SUMMARY

It is well known that both reproductive performance and thermoregulatory capability of mammals decrease with ageing. The reproductive period of mammals is energetically demanding, especially during lactation. According to the heat dissipation limit (HDL) theory, the capacity to dissipate excess heat limits the reproductive effort. The main aim of this study was to test a novel hypothesis that the age-related decline in reproductive performance is due to the age-related decrease of the capacity to dissipate heat. I also hypothesized that the limiting mechanism is more severe in animals with high rates of metabolism. The research was based on a model of experimental evolution, lines of bank voles (*Myodes glareolus*) selected for high swim-induced rate of aerobic metabolism (A lines), which have also increased basal and average daily metabolic rates, and unselected control (C) lines.

In the first of the main parts of the research, I asked how the selection for an increased aerobic exercise metabolism affects the thermoregulation and the age-related changes of the thermoregulatory traits of bank voles. I measured the resting metabolic rate (RMR), evaporative water loss (*EWL*), and body temperature in young adult (4 months) and old (22 months) voles at seven ambient temperatures (13–32 °C). The RMR was higher in the A than in the C lines, but, regardless of the selection group or temperature, it did not change with age. However, *EWL* was higher in the old voles. An increased *EWL/RMR* ratio implies either a compromised efficiency of oxygen extraction in the lungs or increased skin permeability. This effect was more profound in the A lines, which may indicate their increased vulnerability to ageing. Body temperature did not differ between the selection and age groups below 32 °C, but at 32 °C it was markedly higher in the old A-line voles than in those from other groups. As expected, the thermogenic capacity, measured as the maximum cold-induced oxygen consumption, was decreased in the old voles from both selection groups, but the performance of old A-line voles was the same as that of the young C-line ones. Thus, the selection for high aerobic exercise metabolism attenuated the adverse effects of ageing on cold tolerance, but this advantage has been traded off by a compromised coping with hot conditions by aged voles.

In the second main part, I tested the hypothesis that the decline in reproductive capacity with age is the result of the age-dependent thermoregulatory changes in the most energy-demanding period of lactation. In addition, I hypothesized that the selection for an increased exercise metabolism affects the age-related heat dissipation capacity decrease. Measurements of the peak-lactation reproductive and metabolic traits were performed on adult females from three age classes: young (4 months), middle-aged (9 months) and old (16 months). Half of the females were shaved to relieve them from the heat dissipation limitation. Old females had a decreased litter size, mass, and growth rate. The voles from the A lines had higher litter size and mass, litters growth rate, food consumption, average daily metabolic rate (*AMDR*) and metabolizable energy intake than voles from the control lines. However, the differences between selection directions in all reproductive output traits and in food consumption were attributable to differences in maternal body mass. The age-related reproductive performance decrease was not affected by the selection. The peak-lactation *ADMR* was higher in shaved than in unshaved mothers, and this difference was more profound among old than young and middle-aged voles. In females with large litters, the milk production tended to be higher in shaved than in unshaved voles, but I did not find a significant effect of fur removal on the litter growth rate. Thus, the results provided only a mixed support of the HDL theory, and no support for the hypotheses linking the differences in reproductive ageing with either thermoregulatory capability deterioration or genetically based differences in metabolic rate.

Most studies on HDL have focused on immediate effects on females exposed to HDL manipulation during lactation, whereas possible long-term effects in post-lactation period are largely unknown. In the third part of the research, I hypothesized that the adult offspring quality, assessed as their body mass and thermoregulatory, locomotor and aerobic exercise performance traits, decrease with maternal age. Furthermore, I hypothesized that this decrease is due to the age-related decline in mothers' thermoregulatory capacity and is affected by the selection for an increased aerobic exercise metabolism. Weaned pups of both sexes were sampled from litters of mothers from both selection directions, three age classes, and shaving groups. When the individuals were ca 3 months old, I measured body mass, the maximum swim-induced rate of metabolism, thermogenic capacity, run-induced maximum metabolic rate, maximum sprint speed, and endurance running time. Voles from the selected lines were not significantly larger, and generally achieved higher mass-corrected values of the measured performance traits than those from the control lines. Only maximum sprint

speed did not differ between selection groups. Neither body mass nor the thermoregulatory or locomotor performance traits of the offspring decreased with maternal age. The mothers fur removal had no considerable effect on their offspring physical performance traits. Thus, my results did not provide support for the main hypothesis that adult offspring performance traits decrease with mothers age, and that this decrease is due to the age-related decline in mothers thermoregulatory capacity.

To summarize, I addressed for the first time the HDL theory in the ageing context. The main findings and conclusions of the projects are:

1. In agreement with the earlier studies on several species, a decline in reproductive output with increasing maternal age was observed in bank voles, too. However, the mothers age had no adverse carry-over effects on their adult offspring quality.

2. Neither the reproductive performance of mothers nor the performance of their adult offspring were compromised by the heat dissipation limit imposed on maternal energy budgets at peak lactation. Thus, the results do not support the HDL theory or the novel hypothesis linking the reproductive ageing with the ageing of the thermoregulatory capabilities.

3. The selection for high aerobic exercise metabolism (resulting also in an increased basal rate of metabolism) escalates consequences of the inability to dissipate the excess heat in old bank voles.

4. The selection led also to an increased reproductive output, but the effect could be attributed to an increased body mass of mothers from the selected lines. The age-related reproductive performance decrease was not affected by the selection. These results did not support the hypotheses linking differences in reproductive ageing with genetically based differences in metabolic rate.