Zeitschrift: Bulletin de la Société Neuchâteloise des Sciences Naturelles
Herausgeber: Société Neuchâteloise des Sciences Naturelles
Band: 126 (2003)

Artikel: Survival of the hazel grouse Bonasa bonasia rupestris in the Jura mountains : between board and lodging
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DOI: https://doi.org/10.5169/seals-89605

SURVIVAL OF THE HAZEL GROUSE *BONASA BONASIA RUPESTRIS* IN THE JURA MOUNTAINS. BETWEEN BOARD AND LODGING

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Mots-clés: gélinotte des bois, *Bonasa bonasia*, écologie, biologie, comportement

Key-words: hazel grouse, *Bonasa bonasia*, ecology, biology, behaviour

Résumé

La population jurassienne de gélinottes des bois *Bonasa bonasia rupestris* est estimée entre 2'300 et 3'700 couples. Bien qu'elle ne soit pas encore en danger, elle paraît de plus en plus isolée des autres populations au fur et à mesure de la disparition des oiseaux à basse altitude. Confinée dans les hêtraies (*Abieti-Fagetum*) et sapinières (*Abieti-Piceion*) du Haut Jura, elle supporte encore bien les changements d'habitats qui s'annoncent. Mais pour combien de temps ? En passant en revue les exigences de l'espèce du point de vue de son alimentation et de son habitat, il apparaît clairement qu'une pratique sylvicole favorisant le développement en patchwork des buissons et des arbustes fruitiers devrait compenser les effets négatifs du réchauffement climatique.

Summary

The total population of hazel grouses *Bonasa bonasia rupestris* of the Jura is estimated between 2'300 and 3'700 couples. Although not yet endangered, it appears to be more and more isolated from the other populations, due to the disappearance of birds living at low altitude. Confined to the beech wood (*Abieti-Fagetum*) and fir forests (*Abieti-Piceion*) of the High-Jura, it seems it can face the forthcoming change of its habitat. But we don't know for how long. Checking the requirements of the species with regard to feeding and habitat, we come to the conclusion that a forestry practice consisting of the planting of bushes and fruit trees on a patchwork manner would compensate the negative effects of global climatic warming.

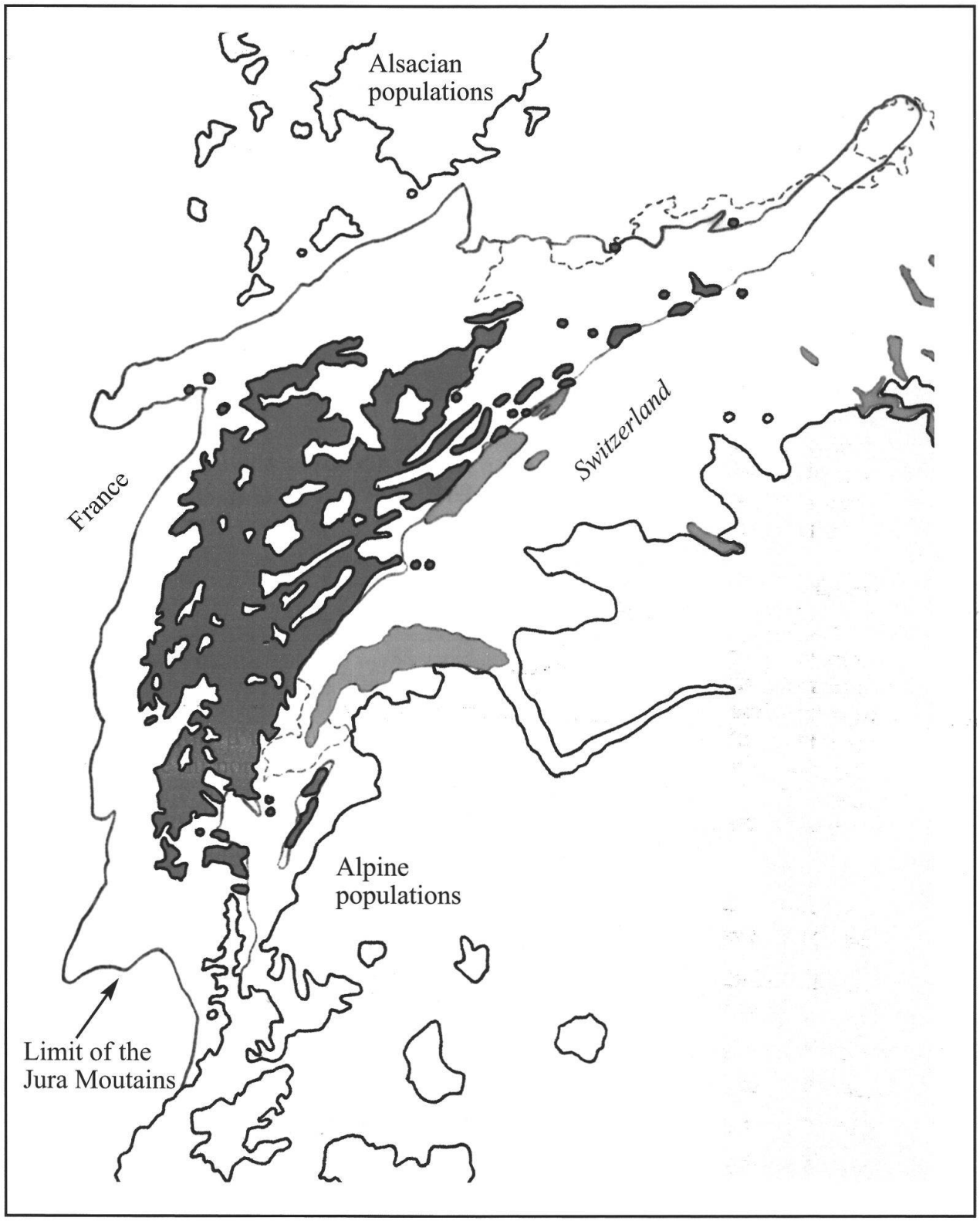

Figure 1: area of distribution of the hazel grouse *Bonasa bonasia* on the Jura (grey pattern) and contacts with the Alpine and Alsacian populations (palish grey).

INTRODUCTION

Since about thirty years, a rarefaction of the hazel grouse *Bonasa bonasia rupestris* can be noticed in the western part of its living area. The hazel grouse has virtually disappeared from the north of the Vosges (GENOT, 1985; BERNARD-LAURENT & MAGNANI, 1994). It declines in the Black Forest (ROTH & HÖLZIGER, 1987; SUCHANT, 1996). Overall in France, it is estimated that the global living area was reduced by 40% since 1960 (COUTURIER, 1964; DRONNEAU, 1999). The sites of lower altitude have been deserted.

Today, this population decline affects partly the Jura Mountains. In the west and the south, the hazel grouse disappears from the deciduous forest situated on the first forland bassin of French Jura. (MONTADERT *et al.,* 1997). In the north, the tabular Jura is poorly occupied (BLATTNER, 1997). In the east, it has nearly disappeared from the Swiss plateau (ZBINDEN & BLATTNER, 1998). It is observed from time to time at the base of the Jura. In the canton of Neuchâtel, where a count could be conducted over the whole territory (800 km^2), 95% of the birds were observed over 1000 m of altitude (SANTIAGO *et al.*, 2003).

It appears that the population of the High-Jura, confined in beech wood (*Abieti-Fagetum*) and the spruce forest (*Piceion*), is more and more isolated from the Alpine and Alsacian populations (fig.1). Summaries of different investigations made on both sides of French and Swiss border have allowed the completion of national distribution maps. Because of the difficulty on making an inventory over large areas, the number of hazel grouses is fixed on the basis of a local panel monitoring. The principle of proportionality is applied over the whole Jura Mountains. The French population of hazel grouses is estimated between 1'500 and 2'500 pairs (DESBROSSES, 1993 for the department of Jura; BERNARD-LAURENT & MAGNANI, 1994; SCHATT, 1995 for the department of Ain). The Swiss population is estimated between 800 and 1'200 couples (GLAYRE & MAGNENAT, 1984 for the Valley of Joux; BLATTNER, 1997 for the north Jura of canton of Soleure; PERRENOUD, 2001 for the Chasseral mountain, SANTIAGO *et al.*, 2003 for the canton of Neuchâtel).

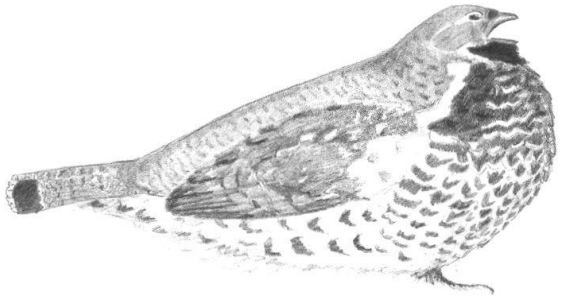

Figure 2: male of hazel grouse singing. Canton of Neuchâtel (Switzerland).
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The total population of the whole Jura Mountains is therefore estimated between 2'300 and 3'700 pairs.

The progressive insulation of this population is worrying, because the process is not restricted to a single area but seems to be generalized. This means that this insulation does not result from an human action (for example, hunting pressure in the French departments or other pollution in the Swiss part of the Jura), but could be influenced by factors affecting the whole Jura Mountains.

The basic question is: What are the constraints, that the hazel grouse has to face in the future? For example, how can it adapt to the environmental changes, that global warming will induce during the next decade? The synthesis of the knowledge about the biology of this gallinacean allows to understand the links to its living conditions and to think up to the solutions for its preservation (MULHAUSER, 2003a).

FEEDING

First of all, it is necessary to remind that for the hazel grouse – as for all species – the fundamental restrictive factor is food. Without food, there is no survival. It is crude to say, but when carrying out a complex study on a species, sometimes this important food factor is minimized for the benefit of other details. Therefore, our study of the hazel grouse begins with its lodging. In the Jura Mountains several specific studies were conducted on the feeding of the hazel grouse at all altitudes, from east to west and from north to south (ZBINDEN, 1979 in the Bernese Jura/Switzerland; JAKOB, 1987 in French Risoux; DESBROSSES, 1997 in the department of Jura/France and SCHATT, 1991 and 1993 in the department of Ain/France). To these data, we can add those collected in the canton of Neuchâtel/Switzerland in 2002 and 2003, based on direct watching observations (being upon the watch).

Bolus

From birth up to the age of two or three weeks, the chick eats almost exclusively invertebrates. As it grows, its diet becomes more and more vegetarian. Within the space of two months, it eats leaves, seeds and fruits. The mature bird is a complete phytophage. If it catches preys from spring to autumn, it is during the summer that it completes its diet with animal protein. These proteins exceed seldom 5% of the total food swallowed (fig. 3).

Although the hazel grouse feeds mainly on leafy and herbaceous plants, it does not rely on one nourishing plant but rather on several resources, which can survive under a special climate. For example, in the fir forest of the High-Jura, during winter, it can survive only thanks to the presence of the sorbs (*Sorbus aucuparia*, *Sorbus aria* and *Sorbus chamaemespilus*). However, in oak groves of lower altitude, the young shoots of hornbeam (*Carpinus betulus*) and hazel tree (*Corylus avellana*) play the

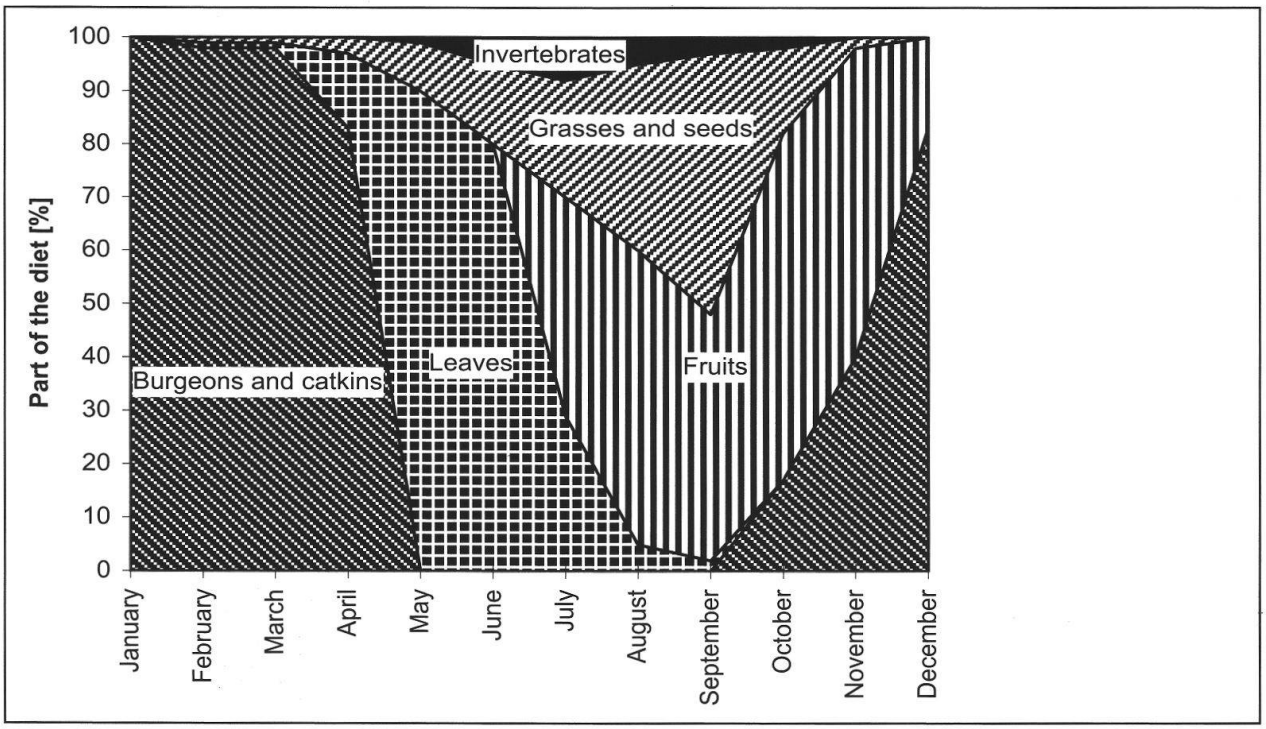

Figure 3: scheme of the annual diet of hazel grouse in the Jura Moutains.

same role (SCHATT, 1991). This small gallinacean deserves the term of opportunist vegetarian. It exploits the feeding resources the most plentiful and more nourishing at the moment.

It would be difficult to draw up a list of all the plants building up the bolus of the hazel grouse. On the other hand, two things are the most interesting: Which are the non-eaten plants and which are the preferred ones ? Comparing to the capercaillie *Tetrao urogallus*, the hazel grouse ingest rarely buds or needles of coniferous trees. It doesn't like tough leaves of oaks (*Quercus sp.*) or maples (*Acer sp.*). But its favourite and essential food comes from the Betulaceae family (Alder, birch, hornbeam, hazel tree), from the Salicaceae family (willow tree) and from the Rosaceae family (Sorb, raspberry bush, hawthorn). Most of these appatent plants grow in a small margin between the big coniferous trees of the taiga under action of a hard continental climate and the strong leafy trees (oaks, beeches, maples, elms, limes) of the temperate forests. The evolutional history of this bird is strongly linked to the tree species "edge wood" with an average growth as the boreal area.

Food quality

Besides the fact that an animal needs food to survive, the quality of the food influences directly its breeding. In the High-Jura, the breeding period begins in the second half of March, sometimes slightly later when the snow coverage postpones the growth of vegetation. The increase of sex hormones for both sexes is linked to the quality of food ingested during spring. As among most of the birds, the breeding is much more important and successful when the food is in good supply and of good quality.

A study on the Red grouse (*Lagopus lagopus scoticus*) (MOSS *et al.*, 1975) shows clearly the link between the food quality and the survival of the young birds. In the Scottish moors, this gallinacean eats almost exclusively fausse heather (*Calluna vulgaris*), thus making the study easier. The abundance of food during spring is therefore essential. The females preferably swallow the shoots rich in calcium, phosphorus and especially nitrogen. The experiment showed that if there is enough food, the females have the choice of quality. They let aside plants of poor quality. When a nitrate fertilizer is added to increase the plant growth, the laying is much more important.

There is no similar study regarding the hazel grouse. But its feeding habit indicates that two periods are crucial for the survival of the species:

- before the laying at the beginning of spring
- at the end of autumn when the birds build up their stocks for the bad season.

In spring the female looks for elements with particular nutritive value, among others calcium to reinforce the shell of the eggs. It tries also to build up a stock of fat to face an energy consumption when forming the eggs. Its diet changes when the couple is together. The female eats herbaceous shoots all day long. It is the growing of this vegetation which marks the beginning of their sexual activity. It is the reason why there is a close correlation between the number of eggs and the weather conditions. If the weather acts negatively upon the growth of vegetation, the laying of eggs will be reduced. When the female have to wait for the nutritive plants, the laying and breeding is delayed. The worst situation is a too early spring followed by a period of cold weather and rain.

In Scandinavia, SWENSON (1991) noticed that there is a period of 37 days between the start of the growth of vegetation and the maximal fertility of the females. During this period, the hens will fatten up to face the period of incubation. This author who mainly investigated in the northern Eurasia, noticed that the days before

the laying, the hen looks after shoots of grass and the inflorescences of linaigrettes (*Eriophorum sp.*). In the High-Jura, DESBROSSES (1997) also noticed that the hens look after food on the ground before the laying, mostly feeding on buds of blueberries (*Vaccinium myrtillus*) and herbaceous shoots. We can add that in the beech wood where there linaigrettes and blueberries are missing, the food is much more varied. When the snow melts, all the hazel grouses fly down on the ground to eat. They peck away the growing herbaceous plants. In some places, they find grasses and sedges, sometimes also leaves of spring crocus (*Crocus albiflorus*), leaves of strawberry plants (*Fragaria vesca*), of *Melampyrum sylvaticum*, primroses (*Primula sp.*), wood anemone (*Anemone nemorosa*) or oxalis (*Oxalis acetosella*). At the same period (in April and May) they visit the hazel trees (*Corylus avellana*) for catkins and the willow trees (*Salix sp.*) for the pussy willows. When the buds of beech (*Fagus sylvatica*) appear (April to May), the hazel grouses stuff themselves, so that this food type can represents 90% of the daily ingested food. From July to December its weight can increase over 30%, going from 320 g after the laying to 420 g before the first snow falls. Thereby, they take advantage of the numerous fruits (Strawberry, blueberry, raspberry, sorb, hawthorn fruit, rosehip and elder-berry), which can be found in clearings and along the edges. These fruits are rich in vitamin C, some also in provitamin A as well as in minerals and flavonic pigments (MULHAUSER, 2003a). To benefit from vitamin C, rosehip or hawthorn fruit have to be eaten row after they have frozen. According to our observations in the canton of Neuchâtel, the hazel grouse is able to manage this very well, as it spaces out the consumption of these two fruits during the whole winter.

PREDATION

If food choice is essential, this can not totally ensure the survival of the species. It must be able to fight against its predators by developing effective strategies. Hazel grouses make not exception to this natural law: eat without been eaten. In the High-Jura, its arboreal habit enables to escape to most of dangers. They are more vulnerable on the ground. During normal time, their plumage ensures an excellent mimicry on the forest ground, together with its natural caution. Nevertheless, during the breeding time and in autumn, the survival of the species needs to take risks. The birds expose themselves when they try to form new couples, they have to protect their territory against the intrusion of males in excess. In autumn, the young birds are the victims of the fight for the best wintering area.

DESBROSSES (1997) calculated that on the whole population of the Risoux (Doubs, France), the rate of survival reaches 49,1% of the individuals per year, thus giving an average survival of 3,4 years. The comparison of this two results shows clearly that the killed birds are mainly immature birds of the year.

With the synthesis of observations made in Jura Mountains, we can figure out the reasons of decease of the hazel grouse (tab. 1). Two cases of accident and natural death (illness, weakening, exhaustion) are reported, through the Museum where the birds were collected. The hazel grouse knows three important predators: the goshawk (*Accipiter gentilis*) in 45% of the cases. Both the marten (*Martes martes*) and the fox (*Vulpes vulpes*) in 35% of the cases. One death is attributed to the lynx (*Lynx lynx*) in Jura of canton of Neuchâtel, by the natural history Museum of Neuchâtel. Another death is attributed to sparrow hawk (*Accipiter nisus*). Regarding the lynx, a special survey shows that, in the Jura, Tetraonidae are occasional preys

for this great predator. These comments could also be valuable for the wild cat (*Felis sylvetris*; personal comments by Martin Liberek).

Of course, our analysis takes into account only known cases of decease. The relation predation/natural decease is certainly different in the reality. However, our figures are quite similar to those obtained in Bavaria, where KÄMPFER-LAUENSTEIN (1995) followed a population of hazel grouses by radio tracking. In the Bavarian Alps 50% of known deceases are attributed to the goshawk (tab. 1). Also there, it is the main predator of the hazel grouse. Investigations made in Finnish taiga show that the hazel grouse is a guarantor for the survival of the goshawk (*Accipiter gentilis*) representing 34% of the ingested biomass during one year by this raptor (LINDEN & WIKMAN, 1987 in BERGMANN *et al.* 1996; TORNBERG & SULKAWA, 1990 in BERGMANN *et al.* 1996).

This type of information is lacking for the Jura Mountains. Observations in the valley of La Brévine (canton of Neuchâtel) indicate that this raptor is quite eclectic in its choice, catching from time to time coots (*Fulica atra*), moorhens (*Gallinula chloropus*) and other birds from banks. DESBROSSES (1997) assumes however that in autumn, sparrow hawks and goshawks (*Accipiter sp.*) focus their hunting on the Tetraonidae.

Regarding the predation of eggs, there are not enough data for the Jura Mountains. According to German studies, the loss of eggs due to predation is estimated to 50% in the Black Forest and in Bavaria (BERGMANN *et al.*, 1996). This loss is attributed to opportunist animals like: wild boar (*Sus scrofa*), fox (*Vulpes vulpes*), badger (*Meles meles*), marten (*Martes martes*) and corvidae (*Corvus sp.*). None of these species is specialized in the search of nests of hazel grouse, because it would need too much energy.

Except in occasional situations, we note therefore that a single predator species cannot be alone responsible for the extinction of a population of hazel grouse. On the other hand, the general pressure exerted by a group of predators can bring it in danger. The reason of this disequilibrium linked to the change of habitat, has to be found out.

Espèce	Jura mountains	Bavarian Alps	Total
Goshawk *Accipiter gentilis*	9	11	20
Marten *Martes martes*	3	5	8
Fox *Vulpes vulpes*	2	3	5
Fox or Marten ind.	2	2	4
Sparrowhawk *Accipiter nisus*	1	0	1
Lynx *Lynx lynx*	1	0	1
Accident	1	0	1
Natural death	1	1	2
Total	20	22	42

Table 1: causes of the know deceases of hazel grouse in the Jura moutains and the Bavarian Alps.
Synthesis of the datas. Jura moutains: DESBROSSES (1997), SCHATT (1995), GEHRINGER (no published) and our datas.
Bavarian Alps: KÄMPFER-LAUENSTEIN in BERGMANN *et al.* (1996).

STRUCTURE OF HABITAT

The hazel grouse occupies preferably diversified plantings with numerous open areas, but also mature afforestation with bushy undergrowth (fig. 4). In the High-Jura, this vegetation is found especially in the beech wood (*Abieti-Fagenion*) and the fir forests (*Abieti-Piceion*). These forests are comparable to Scandinavian and Russian taiga. However the development of human activities and the influence of climatic factors around these mountains of middle altitude condemn them to nearly complete insulation.

In the south, exchanges of populations are still possible between the department of Ain/France and the department of Savoy/France. In the north, the intensification of cultivation and industrial activities in the Rhine valley do not allowed the migration between the Vosges/France and the Black Forest/Germany (fig. 1).

The so-called "island" Jura contains a boreal-alpine fauna, a relic which has to face important changes of its environment (MULHAUSER, 2003b). If the migratory birds have a greater ability of adaptability, the situation is much more delicate for sedentary birds. The case of the hazel grouse is particularly relevant.

Sedentary life and home range

When the hazel grouse has found a favourable site to settle down, it will never leave it. This little area about ten hectares is its home range (SANTIAGO *et al.*, 2003). This extreme settle a way of life is explained by the total adaptability of the bird to its environmental conditions, encountered during the whole year in this area. Even if it has to fight for survival during the wintry weather, it withdraws a great benefit to be on the place at the beginning of breeding.

Nowadays the forests in the High-Jura still offer good conditions. In winter, the climate is similar to a continental one. There are low temperatures and the precipitations occur in the form of snow. With such conditions many predators must tem-

Figure 4: typical habitat of the hazel grouse in the Jura moutains, a clear forest with fir, beech and bushes. © Blaise Mulhauser

porarily migrate towards lower areas. This is the reason why the hazel grouse survives better during hard winters than mild ones. Nevertheless, the hazel grouse must rely on many shelters to survive. The forest structure is therefore crucial allowing the birds to sleep on a roost or in a igloo.

Roosts

When snow is missing, the hazel grouse takes refuge in the trees. A group of coniferous trees, often young spruces between 8 and 15 meters high, forms the structure of the roost. Often at the top of the trees, the branches are joining together to form a hut. For sleeping the bird enters the hut, by choosing an open branch so that it can fly away in case of danger. It perches not far from the trunc, but never against it. This is also a precaution for more safety against predators. Its roost is situated between 2 and 5 meters high (3,2 ± 1,3 for a panel of 32 sites in Jura of the canton of Neuchâtel). We observed in some cases that two individuals lived together in the same group of trees.

After marking these sites and visiting them regularly, we noticed that several individuals are loyal to their main roost, not only during the bad season but also in autumn and spring and this during almost two years (MULHAUSER, 2003a). When studying the moving of the birds and their activity during a whole year, we noticed several diurnal and nocturnal roosts located at different distances form the main one. When comparing the position of the main roost with the coupling activity in the territory of breeding, it becomes clear that the dormitory is in the centre of the home range.

During the day, the hazel grouse uses also resting roosts. They are situated on the nourishing places, in the small copses made up of deciduous bushes and coniferous trees. Generally these are little spruces of less than 5 meters high, with low branches reaching the ground. The birds stay just over the ground (0.8 ± 0,5 m for a panel of 12 observations in Jura of canton of Neuchâtel), on a branch with a good clearing towards the ground.

Igloos (snow-burrow)

When snow falls are important, the hazel grouse is not anymore in security on their roosts. The snow weight bends the branches, reducing the opening for fliying away in case of predation. With 15 cm of snow, the bird comes down to the ground and builds an igloo. The hazel grouse makes a burrow, whose end is fitted out with a small lodge.

There is an actual typology for the snow-burrows (fig. 5 and tab. 2). Most of the informations come from the study of DESBROSSES (1999) on the French High-Jura and MULHAUSER (2003a) in the swiss part. In the whole Jura Mountains, indeed two types of igloos are founded, those used some hours during the day and those used as refuge for the night.

The diurnal igloo contains in general less than 40 droppings, often only 10. With a few exceptions (surprised bird), the caecous dropping is never released.

In the nocturnal igloo a total of more than 40 droppings is founded (very often about 60) at the bottom of the lodge. The cover of fresh snow must exceed 15 cm. The bird cligs its igloo in the late afternoon. From the entrance, a small burrow is excavated up to a little room just big as itself. During the night, it will evacuate regularly its droppings. In Sweden, SWENSON (1991) counted an average of 67 droppings. In extreme cases (long stay), DESBROSSES (op. cit.) found 96 droppings. In the morning, the bird will leave this igloo, which will not be re-used. The caecum pockets are then emptied. Presence of caecous dropping near the burrow entrance is characteristic for a night shelter.

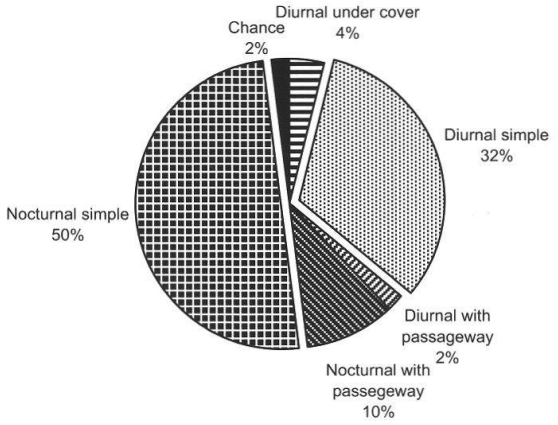

Figure 5: proportion of the different types of igloo founded in the Communal de La Sagne (canton of Neuchâtel, Switzerland) in winter 2002-2003 (n=50).

Diurnal igloo with watching lane

During the very cold day or when the snow falls without stopping, the hazel grouse shelters under the snow. However it has to glean food as long as there is light. The resting periods are dependent on the hunger of the bird and meteorological conditions. During a strong snow fall, the hazel grouse can stay many hours in its igloo, as long as its hunger is satisfied. If there is a danger, instead of flying away, it prefers a discreet escape under the snow. Moving forward in the powder snow, it easily digs out a long tunnel. From time to time it gets the head out of the snow, to watch the intruder. DESBROSSES (op.cit.) mentions three igloos with a tunnel longer than 5 meters, having watching holes.

Simple diurnal igloo

Most of the diurnal igloos are very simple. During a snow fall, the hazel grouse drops into the fresh snow. In the hole produce by its impact , the bird coils up in the snowy basket and lets become covered with the snowflakes. When weather condition improve, it leaves its igloos to seek for food. For a short stay, no entrance will be build.

Diurnal igloo under cover

On several occasions, we observed hazel grouses escaping from igloos build under a cover of a stump or a roof of branches. In the first case, the bird has build one or more lanes between the ramification of the stump. The hole for flying away was at the lowest point in the direction of the slope. One of this igloo has been visited by a marten (*Martes martes*), but unsuccessfully. In the second case, the dense branches build up a thick roof so that the ground was nearly free of snow. The protection against the cold was optimal and the shelter wide enough for the bird to move around.

Nocturnal igloo with antipredator lane

When studying the survival conditions during a cold winter in the High-Jura, DESBROSSES (op. cit.) discovered one of the most remarkable aspect of the intelligence of this gallinacean. In several cases, the access lane leading to the dormitory room made a right angle. This configuration allows the bird to be protected from the predators, especially from the marten (*Martes martes*). When the predator enters in the tunnel, it cannot see its prey and doesn't know if it is resting on the right or on the left. The hazel grouse takes advantage of this surprise effect by flying away directly from its shelter. In one case, DESBROSSES (op. cit.) saw two successive angles.

Simple nocturnal igloo

During very cold periods, the hazel grouse doesn't organise a complex igloo. It only makes an opening so that it can watch the surrounding area. The entrance lane is very short, less than 50 cm.

Chance igloo

A chance igloo is a shelter which could not be organized. A quick fall of temperature as well as the hardening of the snow does not allow the bird to dig out its

Localisation	Number [n]	Slope [%]	Cover trees [%]*	Type of couch
In open pasture, in the breaking-slope	11	0 à 10	5 à 10	Diurnal or nocturnal
In wooded pasture, in the breaking-slope	18	0 à 10	10 à 25	Diurnal or nocturnal
In a forest's clairing, soft slope	10	0 à 5	25 à 50	Diurnal or nocturnal
In a wooded pasture's clairing, in the slope	5	15 à 25	10 à 25	Diurnal or nocturnal
In wooded pasture, under a tree, in the slope	4	10 à 15	10 à 25	Diurnal
Under a stump, in the slope	1	15	25 à 50	Diurnal under cover
Under a stump, in the breaking-slope	1	5	5 à 10	Diurnal under cover

* superficy of 0.25 ha ** Hazel-tree *Corylus sp.* or Sorb *Sorbus sp.* generally

Table 2: snow-burrow sites in the Communal de La Sagne (canton of Neuchâtel, Switzerland), in winter 2002-2003 (n=50).

shelter. The snow packed down and the upper layer has frozen. The hazel grouse tries with difficulty to scratch this layer and cannot bury itself completely under the snow, so that it stays overnight half buried. We can observe this type of behaviour when there is a lot of snow, preventing the bird to take refuge under the foliage of a tree. The traces of furrows without bowl can stay during several weeks on the snow.

The location of the igloos is not a matter of chance. The table 2 shows that the hazel grouses prefer to settle their shelters in a forest clearing with a soft slope. This assertion has to be moderated. When looking at the environment around the igloos, we deduce that the shelters – above all the nocturnal ones – are build up in open pastures, surrounded by trees. The birds use the breaking slope to make a lane for taking flight.

DENSITY AND STRUCTURE OF THE POPULATION

The description of the home range or breeding territory of a pair of hazel grouses is easy. But it is more complex to integrate this concept in a study of the structure for a whole population of hazel grouses. Nevertheless, this is a point which cannot be neglected. A group of 6 pairs isolated the ones from the others in a wide and large forest is weaker than a population with the same number of pairs in territories that are closer from each other. The territoriality of the cocks has therefore a double function: ensuring the females of the best breeders and protectors and securing the social cohesion of the group.

The hazel grouse is monogamous. Each female mates with a single partner. At the beginning of the breeding period and up to the laying, both birds keep very narrow spatial links. The male follows its female everywhere. It protects its territory against every intruder like a sentry. If the female moves away, the male follows within a short space.

Year in year out, the sex ratio varies between 4/6 to 2/8, but the males are always in excess. During bad years, 60% of them never find partners. The singles extend their field of activity, looking for females. As observed by MONTADERT (1995) movements of several kilometres are common. They meet the mated cocks, confined in the best breeding areas, where they have to defend more bitterly their territory not exceeding 10 ha.

Another observation made in the canton of Neuchâtel (swiss Jura) over a population of about 20 mature birds, indicates that the song of the birds has a double function (MULHAUSER & ZIMMERMANN, 2003). The first is to protect the territories, the second is the reinforce to the social structure of the population (fig. 2). During summer for example, the males continue to sing. They reply each otherwithout aggressiveness, but remain silent when an intruder tries to imitate their calls. For them an "unrecognized" bird does not belong to the group.

In autumn, the young males of 3 or 4 months begin to sing. Under the pressure of hormonal development, their aggressivity increases towards fellows. They take risks to chase the mature males out of their favourable territory. However a adult in good health does not give up its place to a younger bird. The knowledge of the breeding territory is a great advantage for the female. The immature birds will settle in less favourable areas, but if possible near to those of the adults. The density reaches 2 to 3 birds per ha when the conditions are optimal (SANTIAGO *et al.*, 2003).

Territoriality

As long as the female has not laid its eggs, the vocal activities are important. When a bird hears the song of its rival, it runs nearby, with the neck stretched, the tail fanshaped and the crest erected. Sometimes, it rustles (a noisy flapping of the wings making the characteristic rustle noise) and leaps lightly. Struggle and chase between opponents are possible but are not the rule. When possible, the mated cock just uses means of intimidation and avoids struggles. Its perfect knowledge of the territory is a real advantage for the hen. It must die, be killed or become weaker to give up its territory. Up to now, it was not possible to prove a change of partner after these types of territorial demonstration.

Figure 6: a very young chicken of hazel grouse recognized by its individual brown marks.
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Abundance and dynamic of the populations: cyclical evolution

The cyclical evolution is well known for some species of rodents like the lemmings and voles (SAUCY, 1988). The cyclical evolution is more or less the same between species of gallinacean. Regarding the hazel grouse, a Finnish study signaled by BERGMANN *et al.* (1996) clearly showed the link between the density of birds per km^2 and the number of hunted birds. During the period 1964-1992, peaks have been observed every eight years, in 1965-66, in 1973, in 1980-81, in 1988-89. Further, in Russian taiga three peaks have been recorded during the same period as in Finland, one in 1964-65, an other in 1981-82 and the last one in 1988 (BESCHKAREV *et al.*, 1994).

In Switzerland, the old cynegetic charts reveal a regular cyclical fluctuation of the hazel grouse population. Two facts are amazing: firstly these fluctuations are synchronous from one canton to the other, whether the hunting takes place in the Alps or in the Jura (SANTIAGO *et al.*, 2003), secondly the cyclical evolution seems to be similar for the capercaillie (*Tetrao urogallus*). This means that external conditions affect periodically the breeding of the tetraonidae, for

example a greater hunting pressure during certain years. This second hypothesis is highly improbable because the number of hunters should increase at the same time and in a cyclical way.

The figure 7 shows the catches of hazel grouses (*Bonasa bonasia*) and brown hares (*Lepus europaeus*) recorded in the canton of Neuchâtel, as well as those of capercaillie (*Tetrao urogallus*) in Switzerland. The analysis shows that there is a close correlation between the fluctuation of the hunting lists of the hazel grouses in the canton of Neuchâtel and those of the capercaillies in Switzerland. This correlation is less pronounced for the populations of hare, but exists too (MULHAUSER, 2003a). During the period 1926 to 1962 in the canton of Neuchatel, the peaks for hazel grouses concern the years 1930-1931, 1946-1947 and 1959-1960. These years are the same for the hare, with another peak in 1981. However, the surveys on these three species show a decrease since the fifties and the peaks become smaller. At the end, the cycles don't seem to be totally regular. On the other hand, we realize that several vegetarian species have an identical destiny. The most plausible hypothesis is that these animals are affected by the growth of the vegetation linked to particular climatic conditions. The effect of the predation occurs later.

CONCLUSION

The hazel grouse has notable abilities to survive in the hard climate of the High-Jura. Several physiological features of its organism allow it to benefit during the winter of a frugal vegetal feeding. Thanks to its sown with double feathers, the hazel grouse can withstand without problem to very low temperature of –45°, as found commonly in the northern Siberia, but seldom in the Jura Mountains. Its basic requirements are guaranteed without moving too much, because it knows quite well its home range. However this strong settling has not only benefits. It also makes the population of hazel grouses vulnerable when its habitat is subject to changes.

Today, the disruptions that take place in the landscape of the Jura can be of climatic order or be generated directly by human activities. The global warming has direct effect on the growth of the vegetation. If this fact persists on the High-Jura, the spruce (*Picea abies*) and the white fir (*Abies alba*) will decrease to the benefit of the beech tree (*Fagus sylvatica*, KIENAST *et al.*, 2000). In this case, the hazel grouse shouldn't suffer too much from the situation, unless the global warming will bring winter with few or without snow falls. Undoubtly, long series of mild winters could allow all opportunist predators, among others the goshawk (*Accipiter gentilis*), the fox (*Vulpes vulpes*) and the corvidae (*corvus sp.*) to set up on a long term basis in the areas that they leave actually during winter time.

If to this climatic effect is added the impact of a too selective forestry, this small gallinacean could know the same fate as its cousin, the capercaillie (*Tetrao urogallus*). In ageing forests where the regeneration of the vegetation is very slow, the quality of the food decreases and the birds weaken. On a long term, the social structure of the population weakens. The density decrease, because the birds are more and more isolated from each others.

Conversely, a management of the forest that improuving the edges and the undergrowth like sorbs (*Sorbus sp.*), hazelnuts (*Corylus avellana*), wild roses (*Rosa sp.*), hawthorns (*Crataegus sp.*) which are the preferred food of the hazel grouse, will lead to the strengthening of the population. The forester has a major role to play to ensure the future of the hazel grouse in Jura Mountains. He must introduce a forestry going from the cluster of trees to a new concept of forestry patchwork.

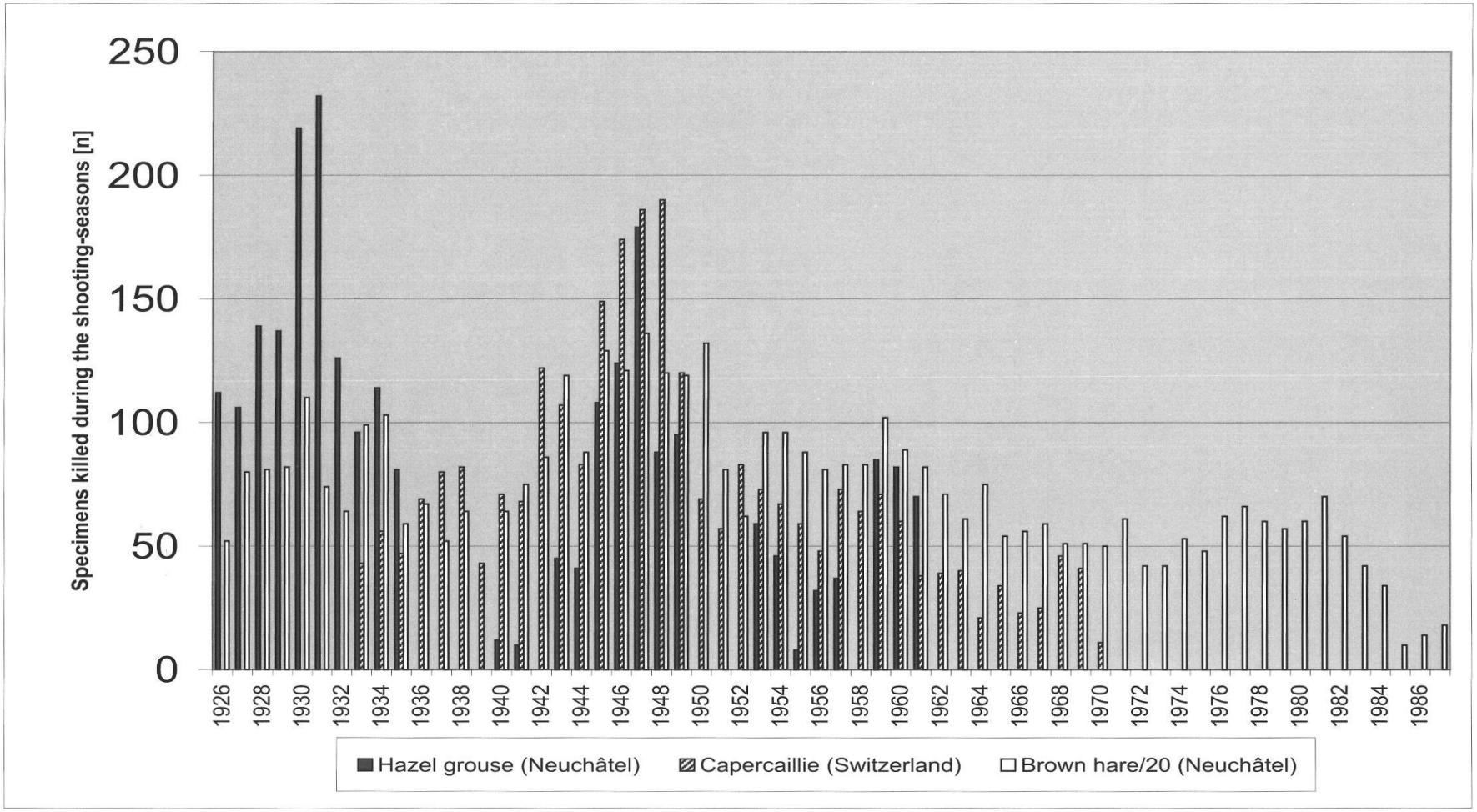

Figure 7: statistik of hunting for hazel grouse *Bonasa bonasia* and the brown hare *Lepus europaeus* (n/20) in the canton of Neuchâtel, and fot the capercaillie *Tetrao urogallus* in Switzerland between 1926 and 1988.
Remark: years without result correspond to a period with forbidded shooting or missing datas (only for capercaillie between 1926 and 1932).

AKNOWLEDGMENTS

Thank you very much to Mme Gertrude Monnet and M. Paul Mulhauser for the great work of english translation. This paper has received the critical support of my colleague M. Sergio Santiago. Thanks for this great apport.

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