

# SIZE OF INDIVIDUALS AND DURATION OF DEVELOPMENT IN ANTS

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## Introduction

Temperature is an extremely important ecological factor for ants as well as for other insects. Within the favourable temperature range, the duration of development of insects and other ectothermic organisms shows an approximately hyperbolic relation with temperature (Campbell et al. 1974; Wagner et al. 1984; Ratte 1985). If we define development rate ( $R$ ) as the reciprocal of development time ( $R = 1/D$ ), the equation will be transformed into the linear form.

## The questions arise:

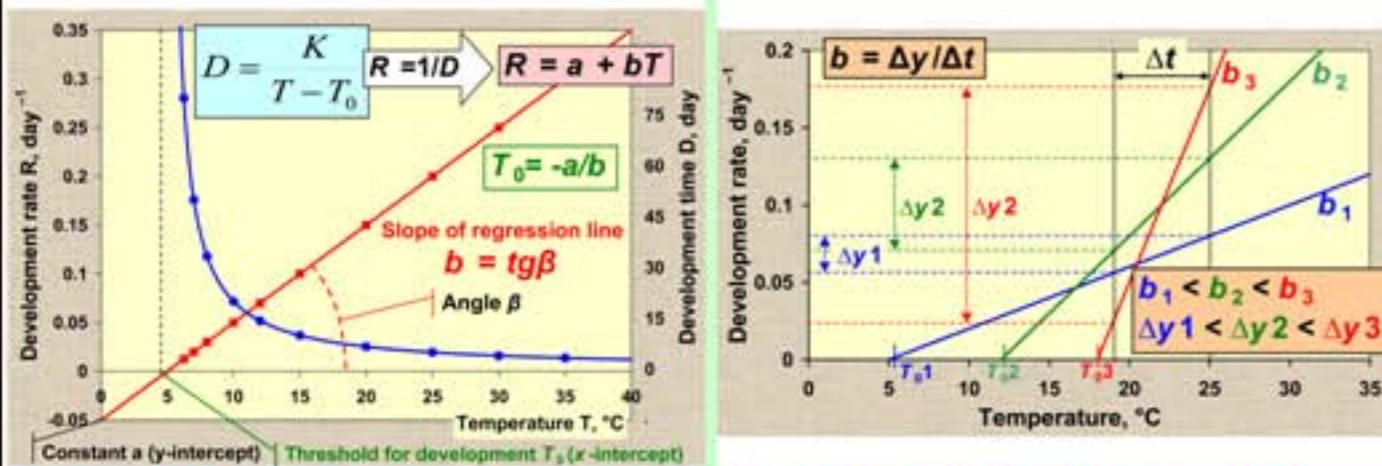
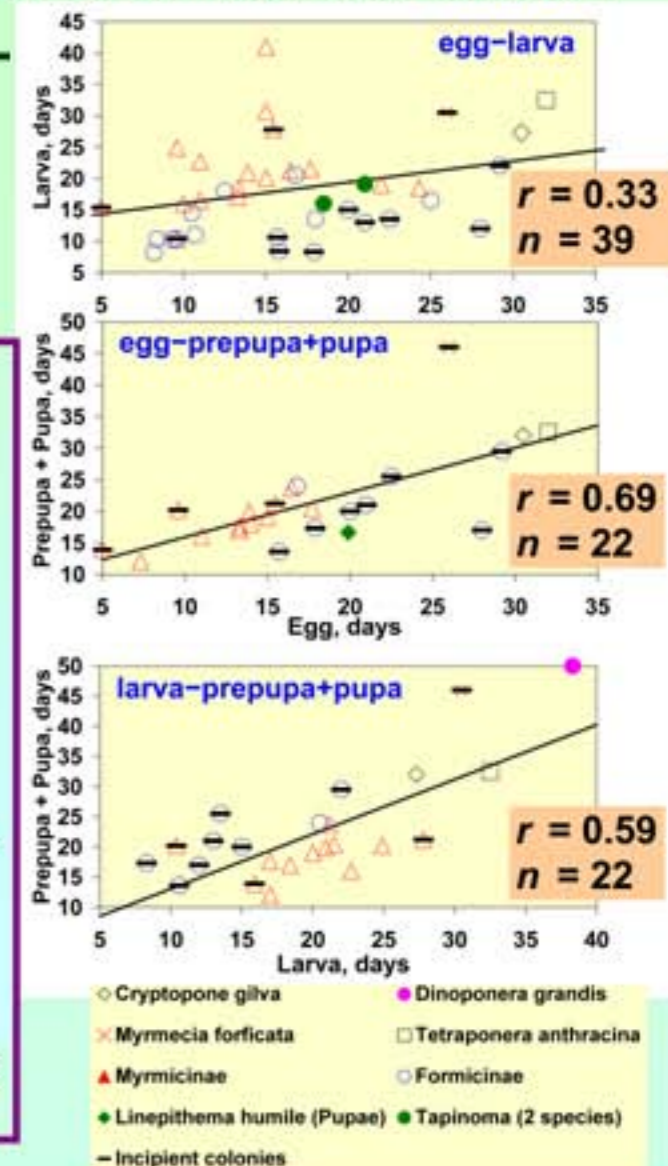
1. Are there any relationships between the duration and the thermal sensitivity of development, and the sizes on individuals within closely related taxonomically groups of insects (e.g., families, subfamilies)?
2. Can the duration of development always be the measure of its thermal sensitivity, as it had been suggested?
3. Will an increase of development time in larger species be accompanied by a decrease of thermal sensitivity in advanced ant subfamilies.

Such an approach to the analysis of interspecific variation of the duration and the thermal sensitivity of development may help to explain the ways of adaptation of closely related species to the environment and the evolution of life-cycle parameters.

## Results and conclusions

1. Interrelations between development times at  $25 \pm 1$  °C of three immature stages.

1. There are significant positive correlations between the durations of development of all immature stages.
2. All stages and total development are the slowest in "primitive" ant species.
3. The egg stage is significantly shorter than the larval stage in Myrmicinae, whereas the opposite is true for Formicinae.
4. The combined prepupal+pupal stage tends to be shorter in Myrmicinae than in Formicinae.
5. The first workers in incipient colonies generally develop significantly faster than workers in mature colonies, but mainly during the larval stage which is much shorter in most cases.

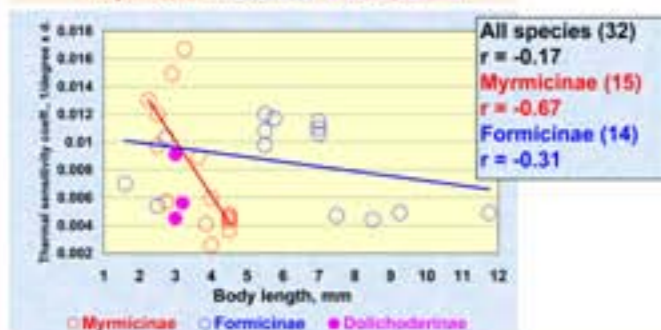
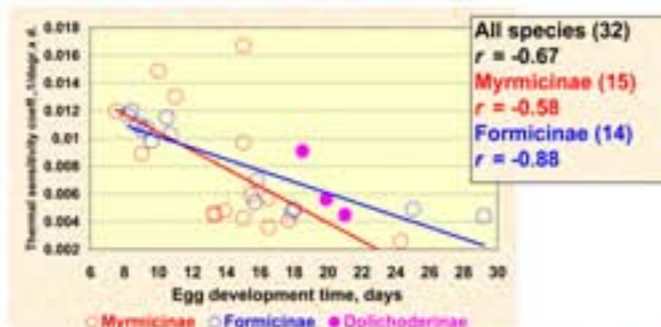
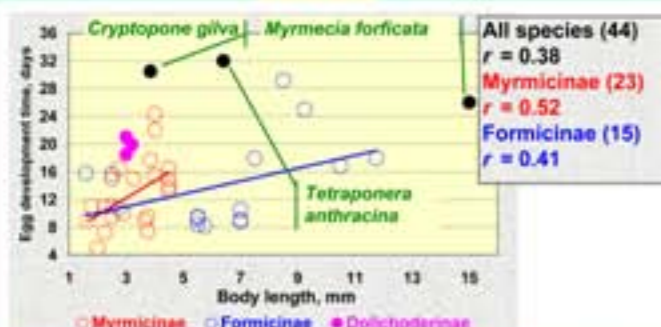


The coefficient of linear regression of development rate on temperature  $b$  determines how development rate changes when temperature increases or decreases by 1 degree. The greater the angle between the regression line and the x-axis (i.e., the  $b$  value), the more drastically development rate changes with temperature, and vice versa. The  $b$  coefficient characterizes the degree of dependence of development rate on temperature, or the thermal sensitivity of development. We therefore call it the coefficient of thermal sensitivity (or the thermal sensitivity coefficient) (Kozhanchikov 1961).

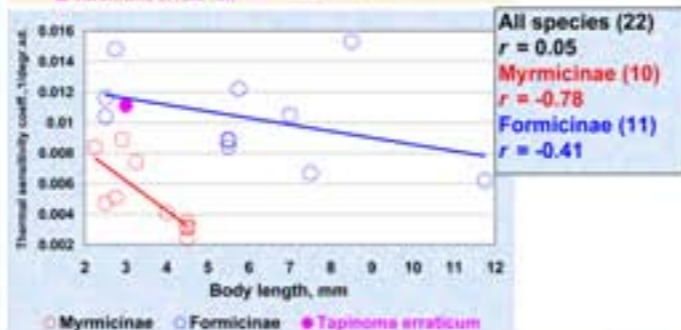
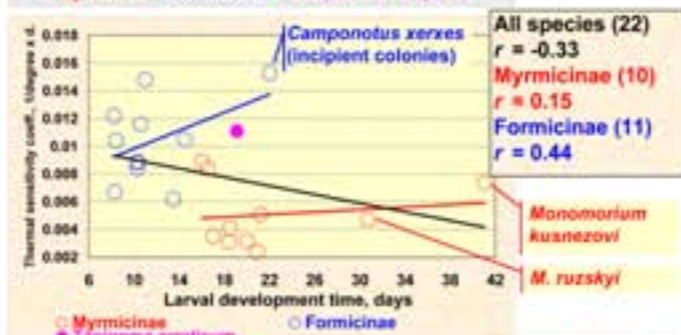
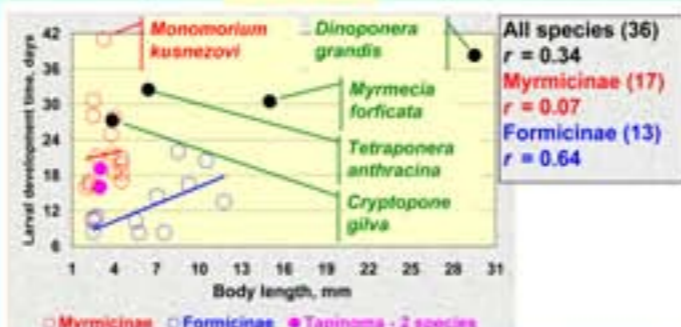
More basal insect groups are characterized by slower and less temperature-sensitive development as well as smaller temperature threshold values (Mednikov 1966, 1977). The thermal sensitivity coefficient tended to increase in the course of insect evolution. More primitive species within the orders and families of insects often have larger sizes. The largest ants (*Dinoponera*, *Pachycondyla*, *Myrmecia*, *Notomyrmecia*) belong to the most primitive subfamilies (Ponerinae and Myrmeciinae). These species are characterized by the slowest development but nothing is known about the thermal sensitivity of their development (Kipyatkov, Lopatina, 2014).

## II. Relationships between body length, development time of different immature stages at $25 \pm 1^\circ\text{C}$ and the thermal sensitivity of their development.

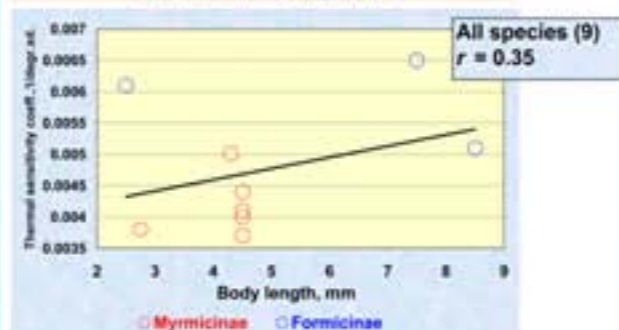
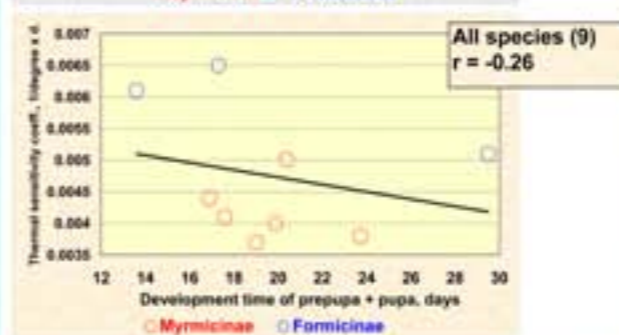
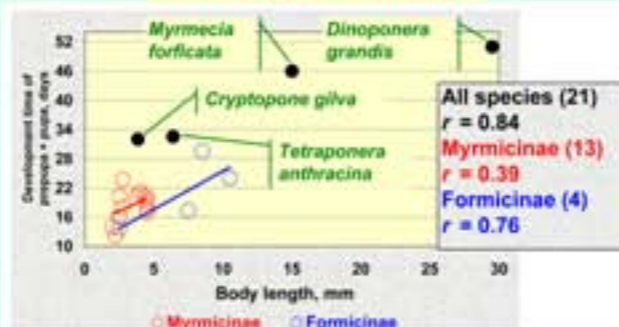
### Eggs



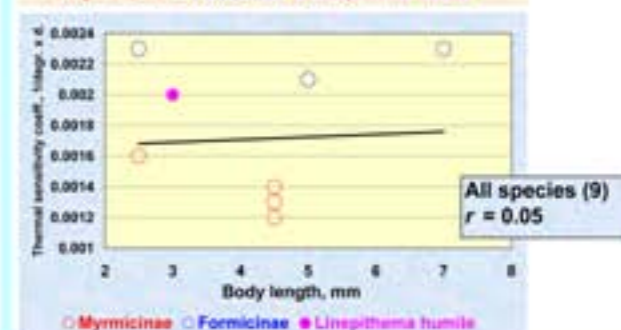
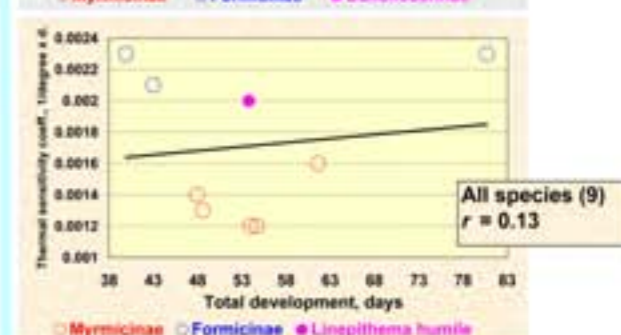
### Larvae



### Prepupa + pupa



### Total development



1. In general, development times of all stages correlate positively with adult body length, which is especially the case for the combined prepupal+pupal stage and total development. The larger the species, the slower it develops. The exception is the larval development times of Myrmicinae which do not correlate with adult size.
2. On the whole, there are significant negative correlations between development times of each stage and the thermal sensitivity coefficient. So, in general, the slower the development, the lower is its thermal sensitivity.
3. The temperature dependence of larval development shows more complicated relationships: the correlation is absent in Myrmicinae, and is positive in Formicinae, albeit the latter is due to outliers. For these reasons the correlation between total development time and the thermal sensitivity coefficient is also absent.

3. On the whole, there is no correlation between adult size and thermal sensitivity coefficient for egg and larval development, but negative correlations are found separately for Myrmicinae and Formicinae. In these two subfamilies, the temperature dependence of development is stronger in smaller species with faster development and weaker in larger species with slower development. The opposite is seen for prepupal+pupal development, but there are not enough data to make any conclusion in this case. This explains the absence of the correlation in the case of total development.
4. The question regarding the thermal sensitivity of the development of "primitive" ant species remains open today.

### Acknowledgements

Our work was financially supported by the Russian Foundation for Basic Research (grants 11-04-00350, 14-04-01156).

### References

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