Variation in *Talitrus saltator* strategies as response to environmental change

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During the day, the “safe place” for *Talitrus saltator* is represented by the wet sand zone, where it can burrow, avoiding both to get dry and to be swashed away by the sea.

Therefore, orientation capability is needed to recover the safe place, in case of displacement.

Cues for orientation: visual, slope, magnetic field

The same cue could be used for multiple mechanisms, e.g. the sun vision could be used for a sun compass or for a simple phototaxis.
Study-site approach
Study-site approach
Material and methods

On field:

A circular arena, placed directly on the beach was used to test the orientation of animals collected in loco. Traps at the arena’s rim, subtending 5° each, were used to calculate the direction chosen by the animals. The landscape vision was avoided, when needed, by placing a white cardboard 10 cm height all around arena’s side.

Air temperature, air humidity, sun visibility and sky cover were recorded at every release of animals.

In the lab:

Individual characteristics of the sample were measured: size (as cephalon length), age (as number of 2.antennae tagma) and sex
Material and methods:
statistical analysis

Dots: individual choices
Curves: density graphs (smoothed with kernel)

$0 < r < 1$: precision around the mean value

TED (Theoretical Escape Direction), perpendicular to the shoreline, included in IC (Batschelet, 1972): directional choice
**Statistics**

- Random distribution
  - Yes
  - No
  - SPLM
    - Additive model
      - Yes
      - No
      - Two or more additive models
        - Significance of every single factor

**Material and methods:** analysis of the models

- Rayleigh test
- Akaike Information Criterion:
  - the best model is the one with the best likelihood and less number of factors
- Chi square test on the difference between the best model and the model without the considered factor
Berkoukech

**One site**, on left bank of Oued Berkoukech
Experiments in April and June
With and without landscape
TED 320°

Model: **interaction** with the factor “month”

What kind of information does “month” include?

**Abiotic:**

- Air temperature (°C);
- Air relative humidity (%)

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![Box plot of air temperature (°C) and air relative humidity (%)](image)
Biotic:
sample structure

(few *Talorchestia brito* were found and excluded in the following analysis)

cephalic length (mm);
tagma of second antennae (n)

Sandhoppers found on the dune

Sandhoppers found on the shore
April

orientation ~ time of the day** + age* + sun azimuth**

Mean 170.1
r 0.8437**
N 148
IC 95% ± 5° shorter dune direction included

June

orientation ~ landscape vision** + age + temperature* + sky cover*

Mean 329.1
r 0.6709**
N 152
IC 95% ± 9° TED included
Means of the single groups released

April

June

TED

shorter dune direction, perpendicular to dune inclination

TED shorter dune direction,
Oued Laou

**Two sites**: left and right bank of the Oued Laou (2 km far each other)
TED 60°
experiments with and without landscape

**Model**: interaction with factor “oued bank”

What kind of information includes “oued bank”?

**Abiotic**:
- air temperature (°C);
- air humidity (%)

![Box plots showing air temperature and air humidity](image)
Biotic:

Oued Laou

Sample structure

Difference in human use between banks

Oued Laou (left bank)  Ka’asrass (right bank)
**left bank**

Orientation $\sim$ ampm* + age** + sex* + temperature* + humidity* + sky cover* + sun visibility**

Mean 14.21
r 0.2313*
N 314
IC 95% ± 27° TED not included

**right bank**

Orientation $\sim$ day** + solar time** + age* + sun visibility**

Mean 51.75
r 0.6275**
N 306
IC 95% ± 9° TED included

Oued Laou
Means of the single groups released

**Left bank**

1. day

2. day

**Right bank**

1. day

2. day
Maremma Regional Park

**Four sites**, subjected to different shoreline dynamics seasonal replicates. Experiments without landscape only

![River mouth diagram]

<table>
<thead>
<tr>
<th>Distance from River Mouth</th>
<th>TED Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>3000</td>
<td>200°</td>
</tr>
<tr>
<td>4000</td>
<td>205°</td>
</tr>
<tr>
<td>5000</td>
<td>213°</td>
</tr>
<tr>
<td>6000</td>
<td>220°</td>
</tr>
</tbody>
</table>

Model: **no interactions** between factors

Best model

Orientation ~ season** + sun** + ampm** + trampling** + distance from river mouth** + air humidity + sex

seasonal variations:

<table>
<thead>
<tr>
<th>Season</th>
<th>Temperature (°C)</th>
<th>Relative Humidity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>maggio settembre</td>
<td><img src="image1" alt="Temperature box plot" /></td>
<td><img src="image2" alt="Humidity box plot" /></td>
</tr>
</tbody>
</table>
Seasonal differences of the sample juveniles were few and not considered in the experiment.

Different seasonal trampling

The estimated trampling was divided in level low-medium-high.

<table>
<thead>
<tr>
<th></th>
<th>Autumn</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>3000</td>
<td>high</td>
<td>low</td>
</tr>
<tr>
<td>4000</td>
<td>low</td>
<td>low</td>
</tr>
<tr>
<td>5000</td>
<td>medium</td>
<td>medium</td>
</tr>
<tr>
<td>6000</td>
<td>low</td>
<td>low</td>
</tr>
</tbody>
</table>
Maremma Regional Park

Orientation ~ season** + sun** + ampm** + trampling** + distance from river mouth** + air humidity + sex

3,000

Sept 2002
Mean 198.5°
r 0.3549**
N 82
IC 95% ± 22° TED included

4,000

May 2003
Mean 179.6°
r 0.3409**
N 191
IC 95% ± 22° TED included

Mean 201.1°
r 0.3208**
N 163
IC 95% ± 24° TED included

Mean 189.5°
r 0.6493**
N 250
IC 95% ± 8° TED not included
Maremma Regional Park

Orientation ~ season** + sun** + ampm** + trampling** + distance from river mouth** + air humidity + sex

**Sept 2002**

Mean 179.6°

r 0.6974**

N 166

IC 95% ± 10° TED not included

**May 2003**

Mean 179.6°

r 0.6464**

N 231

IC 95% ± 8° TED not included

**6,000**

Mean 247.1°

r 0.3862**

N 166

IC 95% ± 19° TED not included; azimuth pm included

**5,000**

Mean 192.8°

r 0.4784**

N 245

IC 95% ± 13° TED not included
conclusions

The use of sun vision could be different, depending on the stability of environmental conditions:

• The sun compass mechanism is used in cases of environmental stability, when the population can fix in its behaviour the directions towards safety, being sure that they will not change through time.

Sun compass use can also be combined with environmental experience, to face sudden but temporary disturbances.

• The phototaxis is mainly used in cases of environmental instability, co-occurring with less precision, because it is more plastic than the sun compass and often related with fringe populations or explorative behaviour.
conclusions

Landscape vision is also a cue for orientation, but with a minor weight in the choice of the escape direction.

Differences in behaviour regarding sex and age of the individuals were also observed.

Such differences are related with the precision of the direction, not with the direction chosen.
acknowledgements

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