Adaptation of beavers (*Castor fiber*) to extreme water level fluctuations and ecological implications

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Abstract: We have observed how beavers (*Castor fiber*) cope with water fluctuations in the Millingerwaard, part of the Gelderse Poort, a floodplain system of the river Rhine in the Netherlands. Beavers were introduced here in the mid 1990s. After severe losses in the first years the population grew gradually, up to about 60 animals in 2004. The narrow floodplain causes extreme fluctuations in water levels, normally between 6-7 m on an annual basis. During a series of floods in the 1990s it was observed that the beavers could cope with these fluctuations, constructing special lodges on higher ground within a few days. During the extreme dry summer of 2003 most beaver habitat in the Millingerwaard dried up completely. The beavers constructed burrows in the banks of a sand pit as safe homes to survive the drought. These events show that beavers readily adapt to periods of extreme flooding and drought. Each event stimulates the settlement of beaver territories at new locations. The concentration of beaver activity in periods of extreme drought may heavily influence the landscape. In the Millingerwaard concentrated beaver activity in the summer of 2003 resulted in more open alluvial forests.

Keywords: river dynamics, population growth, habitat, stress, Rhine, Gelderse Poort, Millingerwaard, migration, beaver activity.

Introduction

In large river ecosystems beavers (*Castor fiber*) have to cope with quite severe water level fluctuations. During extreme floods beaver families are forced to leave their permanent homes (lodges and tubes) to avoid drowning and temporarily move to higher and drier locations. Research in the Elbe floodplain in Germany has shown that beavers are able to construct new lodges and other types of refuge in response to rising floods (Nitsche 2001). Although beavers are able to adapt to flooding, these events cause stress and a loss of animals, particularly of the young. During extreme droughts beavers are also forced to leave their permanent homes, in this case to stay close to the water edge, which provides them with food and safety from predators. In this article we describe the impacts of extreme flooding and extreme drought on beaver territories in the floodplains of the Millingerwaard.

Beavers in the Millingerwaard

Between 1994 and 2000, 54 beavers from the Elbe region (Germany) were introduced in the Gelderse Poort area in the eastern part of the Netherlands (figure 1). The area is characterised by the river Rhine and its floodplains (3000 ha) near the Dutch-German border. One of the largest floodplain reserves in the Gelderse Poort area is the Millingerwaard (500 ha), which is largely managed by the State Forestry Service. In recent times the agricultural fields (formed by centuries of clay sedimentation) in this floodplain were transformed into natural habitats as a result of clay extraction. Today a wide variety of habitat types exists in the floodplain: sandy river dunes, alluvial forests, marshland, and newly excavated side channels.

After severe losses (more than 50%) in the years immediately following their reintroduc-

tion, the beaver population in the Gelderse Poort has started to gradually increase. The number of adults in spring 2002 was estimated at about 40 (ten families and nine solitary territories; Niewold 2002). In the beginning of 2004 the total number of beavers may reach approximately 60 animals, of which some 20 are present in the Millingerwaard (Teunissen 2004).

In the Millingerwaard floodplain beaver habitat consists of former riverbeds with nymphaeid vegetation, clay and sand pits with pioneer and marshland vegetation, and alluvial forests that mainly consist of *Salix alba*, *Salix viminalis* and *Populus nigra*. Niewold and Müskens (2000) showed that, apart from trees, the beavers in this area prefer to feed on plants such as *Glyceria maxima*, *Nymphoides peltata* and *Senecio paludosus*.

Figure 1. Location of the Gelderse Poort area, i.e. where the river Rhine enters the Netherlands from Germany.

River dynamics and adaptations to extreme water level fluctuations

Human intervention has diminished the size of the lower Rhine's floodplain from an original 15 km to approximately 1 km. This process started in the 13th century, with the construction of the first dikes. The much narrower floodplain and the canalisation and normalisation of the upstream river have led to extreme fluctuations in water levels, whose amplitude reaches almost ten metres. Since the beavers were reintroduced to the Millingerwaard they have already had to deal with extreme flooding (January 1995: +16.6 m above sea level) and an extreme drought, with the lowest discharge in decades (September 2003: +6.9 m above sea level). Normal annual water level fluctuations vary between 6-7 meters.

At times of average water levels (between +9 and +12 m above sea level) the beavers in the Millingerwaard live in lodges on the banks of clay pits and former river beds. During a series of floods in the 1990s it was observed that the beavers coped rather well with sudden and severe inundations. When the regular lodges disappeared under water the beavers quickly constructed special lodges or tubes on higher grounds, preferably within their territories (e.g. at old dikes or raised brick factory terrains). Sometimes these high water lodges were finished within a few days. During next floods those additional lodges were occupied again and often extended.

Extreme high water levels, as experienced in January 1995, were stressful events for beavers because even the highest grounds were flooded. In these circumstances they survived by sitting on top of the 'high water' lodges or by resting on floating wood in the alluvial forests (photo1). Afterwards typical signs of beaver activity were found high up in the trees.

During the extreme dry summer of 2003 (which lasted until flooding in mid-January 2004) most beaver habitat in the Millingerwaard dried up completely (photo 2). Nearly all regular lodges were abandoned and the beavers moved to the few remaining deeper water bodies (sand pits). They constructed burrows in the sandy banks as safe homes to survive the drought. To

reach their favourite food (pioneer willow forest) the animals had to pass broad sandy beaches. Tracks in the sand, usually a combination of dragged branches, leg and tail prints, revealed that distances of up to 20 m were crossed. A few beaver families stayed in their lodges near the deep sand pit and daily used a track of more than 100 m to the water. The animals constructed a large network of deep channels to get the last bit of water around their lodges.

Although similar experiences have been reported from the floodplain of the river Elbe in Germany (water level fluctuations up to 6 m; Heidecke 1988), adaptation of beavers to fluctuations of nearly ten metres has not reported before. It re-emphasises the capability of beavers to survive in different habitats and extreme circumstances.

Ecological implications

Although severe flooding and extreme drought can cause major stress for settled beaver families in large river systems, and cause a loss of individuals, these events also have important ecological implications for the population on a larger scale and for the landscape development of the floodplain.

Both flooding and drought stimulate the settlement of new beaver territories within the floodplain, downstream as well as upstream. As suggested by Nitsche (2001) flooding may lead to migration of young beavers to other territories and to the formation of new pairs. Consequently, it affects genetic diversity of populations and thus may improve the viability of beaver populations in the long term.

During the drought in the Millingerwaard we found an extreme concentration of beaver activity around the last remaining water body in the reserve. Over the past ten years hardly any beaver activity was found in this part of the reserve. From autumn onwards, but mainly in winter, the beavers cut most of the willow scrub and wood along the shore of this sand pit. In this way the drought forced the beavers to find food in totally new locations. Because of the concen-

Photo 1. Beaver sitting on floating wood during extreme flooding in January 1995. *Photograph: Johan Bekhuis.*

Photo 2. Dried up beaver pond with lodge and canals in the Millingerwaard (August 2003).
Photograph: Johan Bekhuis.

tration of beaver activity the landscape of the sand-pit has been heavily influenced. Instead of closed alluvial forest the habitats around the lake are more open as a result of this beaver activity, which is likely to lead to a shift in the species composition of the forests.

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Samenvatting

Aanpassingen van bevers aan extreme wisselingen in de waterstand en de ecologische implicaties daarvan

We observeerden hoe bevers (*Castor fiber*) reageren op veranderingen in het waterpeil in de Millingerwaard. De Millingerwaard is een onderdeel van de Gelderse Poort, een uiterwaar-

densysteem van de Rijn in het oosten van Nederland. In het midden van de jaren ’90 zijn hier bevers uitgezet. Na zware verliezen in de beginjaren, groeide de populatie langzaam, tot ongeveer 60 individuen aan het begin van 2004. De smalle uiterwaarden hebben er toe geleid dat er extreme wisselingen in de waterstand optreden, onder normale omstandigheden 6-7 m op jaarbasis. Tijdens een reeks van overstromingen van de uiterwaarden in de jaren ’90 werd waargenomen dat bevers adequaat reageerden op de wisselingen in de waterstand; zo bouwden ze binnen een paar dagen speciale burchten in hoger gelegen delen van het gebied. Tijdens de extreem droge zomer van 2003 kwam vrijwel al het beverbiotoop in de Millingerwaard volledig droog te liggen. Om deze droogte veilig te kunnen doorkomen bouwden de bevers burchten in de zandige oevers van een zandwinplas. Deze gebeurtenissen tonen aan dat bevers zich gemakkelijk aanpassen aan perioden van extreme overstroming of extreme droogte. Zowel overstroming als droogte stimuleert de vestiging van beverterritoria in nieuwe gebieden. De concentratie van beveractiviteit in perioden van extreme droogte kan een grote invloed hebben op het landschap. In de Millingerwaard resulteerde de geconcentreerde beveractiviteit in de zomer van 2003 tot meer open rivierbegeleidende bossen.

Received: 5 November 2003
Accepted: 25 January 2004