SUMMARY

THERMAL ECOLOGY OF REPTILES: CONSISTENT BEHAVIOURAL THERMOREGULATORY STRATEGIES FROM INDIVIDUAL TO POPULATION LEVEL

Thermal ecology is crucial in reptilian biology, as body temperature affects metabolic and developmental rates. Reptiles, like other ectotherms, face ecological and physiological challenges due to global climate change. Despite their thermal limitations, reptiles have diverse coping strategies, such as physiological and behavioural plasticity, shifting geographical range, or evolutionary adaptation. Although reptiles primarily regulate their body temperature by utilizing spatial and temporal thermal gradients through behavioural thermoregulation, the inclusion of thermal physiology into the behavioural syndrome framework occurred not long ago. Recent studies have reported consistency in thermal traits in ectotherms. Nonetheless, there is a lack of thermal traits studies investigating consistent individual differences in both between- and within-individual variations.

This thesis aims to explore the consistency of behavioural thermoregulatory strategies of different reptile populations as they respond to challenging thermal environments, focusing on individual and population levels as physiological and behavioural plasticity can act as buffers against climate change.

CHAPTER II examines the consistency in between- and within-individual variation in both thermal and 'classic' behavioural traits in small-bodied ectotherms, using *Zootoca vivipara* as a model species. The study focuses on individual (animal personality) and aggregated traits (behavioural syndrome), as well as behavioural predictability, an understudied component of thermoregulatory strategy variation. The hypothesis was that thermoregulatory and behavioural strategies are integrated, with a positive correlation between risk-taking and thermal preference, predicted based on the proposed 'hot-cold' axis. Consistent individual differences in thermoregulatory strategy – or thermal – and 'classic' behavioural traits (movement activity, sheltering and risk-taking) were found, supporting the presence of animal personality in all studied traits. Individuals also differed consistently in behavioural predictability in all thermal and 'classic' behavioural traits. Individual state did not affect behavioural type or predictability, except for high body condition, which showed higher sheltering predictability. A significant positive correlation was found between behavioural type and predictability, with individuals favouring higher body temperature being more predictable. A behavioural syndrome was also found within the thermal and

‘classic’ behavioural traits, revealing a positive correlation between selected body temperature and risk-taking behaviour.

Understanding the upper limit of thermal tolerance is crucial for studying reptile thermal physiology as it provides insights into their ability to regulate their body temperature in response to harsh environmental conditions. The degree to which thermal physiology, specifically consistency in thermal traits, is influenced by local adaptation remains an active area of research. CHAPTER III presents behavioural or voluntary thermal tolerance (VT_{max}) measurements and estimates for nine grassland viper species and subspecies of Acridophaga subgenus. The study results contradict the hypothesis that environmental temperature is positively correlated with VT_{max}. Alpine habitats promote increased thermal tolerance, allowing vipers to efficiently utilize the brief yet hot periods for physiological purposes. In contrast, lowland taxa display lower upper thermal limits, thrive within a narrower temperature range and, consequently, are more susceptible to habitat alterations. Therefore, conservation efforts should prioritise considering thermal biology traits for critically endangered populations and integrate thermal ecology into conservation strategies.

Previous studies on thermal physiology have primarily focused on species or population averages, with less emphasis on between- and within-individual variation. In CHAPTER IV, the individual strategies in VT_{max} of grassland vipers were also assessed. The hypothesis was that individuals from alpine populations would exhibit higher consistency in their VT_{max} than their steppe counterparts, as they are closer to their critical thermal maximum (CT_{max}). As a result, consistent between-individual differences in the average VT_{max} were found, suggesting the presence of animal personality within this trait. Some individuals exhibited lower or higher VT_{max} than the population average. Furthermore, vipers also differed significantly in their behavioural type and behavioural predictability. Vipers from alpine populations showed slightly higher repeatability in VT_{max} compared to those from steppe regions, suggesting that past selection pressures have shaped a different distribution.

To sum up, consistent individual thermal behavioural variation in reptiles may be attributed to steady thermoregulatory behaviours or strategies. These strategies are integrated at the individual level on the ‘hot-cold’ axis. Consistent differences in thermal and behavioural traits support the presence of animal personality. At the population level, consistent behavioural thermoregulatory strategies maintain different thermal tolerance values. Consistent differences in thermal tolerance were also observed between and within individuals due to diverse and consistent behavioural strategies.

The importance of thermoregulatory behaviour in reptiles nowadays' climate change scenario is evident, and applying animal personality studies could provide valuable insights into its ontogenetic and evolutionary flexibility. Furthermore, understanding the individual-level adaptive and evolutionary potential of thermal tolerance in ectotherms will improve our ability to predict the consequences of warming climates on both population and species levels.

Keywords

thermoregulatory strategy, behavioural consistency, animal personality, behavioural syndrome, behavioural predictability, thermal physiology, voluntary thermal maximum, environmental temperature, ectotherm, reptile

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