**Material supplementing**

**A novel biomechanical approach to infer size-based functional response in aquatic and terrestrial systems**

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# **1. Main framework**

Our approach is based on the recently published biomechanical model (Portalier et al., 2019)⁠. This model uses body size and physical features of the medium, to predict predator to prey interactions.

Hence, the model requires body masses of both the predator and its prey. The physical parameters are acceleration due to gravity, body density, medium density, and medium viscosity. Then, the model computes all necessary information to predict feasible predator-prey interactions.   
 In the present article, only elements required for the computation of a functional response will be described. A full description of the model can be found in the original study (Portalier et al., 2019)⁠. A list of parameters computed from the biomechanical model and used in the present study can be found in table S1.

# **2. Predation**

Predation is broken up into three successive sequences: a predator needs to search, capture and then handle its prey. Each predation sequence leads to time expenditures. Thus, predation on a given prey requires time for searching (*ts*), time for capturing (*tc*) and time for handling (*th*) this prey. Each predatory activity implies motion, and motion is constrained by physical factors (mentioned above).

## 2.1 Search sequence

During searching time, both predator and prey move at a species-specific speed (*vp* for predator and *vn* for prey) that scales with body size. A given predator will encounter an individual from the prey population at a rate *Er* (Rothschild and Osborn, 1988)⁠ depending on prey abundance (*N*), and predator detection distance (*DP*). Predator detection distance scales with its size (Pawar et al., 2012).

|  |  |  |
| --- | --- | --- |
|  |  | (1) |

For a given predator and a given prey, all parameters are constant except prey abundance (*N*). Thus, encounter rate (eq. 1) can write

|  |  |  |
| --- | --- | --- |
|  |  | (2) |

## 2.2 Capture sequence

Once a prey is detected, the capture sequence begins. The predator jumps and tries to seize its prey, while the prey tries to escape, the distance between the predator and the prey is assumed to be the detection distance of the prey (that scales with prey size). Relative speed at time when predator reaches the prey leads to a capture probability (*PC*) using a logistic function.

|  |  |  |
| --- | --- | --- |
|  |  | (3) |

If the predator cannot reach the prey, then *PC* = 0.

## 2.3 Handling sequence

Last, the predator is kept busy during the time needed to consume the prey: the handling time (*th*).

|  |  |  |
| --- | --- | --- |
|  |  | (4) |

where *tcons* is consumption time, and *tdig* is digestion time.

|  |  |  |
| --- | --- | --- |
|  |  | (5) |

where *Bt* is bite time, *Bs* is bite size, *MN* is prey mass. Bite size scales with predator size (Wilson and Kerley, 2003)

|  |  |  |
| --- | --- | --- |
|  |  | (6) |

where *B0* is bite diameter at reference size, *MOb* is reference size, and *ρb* is body density. Bite time depends on bite size (Laca et al., 1994)⁠.

|  |  |  |
| --- | --- | --- |
|  |  | (7) |

Digestion time writes (Hendriks, 1999)

|  |  |  |
| --- | --- | --- |
|  |  | (8) |

where *tdig0* is digestion time for 1 kg of organism.

## 2.4 Time computation

Overall, the biomechanical model gives the total time that a predator needs to feed on a prey (for searching, capturing and handling the prey). Searching time is assumed to be the inverse of encounter rate times the probability of capture (i.e., the time needed to contact one prey that would lead to a successful capture).

|  |  |  |
| --- | --- | --- |
|  |  | (9) |

Capture time (*tc*) is the time needed for the predator to reach the prey during that jump. Last, handling time (*th*) is the time needed to consume and digest the prey.

## 2.5 Functional response

The functional response is defined as the inverse of the time needed for searching, capturing and handling one unit of prey.

|  |  |  |
| --- | --- | --- |
|  |  | (10) |

Using equations (2) and (9) to replace search time, equation (10) writes

|  |  |  |
| --- | --- | --- |
|  |  | (11) |

And rearranging

|  |  |  |
| --- | --- | --- |
|  |  | (12) |

Under this form, one can recognize a modified version of Holling's disk equation (Holling, 1961)⁠, where *βPc* represents attack rate, and where capture and handling times are taken into account instead of handling time only.  
 Given the assumptions made on the encounter rate (eq. 1), it is a type II functional response. In addition to prey abundance (*N*), its value changes according to both predator size, prey size and the medium (i.e., aquatic versus terrestrial).

# **References**

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