THE KRKONOŠE MOUNTAINS AT NIGHT

SPRÁVA KRKONOŠSKÉHO NÁRODNÍHO PARKU

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The Krkonoše Mountains at Night ...or what happens in the Krkonoše Mountains when the sun sets?

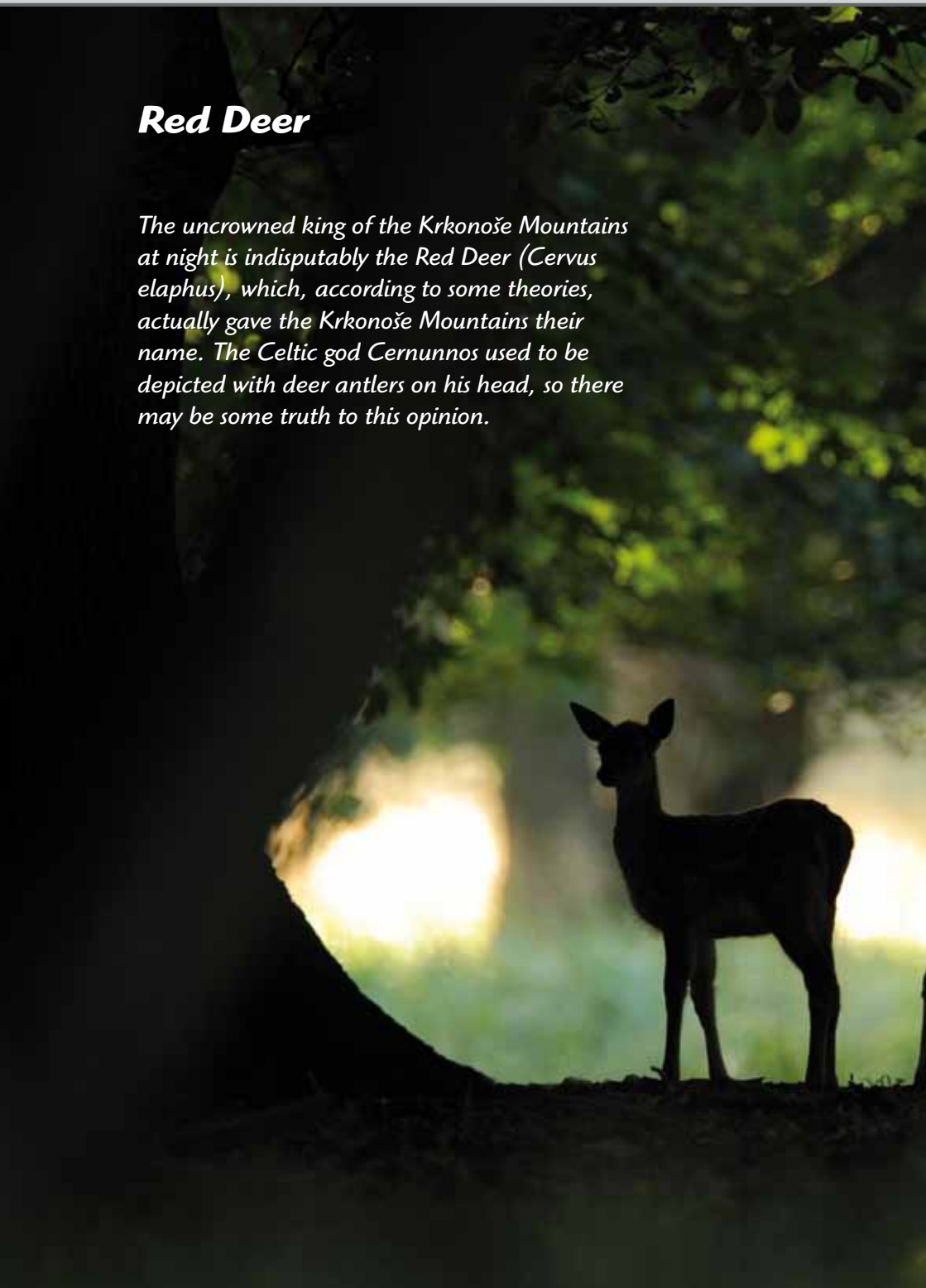
The nocturnal life of animals is at least as exciting as the day-time life. However, most people know nothing about it. Only a handful of people know what happens on the ridges of the Krkonoše Mountains, in the mountain valleys and on the meadows, in the areas surrounding the mountain chalets or in the deep forests. Yet everyone has access to this secret world – you simply have to know what to look for and where to go.

The thunder of hooves, mysterious shrieks, hooting or eerie snorting is just a modest trace of what takes place after dark in the Krkonoše Mountains. The secret life of nocturnal animals is fascinating and simultaneously shrouded in mystery. Typical nocturnal animals of the Krkonoše Mountains include species of rodent, bats and owls. But some insect species will also surprise you with their activities after dusk.

The Krkonoše Mountains are a Noah's Ark in the heart of Europe, which is most active when people go to sleep. There are a number of reasons why animals are most active at night. While diurnal animals hunt, feed and reproduce during the day, and renew their energy at night, nocturnal animals are more active after dusk. It is no coincidence that many mammals have some nocturnal traits. This is a result of evolution during the last several million years, when animal species were forced to adapt to new conditions and the characteristics of nocturnal animals were appreciable. For example, sensitive eyes were useful for surviving sudden climate changes, a trait also appreciated by birds, fish, invertebrates and insects. The nocturnal activities of mammals are conditional to a specific degree to the varied nocturnal activities of insects. A number of rodents, such as the Common Mole, the Western Hedgehog, the Common Shrew or Alpine Shrew are insectivores. They eat various invertebrates, particularly earthworms and insect larvae. The very active and very rare Krkonoše Mountains Door Snail, which is highly active at night, and a number of butterfly species are also worth mentioning.

Red Deer

The uncrowned king of the Krkonoše Mountains at night is indisputably the Red Deer (Cervus elaphus), which, according to some theories, actually gave the Krkonoše Mountains their name. The Celtic god Cernunnos used to be depicted with deer antlers on his head, so there may be some truth to this opinion.



Antlers are the most typical feature of males.

It is not such a big step from the name Cernunnos to “Kéerkonoš”. The Red Deer is easily the biggest wild animal in the Krkonoše Mountains, but the deer only dare to wander into open areas at night. During the day they lie in the forest undergrowth, where they rest and sleep. At night they rule the meadows and also the plains on the mountain ridges, known as the arctic-alpine tundra. Groups of stags and hinds with fawns graze separately for most of the year. They either seek food early in the morning or at dusk, primarily eating grass, shoots, leaves and also young trees and lichen. Red Deer have no natural predators in the Krkonoše Mountains, which is why their numbers must be monitored continuously and they need to be regulated if there are too many of them. If they become overpopulated they cause considerable damage to the forest growth, particularly during the summer. During winter they are usually found in game parks where they are regularly fed by gamekeepers. Red Deer are most interesting during the rutting season. From the middle of September until the beginning of October, mainly after dusk, there is no doubt who is king of the Krkonoše Mountains. Their loud roaring can frequently be heard over a distance of several kilometres. The loud noises made by the stags are part of the battle to see which male will rule the harem of hinds. The deer rut is nothing else than the mating season. Roaring can most frequently be heard at dawn or at dusk, when the deer are most active. In the Krkonoše Mountains this mainly occurs at altitudes of between 1,100 and 1,400 metres.

Roaring can most often be heard at dawn or, on the contrary, at dusk

Krkonoše Mountains Door Snail

This rare snail is endemic to the Krkonoše Mountains and is not found anywhere else in the world. The Krkonoše Mountains Door Snail (Cochlodina dubiosa ssp. Corcontica) is an animal with a very fitting name.

Cochlodina dubiosa lives in old close-to-nature broadleaved or mixed woods

This snail, which is only 15 mm long, avoided attention for some time before it was described in 1967 as an endemic subspecies of the Krkonoše Mountains. Its habitat is the local, deciduous or mixed forest at an altitude of 600–800 m, where it hides beneath the bark of dead trees. This Door Snail can be found in greater numbers in the East Krkonoše Mountains in the Rýchory area, but has also been found in Obří důl valley. It crawls to the surface and grazes on algae growth or other organisms after rain, but mainly at night when it is damp. The door snail is registered in the Red List of endangered species of the Czech Republic.

Herald Moth

This animal is difficult to see during the day, as it rests on the tree bark or among the leaves, but at night it rules the sky. We are talking about moths, of which there are tens of species in the Krkonoše Mountains.

The herald is a butterfly of brown-orange colour with marked light transverse lines and a white dot on the forewings.

An important species of moth is the Herald Moth (*Scoliopterix libatris*), a moth of about 4 cm from the Erebidea family. You can recognise it by the large orange blotches on its wings, two white spots and two white wavy lines across its wing. This is a moth native to parks and gardens, but you can also find it at the edges of forests and near streams and rivers. There are approximately 1,000 species of butterfly in the Krkonoše Mountains and it is assumed that the actual number of species may be up to thirty percent higher. There are even butterflies living in the extensive area of the subalpine zone, and they are among the group of insects most affected by changes to the landscape in relation to how traditional methods of agriculture and forestry are being abandoned. Even though the situation is gradually improving, a number of formerly common and widespread species are now rare and frequently endangered over entire extensive areas.

Short-winged Firefly

We are all familiar with this insect from Czech fairy tales. Sometimes they appear as little lights bringing hope, at other times they appear as treacherous willow-the-wisps. Yes, we are talking about fireflies.

The common glow-worm is a beetle of brown to black colour with pinkish membranes between the segments

There are three species of insect in the Czech Republic – the Lesser Firefly, the Greater Firefly and the Short-winged Firefly. The last of these (*Phosphaenus hemipterus*) – the rarest of the three species – has been found in the Château park in Vrchlabí and in Podhuří. The manner in which they emit light differentiates males from females. Males fly, or in the case of the Short-winged Firefly, crawl like bright points of light looking for the females, who glow brighter than the males and stay still, but flash through the vegetation. The females have to glow so that the males can see them from a distance and move towards them. When they find each other, the female stops emitting light and the pair mates in the dark. God forbid if another female starts glowing nearby. Then the male leaves his current dim female and flies after the glowing one. How typical of human behaviour also... The fireflies emit light generated as a result of a chemical reaction taking place in their bodies. It is caused by a substance called luciferin, which the insects have in special cells below their transparent skin. When luciferin is split by the enzyme luciferase it generates energy, and this is radiated as light. The sexes not only differ in the manner in which they emit light, but also in the fact that only one abdominal segment glows in the males, while two abdominal segments glow in the females, complemented by lateral glowing fields on other segments. These Midsummer beetles are most active in summer. You have the biggest chance of seeing fireflies on warm nights in June (around the holiday of Saint John), July and August. They glow from dusk until the early morning.

Eagle Owl

The owl is the perfect nocturnal animal, protected by its colour and its life style. Owls have the reputation of being silent, invisible, solitary nocturnal hunters.

The eagle-owl has a wingspan of 140–170 cm

The night is their day and the day their night, and they have excellent traits for living like this. Apart from having wonderful eyesight, they also have perfect hearing, without which they would be unable to hunt at night. Large, forward-facing eyes are typical for these animals, as well as the ability to turn their heads by 270 degrees. Nature has also gifted them with soft feathers, which help them fly almost silently. A number of owl species live in the Krkonoše Mountains: the Eagle Owl, Tawny Owl, Tengmalm's Owl, Pygmy Owl and others. These owls grow to various sizes – from the smallest, which are a maximum of 15 cm tall, to species that are nearly three quarters of a metre in height. They are usually at home in mixed or coniferous forests or in abandoned quarries. It is interesting that they do not build nests but instead lay eggs in hollows in trees or use old nests abandoned by other birds of prey. The largest of the owls is the Eagle Owl, also known by its Latin name Bubo bubo. In the Krkonoše Mountains this owl nests just once a year at altitudes of up to 700 metres. It lays a maximum of four eggs and only a few of the chicks reach adulthood. This is why the Eagle Owl is an endangered and very rare species. With regard to hunting, Eagle Owls eat a great range of animals from mammals up to the size of hares, through amphibians and other predators, to other owls. However, they specialise in hunting hedgehogs. The noisy hedgehog is also active at night and is therefore an easy target. The smallest Krkonoše Mountains owl is the Pygmy Owl. It is slightly smaller than a sparrow and is distinguished by its speed and agility. It occurs in the Krkonoše Mountains up to altitudes of 1,000 metres. On the contrary to the Eagle Owl, the Pygmy Owl prefers glades or copses in an agricultural landscape. It is also distinguished from other owls by its diurnal activity. It eats small mammals and birds up to the size of a finch. Looking for owls is hard work, not only at night. The only clue you can rely on is their so-called "pellets", cylindrical masses, similar to faeces, which the owls regurgitate. These contain all the indigestible remains from the owl's food.

It is the largest owl living in our country

European Hedgehog

The European Hedgehog (Erinaceus europaeus) is a typical nocturnal animal. It is one of the noisiest mammals. During the daytime it usually remains hidden in a mound of leaves or branches; at night it goes hunting.

The European hedgehog is the largest of the insectivores living in our country

It is given away by its noisy stamping and snorting, which tends to be fateful. It is the prey of many predatory animals and birds of prey. It becomes even noisier during the mating season, which is when the usually solitary hedgehogs spend more time together. The mating season lasts from May to October. First of all the male chases the female, then he bites her and bumps into her, he hisses, spits and waits for the right time to mate with her. The European Hedgehog is fairly common in the Krkonoše Mountains. You can encounter this species at altitudes of up to 800 metres, sometimes even up to 1,100 metres. Its territory consists of the edges of forests, meadows, bushes and also the areas around Krkonoše Mountains chalets. It is an omnivore, but prefers invertebrates such as slugs, worms, beetles and other insects. When it feels threatened it rolls into a ball, relying on its spines as protection.

Wild Boar

Another actor in the nocturnal theatre of the Krkonoše Mountains is the Wild Boar (Sus scrofa). These animals are also most active at night, and usually rest or sleep during the day.

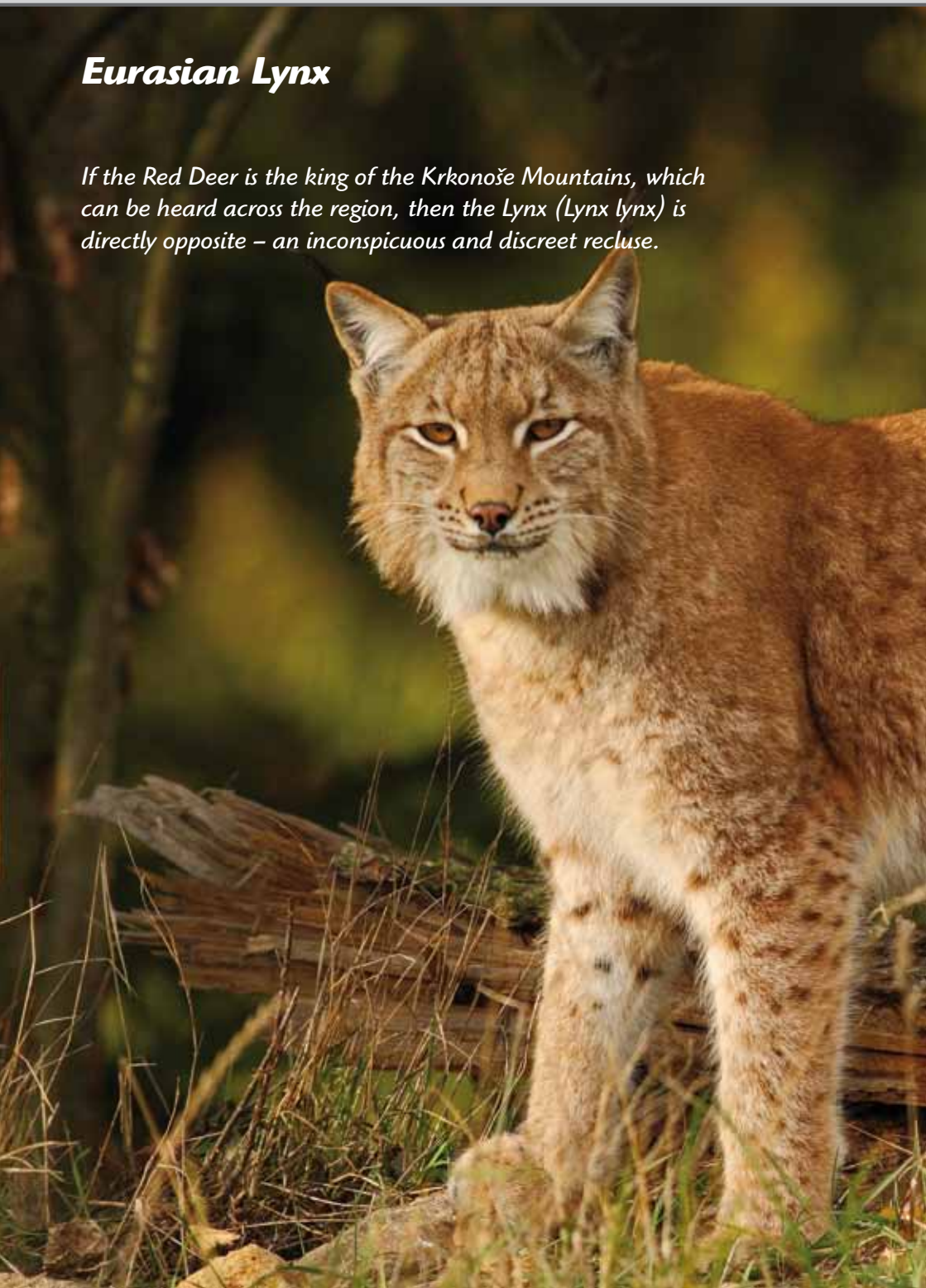
The wild boar weighs up to 200 kg

They mostly remain in areas where they can find enough food. They have no problem finding such places in the summer, even in the mountains. They are a quite numerous wild species in the Krkonoše Mountains, which is why the park administration is required to regulate their numbers.

A distinctive trait of these animals is their coat consisting of dense bristles, which protect them against inclement weather. Their coat is much thicker and darker in the winter. Their ferocity is chiefly emphasised by their four distinctive triangular tusks, which curve upwards as they grow in length. These are mainly used as an effective weapon during fights and can grow up to twenty-five centimetres long in the males. The Wild Boar has an excellent sense of smell and hearing; its most poorly developed sense is its sight.

Eurasian Lynx

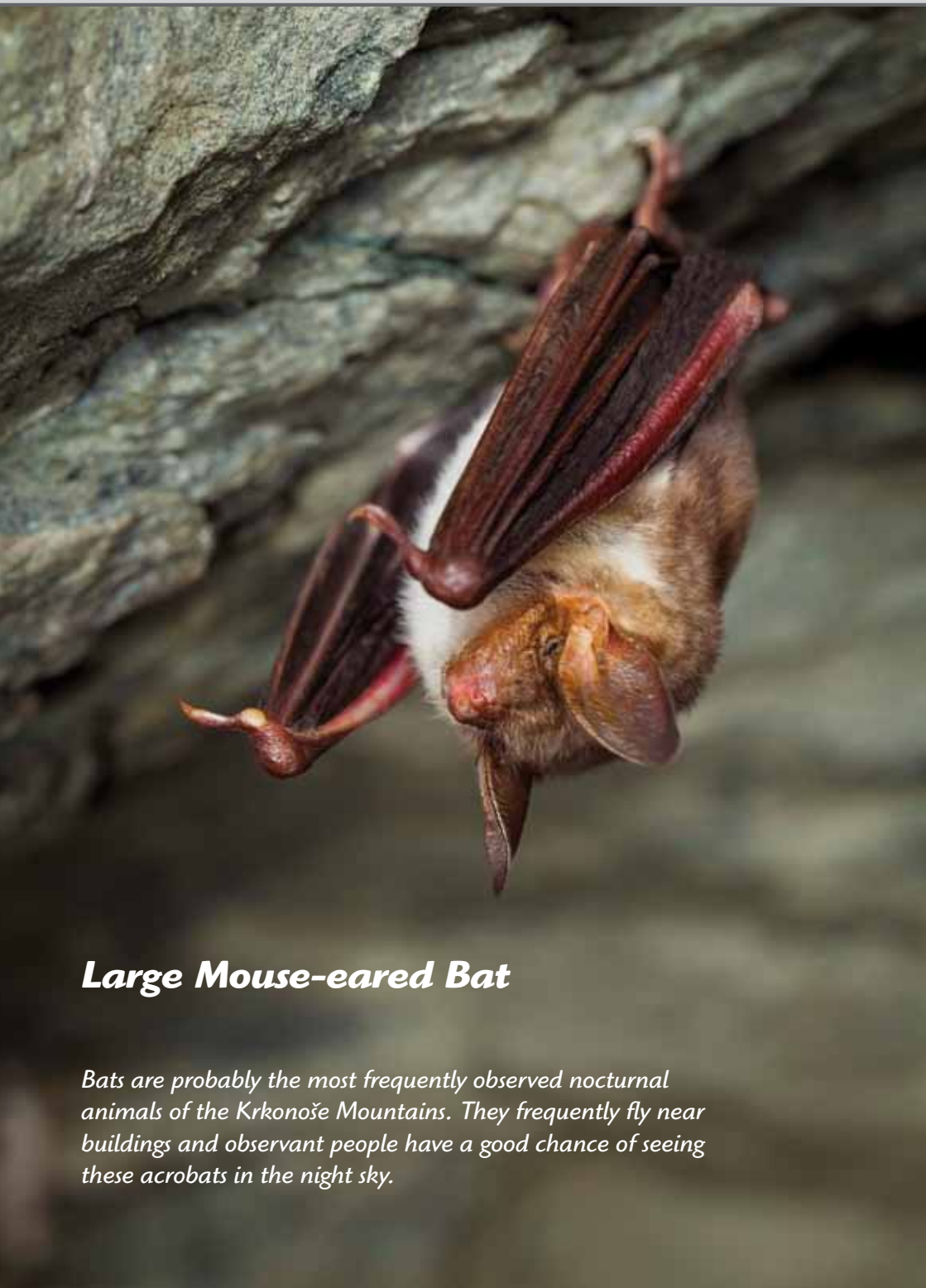
If the Red Deer is the king of the Krkonoše Mountains, which can be heard across the region, then the Lynx (Lynx lynx) is directly opposite – an inconspicuous and discreet recluse.



The lynx has been exterminated in many areas of its original habitat

The sexes only come together during their mating season, which is also very brief, and is further the only time you can actually hear the lynx. However, the sound it makes is reminiscent of the hooting of an owl and, as it can most frequently be heard at night, few people realise that it could by a lynx. It is practically a miracle to see this feline predator, with the characteristic tufts on its triangular ears and short tail, in the wild with your own eyes. Not only because there are fewer than five individuals in the Krkonoše Mountains, but mainly because it is active at dusk and chiefly at night. The Eurasian Lynx, which is the largest wild feline predator in Europe, was previously hunted to extinction in the Krkonoše Mountains, but has re-appeared in recent years. It usually grows to one metre in length and weighs over 25 kilograms. It lives in various types of dense forest and prefers rocky sites, from which it can observe the surrounding area. It does not chase its prey, but hunts by ambushing it: quickly and unexpectedly. It hunts across an enormous territory, of an area of up to several square kilometres and eats up to three kilograms of meat a day. It mainly eats hares, rodents and less frequently deer or birds. It often buries its prey and returns to consume it over several days. You are much more likely to find the spoor of the Lynx, mainly its scat, than the Lynx itself. The Lynx can live for 10 to 15 years of age and is the only large predator living in the wild in the Krkonoše Mountains. The Lynx was first observed in modern times in the Krkonoše Mountains in Jizerský důl valley between Mýto and Vilémov in the autumn of 2002. This sighting was followed three years later by a number of sightings of spoor and sightings of individual animals themselves in the eastern area of the Mountains – the area of Jelení hora mount, Dolní Malá Úpa and Rýchory. However, the Lynx has been moving between the Jizera Mountains and the Krkonoše Mountains in the area of Polubný, Kořenov and Jizerský důl valley for some time, yet other findings of prey and observation of individuals have been reported from Trutnov and Horní Maršov. A number of older and newer findings have also been reported from the Krkonoše Mountains ridges (Kozí hřbety, the slopes of Mt. Sněžka and from the Polish side of the mountains. Most of the existing evidence of the presence of Lynx is based on spoor. However other evidence of its occurrence in the mountains, such as the remainders of its prey, has also been repeatedly found.

The Eurasian lynx is the largest European felid



Large Mouse-eared Bat

Bats are probably the most frequently observed nocturnal animals of the Krkonoše Mountains. They frequently fly near buildings and observant people have a good chance of seeing these acrobats in the night sky.

The greater mouse-eared bat can even adapt to coexist with people, it lives in old cellars

There are 19 species of bat in the Krkonoše Mountains. They are mainly active at night, sleeping during the day. They are the only predators to hunt nocturnal flying insects and are perfectly equipped for hunting this prey. As well as having wings – wing membranes – they are capable of orientating themselves in spite of it being completely dark. Even though the bat can see about as well as a dog, in black and white, its eye is an imperfect organ in the dark. This is why bats have developed echolocation. This system works like a sonar in submarines. Bats emit very high-pitched shrieks (we cannot hear these sounds), which they are capable of perceiving and assessing using a membranous flap in their ear. This ability allows bats to move about in the night almost unerringly. The Large Mouse-eared Bat (*Myotis myotis*), which has a wingspan of up to 40 cm, is a species of interest in the Krkonoše Mountains. The summer colonies of females with young are frequently located in the attics of churches or other buildings and consist of several hundreds of individuals, but the males live solitary lives. The Large Mouse-eared Bat mainly hunts Ground Beetles, which it picks up from ground. It can live for over 35 years. One of the most common species is the similarly coloured, but smaller Daubenton's Bat, which mainly occurs near water courses and bodies of water, where it hunts for insects above the water surface. It appears regularly in all the known Krkonoše Mountains overwintering sites. There are nearly 30 sites used by bats for overwintering in the Krkonoše Mountains. For example the tunnels in Herlikovice, where bats from the foothills also gather in winter, are used by several species of bat: the Large Mouse-eared Bat, Whiskered Bat, Daubenton's Bat, Northern Bat, Long-eared Bat, and others. Two other small species are also quite frequently found in the Krkonoše Mountains – the Whiskered Bat and Brandt's Bat. Both live in the forest and are frequently found in the overwintering sites. Bats are protected by law and registered in the Red Book of endangered species of the Czech Republic.

Black Grouse

The Black Grouse is sometimes called Mr. Cimrman (Czech fictional character) of the Krkonoše Mountains – everyone talks about it, but no one has actually seen it. The Black Grouse (Tetrao tetrix) is a very shy species of bird of exceptional value from the aspect of natural science. This species is dramatically disappearing from nature and the Krkonoše Mountains are one of its last outposts. However, there is only a small number of birds even here.

The black grouse has a noticeable red crest above the eyes and a lyre-shape tail

The mountain dwellers tell legends about its spectacular nocturnal performances at its breeding grounds. The most important period in the Black Grouse's year occurs with the arrival of spring, when the breeding season begins. The males give bubbling calls to announce their desire to mate. They choose open areas for courting and compete for the favour of the hens, including fights between the males. The mating season begins at the beginning of March and frequently lasts until June. During this period the unique sound can be heard across the landscape at night and evokes the wilderness and remoteness of northern plains covered with heather. The cocks start to perform before the hens at dawn. The males make sounds called grunting, bubbling and knocking. At dawn or even at night you can observe the black and white cocks as they compete for the best place on the mating ground, fighting each other with lowered wings, with their head stretched out and their tail spread into a beautiful lyre shape. If the battle is very brutal the cocks fly towards each other and try to chase their opponent away. It is very rare to observe several of them at one lekking ground. In Europe the Black Grouse only occurs sporadically and mainly in mountain areas. It is most common in Scandinavia and Siberia. Until the middle of the 20th century the Black Grouse was a fairly common bird in our country. It currently only occurs in the Ore Mountains, in Šumava, in the Jizera Mountains and in the Krkonoše Mountains. You can only see it in the lowlands in military training grounds such as Libavá and Doupovské hory mountains. It seeks out open landscapes with a mosaic of peat bogs, forest growth of various ages and open areas such as meadows, pastures or glades. In recent years its numbers have fallen in this country and throughout Europe. It is currently estimated that there are 800 to 1,000 males in the Czech Republic, 110–120 of which are in the Krkonoše Mountains. Its population is a fairly stable group. The Black Grouse is a very timid bird and frequently suffers due to this trait. Repeated disturbance and the frequent presence of people at its overwintering sites can exhaust the Black Grouse so much that it easily becomes prey to a predator or dies of exhaustion.

Red Fox

The only wild canine predator in the Krkonoše Mountains is the Common Fox (Vulpes vulpes). It prefers hunting early in the morning before the sun rises and at dusk.

The red-coloured canine grows up to 90–120 cm long including its shaggy tail

It most frequently hunts Voles and Field Mice. In order to conserve energy when hunting, it initially determines the location of its prey by listening, then it pounces by jumping up to 5 metres, using its tail to steer in flight. During its nocturnal hunts the Fox also preys on birds nesting on the ground, or at least plunders their nests. It also won't spurn small hares, and eats carrion, which it mainly enjoys at night. The Fox is a fairly common species in the Krkonoše Mountains and also inhabits the delicate, but more varied eco-system of the flowering tundra on the leeward sides of the Krkonoše Mountains glacial corries. It shares this space with alpine and lowland plants and animals. This community is the result of a specific coincidence of a number of natural conditions and processes – air-flow, snow and earth avalanches, temperature and humidity, and the relief of glacial corries.

Common Otter

A keenly observed inhabitant of the water courses in the Krkonoše Mountains is the Mustelid predator – the Common Otter (Lutra lutra), which is an apex predator. It was previously hunted to extinction in the Krkonoše Mountains, but began reappearing at the beginning of the new millennia in the water courses and their surrounding areas.

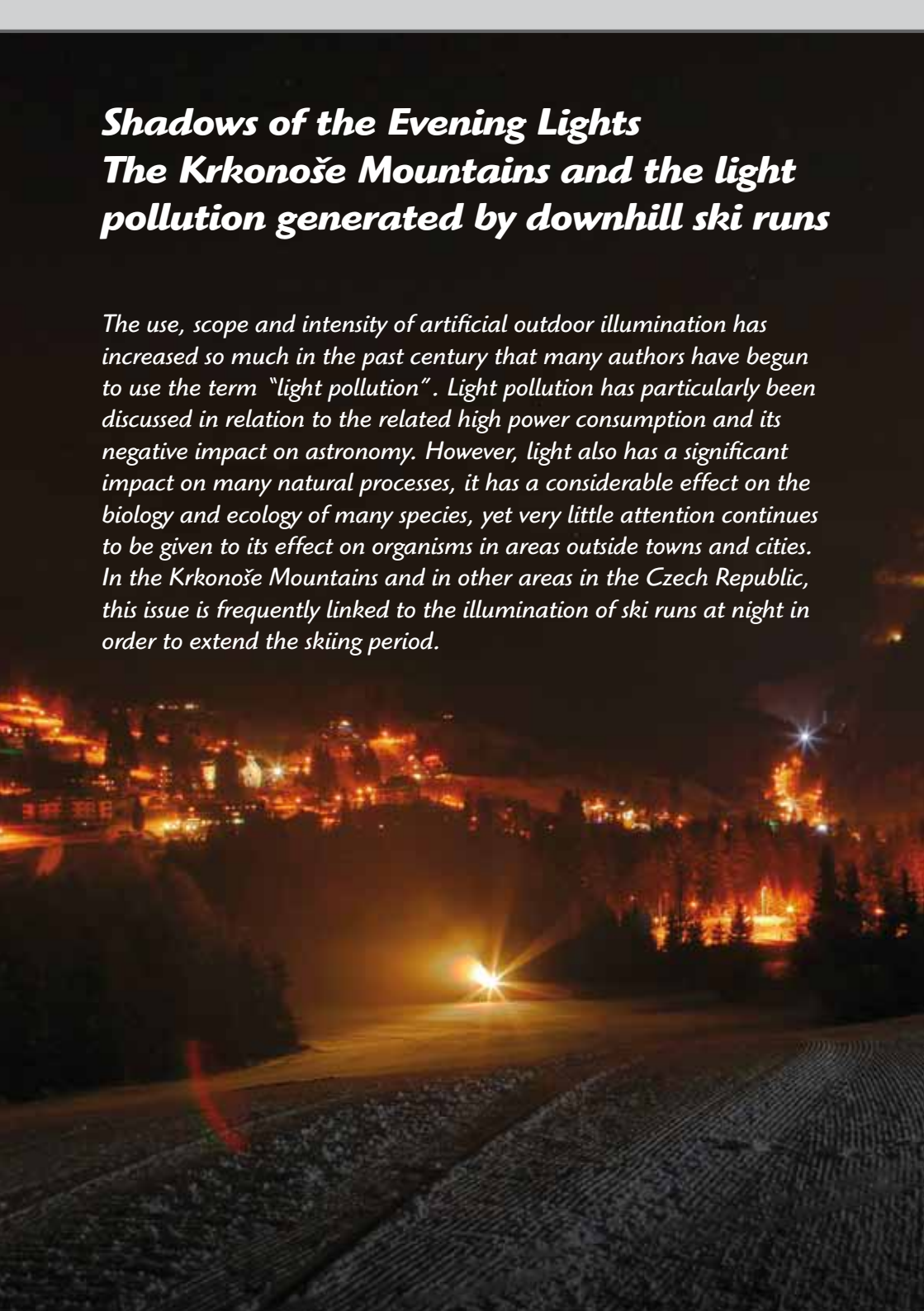
With the shape of its body, dense fur and short legs with webs between the toes, the otter is well adapted to living in water

The Otter is a nocturnal animal. It is capable of travelling several kilometres in a night, which is why it is quite difficult to establish how many individuals there are in a specific area. In recent years, traces of the Otter's activities have been found most often on the Jizera River and on its tributaries between Jablonec nad Jizerou and Horní Sytov, and also on the upper Elbe above Vrchlabí. The main factor influencing the occurrence and number of Otters is the quantity and availability of their prey, of which seventy five per cent is fish. It also eats insects, molluscs, amphibians, reptiles, birds and mammals. The Otter also depends on the availability of above-ground and underground shelters, where it rests, brings up its young and hides from enemies and inclement weather.

Fish are the basic diet of otters

Shadows of the Evening Lights The Krkonoše Mountains and the light pollution generated by downhill ski runs

The use, scope and intensity of artificial outdoor illumination has increased so much in the past century that many authors have begun to use the term "light pollution". Light pollution has particularly been discussed in relation to the related high power consumption and its negative impact on astronomy. However, light also has a significant impact on many natural processes, it has a considerable effect on the biology and ecology of many species, yet very little attention continues to be given to its effect on organisms in areas outside towns and cities. In the Krkonoše Mountains and in other areas in the Czech Republic, this issue is frequently linked to the illumination of ski runs at night in order to extend the skiing period.



The image of Europe at night shows locations where people, industry and luxury are concentrated. The data was acquired by the VIIRS apparatus from the Suomi NPP satellite, orbiting the Earth on the polar orbit, in April and October 2012 when flying over at about 1:30 am. Photo by NASA

Light

Light is an important ecological factor, a source of energy and an important informational factor, directly or indirectly affecting a number of organisms.

The mammalian eye is sensitive to visible light of a wavelength of between 380–760 nm. Birds, reptiles and some insects are also able to see ultraviolet radiation (electromagnetic radiation of wavelengths shorter than visible light, but longer than X-ray radiation).

A system consisting of optic nerve fibres and ending in the so-called suprachiasmatic nucleus in the hypothalamus that, for example, affects the body's biological functions through excretion of the hormones melatonin and serotonin, which have the role of setting circadian biorhythms, are important in mammals, birds and other vertebrates.

Light pollution as an ecological threat and its effect on animals

Light pollution is when the light is considered a pollutant, a substance that is foreign to the environment, which does not belong there, and is surplus to the environment. According to the amendment of Act No. 86/2002 Coll.,

on atmospheric protection, every form of artificial light is that is scattered outside the area for which it is intended, particularly if it is aimed towards the horizon. Travis Longcore and Catherine Rich include chronic or periodical increase in illumination, unexpected changes in illumination and direct glare in ecological light pollution. Therefore, any outdoor anthropogenic lighting at night must be considered pollution, Jan Hollan points out.

With regard to the fundamental role of vision in orientation and control of circadian (approximately daily), circannual (yearly) and other rhythms, it is no surprise that light has a considerable impact on the behaviour of animals (Alena Sumová and Helena Illnerová of the Physiological Institute of the Academy of Sciences of the Czech Republic discuss this in more detail in their work). Some catastrophic consequences of light for some animal species are well known. The most notorious examples are the deaths of migrating birds near tall illuminated structures and disorientation of freshly hatched turtles because of lights on the beaches they hatched on. However, light also leads to changes in the behaviour of a considerable number of mammal, reptile and amphibian species.

Light pollution in general influences food behaviour, reproduction, communication and other important activities of animals. It is well known, for example, that the timing of the nocturnal behaviour of urban populations of birds is shifted, and that this is linked to outdoor lighting. Many animals avoid open areas in response to the increasing intensity of moonlight, so that they do not become prey. Lunar cycles also play an important

The final section of Hromovka ski slope below Tabulové Boudy

The centre of Harrachov, 3 March 2014 at 8:20 pm. The lighting level of the ski slope appears to be comparable more with ceremonial lighting. The area of the big ski jumps (on the left) does not shine regularly

role in the timing of reproductive behaviour, for example, the start of the rut in ruminants. Under laboratory conditions it was found that artificial illumination of an intensity of 1 lux (lx) during a moonless night may shift the biological clock of vertebrates by 1–2 hours. Replacing moonlight with artificial illumination may change a number of natural processes.

It has also been documented that artificial lighting causes changes in the territorial singing of birds. Artificial illumination changes “competitive conditions” on the level of entire communities of animals, when diurnal species move into the nocturnal light niche.

Disturbance of the illumination cycle, which changes daily biological rhythms, also influences the production of hormones, most importantly melatonin. This hormone not only regulates activities linked to circadian rhythms, but also influences many physiological and behavioural rhythms in vertebrates. One of its most important roles is that it prevents growth of cancerous tumours, as Longcore and Rich pointed out a decade ago.

Vertebrates who are influenced by artificial illumination are also endangered by the changes to their circannual clock. Their annual weight fluctuation occurs, their hormonal

balance is disrupted, reproduction and hibernation times shifted, and basically all activities occurring during the year are disrupted. Artificial lighting also influences the distribution of animals.

The most evident consequences of light pollution are manifested in areas where the lights are close to natural sites, or are event part of the environment of national parks such as this one. As we stated above, the moon, and most importantly the full-moon, which generates light of an intensity of 0.1 lx, has a significant effect on most animals.

This is why we have worked with this limit as the lowest intensity of illumination having a biological effect on organisms, and therefore as the lowest value to be taken into consideration.

The impact of light pollution on humans

Human vision is not anatomically day vision, thanks to light sensitive cells – rods, which enable vision in dim light, so we basically do not need artificial illumination at night. Both aspects of light – day and night – are important for the correct performance of physiological functions. For example, body temperature, release of some hormones, and division and metabolism of some cells are all subject to a rhythm.

There are many conclusions from the most recent research that prove the negative impact of artificially added light on human health. Light pollution, which the entire population of the advanced world is subject to, causes many serious illnesses, such as seasonal depression,

A panorama of Pec pod Sněžkou from Velká Pláň via Malá Pláň up to Zahrádky, 14 February 2014. The full moon cannot compete in the valley with two rows of floodlights on Javor ski slopes

A panorama of Vrchlabí and Herlíkovice from Strážné with low-level clouds on 18 February 2014 at 9 pm

mental disorders, Alzheimer's disease, metabolic disorders, cancer and others, particularly because illumination at night suppresses release of melatonin and disrupts circadian rhythms, I. Drahoňovská summarises in her article "The Impact of Light Pollution on Public Health" (part of the "Mapping of Light Pollution and the Negative Impact of Light Pollution and the Negative Impact of Illumination Using Artificial Light on Living Nature in the Czech Republic" survey, under the direction of Jan Hollan, executed for the Ministry of the Environment in 2003.).

Light pollution and tourism

Light pollution also affects tourism. We can give the situation in the Krkonoše Mountains area we are investigating as an example, whereas the first phenomenon that initially surprises visitors is that they lose the beautiful character of the landscape at night, which is completely obliterated when the lights are switched on over the ski runs. Ski runs appear to cause considerable disruption of

the environment affecting areas up to approximately 20 km away. Their effect only diminishes at a distance of 40–50 km.

The Krkonoše Mountains are a national park with a relatively dense population. If the biggest issues here in the past were excessive logging, intensive grazing, collection of herbs, introduction of foreign species, overpopulation of forest pests or hunting of predators (the wolf, bear, lynx, wild cat), today the nature of the Krkonoše Mountains is fundamentally affected mainly by emissions and intensive tourism, which affects the entire area.

The Krkonoše Mountains characterise the conflict between nature conservation and development of tourism. On one hand local sources of atmospheric pollution are reduced or completely eliminated and the network of wastewater treatment plants is becoming denser, while on the other hand there are continued attempts to renovate or construct new ski lifts, cable cars, ski runs and accompanying structures with increased capacity.

Glowing Špindlerův Mlýn

The character of ski runs in the Krkonoše Mountains

The light pollution affecting the KRNAP (Krkonoše Mountains National Park) was measured on the ski runs themselves and in their surrounding area. The lengths of the ski runs ranged from 300 m to 1,500 m, with widths from 60 m to 200 m. In the spring and summer these areas are primarily maintained by mowing, and by pasture in some places.

They are frequently affected by expansive and invasive plant species such as ragworts, thistles and sorrels. On the other hand, endemic species of clubmoss, which are currently being intensively researched here, also appear in some areas.

The ski runs are usually surrounded by mono-cultures of economically valuable spruce forest of various ages, in which important large mammals such as the Red Deer (*Cervus elpahus*), the Roe Deer (*Capreolus capreolus*), Red Fox (*Vulpes vulpes*), European Badger (*Meles meles*), European Hare (*Lepus europeaus*), Wild Boar (*Sus scrofa*), Pine Marten (*Martes martes*), etc., live. Many of these mammals also live here in the

winter months, which we saw evidence of in the frequently observed tracks.

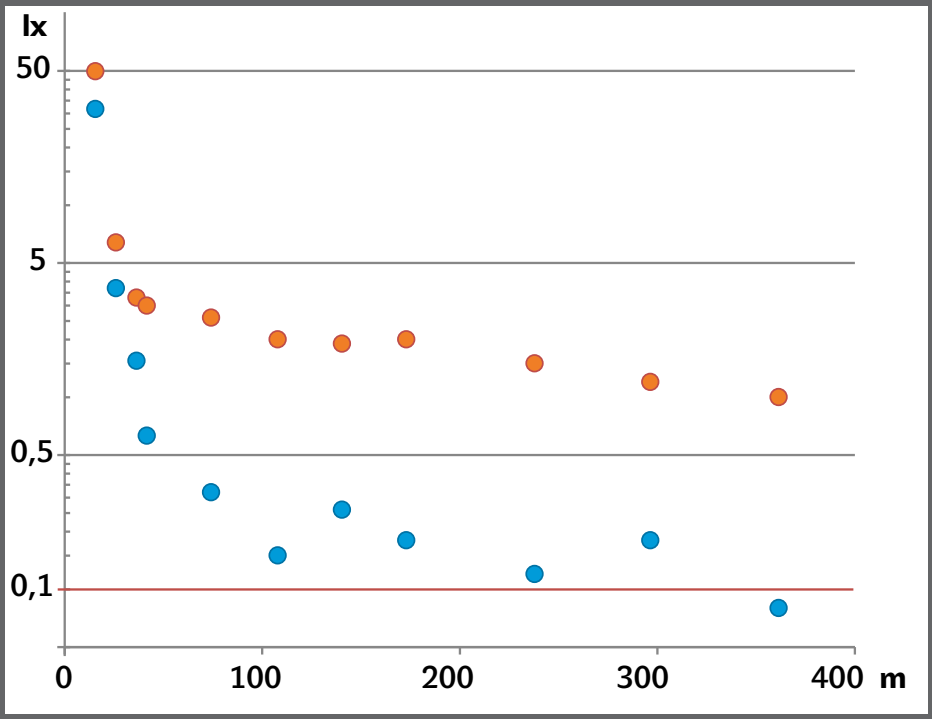
Most ski complexes in the Krkonoše Mountains use part of their ski runs for evening skiing. Ski runs are most often located at altitudes from approximately 500 to 900 metres and lie within the protective zone or in the 3rd zone of the KRNAP. Most of them are located in the vicinity of the more valuable zone. In practice we can also encounter ski runs above an altitude of 1,000 metres, and the tops of these frequently infringe on the most valuable parts of the national park and are usually distinguished by the greatest transport capacity. Ski runs for evening skiing, even though they are located in areas with a smaller level of protection, frequently directly illuminate the most valuable locations on the opposite slopes.

Quality of ski run lighting

The light sources of all lamps found in the field were covered using a straight glass. To ensure that the light from this type of lamp was directed in the right direction, e.g. towards the ground, the lamp would have to be adjusted vertically or slightly perpendicular to the slope. However, in the observed cases most lamps were used incorrectly.

The light sources of the lamps were directed at angles ranging from approximately 40° to 90° towards the other side of the ski run. A large number of the lamps were also directed upwards towards the sky and even more towards the forest (Brychtova et col. 2005).

Protěž as viewed from Bojiště near Trutnov, 15 km as the crow flies. The glare of downhill skiing area at Mladé Buky is slightly visible to the right from Protěž beyond the horizon of Hrádeček



Protěž at Janské Lázně. The illumination value during clear weather (●) and fog (●). The moon, and most importantly the full-moon, generates light of an intensity of 0.1 lx

Research of light pollution on ski runs

Measurements were taken from December to March in the winters of 2008–9, 2009–10 and 2011 throughout the Krkonoše Mountains on 10 ski runs in eight centres – Špindlerův Mlýn, Pec pod Sněžkou, Janské Lázně, Herlíkovice, Vítkovice, Harrachov, Velká Úpa and Vysoká nad Jizerou. An imaginary line was traced from each of these ski runs along the contour line – a transect, on which we recorded illumination values at regular intervals. We designated 2–13 transects on each ski run depending on how rugged the surrounding terrain was and on other favourable factors. We established the transects in the direction of the lighting (the direction of the light and of the transect were parallel) and also against the direction of the lighting (the direction of the light and the transect were antagonistic). Measurements were taken at a total of 700 sites (6–19 b./transect) on 66 transects, always on the surface and at a height of 1.5 m.

Each transect led along the contour line in a homogenous environment. Four of the most usual types of site were chosen for

research: open plains, enclosed spruce growth, open spruce growth and enclosed young spruce growth. Illumination of each point was measured using a sensitive Extech luxmeter ea 30 or mini-lux device.

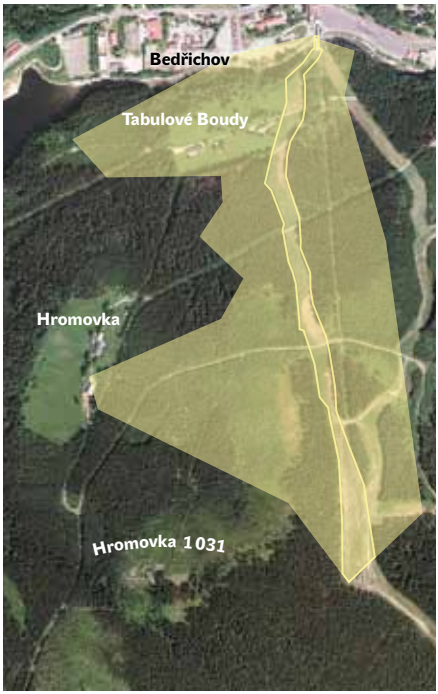
Light pollution on Krkonoše Mountains ski runs in numbers

The average intensity of illumination in the central areas of the ski runs ranged between 32 to 180 lx on the ground and 43 to 227 lx at 1.5 m above the ground. The maximum illumination value was measured on the Kejnos ski run in Benecko at 390 lx.

Comparison of the effect of the direction of the light, the vegetation and the intensity of illumination in the middle of the ski run showed that the illumination along the transects of an intensity of ≥0.1 lx evidently influences vegetation in particular.

When taking measurements on one specific transect over the course of one night in an open plain along the direction of the light under two different types of weather conditions (clear skies vs. fog) it was found that the light illuminated to a significantly greater distance during foggy conditions than during clear weather (see the graph below). The fog increases the intensity of illumination by one hundred. The light scatters in the direction of the light further than in the opposite direction, even though these values are also surprisingly considerable. Comparison of how light scatters in various environments shows that illumination scatters furthest across plains (on average over 500 m, 250–400 m against the direction of the source of light), and to a smaller distance in the other three types of site but at a similar intensity. When comparing how far light scatters depending on the height the measurement was taken, it was found that light scatters further at a height of 1.5 m above the ground.

We also evaluated the data on the intensity of illumination on slopes that are opposite the ski runs (see the table to the left below). This data represents the differences between two measurements taken during the night. The first measurement was taken during full operation of the ski-run at night, and the second several minutes after the lights



Hromovka at Špindlerův Mlýn. Marked with the light yellow colour is an area with a measured illuminance of 0.1 lx, the actual ski slope is marked with the yellow contour

Place	Distance by air	Data during full operation...	...and after the lights were switched off
Benecko	1,2 km	0,1 lx	0,03 lx
Herlíkovice	2,25 km	0,12 lx	0,03 lx
	1,8 km	0,29 lx	0,03 lx
	2,9 km	0,15 lx	0,09 lx
Janské Lázně	2,5 km	0,04 lx	0,02 lx
Pec pod Sněžkou	1,2 km	0,9 lx	0,04 lx
	1,1 km	1,9 lx	0,04 lx
	1,0 km	2 lx	0,68 lx
Špindlerův Mlýn	1,8 km	0,2 lx	0,1 lx
	2 km	0,16 lx	0,09 lx
Harrachov	1,2 km	0,22 lx	0,09 lx
Strážné	0,5 km	0,5 lx	0,08 lx
Dolní Dvůr	0,4 km	0,15 lx	0,05 lx

Values of lighting measured directly on the opposite slopes at a certain distance from the source before and after the lighting on the ski slopes was turned off

were switched off. The illuminated ski run frequently increased the intensity of the illumination on the opposite slopes to a value of ≥ 0.1 lx up to a distance of 1 km. In spite of this, the average increased intensity of illumination on the opposite slopes at a distance of 0.4–2.9 km is 0.35 ± 0.57 lx.

The area directly influenced by illumination at an intensity of 0.1 lx on the Hromovka ski run at Špindlerův Mlýn, which is 1,035 m long and on average 35 m wide (36,225 m^2), is 506,052 m^2 (see the picture on page 45).

Contention of the solution

The level of illumination on the ski runs appears much higher than is necessary. The values we measured are consistent with the observations of Jana Brychtová (2005) and Jan Hollan (2006). The highest values measured on the ski runs themselves were over 300 lx, which is much more than the recommended values, which range from a minimum of 0.3 lx with a median value of 0.5 lx. These values are preferred by most

skiers (Clanton, personal information, 2002) and we can also recommend these on the basis of the physiology of vision and on the basis of comparison with the usual and recommended intensities of public lighting (Brychtova et col. 2005). Observations in the field confirm that skiers do not avoid even the least illuminated areas.

The penetration of light was markedly influenced by the vegetation, particularly by enclosed spruce growth, which appeared a very effective light barrier. This finding shows that suitable adaptation of the management of marginal areas of the forest could result in reduction of light pollution in the areas surrounding the ski runs.

According to my measurements, the intensity of illumination during fog seems to be up to one hundred times higher than during clear weather, due to light being recycled by being scattered from droplets of water and radiated back towards the ground. According to Jan Hollan (2006), the natural situation during a moonless night is exceeded under these conditions by over ten thousand times. However, these values also occur in the Krkonoše Mountains when cloud cover is present at low to middle elevations. Projection of the intensity of illumination (≥ 0.1 lx) on the 1 km long Hromovka ski run represents a surrounding area influenced by light pollution of an area of 0.5 km^2. With regard to the fact that there are 30 km of illuminated ski runs in the Krkonoše Mountains National Park, approximately 13 to 15 km^2 of Krkonoše Mountains landscape (approximately 4 % of the park) is directly influenced by light pollution. This calculation does not include the effect of illumination emitted into space and scattered above the mountains, or the influence from the opposite slopes. The effect of illumination on opposite slopes is more complex and can be influenced by many factors – particularly the shape of the valley, the

vegetation on both sides of the valley, etc. In spite of this, we can approximately estimate that the affected area is probably twice as large with regard to the effect of illumination from opposite slopes.

Determination of the size of the influenced area is directly dependent on the defined limit of illumination that has a probable effect on the biological activities of animals and on the current weather conditions. The limit of 0.1 lx was chosen on the basis of the most recent studies and in compliance with the intensity of illumination during a full moon, which emits light of approximately this value and is known for its biological effects.

Illuminated areas in the landscape are not normally an isolated occurrence, but are usually part of a network of smaller illuminated areas. As a result of the high density of the population living in villages on the bottom of long narrow valleys, street lighting in these villages creates a network of illuminated areas, which more or less separate the individual mountain ridges. The lighting on ski runs is directed perpendicularly to the lighting in the valleys, which also increases the fragmentation of dark, unlit areas of landscape.

Recommendations

1) The lowest values were measured on the ski run in Vítkovice-Aldrov, where the average illumination intensity ranged around 15 lx. Values ranged around 1 lx at the edges of the ski run. This ski run was popular with skiers, who did not avoid even the dimmest of the areas. There is consequently no reason for higher values. With regard to the small area of the Krkonoše Mountains, an illumination intensity between 0.3–0.5 lx is recommended as a long-term sustainable value.

2) Research shows the considerable impact of vegetation on reduction of light pollution, changes to forestry management in the areas surrounding the ski runs would contribute to improvement of the situation.

3) Light is scattered to significantly greater distances by fog and low cloud cover. Light scatters one hundred times farther in fog. Potential prohibition or restriction of skiing at night under these conditions would undoubtedly contribute to reduction of light pollution.

4) With a total length of illuminated ski runs in the Krkonoše Mountains of 30 km, ski runs illuminate an area of 13 km^2 (approximately 4 % of the KRNAP). The Hromovka ski run (Špindlerův Mlýn), which is approximately 1 km long and is an average of 35 m wide (0.035 km^2) illuminates an area of approximately 0.5 km^2. The ski run is only 7 % of the total area directly illuminated by the lighting system. The direction of the illumination would be improved by the correct geometry of the lamps and supplementation of the system with individual shielding elements.

The Krkonoše Mountains at Night

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