Different ways to estimate ‘realistic’ plant species richness on 1 km²

A case study from a semi-arid savanna in Namibia

Presented by:
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Research question

How can we quantify realistic plant species richness in BIOTA Biodiversity Observatories (or 1 km² in general) with low sampling effort?

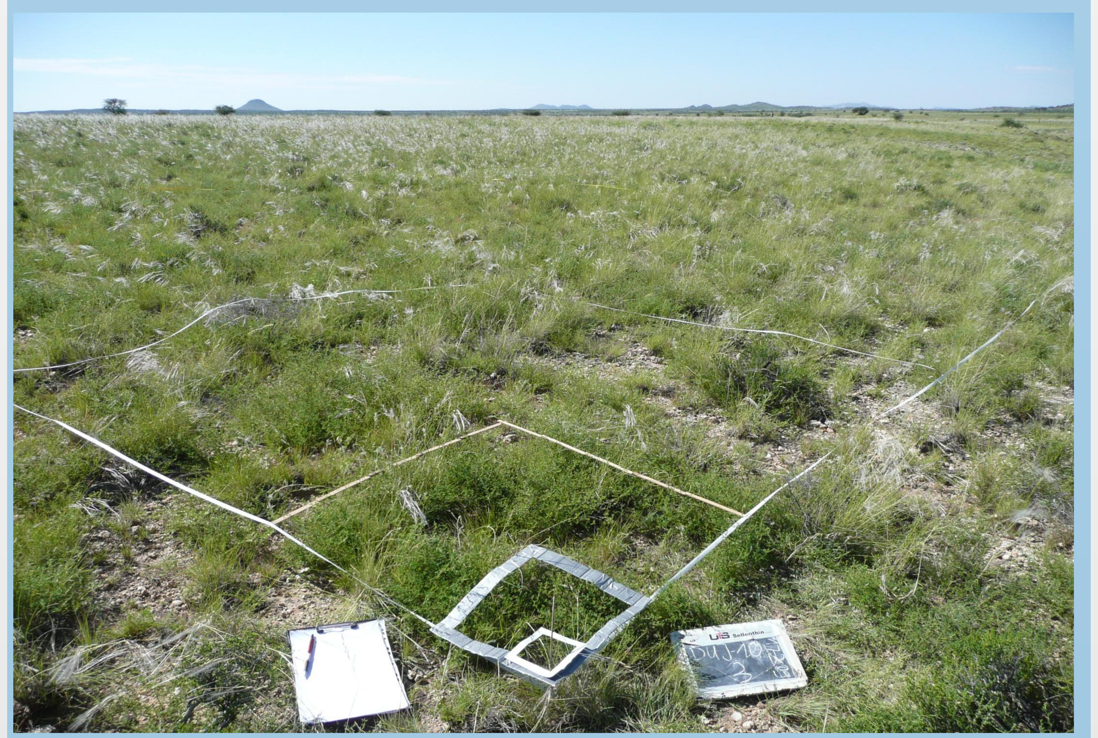

Fig. 2: Vegetation sampling design and landscape impression of the study area

Study Area

- BIOTA Observatories Narais and Duruchaus (1 km² area) in Central Namibia (Fig. 1)
- Climate: semi-arid, average precipitation: 240 mm
- Vegetation: dwarf shrub savannah (Fig. 2)
- Land use: livestock farming with cattle, sheep and goats, with higher stocking rates at Duruchaus

Vegetation sampling

- Random selection of 20 vegetation plots per BIOTA Observatory
- **Nested-plot design**: **1,000 m²** in square shape (31.6 m x 31.6 m). 0.01 m², 0.1 m², 1 m², 10 m² and 100 m² quadratic sub-plots (Fig. 2)
- Combined with species recorded in BIOTA monitoring scheme between 2005–2009

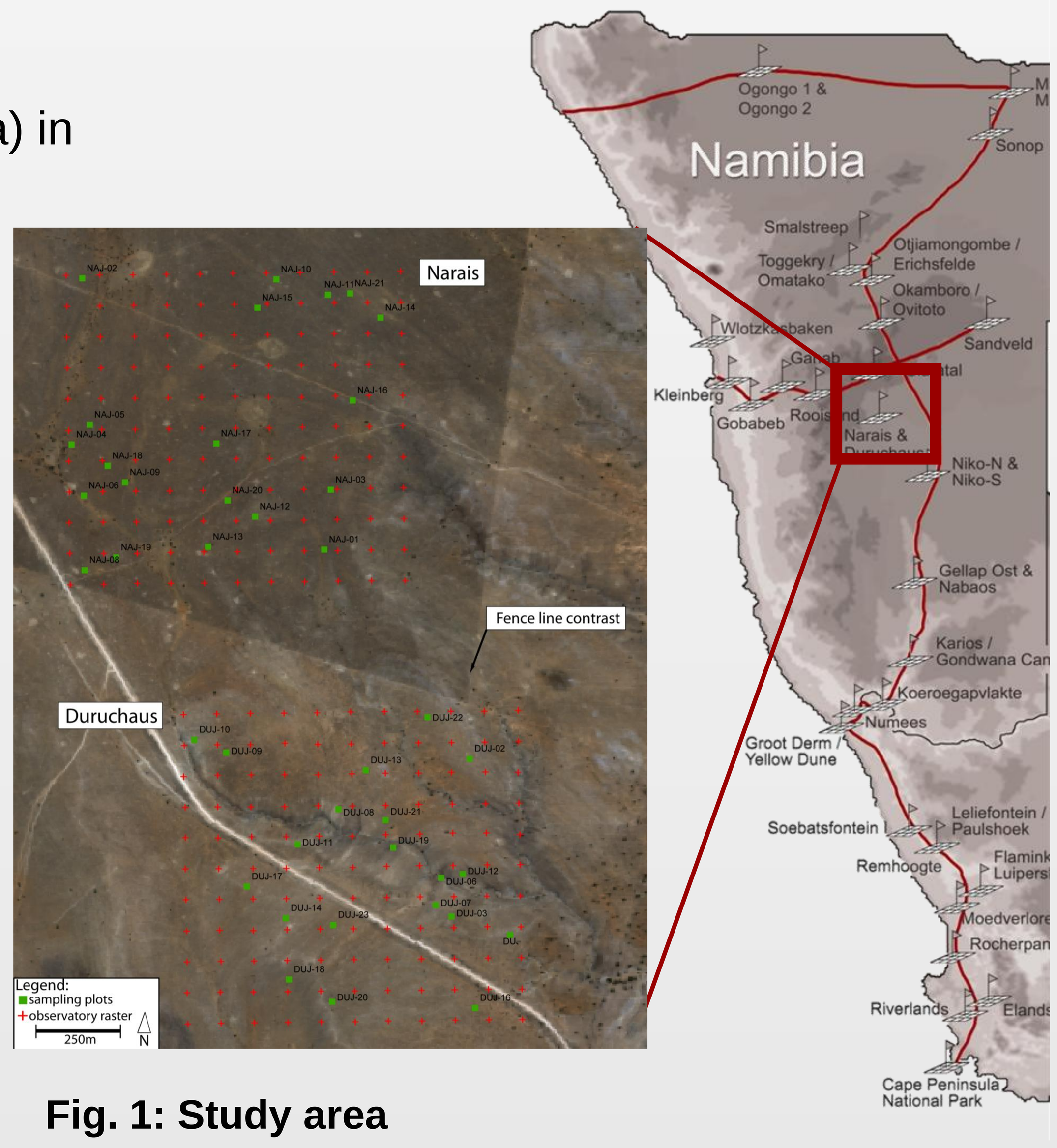

Fig. 1: Study area

Extrapolation methods

1. Species-area relationship

- Fitting of different functions describing the **Species-area relationship (SAR)** (Table 1)
- Selection of best fitting functions with an information criterion approach (ΔAICc) and logarithmic error of extrapolation (LEE)
- **Extrapolation of species numbers to 1,000,000 m²**
- Calculation of average extrapolated species number weighted by the Akaike weights (w_i)

Table 1: Overview of the models used for fitting SARs

Nr.	Model name	Model
1	Power function	$S = b_0 A^{b1}$
2	Power function (quad.)	$S = 10 ^\wedge (b_0+b_1 \log(A)+ b_2 (\log(A))^2)$
3	Logarithmic function	$S = b_0 + b_1 \log(A)$
4	Logarithmic function (quad.)	$S = (b_0 + b_1 \log(A))^2$
5	Michaelis–Menten (Monod) f.	$S = b_0 A / (b_1 + A)$
6	Negative exponential function	$S = b_0 (1-\exp (-b_1 A))$
7	Rational function	$S = (b_0 + b_1 A)/(1 + b_2 A)$
8	Logistic function	$S = b_0 / (1 + \exp (-b_1 A + b_2))$
9	Lomolino function	$S = b_0 / (1 + (b_1 ^\wedge \log (b_2/A)))$

2. Species sampling relationship

- Fitting asymptotical models (Michaelis-Menten (Nr. 5), rational function (Nr. 7), and Lomolino function (Nr. 9) (Table 1)) to **rarefaction curve**
- Determining of **asymptotic levels** of these functions which are equivalent to species number for the observatories

3. Richness estimators

- Calculation of incidence-based **richness estimators** with EstimateS (Colwell, 2006) (Tab. 2)

Results

Table 2: Results of species richness resulting from applied estimation methods

Method	Name	Duruchaus	± 1 SE	Narais	± 1 SE
Sampling	Observed species number	171	-	146	-
	Accumulated species nr.	216	-	195	-
SAR	Power	355	37.35	347	24.96
	Power quad.	314	85.48	170	16.19
	Lomolino	198	35.09	132	9.61
	w_i –weighted average	319	74.50	225	25.55
SAC	Michaelis-Menten	200	-	165	-
	Lomolino	238	-	190	-
	Rational	210	-	172	-
Richness estimator	ICE	200	-	171	-
	Chao 2	194	-	180	-
	Jackknife 2	215	-	193	-
	Bootstrap	190	-	160	-
	Michaelis-Menten	181	-	150	-

Extrapolation of plant species to 1,000,000 m²:

- **Wide range of estimated species numbers** by extrapolating to the target scale
- **Highest values** for the power SAR (Fig. 3A)
- **Generally lower values** for the SSR functions and richness estimators (Fig. 3B & 3C)
- Curves of the richness estimators ICE, Chao 2 and Jackknife 2 show a **stable asymptote** indicating an accurate estimation only for Duruchaus, not for Narais (Fig. 3C)

SAR: best model fit (ΔAICc, LEE):

- ΔAICc : **Power function** in 20 of 40 plots best fit, **quadratic power function** (13x best fit), and the **Lomolino function** (7x best fit)
- LEE values: these 3 functions (power, power quad., Lomolino) cause the lowest values as well.

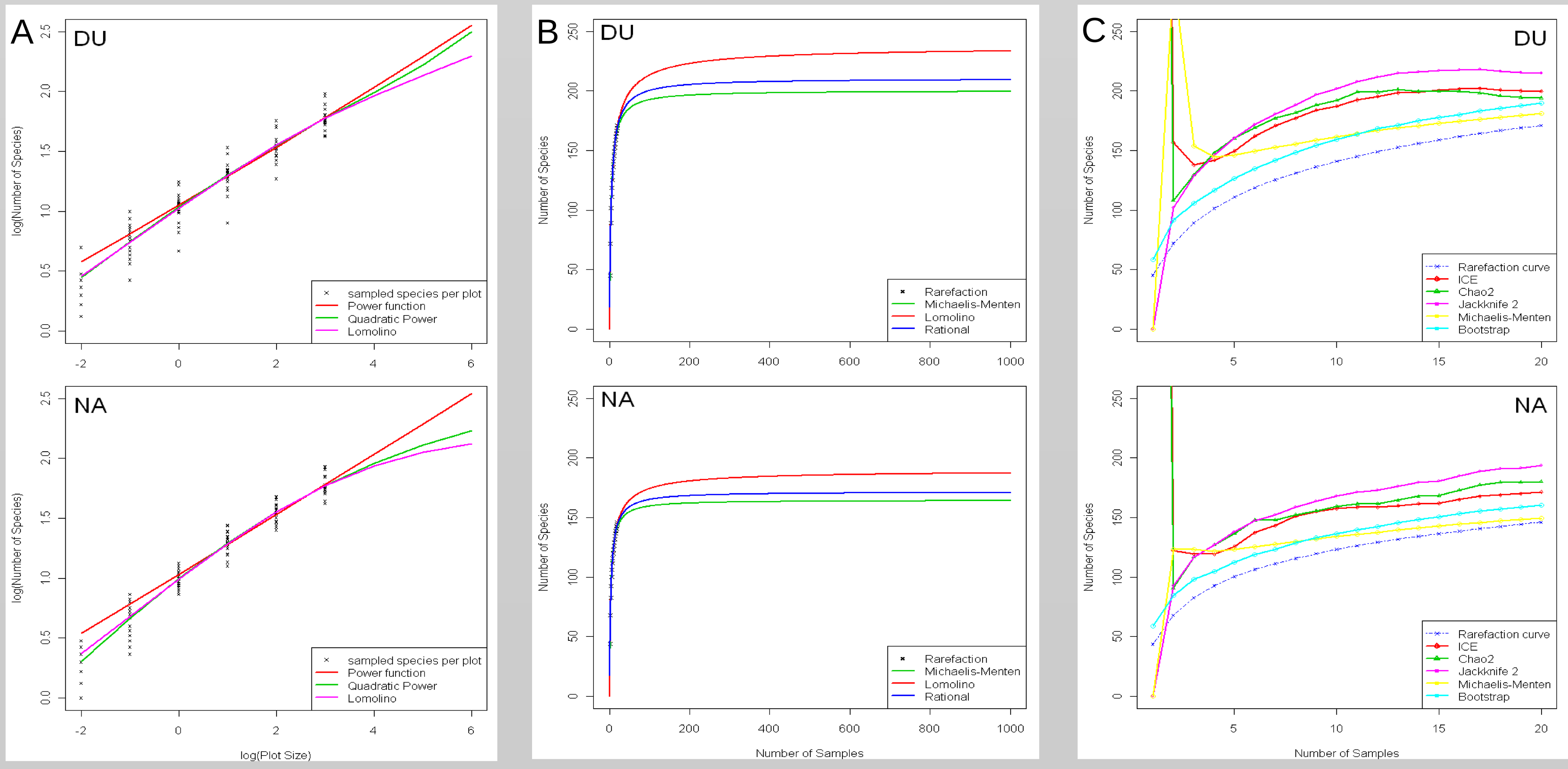

Fig. 3: [A] Extrapolation of fitted SAR functions in log-space; [B] species sampling relationships (SSRs); [C] Rarefaction and richness estimators curve (DU=Duruchaus; NA=Narais)

Conclusions

- Methods which gave lower richness values than actually recorded should be **rejected**; in our study namely Lomolino SAR, all SSR functions; except Lomolino SSR in Duruchaus, and all non-parametric richness estimators.
- SAR-extrapolation has to be handled with care because of the **high standard error**.
- **Further consideration** is needed to improve our multi-methodological approach.

→ Comprehensive data base sampled with different methods on the BIOTA Observatories since 2005 provides a great potential for validation of our estimation approaches.