

# Temperature and Prey Morphology Influence Attack Rate and Handling Time in a Predator-Prey Interaction

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## Introduction

Functional responses describe how the proportion of prey a predator consumes changes as prey density increases. For any predator feeding on a single prey species, its functional response is determined by two parameters:

- **Attack Rate** - the rate at which a predator encounters its prey
- **Handling Time** - the amount of time required to handle prey before it's ready to resume hunting.

The flatworm *Stenostomum* is a predator of two species of Paramecium: *P. multimicronucleatum* (larger, poorer prey) and *P. aurelia* (smaller, better prey).

Here we show that the speed of movement in both predator and prey changes significantly with temperature, leading to changes in the rate of attack. We also show how prey morphology affects the amount of time required to handle prey. We fit a mechanistic model to our data to quantitatively demonstrate how these changes in attack rate and handling time affect overall rates of predation. Our results therefore demonstrate how individual-level differences in movement and morphology can scale up to affect the dynamics of simple food-webs and show how simple but mechanistic models can be used to describe ecological processes.

## Methods

**Speed and Size:** Film all three species at 14°C and 19°C. Use a graticule for scale. Find species' speed and length using the ImageJ software.

**Prey Eaten:** For both *P. aurelia* and *P. multimicronucleatum*, and for both temperatures (14°C and 19°C), complete the following:

In all the wells of two 24-well plates, add 260 µL of 1:10 diluted growth media. Randomly select five wells for each increment of prey density, ranging from three to 80. Using a microscope and pipette, collect *Paramecium* and place them in each well until each has a sufficient quantity. Fill the remaining volume in each well to 500 µL.

Add a single *Stenostomum* by pipette in each well. Place the plates at the indicated temperature. After four hours, use Lugol's solution to kill all organisms. Using a microscope, count and record the number of *Paramecium* that were not consumed.

Fit the data using the mle2 function (maximum likelihood estimator) in R using the equation to the right.



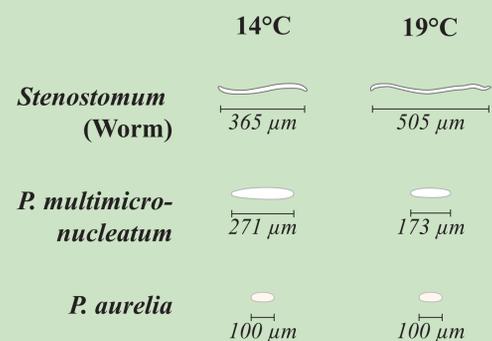
A single *Stenostomum* amongst several *P. multimicronucleatum*

$$f(N) = \frac{aN}{1 + ahN}$$

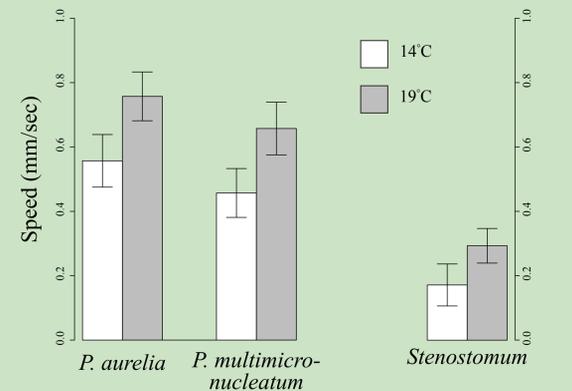
The Type II functional response model, where  $f$  is the rate of prey intake,  $N$  is prey density,  $a$  is the attack rate, and  $h$  is the handling time

## Results

### Average Size



### Average Speed



Effect of species on size:  
 $F_{(1,29)} = 200.48$ , p-value < 0.001

**Significance** Effect of temperature on size:  
 $F_{(1,29)} = 68.92$ , p-value < 0.001

Effect of species-temperature interaction on size:  
 $F_{(1,29)} = 68.53$ , p-value < 0.001

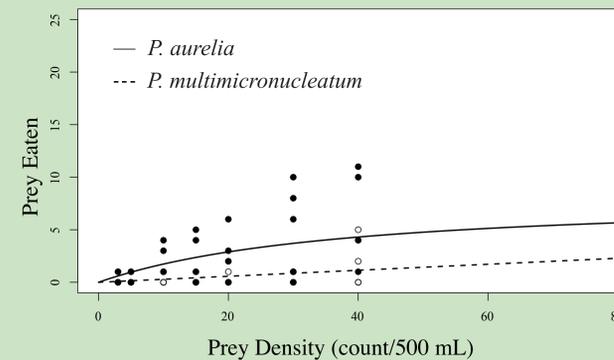
Effect of species on speed of *Paramecium*:  
 $F_{(1,33)} = 1.81$ , p-value = 0.190

Effect of temperature on speed of *Paramecium*:  
 $F_{(1,33)} = 4.82$ , p-value = 0.035

Effect of temperature on speed of *Stenostomum*:  
 $F_{(1,14)} = 2.72$ , p-value = 0.12

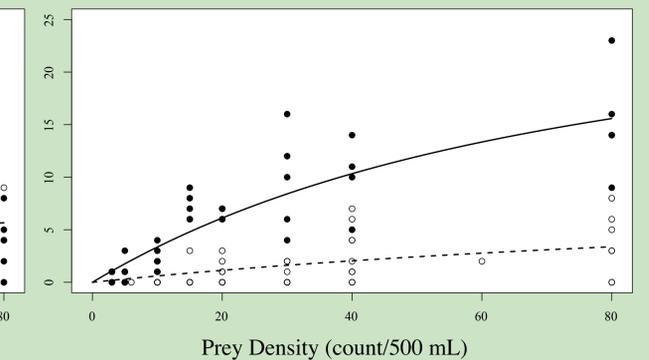
### Functional Response Curve at 14°C

	Attack Rate	SE	Handling Time	SE
<i>P. aurelia</i>	0.242	0.055	0.123	0.032
<i>P. multimicronucleatum</i>	0.029	0.006	0.0001	0.113



### Functional Response Curve at 19°C

	Attack Rate	SE	Handling Time	SE
<i>P. aurelia</i>	0.461	0.063	0.034	0.009
<i>P. multimicronucleatum</i>	0.067	0.016	0.104	0.087



## Conclusion

There is a clear effect of temperature on attack rate. Since the speed of the *Paramecium*'s movement increases with temperature, more encounters between predator and prey occur. With *P. aurelia* as a prey, the handling time decreases with temperature, likely due to the size difference observed in *Stenostomum*. The difference in prey size had a clear effect on handling time, as *P. aurelia* were consumed at a higher rate at both temperatures in comparison to *P. multimicronucleatum*. Interestingly, the increase in attack rate of *P. aurelia* between temperatures was much larger in magnitude than the increase in speed, indicating that another factor besides speed influenced the increased attack rate. It could be that the speed of metabolism in *Stenostomum* increases with temperature, creating a greater need for prey consumption.



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