# First population estimates of two Critically Endangered frogs from an isolated forest plateau in Madagascar

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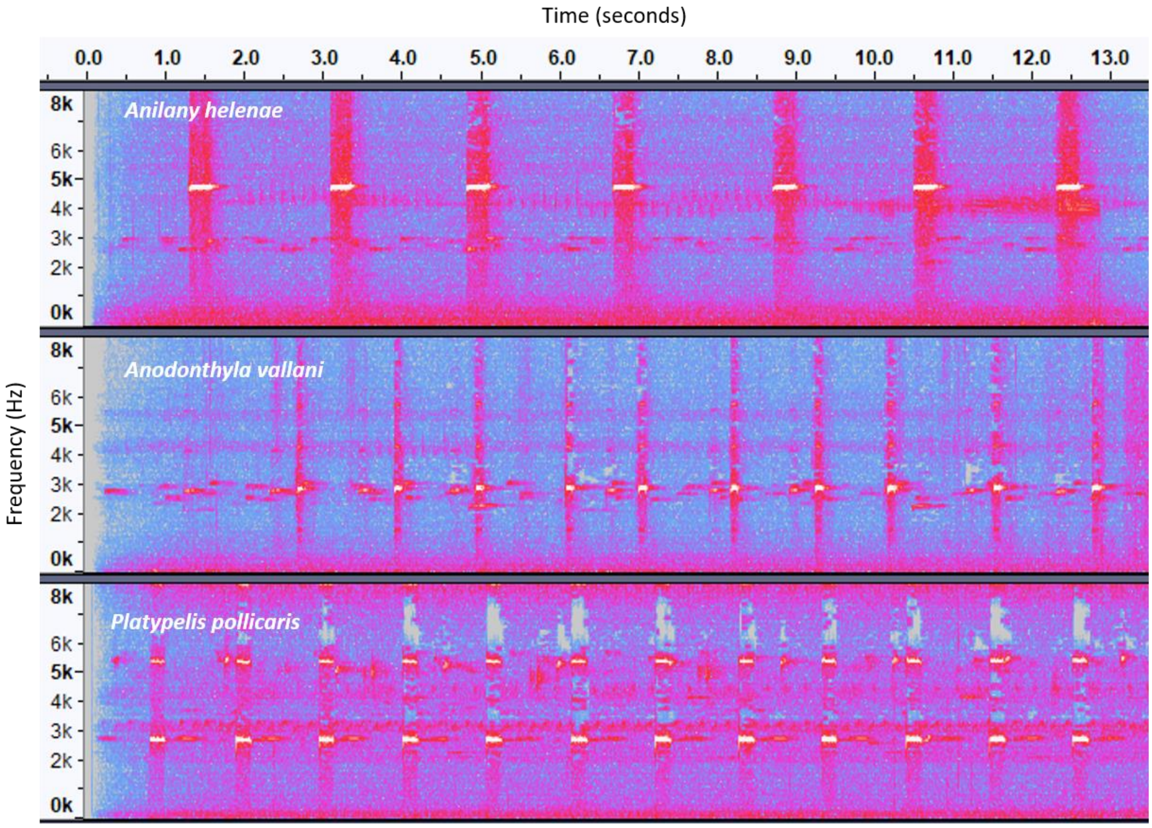
SUPPLEMENTARY MATERIAL 1 Details of model fitting and of covariates influencing species occupancy, abundance and detectability.

We used acoustic surveys to record presence and absence of two targeted species: *Anodonthyla vallani* and *Anilany helenae*. In our study area, both targeted species could be misidentified as *Platypelis pollicaris*. Nonetheless, species can be differentiated by an experienced observer. Acoustic surveys and species identification were performed by a single experienced observer and recordings were available for comparisons in the field to help confirm species identification when there was uncertainty regarding the species. We provide spectrograms for both targeted species, *A. vallani* and *A. helenae,* and for *P. pollicaris* showing the differences in calling patterns (Supplementary Fig. 1). The spectrograms were produced with the Audacity audio software using calls from the CD 'The Calls of the Frogs of Madagascar' (by Vences, Glaw and Marquez). Calls were split to mono audio tracks and 13 seconds were displayed to allow comparison of call characteristics, such as inter-call interval and call duration.



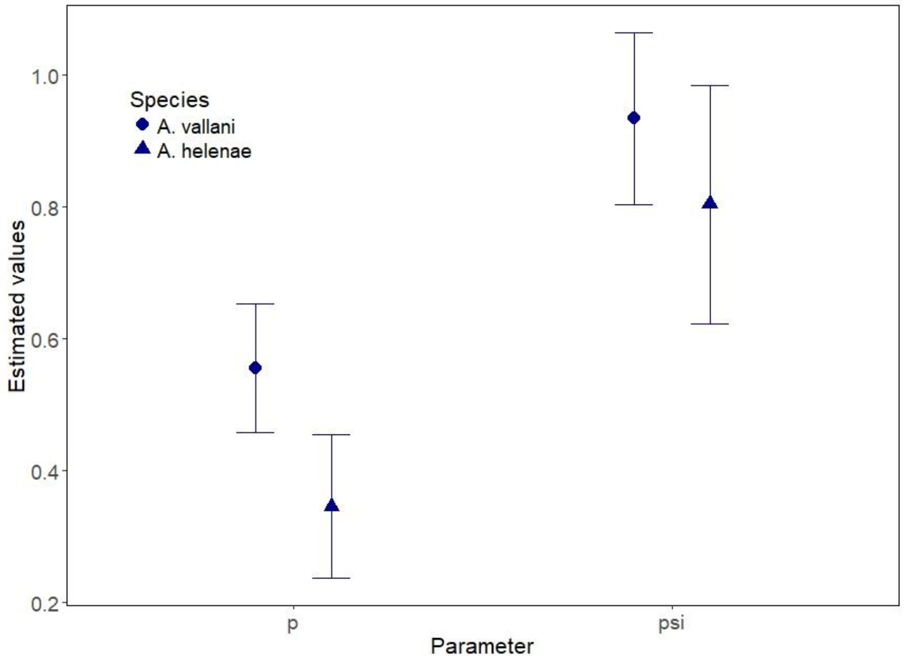

SUPPLEMENTARY FIG. 1 Spectrogram of call recordings of *Anodonthyla vallani*, *Anilany helenae* and *Platypelis pollicaris,* taken from 'The Calls of the Frogs of Madagascar' CD by Vences et al. Differences in calling patterns can be differentiated in the field by an experienced observer.

This supplementary information also details the results from occupancy models and Royle–Nichols models for two Critically Endangered species in the largest fragment of Ambohitantely Special Reserve in the central plateau of Madagascar. While occupancy models detail covariates used to explain species detection and occupancy, the RN models were used to explain covariates of species abundance and estimate population sizes. For *Anilany vallani* best-fitted models included time as an explanatory variable for detection and canopy cover and bamboo number as explanatory variables for occupancy (Supplementary Table 1).

SUPPLEMENTARY TABLE 1 Fitted list with best models for *Anilany helenae* and *Anodonthyla vallani* with predictors of occupancy (ψ) and detection (*p*) (in a single-season occupancy), and abundance (λ) and detection (*p*) (from Royle–Nichols model) at Ambohitantely Special Reserve, Madagascar. Pars = number of parameters; AIC = Akaike's Information Criterion; ΔAIC is the difference between the model with the lowest AIC and the given model; AIC*w* is AIC weight.

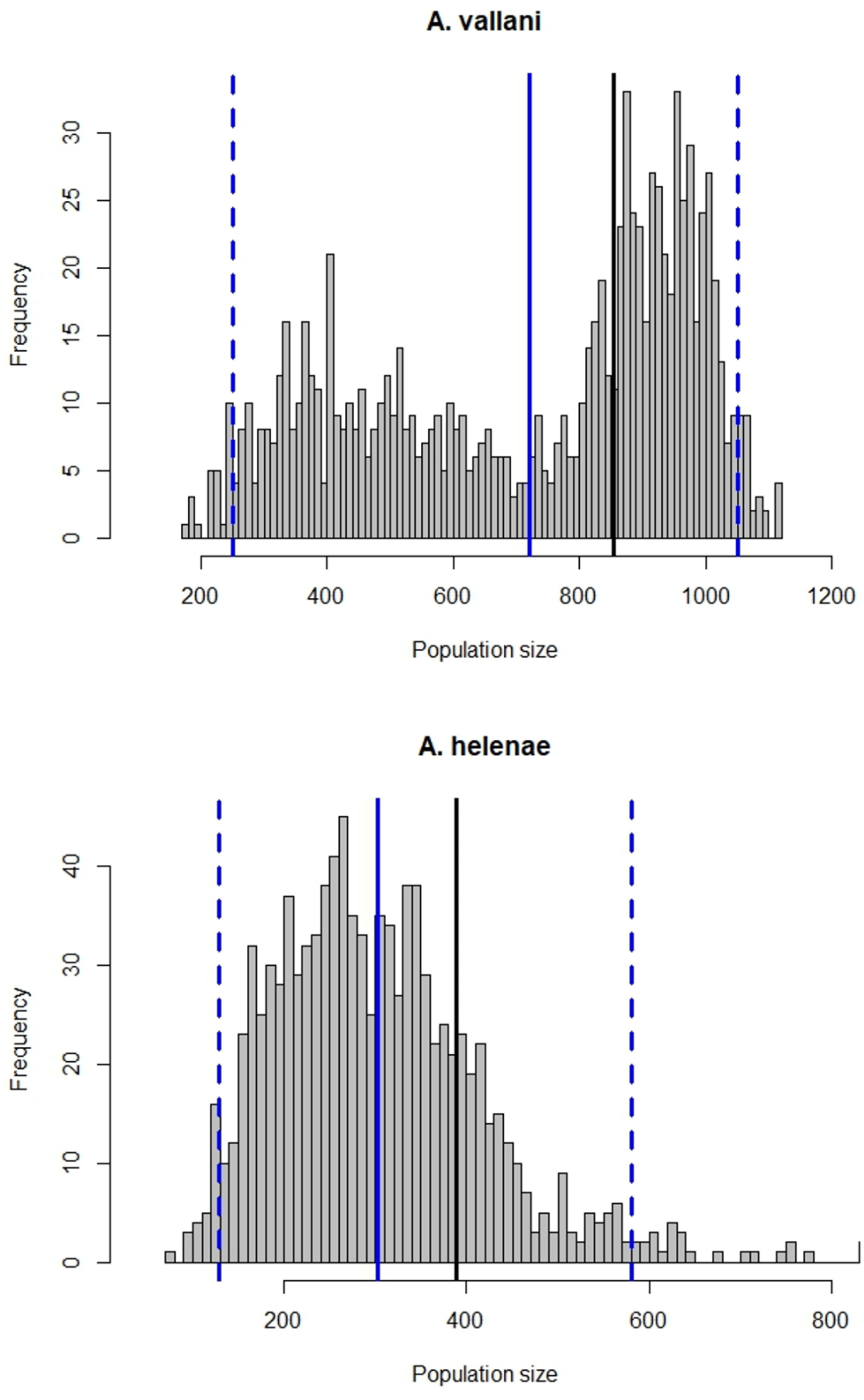
| Model | Pars | AIC | ΔAIC | AIC*w* | Cumulative weight |
|---|---|---|---|---|---|
| **Single-season occupancy models** | | | | | |
| *Anodonthyla vallani* | | | | | |
| ψ(canopy) *p*(time) | 4 | 325.27 | 0 | 0.37 | 0.37 |
| ψ(canopy + bamboo) *p*(time) | 5 | 325.78 | 0.51 | 0.29 | 0.66 |
| ψ(bamboo) *p*(time) | 4 | 326.51 | 1.24 | 0.20 | 0.86 |
| ψ(.) *p*(time) | 3 | 327.41 | 2.14 | 0.13 | 0.99 |
| *Anilany helenae* | | | | | |
| ψ(bamboo) *p*(rain) | 5 | 265.73 | 0 | < 0.01 | 0.5 |
| ψ(bamboo + canopy) *p*(rain) | 6 | 265.83 | 0.1 | < 0.01 | 0.98 |
| ψ(canopy) *p*(rain) | 5 | 273.28 | 7.55 | < 0.01 | 1 |
| **Royle–Nichols models** | | | | | |
| *Anodonthyla vallani* | | | | | |
| λ(bamboo) *p*(time) | 4 | 326.01 | 0 | 0.32 | 0.32 |
| λ(canopy) *p*(time) | 4 | 326.17 | 0.16 | 0.30 | 0.62 |
| λ(.) *p*(time) | 3 | 327.02 | 1 | 0.20 | 0.81 |
| λ(canopy + bamboo) *p*(time) | 5 | 327.16 | 1.15 | 0.18 | 1 |
| λ(bamboo) *p*(.) | 3 | 338.35 | 12.34 | 0.00 | 1 |
| *Anilany helenae* | | | | | |
| λ(bamboo + pandamus) *p*(rain) | 6 | 264.75 | 0 | 0.84 | 0.84 |
| λ(bamboo) *p*(rain) | 5 | 268.34 | 3.59 | 0.14 | 0.98 |

Estimated values of occupancy (especially for *Anodonthyla vallani*) were close to a boundary (i.e. very close to the limit of 1; Supplementary Fig. 2) and could potentially represent a failure of the fitted models to accurately predict these values. Nonetheless, naïve occupancy was also considered high for *A. vallani* (0.84) and moderate for *Anilany helenae* (0.61), demonstrating that both species indeed occupy a great proportion of sampled sites and that our estimates are likely reasonable and close to the truth. Detectability had low standard errors and estimates for both species had good precision. Detection rates were higher for *A. vallani* compared to *A. helenae* and estimates for both species were considered moderate (0.55 for *A. vallani*) to low (0.34 for *A. helenae*; Supplementary Fig. 2).




SUPPLEMENTARY FIG. 2 Estimated values of detection (*p*) and occupancy (ψ) for *Anodonthyla vallani* and *Anilany helenae*. Predicted parameters are based on model averaging.

The two top-fitted models for *Anodonthyla vallani* (bamboo number, canopy cover and time) explained 62% of species abundance and detection (Supplementary Table 1). For *Anilany helenae*, the top fitting model alone (bamboo, pandanus and rain), explained 84% of the variation in estimated parameters (Supplementary Table 1). For *A. vallani*, models which included bamboo and canopy cover showed a negative relationship with estimated abundance (Fig. 2 in main text), whilst for *A. helenae* bamboo and pandanus numbers were positively related to the abundance (Fig. 2 in manuscript). Population size was considered low for both species (*A. vallani*: 855, 95% CI = 250–1052; *A. helenae*: 388, 95% CI = 128–580). Overall, our results suggest these estimates are an overestimation of the sampled distribution of the population based on the best fitted model (Supplementary Fig. 3).




SUPPLEMENTARY FIG. 3 Population size for *Anodonthyla vallani* and *Anilany helenae* based on the best fitting model for each species. Bootstrapped sampling distribution of the number of males in the population in studied sites; black line shows estimates of actual dataset and solid blue line indicates the mean value in 1,000 replicates. Dashed blue lines show 95% CIs.