herbivores do not have this problem as they can move to areas where more food is available.

The central-place foragers' dilemma can be resolved when free-ranging large herbivores lower the vegetation height, resulting in a higher intake by rabbits, creating a facilitative effect (Chapter 5). Dekker models this relationship in space, i.e. he predicts that facilitation only occurs in areas which sustain a high plant production. When production is too low central-place foragers do not benefit from the presence of free-ranging large herbivores as they are competing for the same limited food source.

In the synthesis (Chapter 8), Dekker expands on this facilitation effect. Facilitation of small herbivores by large ones has been shown to occur in the field, but only in the sense of increased patch use by rabbits or other small herbivores. However, it would be very interesting to know whether this increased patch use eventually leads to increased numbers of rabbits, i.e. facilitation at the population level. Dekker's model addresses and predicts this issue, which is a highly relevant question for nature conservation. With the decline of rabbit numbers in Western Europe due to the RHD virus, it is useful to know whether the return of rabbits could be facilitated by introducing large herbivores (such as cattle or horses) for nature management purposes. In this case this has to be population facilitation. However, to restore rabbit numbers by introducing large herbivores, facilitation has to occur at the population level. Currently the outcome is unknown, as population facilitation has never been proven. This does not mean that it does not exist; although it is very difficult to prove, doing so involves having replicate populations where the conditions, apart from grazing by large herbivores, are standardized or at least similar. Dekker attempted to create an experimental setting for this, but the difficulties of getting a small founder population of wild-type domestic rabbits to reproduce, combined with problems with predators meant that no useful results could be obtained.

Despite this, the thesis gives a comprehensive overview of the factors affecting the foraging behaviour of central-place foragers. Even though European rabbits have been intensively studied, especially with relation to social interactions and disease ecology little was known about their foraging behaviour. This is even more the case for almost all other species of central-place foraging herbivores. This thesis therefore represents an important contribution in understanding the ecology of this group of mammals.

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Pollutants and hedgehogs

Non-destructive exposure and risk assessment of persistent pollutants in the European hedgehog (*Erinaceus europaeus*). H. d'Havé 2006. PhD thesis. University of Antwerp, Antwerp, Belgium. 231 pp. ISBN 90-5728-064-7.

At the end of 2006 Helga d'Havé successfully defended her thesis "Non-destructive exposure and risk assessment of persistent pollutants in the European hedgehog (*Erinaceus europaeus*)" at the University of Antwerp. The research was initiated to analyse levels of contaminants in hedgehogs in Flanders, and to assess whether they might be at risk due to exposure to these contaminants. The hedgehog is a good choice for this kind of study because they forage heavily on earthworms, which are very efficient in transferring contaminants from soil to predators. In this way, vermivore predators are generally exposed to rather high levels of contaminants, and are more likely to be at risk.

Hedgehogs are widespread in Flanders, and are often the victims of road kills. These Corpses were used to assess levels of contaminants among hedgehogs. However, the risk assessment had to

done using free-ranging living animals and one of the main goals of this research was to perform this assessment on living hedgehogs in a non-destructive way. This is a very important issue from both an ethical and a scientific perspective, and this research is an excellent example of ethics directing and driving research, rather than constraining it.

The thesis is well structured, with an extensive introduction on contaminants in insectivore animals, chapters on the development and validation of the non-destructive methods, and an assessment of using hedgehogs for monitoring purposes. Another chapter discusses the effects of exposure to contaminants in living animals, and the thesis concludes with an in-depth discussion of the results.

This research developed and validated new methods to assess contaminant levels in individual animals, based on samples of hairs and spines. Hair has been previously used to assess metal levels, but this method has not previously been used for organic contaminants especially brominated flame retardants. The use of spines is also a novel approach, which does not appear to have been used before. D'Havé critically discusses the suitability of hair and spines as indicators, and concludes that for some, but not all contaminants these provide suitable samples for monitoring individual animals. The overall conclusion is that hair and spines are suitable indicators for monitoring most contaminant levels among the hedgehog population. This is a big step forward in assessing general risks for hedgehog populations, but it limits the use of these methods to monitor individual animals, for instance in time.

Another goal of the research was to assess the effects of exposure to contaminants on hedgehogs in Flanders. This part of the thesis is an important piece of work from an ecotoxicological point of view. Besides the chemical analyses, and the physiological effect parameters, the study included demographic parameters. The latter were not only included as effect parameters, but are also considered as explanatory factors to describe differences between populations. This turned to be crucial, as it prevented the wrong conclusions being drawn. For instance, the study shows that levels of HCH were positively related to testo-

Hedgehogs show high individual variation in contaminant concentrations. *Photograph: Edgar van der Grift*

sterone levels in hedgehogs, which contrasts to most other literature data. In a limited ecotoxicological study the conclusion would have been that "HCH affects testosterone levels in hedgehogs, although in a different way than in other species". The study shows that the populations with highest HCH levels contained significantly more males than females, and that HCH levels were highest in those populations with best recruitment and highest population densities. The study was therefore able to conclude that it was unlikely that HCH affects testosterone levels, and that demographic factors are probably of more importance. This is quite different to the conclusion that would have been drawn from a more limited study, and clearly shows the importance of including demography in ecotoxicological studies when seeking to explain differences between populations.

The chapter on risk assessment concludes that hedgehogs are generally unlikely to be affected by contaminants. However, it illustrated that individual animals showed concentrations that exceeded critical levels. This raises the question of why hedgehogs, and also other species, show such high individual variation when it comes to contaminant exposure. In this light it is good to see that a follow up to this project is currently underway at the University of Antwerp to investigate the relationships between individual foraging behaviour and contaminant exposure.

To conclude, D'Havé's thesis describes a coherent and scientifically sound study, which is reflected in the fact that most chapters have been published in high quality peer reviewed journals. Besides the scientific quality, it shows that ethical considerations may direct research away from more familiar paths, and this may increase the applicability of the results.

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