

= Phengaris rebeli =

The *Phengaris rebeli* (formerly *Maculinea rebeli*) , common name mountain alcon blue , is a species of butterfly in the *Lycaenidae* family . It was first found and described in Styria , Austria on Mount Hochschwab around 1700 . Although it was initially classified as a subspecies of *P. alcon* , a European researcher , Lucien A. Berger , designated it as a separate species in 1946 .

Although *P. rebeli* is found across the Palearctic (see subspecies) , it is difficult to determine exactly where they inhabit because of their similarity with *P. alcon* . In West Europe they are thought to be concentrated in the Alps and in Southern Europe .

Behavioral ecologists have found its role as a brood parasite to be of particular interest as , unlike many brood parasites , it does not directly oviposit in the hosts ' nests . The *P. rebeli* parasitizes the colony ant species *Myrmica schencki* as a larva by using chemical mimicry to trick the ants into believing that they are ant larvae ; thus , the ants bring the *P. rebeli* larvae back to their own nests and feed them . It also parasitizes the foodplant *Gentiana cruciata* early in its lifecycle , but in turn , is parasitized by the *Ichneumon eumerus* when it is in the *M. schencki* 's nest . It was placed on the IUCN Red List in 2000 and is classified as a species ' vulnerable ' to extinction . Although a separate species from the *P. alcon* , its DNA genome and appearance are extremely similar , leading many researchers to argue that any differences between the two species are due to intraspecific variation .

= Taxonomy =

The *Phengaris* genus is a subset within the *Maculinea* genus (explaining why the *P. rebeli* was formerly known as the *M. rebeli*) and the *Maculinea* @-@ *Phengaris* clade is thought to be a sect within *Glaucopsyche* . There are three groups within this *Maculinea* @-@ *Phengaris* clade : the alcon group , the teleius group , and the Arion @-@ *Phengaris* group .

The groups are divided based on their alternative strategies of parasitizing its host colony (*Myrmica* ants) . The predatory (in which the caterpillar preys on the host ants) and ' cuckoo ' (in which the caterpillars feed off of the ants ' regurgitation) strategies are derived characteristics from the alcon group , with the predatory strategy having evolved from the teleius group and the cuckoo strategy having evolved from the arion @-@ *Phengaris* group . Another way these groups are categorized is by whether or not they release a certain chemical (dorsal nectary organ secretions) to attract the attention of the host ant . This trait is not as prominent in ancestors of the alcon group and in the *M. nausithous* , which is part of the teleius group .

The *P. rebeli* is most closely related to both species of the *Maculinea alcon* (the *M. alcon alcon* and the *M. alcon kondakovi*) with the *M. alcon alcon* being more closely related to the *P. rebeli* than to the *M. alcon kondakovi* .

= Subspecies =

Phengaris rebeli rebeli (Hirschke , 1904) Central and South Europe

Phengaris rebeli cordidula (Jachontov , [1909]) Caucasus Major

Phengaris rebeli imitator Tuzov , 2000 North Tian @-@ Shan , Dzhungarsky , Alatau

Phengaris rebeli kondakovi Kurentzov , 1970 Transbaikalia , Amur Oblast , Ussuri Northeast China

Phengaris rebeli monticola (Staudinger , 1901) Armenia

Phengaris rebeli ssp . Altai mountains

= Appearance =

The *P. rebeli* are noted for their large blue wings , with the males displaying a violet blue shade and the females displaying blue basal areas interspersed with brown spots , similar to other butterflies in its genus . The undersides of the butterfly are a dark brown with small black spots that are circled in white . It can be distinguished from its close relative , the *P. alcon* , by the broader black margins of

the upperside male and the extensive blue basal areas in the females . It has a wingspan of approximately 32 ? 36 mm long .

= = Habitat = =

It resides in fairly dry areas at lower levels and damp meadows amongst trees at alpine levels and is found in altitudes of 1000 ? 2000 meters . Although it is found around the globe , populations of *P. rebeli* are concentrated in the northern part of Portugal and Greece , the western Pyrenees , France , and eastern part of Germany .

= = Brood parasitism = =

= = Discovery of brood parasitism = = =

The *Phengaris rebeli* is a brood parasite , an organism that manipulates another organism (the host) to raise its offspring ; in this case , the *P. rebeli* parasitizes a particular species of ant , the *Myrmica schencki* . The *P. rebeli* was first discovered to be a brood parasite when a researcher observed *M. schencki* ants bringing the *P. rebeli* larvae back to their own nest . One of the proposed hypotheses for this parasitism was that *P. rebeli* larvae released chemicals to confuse the ants into believing they were ant larvae .

It was determined that *P. rebeli* larvae use chemical mimicry to persuade the *M. schencki* ants that the *P. rebeli* are part of the ant brood . Furthermore , *M. schencki* ants cannot distinguish the physical differences between the *P. rebeli* larvae and other non @-@ kin brood because the *P. rebeli* larvae are far more similar to the *M. schencki* ' s larvae than to any other ant species larvae .

P. rebeli live in different habitats ; therefore , they do not parasitize the same *Myrmica* ant species . Through observation and experimentation , researchers found that if *P. rebeli* try to parasitize a different *Myrmica* ant species than the one they normally do , the *Myrmica* ants will identify the *P. rebeli* larvae as intruders and will kill 100 % of the *P. rebeli* larvae . The differences between the *P. rebeli* are that they synthesize different hydrocarbons , which allow them to mimic different species of *Myrmica* ants . This explains why they have no success in being mistaken for another species of *Myrmica* ant and the ensuing 100 % mortality rate when the other *Myrmica* ant species is not fooled .

= = Acoustics and social rank in host hierarchy = = =

Once the *P. rebeli* larvae infiltrate the host ' s brood , they ascend to the highest social ranks of the host ' s hierarchy by using acoustics to achieve social acceptance from worker *M. schencki* ants . *P. rebeli* larvae and pupa accomplish this by mimicking the sound that the queen of the ant colony makes , both while as a larva and as a pupa in the colony .

While the *Myrmica* ant colony can identify each other through chemical signaling , social ranks are partially determined by sound acoustics . Therefore , once the *P. rebeli* begin to mimic the sound of the queen ant , the worker ants begin to treat the *P. rebeli* as if it were the queen ant . On the other hand , the queen ant treats the *P. rebeli* larvae and pupae as if they were rivals , as she is the only one in the colony that recognizes that the *P. rebeli* larvae is not ant larvae .

The most common functions of the queen ant sounds are to recruit workers , smell nestmates , and facilitate oral exchanges of food and pheromones . Most importantly , however , is the fact that distress noises made by the queen causes workers to raise their guard and bolster her protection .

Researchers speculate that acoustical mimicry is related to the level of interaction between the host and parasite . In the *Phengaris* genus , there are two different strategies : the cuckoo strategy used by *P. rebeli* and the predatory strategy used by *Phengaris arion* . In *P. rebeli* , the *Phengaris* larvae become integrated into the colony and are attended by worker ants . However , larvae in predatory species prey on the ants ' brood and consequently spend much of their life hiding in pockets of the

brood nest .

== Integration into host ? s life ==

There are two phases for *P. rebei* ? s complete integration into the *Myrmica schencki* ant colony : initial integration and full integration . In both stages of integration , the *P. rebei* caterpillar is brought into the brood nest ; however , in full integration , the *P. rebei* also achieves its high social status within the host society . That status is crucial for surviving periods of host colony stress such as food shortage .

Studies have shown that the *P. rebei* caterpillars benefit most when they parasitize off of the *Myrmica schencki* ant colony than any other ant colony . When *Myrmica* ant colonies encounter a period of food shortage , more *P. rebei* caterpillars survive than if this food shortage were to occur in any other species of ant colony . This is because the *P. rebei* caterpillars have a lower social rank in other ant species compared to their social rank in the *M. schencki* ant colony . This phenomenon is seen during times of stress , when some of the hungry *P. rebei* caterpillars secrete compounds to attract attention from the ant colony it has parasitized . While the *M. schencki* ants are still fooled into believing that the *P. rebei* are of their own brood , these compounds do not mimic those of non @-@ host species ' societies in other ant species , and thus , results in the *P. rebei* being identified as intruders and killed .

On the other hand , the *M. schencki* prefers to feeds the *P. rebei* during times of food shortage . Thus , in periods of starvation , *P. rebei* caterpillars overall exhibit a higher survival rate than those of the *M. schencki* larvae .

== Polymorphism of growth in larvae ==

Polymorphism in Lepidoptera is a common occurrence and the *P. rebei* caterpillar is no exception as it displays polymorphism in its larval form . The *P. rebei* caterpillars have two strategies for living and growing underground : to exist as fast @-@ developing larvae (FDL) or slow @-@ developing larvae (SDL) . After the ant brood adopts the FDL , which comprise approximately 25 % of the total *P. rebei* larvae , the FDL complete growth the following spring and eclose (emerge as an adult from the pupa) in early summer to complete their life cycle . The SDL , which comprise 75 % of *P. rebei* larvae , do not grow much during the first year , but grow rapidly during the early part of the second summer and remain a second winter within the ant colonies . While both larva types ultimately form similar @-@ sized pupae , their polymorphic growth rates could indicate alternative fitness strategies and different ways to exploit the *M. schencki* ? s food resources .

Other researchers hypothesize that another alternative growth strategy will evolve in the *P. rebei* , in which the *P. rebei* will parasitize the *M. schencki* ants for an even longer period of time than the slow developing larvae . Most researchers , however , find this hypothesis highly unlikely because it is not an evolutionarily stable strategy . At the rate the *P. rebei* parasitizes the *M. schencki* ants , the host colony is unlikely to last as a viable food source for more than two years (the average lifespan of the longer polymorph of *P. rebei*) . Once the host colony reaches its lifespan of two years and dies , the *P. rebei* loses its food source and dies as well .

The *P. rebei* ? s developmental rate shows great phenotypic plasticity (changing its developmental rate in response to changes in the environment) , as it develops very quickly in the lab and in the Pyrenees and Southern Alps . Scientists hypothesize that this plasticity is due to warm conditions and more light exposure , which affects larval development . Abundant food resources are also thought to play a part in quickened development .

Studies have shown that smaller @-@ sized *P. rebei* from Hungary normally eclose at the end of June or mid @-@ July ; however , when these populations are studied in laboratories , they do not eclose until late August . This has led researchers to speculate that *P. rebei* larvae that do not receive adequate food can still fully develop in one year and act as a functioning adult . However , they are unlikely to be bivoltine (producing two broods in one season) . This hypothesis is supported by the fact that certain researchers claim that *P. rebei* larvae can have continuous

development .

= = = Vestigial mutualism = = =

P. rebeli pupae prey upon their broodmates , while producing sugar @-@ rich secretions which worker ants imbibe . In one experiment , *P. rebeli* specimens which consumed ant larvae developed more quickly than those who did not . However , despite their nourishing offering to the community , they invariably imposed a net loss in the survival rates of workers and broodmates , demonstrating that the species is parasitic (rather than mutualistic) at all stages in its host colony .

= = Relationship with host plant *Gentiana cruciata* = =

Besides parasitizing the host ant , *P. rebeli* also parasitizes the grassland plant *Gentiana cruciata* as a source of nutrition and feed off of its flowers and developing fruits .

The larger the population size of the *G. cruciata* , the more flowers and seeds the plant produces ; however , there is also a positive link between the population size of the *G. cruciata* and the frequency of *P. rebeli* parasitizing the plant . Researchers are particularly interested in the *G. cruciata* plant because both the *P. rebeli* and *G. cruciata* are endangered . As a result , lepidopterists believe that conserving the *P. rebeli* requires focusing conservation efforts on preserving *G. cruciata* as well .

Researchers discovered that where the *P. rebeli* lay their eggs is based on the size of the *G. cruciata* leaves and not upon the location of the closest *Myrmica* ant colony . Evidence for *P. rebeli* ' s oviposition depending upon the range of the food plant rather than the range of the ants is supported by the timing of its oviposition . *P. rebeli* lays their eggs during the warm summer season , when *Myrmica* ants are most likely to be underground . Researchers also observed females did not base their oviposition on where they found *Myrmica* nests .

= = Relationship with the parasitic wasp , *Ichneumon eumerus* = =

Though *P. rebeli* parasitizes the *Myrmica schencki* ants and *Gentiana cruciata* foodplant , it also acts as a host to the parasitoid *Ichneumon wasp* (*Ichneumon eumerus*) . The *I. eumerus* is a wasp that attempts to parasitize the *P. rebeli* after it has been introduced to the *Myrmica* ants ' nests . The adult wasp searches for *Myrmica* ant nests by responding strongly to the scent of *Myrmica schencki* ants , the species that *P. rebeli* most commonly and successfully parasitizes .

After locating the *M. schencki* nest , the wasp enters only the nests that contain *P. rebeli* caterpillars . It is able to enter the nest without being swarmed because it releases a chemical that causes the worker ants to attack one another instead of concentrating all their efforts on the wasp . Once the wasp reaches the caterpillars , it marks the individuals most likely to survive by ovipositing in them . Once the wasp ' s eggs hatch from the caterpillar ' s body , the newborn offspring feast on the caterpillar ' s carcass .

= = Conflicts over classification = =

Several researchers argue that the *P. rebeli* has not evolved into a separate species from the *Phengaris alcon* . Researchers have determined that both species share a similar adult morphology , DNA and allozymes . They found that any variation between the two species is due to intraspecific variation , meaning that they are not distinct species . Furthermore , they both have similar methods of parasitizing the host ant : they act as parasitic " cuckoos " within the ant nest and feed upon the ants ' regurgitation . This is compared to the alternative method of predation that other butterflies , such as the *Maculinea arion* utilize to parasitize the host ant .

To test this hypothesis , researchers examined how each species utilized the host ants . The *M. schencki* , *M. sabuleti* are parasitized by *P. rebeli* while the *M. salina* and *M. vandeli* are parasitized by the *P. alcon* . The *M. scabrinodis* is parasitized by both the *P. rebeli* and the *P. alcon* ; however ,

the *P. alcon* is far more likely to parasitize *M. scabrinodis* than the *P. rebeli* . Researchers found that in general , *P. alcon* was far more likely to parasitize the host ant than *P. rebeli* ; however , ant nests that supported the *P. alcon* were much smaller and supported lower populations than ant nests that supported *P. rebeli* .

= = Conservation status = =

The *P. rebeli* has been rigorously studied in Europe because it has priority conservation status and was classified as ? vulnerable ? in 2000 by the IUCN Red List of Threatened Species , which is described to be ? the world ? s most comprehensive inventory ? that lists the conservation status of plants and animals . It was first brought to the IUCN ? s attention and listed on the IUCN Red List of Threatened Species in 1986 . The reason for being categorized as ? vulnerable ? is that despite its wide distribution , it has decreased by 20 @-@ 50 % over the last 25 years and has reached extinction in at least one country .

The reasons for this drastic population reduction are thought to be due to agricultural improvements , abandonment of extensive management , and deforestation . As the area of the *Gentiana cruciata* , the foodplant that the *P. rebeli* depends on , decreases , the *P. rebeli* population also decreases .

= = Gallery = =