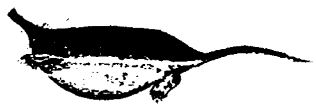

The small hydroplants: predicted impacts on the Pyrenean desman populations (*Galemys pyrenaicus*, Geoffroy)

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Summary: Legislation concerning the exploitation of hydroelectric energy by the private sector is causing a large increase in the number of small hydroplants in Portugal. Since 1988, about 900 requests were presented to obtain the necessary licences. Most of them are in watersheds in the North and Center of the country. Small streams and fast running rivers can be significantly transformed by these projects. An important overlap between requested sites and distribution area of pyrenean desman is recorded.

We predict a number of direct and indirect negative impacts on the species during construction and exploitation. These include changes in patterns of instream flow, solid transport, substratum composition, the impoverishment of the benthic organisms on which this species feeds and the formation of physical barriers reducing gene flow and dispersion ability. This effects have unpredictable consequences for the social structure and dynamic of the local populations.

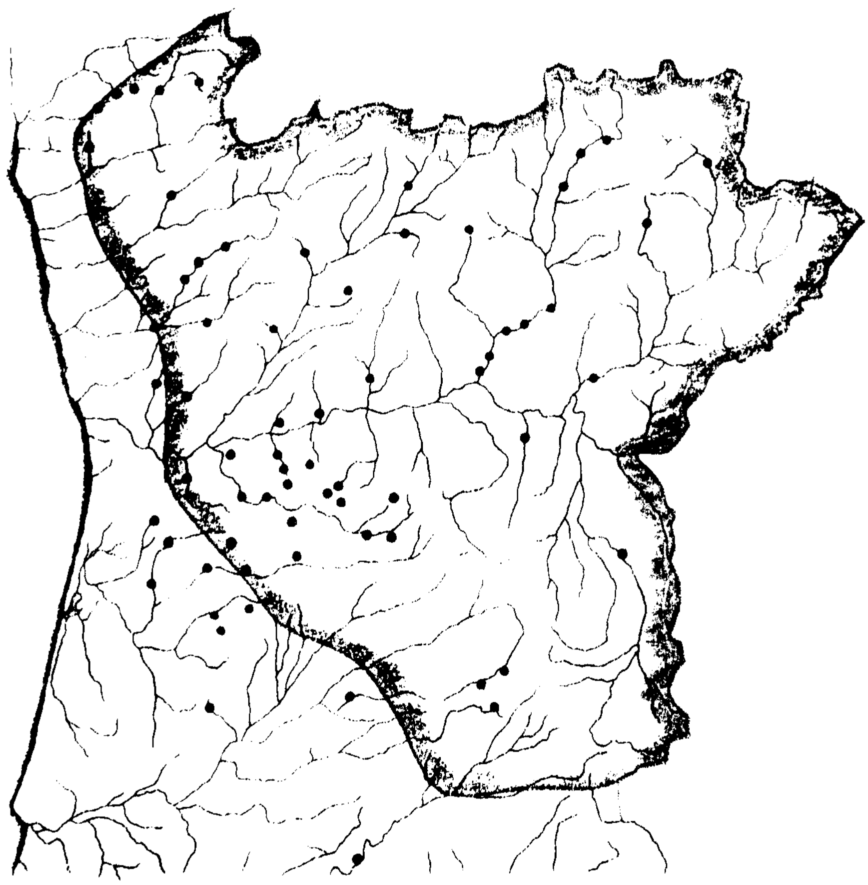
We suggest some mitigation measures.

Introduction

Legislation concerning the exploitation of hydroelectric energy by the private sector is causing a large increase in the number of small hydroplants in Portugal. Since 1988, about 900 requests were presented to obtain the necessary licences.

Most of them are in watersheds of the North and Center of the country. Small streams and fast running rivers can be significantly transformed by these projects. An important overlap between requested sites and distribution area of the pyrenean desman is recorded.

It is well known that the installation of hydroplants causes a number of



• sites licensed to small hydroplants

limits of potential distribution area of *Galemys pyrenaicus* in Portugal

Fig. 1 - Distribution area of the Pyrenean Desman and locations of requested sites for hydro plants, until 1991 (ESPÍRITO SANTO, M.J. et al. 1991)

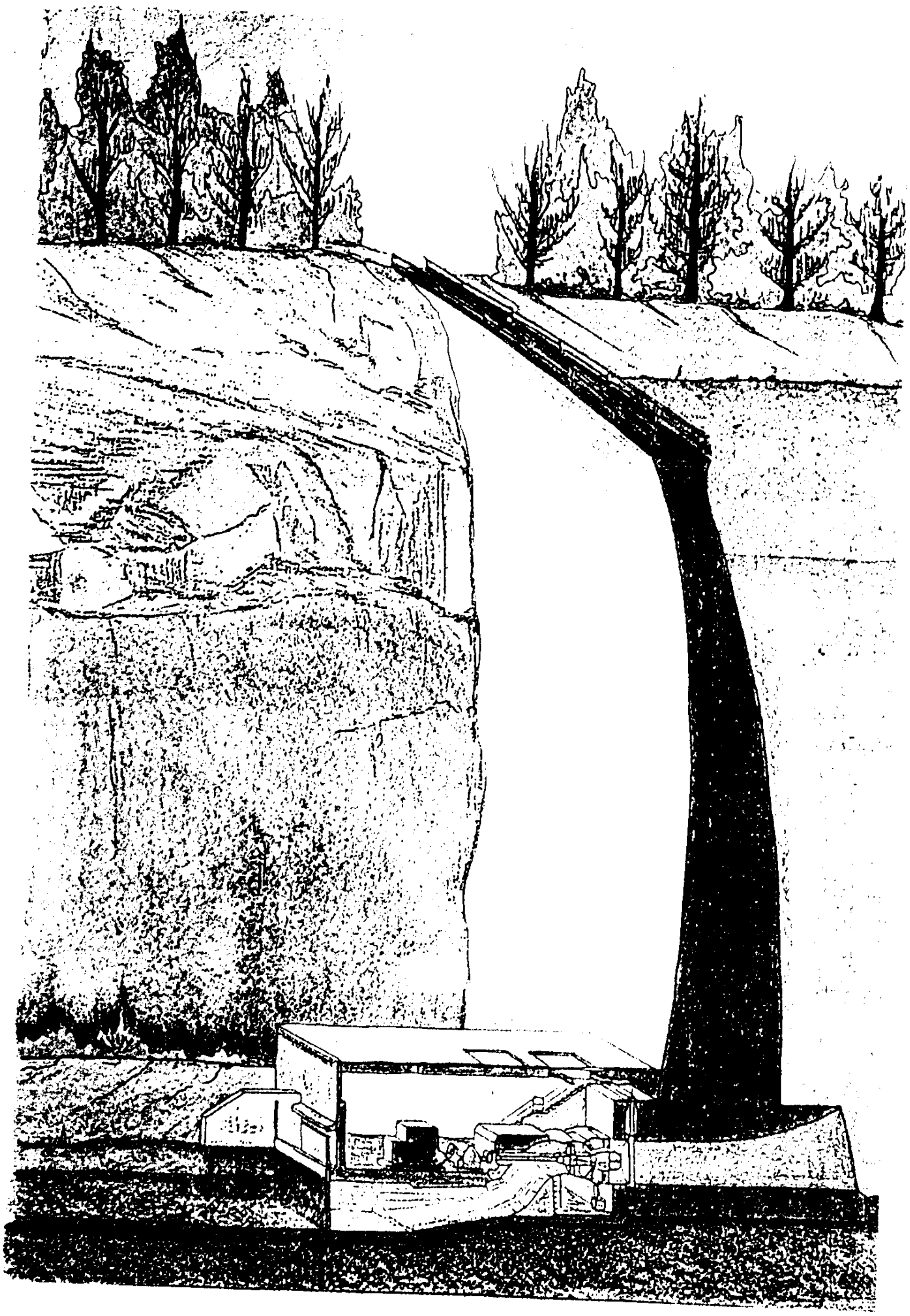


Fig. 2 - Hydro plant with the generator placed at the base of the dam

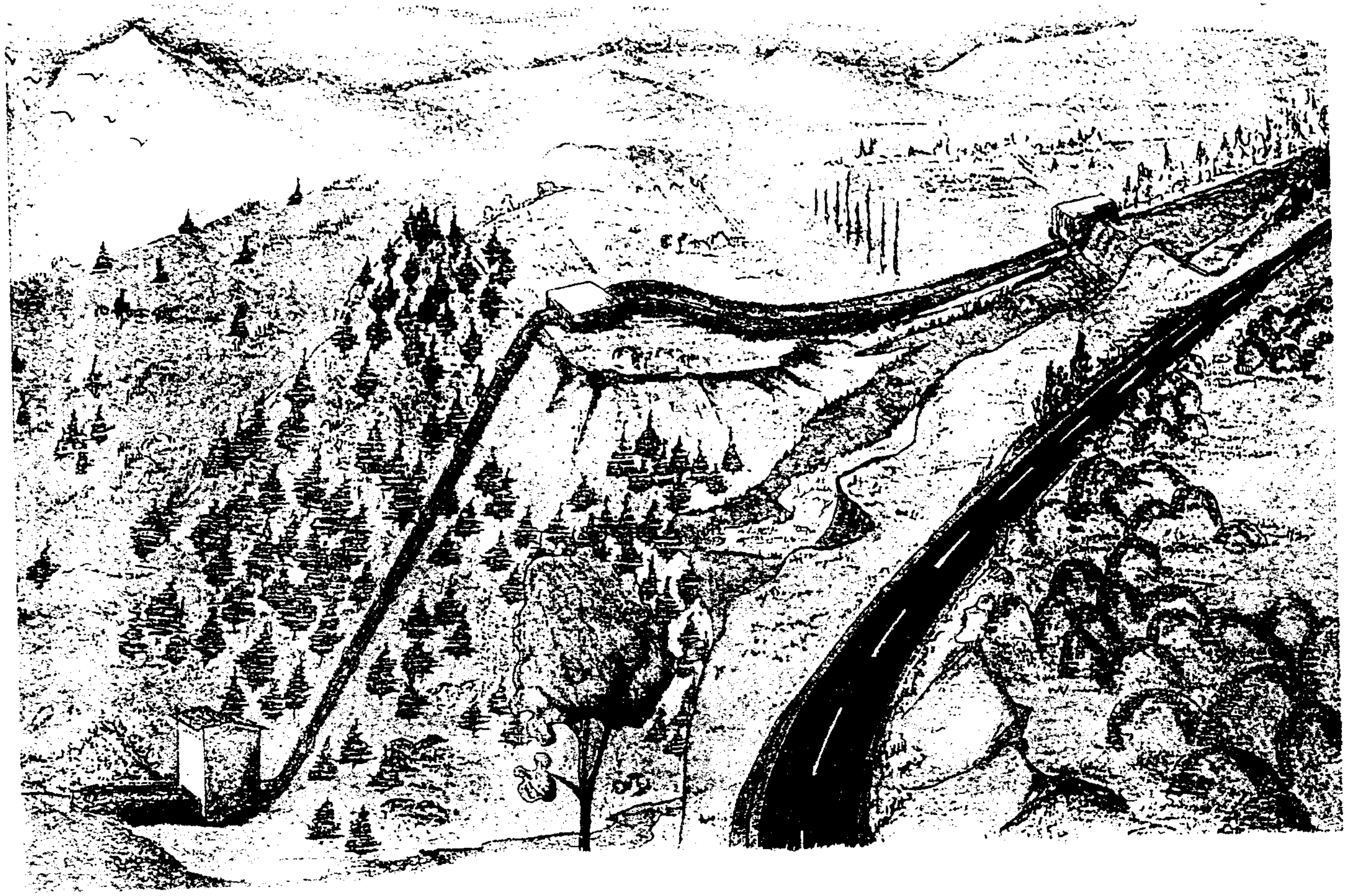


Fig. 3 - Hydro plant where a large part of the river flow is driven to a channel

physical and biotic modifications on the streams and rivers where they are implanted (TELHADO et al. 1989; ALVES, 1991) during both construction and exploitation phases. This information, together with available data on the life history and behaviour of the pyrenean desman, leads to several predictions concerning the effects of a rapid increase of the number of hydroplants on the *Galemys* populations.

In this paper we discuss the probable threats that these intensive environmental changes may cause. Our aim is to define mitigation measures that should be taken into account in designing, and managing hydroplants, in order to minimize the risk of a massive population destruction.

Overlap between distribution area of *Galemys pyrenaicus* and requested sites for small hydroplants installation

In fig.1, we present the potential distribution area of the pyrenean desman and the locations of requested sites for small hydroelectric schemes, until December 1991.

Data on potential distribution area of *Galemys pyrenaicus* are based on a survey of the ecological literature about the species (RICHARD,1986; PALMEIRIM & HOFFMANN, 1983; PODUSCHKA, W. & B. RICHARD, 1986), an inventory of the watersheds that fulfilled the ecological requirements of the species and the available information on the occurrence of the species in Portugal (QUEIROZ, 1989; QUEIROZ, 1991; RAMALHINHO & TAVARES, 1989)

The analysis of Fig.1 clearly shows that the projects for hydroplant building are heavily concentrated in the North and Center of the country, coinciding with the potential distribution area of the pyrenean desman.

Some of the most suitable sites for small hydroplants are streams with steep profiles that keep a flow even in the summer. Watersheds with these characteristics are just those where *Galemys* is found. Thus, the overlap shown in Fig.1 is not merely geographical but also ecological. If we consider that from this potential habitat for desman only a fraction is currently known to be inhabited by this species we conclude that the situation is even more serious than Fig.1 would suggest.

Predicted impacts of hydroplants on pyrenean desman habitat

There are basically two types of small hydroplants, illustrated in Fig.2 and 3.

The first type is constructed in rivers that carry large water volumes and involve the formation of a small artificial lake upstream of the dam. The generation plant is placed at the base of the dam.

On the second type, a large part of the river flow is deviated to a channel, leaving a section of the river without water or with a reduced flow. The water rejoins the river downstream of the generation plant.

Thus, in predicting the impact of a hydroplant three river sections must be considered: upstream of the dam, between the deviation and the release and downstream of the release. Only in the second type of hydroplant the area between deviation and release exists.

Upstream of the dam the building of a small hydroplant involves the formation of an artificial lake. With the rise of water level the primitive stream banks are submerged and burrows used by desman as shelter and nest sites cease to be available. It is also probable that the new shore line does not present replacement shelters and nest sites unless they are artificially provided. The formation of the lake also causes a sharp decrease in water velocity and an increase in water depth. These modifications tend to drastically affect substratum composition, promoting the accumulation of fine sediments and reduce oxygen concentrations near the bottom.

These changes typically impoverish both the abundance and the diversity of the benthic invertebrate fauna upon which desmans rely for food (SANTAMARINA & GUITIAN, 1989 ; BERTRAND, 1991). Thus, the new muddy and poorly oxygenated substratum may cease to provide adequate food supplies for the desman. It is also unknown if the sensory mechanisms of desmans allow them to search and detect prey in these conditions.

When feeding in a gravel bottom the desman "anchors" itself with the claws of the hindpaws, while the proboscis scans the substratum for food.

It seems unlikely that such prey catching behaviour can be operated efficiently in soft substratum.

This problem may be even more serious due to the following reasons:

1. The animals tend to float and unless they are able to anchored in the bottom they must perform continuous swimming movements with the hindpaws (QUEIROZ & ALMADA, 1991) to keep near the substratum. Thus, even if they can get some food in these muddy conditions, the net energy obtained may be insufficient to offset the costs of diving and swimming;

2. The increase in water depth caused by the formation of the lake means that the animal must swim longer distances and will take more time to reach the bottom. This situation will further increase the energetic cost of feeding and is likely to reduce the time available in each dive for effective prey catching.

The potential problems mentioned in the previous section apply to the area upstream of the dam. However, the river bed is also affected downstream the dam. Between the points of deviation and release, the water flow is reduced and may affect the invertebrate fauna.

Downstream of the dam a different set of problems has to be dealt with.

Near the point where the water is returned to the river the substate is strongly washed out of benthic organisms, water turbidity tends to increase, while fine sediments tend to accumulate further downstream. In these conditions the water flow becomes subject to sudden fluctuations that the animals will not able to track.

Thus, this river section downstream of the dam is also an area of unstable conditions and lowered productivity.

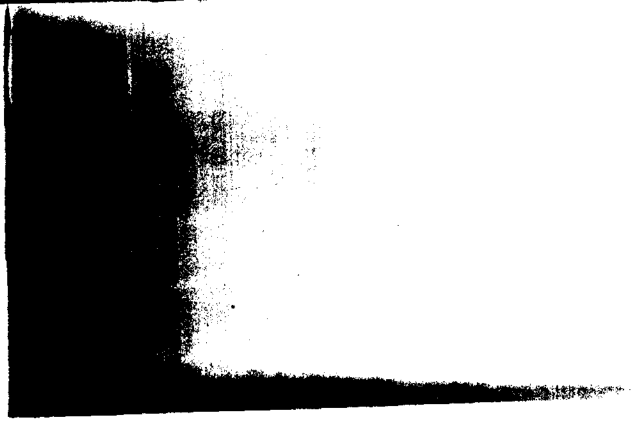
In the case of large dams with regular discharges the impoverishment of the river fauna may extended to 3 Km downstream of the dam (BOON, 1988).

In conclusion, it is predicted that the construction of a small hydroplant is likely to affect the desman populations both upstream and downstream of the dam, both in terms of destruction of shelters and nest sites and in terms of food availability and efficiency of prey catching by the desman.

Apart from these treats, there are also reasons to suppose that this type of habitat modifications may exert a direct negative impact in the desman populations.

Predicted impacts of hydroplants on pyrenean desman populations

The available data on social behaviour indicates that the adults are solitary in nature and aggressive to



conspecific (STONE, 1987 RICHARD, 1986) In such way the population density is always very low.

RICHARD (op. cit.) found that when two individuals are confined in a restricted space very serious aggression acts results and one of them being usually badly wounded. Based on radio-tracking studies STONE (1987) found that in a section of about 500 m of river only a single pair can occur. Male and female use separate nests and their patterns of movement both in time and space tend to minimize the possibility of direct contact. Thus the available data indicate that in this species agonistic behaviour causes a wide spacing of individuals and it is likely that juveniles are forced out of their parents home-range.

The building of an hydroplant may affect desman populations in several ways:

1. The habitat will be fragmented in small units between which the animals are unable to move, unless special measures are taken to ensure that the animals can effectively cross the obstacles, resulting from the construction and river modifications. The fragmentation of a population in very small units is usually detrimental due to the increase of inbreeding with the depression in variability and fertility that commonly accompanies it. On a larger time scale the reduction of genetic diversity may affect the potential of the population to adapt to new conditions. This is probably much more serious for populations like those of the desman in which is low population density even in unchanged conditions.

2. Apart from the negative consequences of inbreeding, the sub--populations in a river system cut by several barriers may become so small in size that they may be at high risk of local extinction. It is important to remember that fertility in this species is low.

PEYRE (1961) found that the litters are of three to four young at best and the females produce only one litter a year. The same author PEYRE (1968) found that in a pyrenean populationof 72% of multiparous females have ovarian cysts that can be an important limiting factor to the reproductive success of this species.

3. Small insectivores are highly susceptible to stress that can inhibit reproduction. When in a confined river section there are serious risks of aggression and stress due to the inability of juveniles to move out of the parental home-range. This may further decrease the reproductive output of the population and increase mortality.

4. The formation of barriers that the animals are unable to cross means that local extinctions are not compensated by immigration from the areas where the population density is high.

Taken together, the facts reviewed above indicate that desman populations may be seriously affected by habitat fragmentation and great care must be taken to avoid it.

Mitigation measures

The relative importance of the different potential threats listed in this paper needs to be assessed with adequate empirical data. It is important to remark, however, that biological studies of this species have a slow progress. We think that it is not admissible to allow major habitat disruption with the argument that empirical data are not yet available to support the resolution of all the potential problems that were outlined above.

A number of cautionary measures should be taken in order to anticipate the probable detrimental effects for the desman caused by the increase of small hydroelectric schemes.

We propose the following global measures:

1. Establishment of undisturbed rivers that should be sanctuaries for the species.

2. Management of the river basins ensuring that the localization of hydroplants will minimize the fragmentation of the populations in order to keep viable populations.

3. Ensuring a minimum flow in the stream to allow the maintenance of the natural levels of abundance and diversity of invertebrates.

4. Development of biological studies in order to determine minimum viable population size.

In addition, the following specific measures should be considered:

1. Development of devices, including the eventual adaptation in fishways, in order to allow desman movements across the dams.

2. Adaptation of the banks to ensure the availability of shelters and nest sites.

a) Recuperation of affected river banks

b) Revegetation of new banks of the reservoirs

c) Placement of rock and artificial burrows in the new banks of the reservoirs.

The hydroplant are not the only cause of disruption of desman habitat. Pollution, deforestation of river banks, and all kinds of stream modifications, contribute to threaten *Galemys* populations. In this way, the set of measures proposed to minimize the impact of hydroplants must be integrated in a broader framework of a global policy of river conservation.

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