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Comparing levels of herbivory between pristine and restoration mangrove forests in Northern Sulawesi, Indonesia.

Introduction

Mangrove forests are unique coastal wetlands that sustain millions of people globally through protection against coastal erosion, provision of food and materials, and through filtering of water-borne pollutants. Despite this, mangroves suffer significant destruction, with more than 20% of their global cover lost between 1980 and 2000. Recently, considerable effort has aimed to restore mangroves, but the success of these schemes are limited. A possible cause of which may be elevated levels of herbivory.

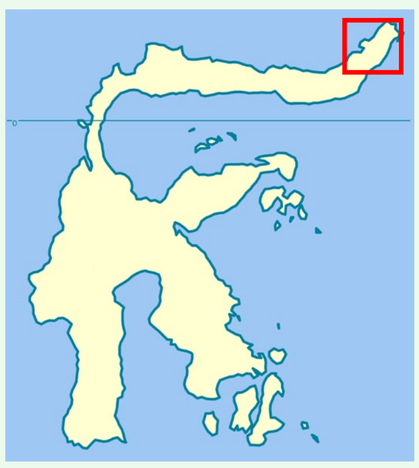

Figure 1: Map of Sulawasi, with the location of the study sites, Likupang and Tiwoho highlighted.
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Aims

To compare the variation in leaf herbivory between natural, planted monoculture and mixed ecologically restored mangrove forests. The results have the potential to advise future schemes on the best practice for habitat restoration.

Figure 2: Top: pristine mangrove forest site. Bottom: monoculture restoration site of Rhizophora apiculata in Likupang.

Methodology

- 18 quadrats (10m x 10m) were set up in Tiwoho and Likupang (figure 1).
- 6 quadrats covered forest that had been ecologically restored, 6 covered forest restored with one species (monoculture restoration) and 6 were the control (natural forest) (figure 2).
- In each quadrat a basket of leaves were collected from the most abundant species in the plot at shoulder height. Baskets can be recognised as the cluster of leaves at the tip of a branch.
- The tree species were recorded along with the tree height and circumference at breast height. All trees were marked with an aluminium tag for later clarification on species.
- In the lab each of the 228 leaves used in this study were scanned and analysed using the LeafByte application.
- Each basket of leaves were labelled according to age which can be determined by node position on the stem.
- The data was analysed with a two-way ANOVA using arcsine transformed herbivory % data.

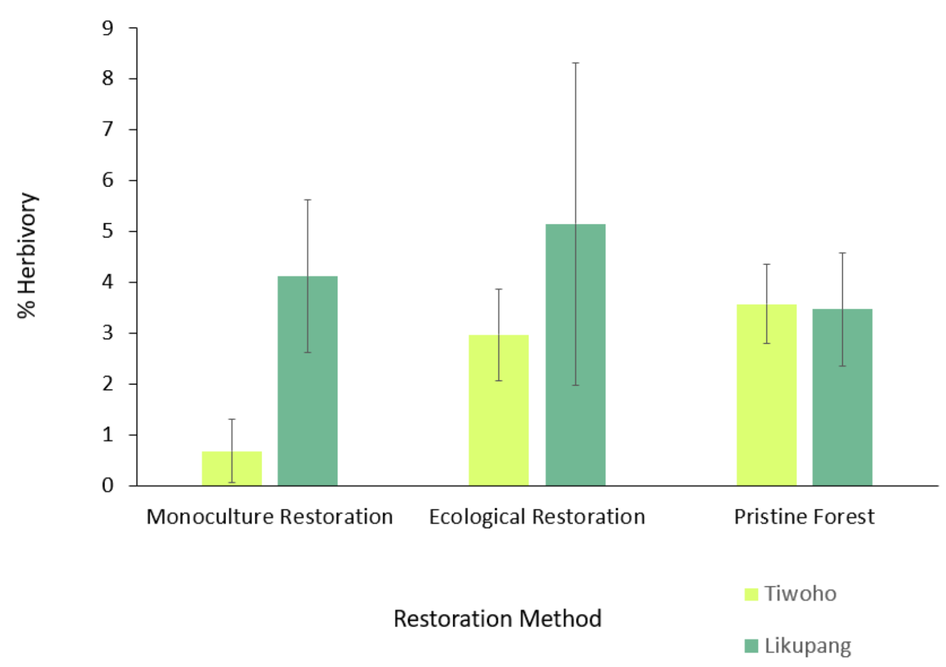

Figure 3: The mean percentage herbivory measured across the 2 restoration methods and the natural sites with error bars representing 95% confidence intervals. The means for Likupang and Tiwoho are plotted separately.

Results

There was considerable variability in herbivory when the same treatment was applied in Tiwoho and Likupang (figure 3). Only the pristine forest had similar results for herbivory (3.58 ± 3.39 in Tiwoho, compared to 3.47 ± 6.44 in Likupang). The 95% confidence interval error bars demonstrate the fluctuation in results, for example in Likupang in the ecologically restored sites the mean herbivory was 5.15% however 95% of results sit within 3.18% either side of this value.

Further analysis was carried out in RStudio using transformed data. There was a significant effect of treatment ($F=9.23$, $df=2$, $p<0.001$), site ($F=6.50$, $df=1$, $p= 0.01$) and the treatment-site interaction ($F=18.324$, $df=2$, $p<0.001$) on leaf % damage. Overall, herbivory was lower in Tiwoho, with contrasting effects between treatments.

Discussion

- It has been previously described that newly established plants invest more of their resources into growth rather than defence (Zust and Agrawal 2017).
- This could explain the high levels of herbivory in the ecologically restored sites, although this hypothesis does not explain the low mean herbivory in the monoculture restoration sites.
- One possible explanation could be the disparity in herbivory levels between species. *Sonneratia alba* had a mean herbivory of 22.73% which would have inflated the herbivory result of any plot which sampled *S. alba*.
- Mangrove forests remain largely unstudied ecosystems, leaf herbivory and mangrove stress appear to have only been investigated previously by Maldonado-López et al. 2019.
- In northern Sulawesi the impacts of herbivory on mangrove restoration remain uncertain. In total, approximately 2000 leaves were collected and scanned (figure 4), only 10% of these were analysed for this study.
- Further analysis of other data collected such as chew counts or a larger sample size could help elucidate the observed variation between sites.

Figure 4: Leaf scans from left to right; Ceriops *tagal* and *Rhizophora apiculata.*

References

Maldonado-López Y, Vaca-Sánchez MS, Canché-Delgado A, Garcia-Jain SE, Gonzalez-Rodrigues A, Cornelissen T, Cuevas-Teyes P (2019) Leaf herbivory and fluctuating asymmetry as indicators of mangrove stress. Wetlands Ecology and Management 27:571-580

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