger skin rashes and, in sensitive persons, even burns. Therefore, this plant should be eradicated as soon as it appears for the first time at a site. Common ragweed (*Ambrosia artemisiifolia*) is another dangerous newcomer because its pollen can trigger strong allergic reactions in many people with hay fever, in very low concentrations of 5 to 6 pollen grains per cubic metre of air. When removing these plants, protective clothing including gloves and face protection is important.



02



03

01 Donkeys serve as landscape workers in a quarry where lots of withered giant goldenrods (*Solidago gigantea*) grow.

02 Inflorescences of the giant goldenrod; the upper flowers have produced seeds already.

03 The giant hogweed (*Heracleum mantegazzianum*) is only to be handled with gloves because of its phototoxic sap.



A common trait of invasive species is that they are rarely eaten by native insects or other wild animals. So they are of little use in the food chain and herbivores can seldom if ever regulate their populations. Fortunately, some invasive plants can effectively be controlled or eliminated by livestock grazing, especially goats.





Introduced species – archaeophytes, neophytes, and invasives

Plant species that are non-native in Europe are differentiated depending on their date of arrival. Plants that were introduced prior to 1492, when Christopher Columbus discovered the New World, are termed **archaeophytes**. Plants that arrived in Europe after that point of time are called **neophytes**, invasive, exotic, or alien species.

Many **archaeophytes** in Central Europe have their origin in the Mediterranean Basin and Western Asia and were usually introduced unwittingly by humans with cereal seed. They are by now considered as integrated parts of the native flora. Among them are many wild herbs of arable fields such as the cornflower (*Centaurea cyanus*) or the German chamomile (*Matricaria chamomilla*).

Neophytes often stem from North America. They have come and keep coming to Europe as ornamental plants or crop plants, or as "stowaways". Examples are the devil's trumpet (*Datura stramonium*) and the common evening primrose (*Oenothera biennis*). Some exotic plants spread rapidly and abundantly and deserve to be termed invasive species, whereas others blend into the native flora without harming or changing it significantly.

- 01** The Himalayan balsam (*Impatiens glandulifera*) has attractive flowers with much nectar and is therefore popular among beekeepers. However, it forms dense stands in wet sites that can completely displace native plants.
- 02** The common ragweed (*Ambrosia artemisiifolia*). Its pollen is a very strong allergen.
- 03** Japanese knotweed (*Fallopia japonica*) occurs regularly at landfills and garbage dumps. Along flowing waters, the plants pose a problem, because, in contrast to the finer roots of native shore plants, its rhizomes do not stabilise the shores. Because a huge clone may develop from one small piece of rhizome, it is important to make sure that none of its plant parts are introduced to new places with soil sticking at tractor tyres or caterpillar tracks.

Grazing for nature conservation

Maintenance of valuable grasslands is accomplished by regular mowing and removal of the material is necessary, otherwise shrub succession is just a matter of time. To restore grasslands

overgrown by woody plants, grazing by goats and other livestock, as well, can be a good option. Goats prefer young plant material and reduce shrubs in a gentle manner. Partially open landscapes that are interspersed

with copses and shrubs are highly valuable for nature conservation. Because they provide cover and food for many bird species they should be protected and preserved.





02

Ecotones and the edge effect

If grasslands are not used or managed regularly, tall forbs and woody plants take over. Such complexes of dry semi-natural grasslands, marginal vegetation, and bushes can be highly valuable for the protection of nature. Many animal species profit by an increase in plant and structural diversity, because they need a mosaic of low and tall vegetation, sunny and shady spots for foraging, mating behaviour, breeding locations, shelter, and so on. The increase of species diversity in richly structured areas is called **edge effect**. Without any kind of land use or management, however, such areas soon turn into uniform copses and finally woodland – resulting in losses of richly structured transition zones (termed **ecotones**) and borderlines.

The first step in the design of a management plan is that specialists evaluate the site, record the species that occur at the site or in its surroundings, and define target species and their vegetative communities. In order to achieve the nature protection objectives, a management plan has to be developed and implemented. A monitoring programme needs to be carried out to evaluate the effectiveness of the management plan. It also provides data that can be used to update and improve the plan. In many of our gravel pits and quarries, such so-called Biodiversity Action Plans (BAP) exist already today.

01 Goats are very useful cooperators in severely pruning back, even killing, woody plants that encroach on orchid habitats.

02 Steep faces, piles of rocks, woody plants, and greenland – this quarry has high habitat diversity with many edges and ecotones.

Literature

BAUMANN, H. & S. KÜNKELE (1988): Die Orchideen Europas – Franckh (Stuttgart), 191 pages.

BRESINSKY, A., C. KÖRNER, J.W. KADEREIT, G. NEUHAUS & U. SONNEWALD (2008): Strasburger – Lehrbuch der Botanik, 38th edition – Spektrum Verlag (Heidelberg), 1176 pages.

BUTTLER, K.P. (1986): Orchideen – Die wildwachsenden Arten und Unterarten Europas, Vorderasiens und Nordafrikas – Mosaik Verlag (München), 288 pages.

DANESCH, E. (1972): Orchideen Europas/Mitteleuropa – Hallwag Verlag (Bern), 263 pages.

DRESSLER, R.L. (1987): Die Orchideen – Bechtermünz Verlag (Augsburg), 394 pages.

DÜLL, R. & H. KUTZELNIGG (2011): Taschenlexikon der Pflanzen Deutschlands. Ein botanisch-ökologischer Exkursionsbegleiter, 7th edition – Quelle & Meyer Verlag (Heidelberg/Wiesbaden), 590 pages.

EBERLE, G. (1954): Die Orchideen der deutschen Heimat – Senckenberg-Buch (Frankfurt) 30, 149 pages.

ELLENBERG, H. & C. LEUSCHNER (2010): Vegetation Mitteleuropas mit den Alpen: In ökologischer, dynamischer und historischer Sicht, 6th edition – UTB (Stuttgart), 1357 pages.

KIRCHNER, O. (1911): Blumen und Insekten – Ihre Anpassungen aneinander und ihre gegenseitige Abhängigkeit – BG Teubner-Verlag (Leipzig), 436 pages.

KLÜBER, M. (2009): Orchideen der Rhön – Edition Alpha Verlag (Künzell), 256 pages.

NOVAK, N. (2010): Heimische Orchideen in Wort und Bild – Leopold Stocker Verlag (Wien), 31 pages.

LFU (LANDESANSTALT FÜR UMWELTSCHUTZ BADEN-WÜRTTEMBERG) (2000): Vom Wildstrom zur Trockenaue – Verlag Regionalkultur (Ubstadt/Weiher), 496 pages.

LINCOLN, R., G. BOXSHALL & P. CLARK (1998): A Dictionary of Ecology, Evolution and Systematics. 2nd ed.; Cambridge University Press, Cambridge, UK, 361 pages.

REINEKE, D. (1993): Der Orchideenbestand des Großraumes Freiburg i. Br. – Beihefte Veröffentlichungen Naturschutz und Landschaftspflege Baden-Württemberg 33 (Karlsruhe): 128 pages.

REINHARD, H. R., P. GÖLZ, R. PETER & H. WILDERMUTH (1991): Die Orchideen der Schweiz und angrenzender Gebiete – Fotorar AG Druck + Verlag, 348 pages.

SCHOONHOVEN, M. L., J.J.A. VAN LOON & M. DICKE (2005): Insect-Plant-Biology – Oxford University Press, 421 pages.

SEBALD, O., S. SEYBOLD, G. PHILIPPI & A. WÖRZ (1998): Die Farn- und Blütenpflanzen Baden-Württembergs (Band 8). Ulmer Verlag (Stuttgart), 540 pages.

SUNDERMANN, H. (1981): Europäische und mediterrane Orchideen – Brücke-Verlag, 243 pages.

WARTMANN, B. A. (2008): Die Orchideen der Schweiz – Haupt Verlag, 246 pages.

WILMANN, O. (1998): Ökologische Pflanzensoziologie – Eine Einführung in die Vegetation Mitteleuropas, 6th edition – Quelle & Meyer-Verlag (Wiesbaden), 405 pages.

WITHNER, C. L. (1974): The Orchids – Scientific Studies – John Wiley & Sons Press, 604 pages.

Internet sources: www.wikipedia.de, www.scinexx.de

Special literature

Sidebar “Talking plants? The cunning broad-leaved helleborine”: BRODMANN, J., R. TWELE, W. FRANCKE, G. HÖLZLER, Q. ZHANG & M. AYASSE (2008): Orchids mimic green-leaf volatiles to attract prey-hunting wasps for pollination – *Current Biology* 18 (10): 740-744.

Imprint

ISBN 978-3-9815050-2-3

Editor

Dr. Michael Rademacher,
Global Manager Biodiversity & Natural Resources, HeidelbergCement

Production

INULA – Institut für Naturschutz und Landschaftsanalyse, Freiburg i. Br.
www.inula.de

Conception

Dipl.-Biol. Dr. Holger Hunger & Dipl.-Biol. Franz-Josef Schiel (INULA),
Dipl.-Biol. Dr. Michael Rademacher (HeidelbergCement)

Layout, setting, design

Werbeagentur ServiceDesign, www.servicedesign.eu

Text

Dipl.-Biologen Kerstin Geigenbauer, Dr. Holger Hunger & Franz-Josef Schiel (INULA)

Translation

Dr. Holger Hunger

Scientific language advisor

Prof. Dr. Burton V. Barnes, Ann Arbor, Michigan (USA)

Drawings

Dipl.-Biol. Kerstin Geigenbauer

Photographs

Franz-Josef Schiel (71 photos); Dr. Holger Hunger (50); Dr. Michael Rademacher (3); Dr. Claudia Gack (1);
Prof. Dr. Hannes Paulus (1); Gaby Rehm (1); David Veer (1); Gerhard Veer (1).

Cover picture: Lady's-slipper orchid (*Cypripedium calceolus*). Photo by Franz-Josef Schiel.

Recommended form of citation

INULA (2012): Orchids in quarries and gravel pits. – Biodiversity in mineral extraction sites, volume 2.

Editor: M. Rademacher, Global Management Biodiversity and Natural Resources, HeidelbergCement, 98 pp.

HEIDELBERGCEMENT





ISBN 978-3-9815050-2-3



9 783981 505023 >