

Supporting Materials

The opposite of biotic resistance: herbivory and competition suppress regeneration of native but not introduced mangroves in southern China

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Supplementary Figures and photographs of mangroves and their herbivores at the two study sites

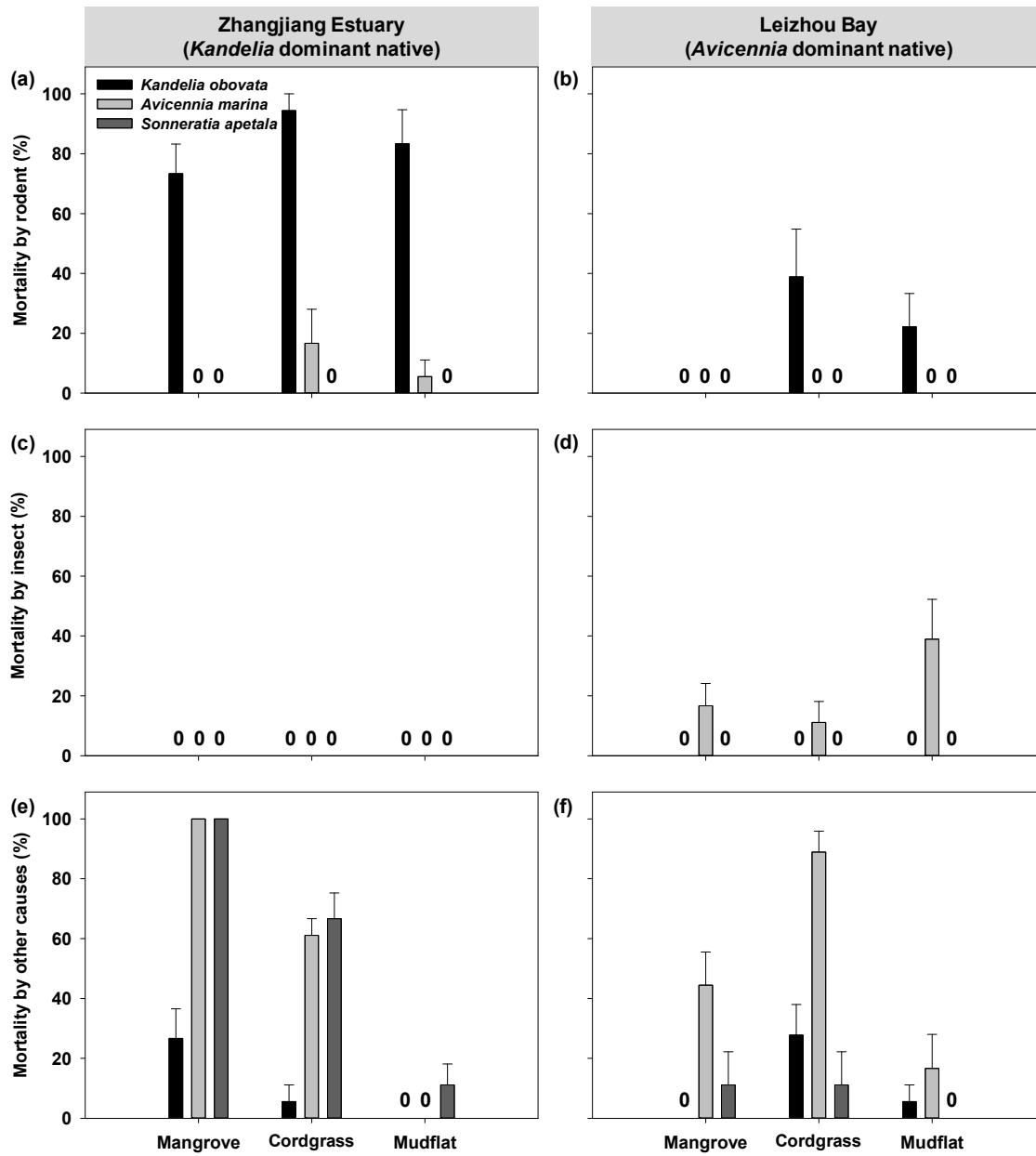


Figure S1. Causes of mortality of seedlings of the three mangrove species. We assigned mortality to either (a, b) grazing by rodents on the plant stem, (c, d) insect herbivory on the leaves, and (e, f) other causes (competition and abiotic stress) in three habitats in Zhangjiang Estuary and Leizhou Bay. Data are means + SE ($n = 6$ per treatment).



Figure S2. The native rat *Rattus losea* and its nest in Zhangjiang Estuary (a, b) and in Leizhou Bay (c, d). The nests are built in the canopy of mangrove trees, but are made out of stems of *Spartina alterniflora*.



Figure S3. (a, b) *Kandelia obovata* seedlings that were grazed by rodents, (c) *Avicennia marina* seedling that was grazed by rodents (stem) and insects (leaf), (d) resprouting *Kandelia obovata* seedling that survived grazing by rodents.

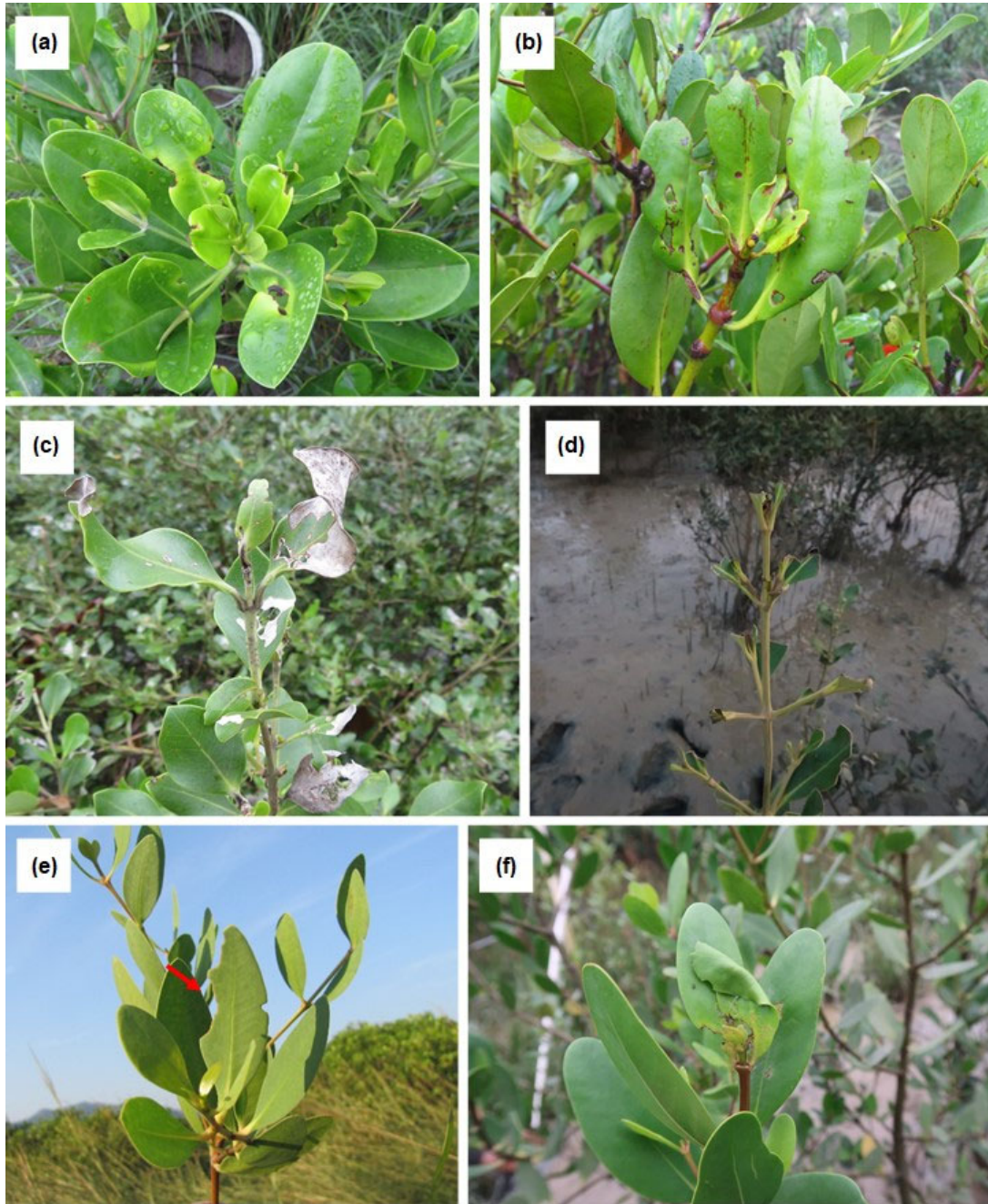


Figure S4. Examples of mangrove leaves grazed by insects. (a, b) *Kandelia obovata*, (c, d) *Avicennia marina* and (e, f) *Sonneratia apetala* in Zhangjiang Estuary and Leizhou Bay.

Supplementary Tables

Table S1. Density and vegetation structure of two native mangrove forests and *Spartina alterniflora* in Zhangjiang Estuary and Leizhou Bay. Data were shown as means \pm SE ($n = 6$ per treatment).

BSD = basal stem diameter (at 30 cm height for mangroves, and 10 cm for *Spartina alterniflora*). NA = Data not available.

| Site | Vegetation type | Height (m) | BSD (cm) | Canopy diameter (m) | | Density (Indiv m ⁻²) |
|--------------------|------------------------------|---------------|---------------|---------------------|---------------|----------------------------------|
| | | | | Length | Width | |
| Zhangjiang Estuary | <i>Kandelia obovata</i> | 4.0 \pm 0.2 | 8.1 \pm 0.7 | 1.8 \pm 0.1 | 1.7 \pm 0.1 | 2.5 \pm 0.1 |
| | <i>Spartina alterniflora</i> | 1.9 \pm 0.1 | 0.8 \pm 0.1 | NA | NA | 281 \pm 21 |
| Leizhou Bay | <i>Avicennia marina</i> | 1.5 \pm 0.1 | 4.7 \pm 0.5 | 2.1 \pm 0.4 | 1.8 \pm 0.3 | 1.4 \pm 0.1 |
| | <i>Spartina alterniflora</i> | 1.0 \pm 0.1 | 0.5 \pm 0.1 | NA | NA | 553 \pm 42 |

Table S2. Results of the best subset linear regression using up to six independent variables to predict survival of *Kandelia obovata*, *Avicennia marina*, *Sonneratia apetala* in Leizhou Bay and Zhangjiang Estuary. Models were chosen based on Adj R^2 and Mallow's Cp.

| Model # | Variable | Cp | R ² | Adj R ² | ro- dent | insect | Sediment water con- tent (%) | Sediment porewater sa- linity (PSU) | Light inten- sity (Lux) | Temp ture (°C) |
|-------------------------|----------|------|----------------|--------------------|-------------|--------|------------------------------------|---|----------------------------|-------------------|
| <i>Kandelia obovata</i> | | | | | | | | | | |
| 1 | 3 | 5.49 | 0.83 | 0.82 | * | | | * | * | |
| 2 | 4 | 5.83 | 0.83 | 0.81 | * | | | * | * | * |
| 3 | 5 | 5.70 | 0.84 | 0.81 | * | * | * | * | * | |

| | | | | | | | | | | |
|---------------------------|---|------|------|------|---|---|---|---|---|---|
| 4 | 4 | 5.50 | 0.82 | 0.80 | * | * | | * | * | |
| 5 | 3 | 5.88 | 0.81 | 0.81 | * | * | * | | | |
| 6 | 5 | 5.83 | 0.83 | 0.81 | * | * | | * | * | * |
| <i>Avicennia marina</i> | | | | | | | | | | |
| 1 | 4 | 3.75 | 0.60 | 0.54 | * | * | | | * | * |
| 2 | 5 | 5.33 | 0.60 | 0.54 | * | * | * | | * | * |
| 3 | 5 | 5.62 | 0.60 | 0.53 | * | * | | * | * | * |
| 4 | 3 | 3.88 | 0.56 | 0.53 | | * | | | * | * |
| 5 | 6 | 7.00 | 0.61 | 0.52 | * | * | * | * | * | * |
| 6 | 4 | 5.02 | 0.58 | 0.52 | | * | * | | * | * |
| <i>Sonneratia apetala</i> | | | | | | | | | | |
| 1 | 2 | 5.36 | 0.74 | 0.72 | | | | | * | * |
| 2 | 2 | 6.23 | 0.72 | 0.71 | * | | | | | * |
| 3 | 3 | 7.10 | 0.72 | 0.70 | * | | | | * | * |
| 4 | 3 | 7.18 | 0.72 | 0.70 | | * | | | * | * |
| 5 | 3 | 7.18 | 0.72 | 0.70 | * | * | | | | * |
| 6 | 3 | 7.79 | 0.72 | 0.70 | * | | | * | | * |

Table S3. Summary of three-way ANOVAs examining the effects of site, species, habitat and the interaction between them on plant survival in Zhangjiang Estuary and Leizhou Bay. Significant p -values ($p < 0.05$) are in bold.

| Factors and | | | |
|---------------------------|-----------|-----------------|-----------------|
| | df | <i>F</i> | <i>p</i> |
| Source of variance | | | |
| Survival | | | |
| Site | 1 | 68.5 | < 0.0001 |
| Species | 2 | 23.2 | < 0.0001 |
| Habitat | 2 | 33.7 | < 0.0001 |
| Site × Species | 2 | 30.1 | < 0.0001 |
| Site × Habitat | 2 | 24.6 | < 0.0001 |
| Habitat × Species | 4 | 7.5 | < 0.0001 |
| Site × Species × Habitat | 4 | 2.4 | 0.06 |

Table S4. Summary of one-way ANOVA examining relative growth rate of different species in three habitats (Mangrove, Cordgrass, Mudflat) in Zhangjiang Estuary and Leizhou Bay. Significant p -values ($p < 0.05$) are in bold. NA = Data not available.

| Factors and Source of variance | df | F | p |
|---|-----------|-----------------------|-----------------------|
| Zhangjiang Estuary | | | |
| Mangrove | NA | NA | NA |
| Cordgrass | 1 | 39.1 | 0.0004 |
| Mudflat | 2 | 160.0 | < 0.0001 |
| Leizhou Bay | | | |
| Mangrove | 2 | 84.7 | < 0.0001 |
| Cordgrass | 2 | 61.7 | < 0.0001 |
| Mudflat | 2 | 104.1 | < 0.0001 |

Table S5. Summary of one-way ANOVA examining height of different species in three habitats (Mangrove, Cordgrass, Mudflat) in Zhangjiang Estuary and Leizhou Bay. Significant p -values ($p < 0.05$) are in bold. NA = Data not available.

| Factors and Source of variance | df | F | p |
|---|-----------|-----------------------|-----------------------|
| Zhangjiang Estuary | | | |
| Mangrove | NA | NA | NA |
| Cordgrass | 1 | 9.9 | 0.016 |
| Mudflat | 2 | 69.0 | < 0.0001 |
| Leizhou Bay | | | |
| Mangrove | 2 | 98.4 | < 0.0001 |
| Cordgrass | 2 | 15.5 | 0.0043 |
| Mudflat | 2 | 63.0 | < 0.0001 |

Table S6. Summary of three-way ANOVAs examining the effects of site, species, habitat and the interaction between them on the rodent stem grazing rate and the insect leaf herbivory rate in Zhangjiang Estuary and Leizhou Bay. Significant p -values ($p < 0.05$) are in bold.

| Factors and Source of variance | df | F | p |
|---|-----------|-----------------------|-----------------------|
| Rodent stem grazing rate | | | |
| Site | 1 | 142.5 | < 0.0001 |
| Species | 2 | 132.8 | < 0.0001 |
| Habitat | 2 | 28.4 | < 0.0001 |
| Site \times Species | 2 | 33.5 | < 0.0001 |
| Site \times Habitat | 2 | 18.0 | < 0.0001 |
| Habitat \times Species | 4 | 10.2 | < 0.0001 |
| Site \times Species \times Habitat | 4 | 10.4 | < 0.0001 |
| Insect leaf herbivory rate | | | |
| Site | 1 | 10.6 | 0.0016 |
| Species | 2 | 12.2 | < 0.0001 |
| Habitat | 2 | 1.0 | 0.38 |
| Site \times Species | 2 | 9.2 | 0.0002 |
| Site \times Habitat | 2 | 16.3 | < 0.0001 |
| Habitat \times Species | 4 | 5.9 | 0.0003 |
| Site \times Species \times Habitat | 4 | 5.3 | 0.0007 |

Table S7. Summary of three-way ANOVAs examining the effects of site, species, habitat and the interaction between them on mortality by rodent and competition in Zhangjiang Estuary and Leizhou Bay. Significant p -values ($p < 0.05$) are in bold.

| Factors and Source of variance | df | <i>F</i> | <i>p</i> |
|---|-----------|-----------------|--------------------|
| Mortality by rodent | | | |
| Site | 1 | 62.4 | < 0.0001 |
| Species | 2 | 126.2 | < 0.0001 |
| Habitat | 2 | 6.1 | 0.0032 |
| Site × Species | 2 | 44.9 | < 0.0001 |
| Site × Habitat | 2 | 0.1 | 0.95 |
| Habitat × Species | 4 | 3.0 | 0.022 |
| Site × Species × Habitat | 4 | 0.9 | 0.45 |
| Mortality by other causes | | | |
| Site | 1 | 28.3 | < 0.0001 |
| Species | 2 | 46.9 | < 0.0001 |
| Habitat | 2 | 59.0 | < 0.0001 |
| Site × Species | 2 | 23.5 | < 0.0001 |
| Site × Habitat | 2 | 31.4 | < 0.0001 |
| Habitat × Species | 4 | 10.0 | < 0.0001 |
| Site × Species × Habitat | 4 | 3.7 | 0.0073 |

Table S8. Summary of two-way ANOVAs examining the effects of site, habitat and the interaction between them on the abiotic factors in Zhangjiang Estuary and Leizhou Bay. Significant p -values ($p < 0.05$) are in bold.

| Factors and Source of variance | df | F | p |
|---|-----------|-----------------------|-----------------------|
| Light intensity | | | |
| Site | 1 | 56.7 | < 0.0001 |
| Habitat | 2 | 190.6 | < 0.0001 |
| Site \times Habitat | 2 | 1.3 | 0.28 |
| Temperature of the coldest month | | | |
| Site | 1 | 1118.1 | < 0.0001 |
| Habitat | 2 | 0.0 | 1.00 |
| Site \times Habitat | 2 | 2.0 | 0.18 |
| Sediment water content | | | |
| Site | 1 | 903.4 | < 0.0001 |
| Habitat | 2 | 50.4 | < 0.0001 |
| Site \times Habitat | 2 | 44.8 | < 0.0001 |
| Sediment porewater salinity | | | |
| Site | 1 | 13.0 | 0.0004 |
| Habitat | 2 | 1.4 | 0.24 |
| Site \times Habitat | 2 | 2.2 | 0.11 |