

Exploring the germination dynamics of *Primula palinuri* Petagna, endemic species of southern-Italy.

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Background

- Italy's rich biodiversity is characterized by a high rate of endemic plant species, accounting for 18.9% of its total flora.
- Primula palinuri* is an endangered and endemic plant found exclusively on the cliffs along Italy's Tyrrhenian coast.



Fig. 1 *P. palinuri* on a plunging cliff, Cape Palinuro, February 2023

Objectives

- Investigating the impact of temperature and salinity on the germination of *P. palinuri* populations.
- Assessing the morphometric differences between seeds and fruits of the analyzed populations
- Understanding these variations can shed light on the species' adaptive survival strategies and contribute to its conservation.

Methodology

Sampling:

In July 2022, *P. palinuri* seeds were gathered from two distinct sites within the Cilento Vallo di Diano and Alburni National Park: Porto Palinuro (coastal plot) and Vaccuta (inland plot). The geographical diversity of these two plots may have driven a morphological diversity in both the seeds and fruits of the analyzed populations.

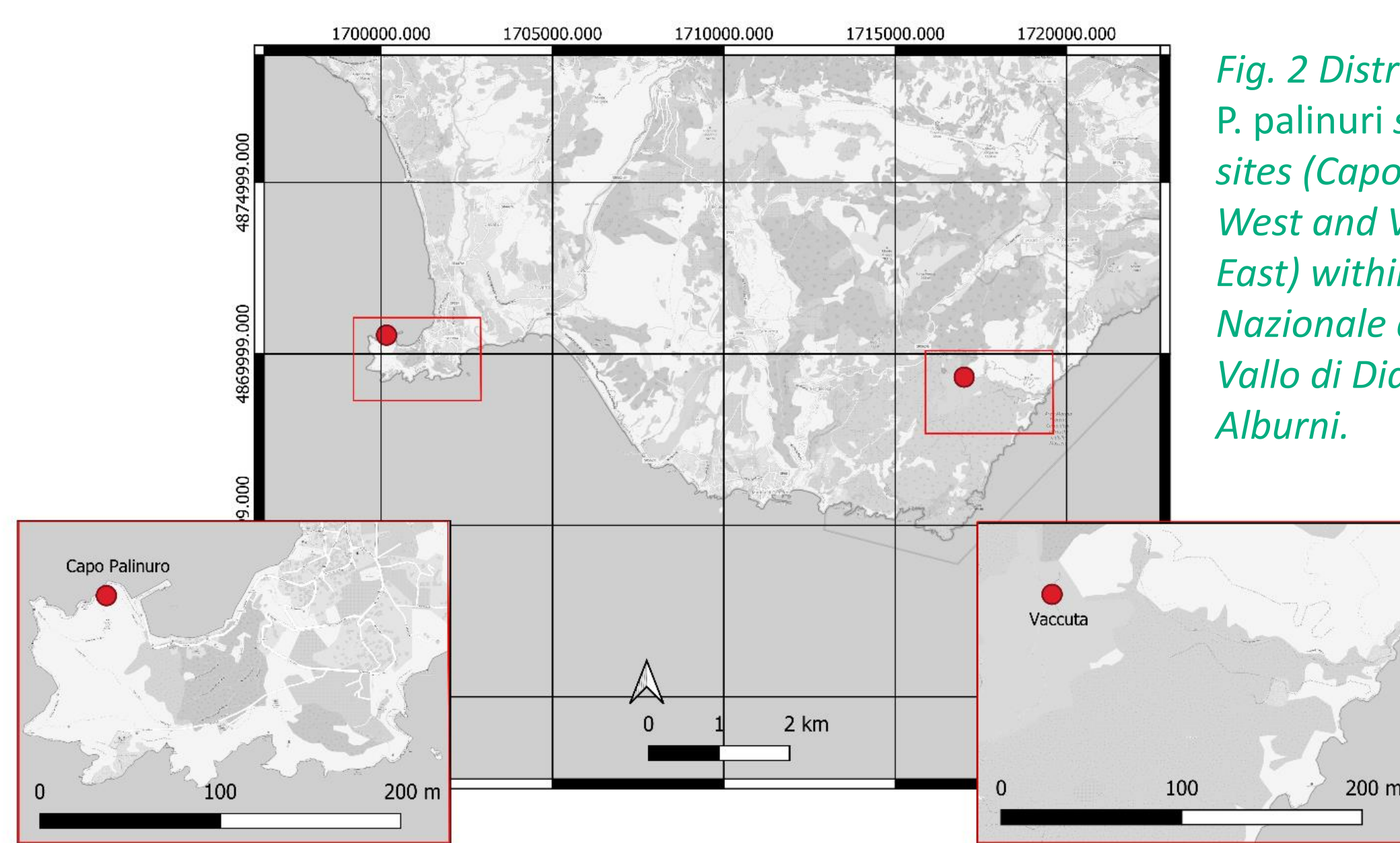


Fig. 2 Distribution of *P. palinuri* sampling sites (Capo Palinuro West and Vaccuta East) within Parco Nazionale del Cilento Vallo di Diano e Alburni.

Capsule and Seed Morphometric Traits:

- Capsule volume and number of seeds
- Major and minor axes of seeds

Germination Test:

- Experiment 1: Three temperature levels: minimum (15-6°C), average (20-10°C), and maximum (25-15°C).
- Experiment 2: Different salt concentrations (NaCl solution): 0 mM, 50 mM, 100 mM, 200 mM, and 300 mM.
- 12-hour light-dark cycles
- For each treatment: 4 Petri dishes of 25 seeds
- Filter paper and distilled water.

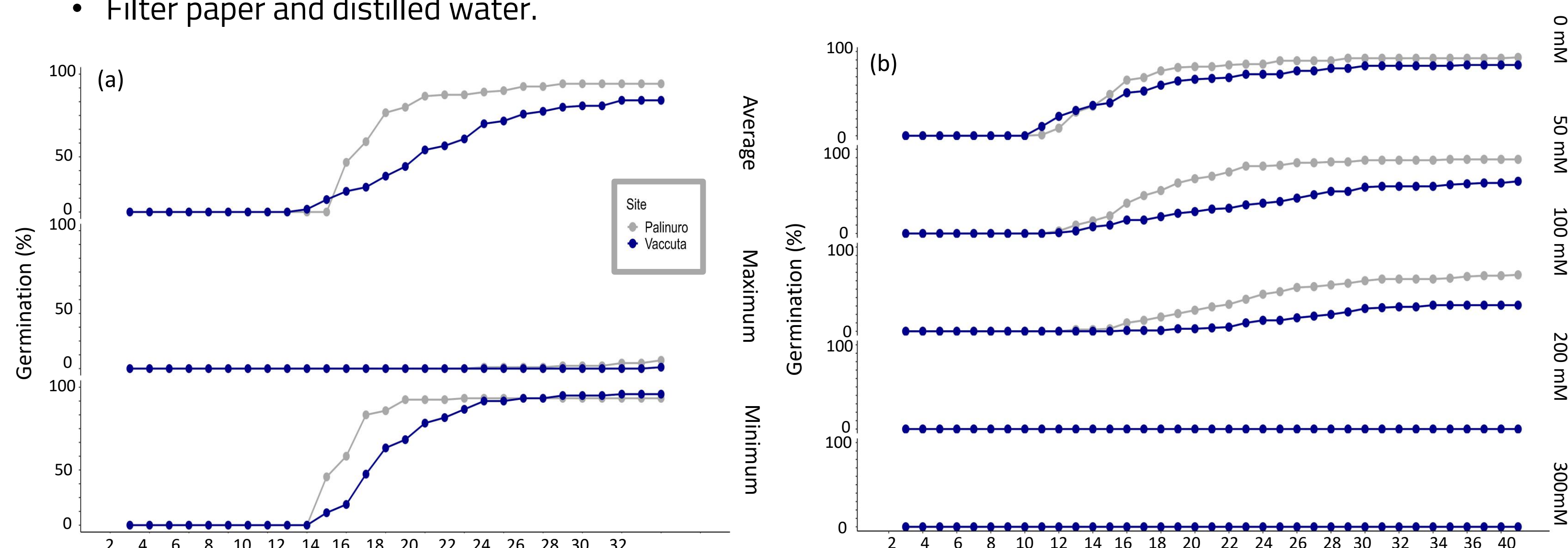


Fig. 3 Germination of *Primula palinuri* in relation to Temperature (a) and different salt concentrations (b).

Data Analysis:

- Seed Count Data Analysis:** Poisson Generalized Linear Models (GLM) with logarithmic link function.
- Moisture Content (mc %):** Beta Regression Model with logit link function.
- Capsule and Seed Morphometry:** Gamma GLM with logarithmic link function.
- Maximum germination:** Beta Regression Models with logit link function for maximum germination percentages.
- Survival Data Analysis:** time-to-event data (Fenlon, 2001), the analysis focuses on cumulative proportions of individuals experiencing the event of interest. The exact timing of these events cannot be precisely determined due to interval-censoring (D'onofri et al., 2018). The two-parameter log-logistic function is given by the equation:

$$f(x) = \frac{1}{1 + \exp(b(\log(x) - \log(e)))}$$

Results

Capsules and Seed Morphometric Traits:

- Same number of seeds per fruit but a difference in the number of capsules per sampling site.
- The volume of the capsules differs between the two sites.
- There were no significant differences in the morphometries of seeds between the two sampling sites.

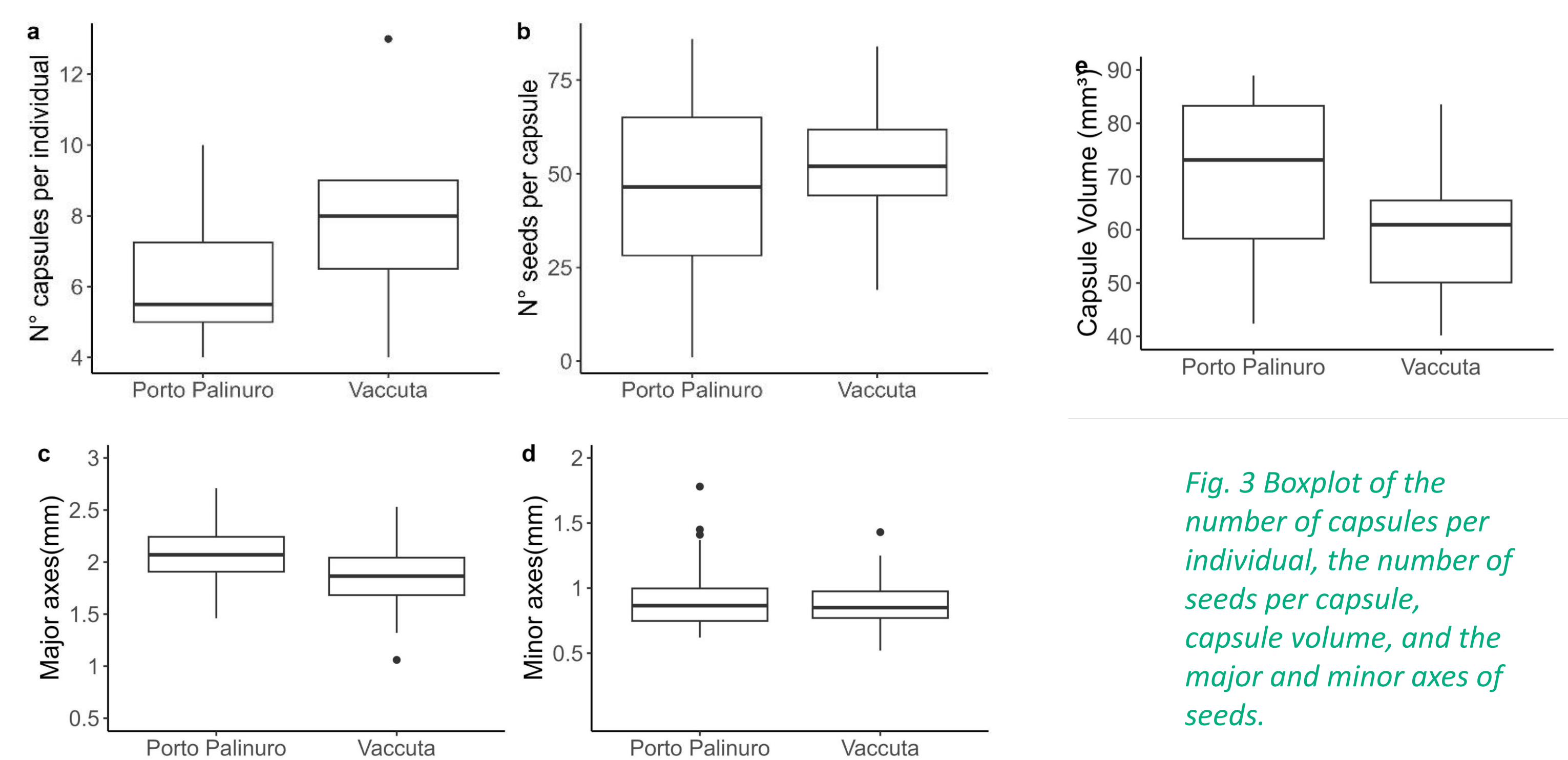


Fig. 3 Boxplot of the number of capsules per individual, the number of seeds per capsule, capsule volume, and the major and minor axes of seeds.

Germination and temperature:

- Minimum temperatures resulted in similar germination percentages between Vaccuta and Palinuro
- At average temperatures, Palinuro exhibited higher germination compared to Vaccuta.
- The time to reach 50% germination was longer for the average temperature compared to the minimum temperature at both sites.
- Faster initial germination in Palinuro ('b' parameter).

Table 2 Estimates of time-to-event model for different temperature and sampling site

Parameter	Temperature	Site	CI (2.5%)	Estimates	CI (97.5%)
b	Average	Palinuro	-9.91	-8.43	-6.95
b	Minimum	Palinuro	-9.87	-8.35	-6.83
b	Average	Vaccuta	-5.17	-4.38	-3.59
b	Minimum	Vaccuta	-11.443	-9.78	-8.12
e	Average	Palinuro	12.72	13.24	13.76
e	Minimum	Palinuro	11.55	12.01	12.48
e	Average	Vaccuta	16.35	17.74	19.13
e	Minimum	Vaccuta	13.33	13.83	14.35

Table 1 Estimates of maximum germination in percentage of Beta-regression model for temperature.

Temperature	Site	CI (2.5%)	Estimate	CI (97.5%)
Average	Palinuro	86%	92%	95%
Average	Vaccuta	58%	82%	94%
Minimum	Vaccuta	74%	92%	98%
Minimum	Palinuro	76%	91%	96%

Germination and salt stress:

- Differences in germination responses to different salt concentrations between the two sampling sites.
- At average salt concentrations, Palinuro exhibited similar behavior to 0 NaCl, while Vaccuta showed lower maximum germination, indicating different responses.
- Treatments with 100 mM NaCl had a significant negative impact on germination in both stations, but Palinuro still had higher germination compared to Vaccuta, suggesting greater adaptation to higher salt concentrations.

Table 4 Estimates of time-to-event model for different salinity level and sampling site

Parameter	Salt	Site	CI (2.5%)	Estimates	CI (97.5%)
b	0	Palinuro	-7.39	-6.28	-5.16
b	50	Palinuro	-7.88	-6.66	-5.42
b	100	Palinuro	-7.32	-5.67	-4.03
b	0	Vaccuta	-4.70	-3.95	-3.21
b	50	Vaccuta	-5.02	-3.83	-2.64
b	100	Vaccuta	-21.03	-13.73	-6.42
e	0	Palinuro	12.51	13.24	13.96
e	50	Palinuro	14.36	15.22	16.08
e	100	Palinuro	20.16	21.93	23.70
e	0	Vaccuta	13.37	14.67	15.98
e	50	Vaccuta	22.44	26.12	29.80
e	100	Vaccuta	14.45	18.95	20.46

Table 3 Estimates of maximum germination in percentage of Beta-regression model for salinity level

Salt (mM NaCl)	Site	CI (2.5%),	Estimate	CI (97.5%)
0	Palinuro	84%	90%	94%
0	Vaccuta	57%	84%	95%
50	Palinuro	62%	87%	96%
50	Vaccuta	34%	65%	87%
100	Palinuro	40%	71%	90%
100	Vaccuta	13%	36%	68%

Conclusions

- There are differences between the two populations under study that need to be further investigated.
- The population near the sea tolerates higher levels of salinity compared to the more inland population.
- Optimal germination temperature for both populations is 6-15 °C.
- Further research is needed to ascertain if observed differences among populations are due to genetic variations or other factors, requiring in-depth genetic and physiological investigations to understand the underlying mechanisms.

