Altitudinal shifts of amphibian species over 80 years on Mount Kinabalu, Borneo

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1. Introduction

Climate change is predicted to have major impacts on the distribution of species[1-2]. Anurans present a specifically vulnerable group as they are ectothermic and are thus often unable to adapt to temperature change locally and instead need to migrate[3-4]. Few data sets are available to test the extent to which anurans have shifted in recent decades. In this study, we aimed to compare a historical dataset from 1929 from Mount Kinabalu in Borneo, and compare it to modern-day data to assess altitudinal shift in amphibian species.

2. Methods

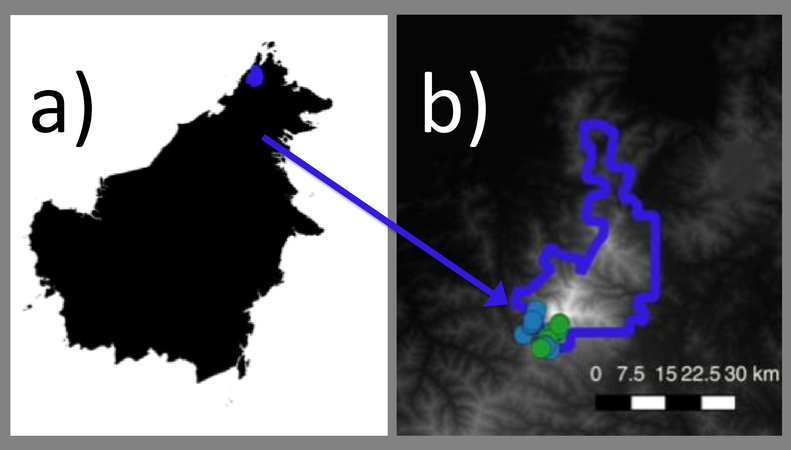

Fig 1. The island of Borneo (a), and Kinabalu Park (b) outlined in blue.

This study was conducted on Mount Kinabalu (fig 1 and 2), Borneo, between 900 to 3300m asl. An original dataset was collected in 1929[5] and additional ones collected in 2007, 2010 and 2016 which attempted to re-survey the previously reported areas. We calculated the weighted altitude mean [6,7], first on the raw data from all the years and secondly we sub-sampled the modern years to match the number of survey sites in 1929. We assessed changes in species richness using iNEXT [8-9].

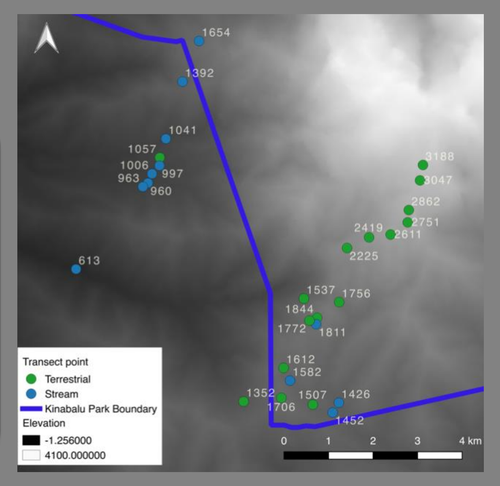

Figure 2. Survey areas for 2016 indicated by dots.

3. Results

Over 80 yr, with the average shift of amphibians was 48 m upwards (figure 2). The sub-sampling to site results indicate an even greater upwards shift of 72 meters (figure 3). The values are within the range that we predicted would occur if the species were responding to the estimated increase in temperature of 2°C .

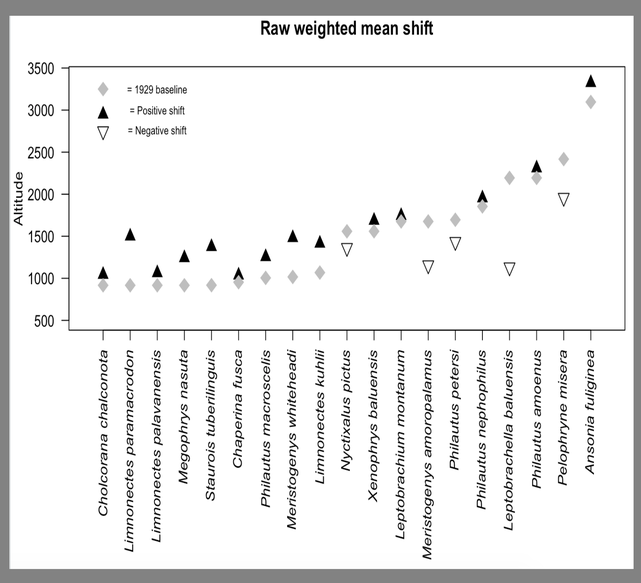

Figure 2. Weighted mean shift in species altitude distribution. Grey rhombs is the baseline in 1929. Triangles are modern year, filled black triangle indicate a positive shift and unfilled triangles a negative shift.

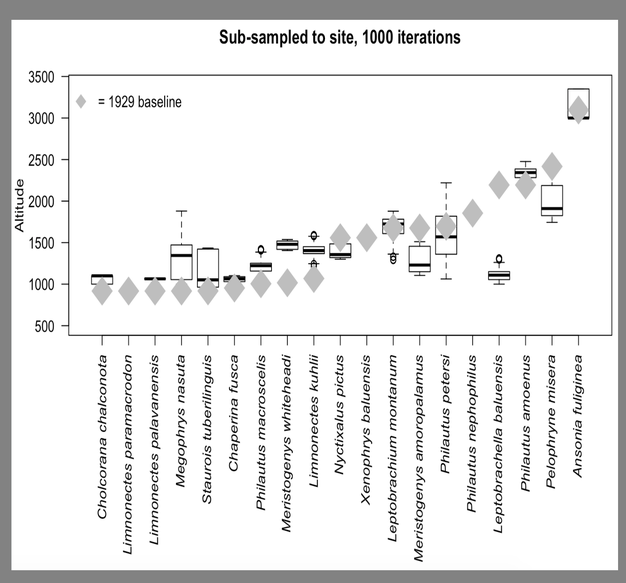

Figure 3. Weighted mean altitude with baseline (grey rhomb's) from 1929 and modern years (boxplots). The modern data was subsampled to match the number of sites in 1929 for 1000 iterations per year .

iNEXT indicate that site species richness at low altitudes remained roughly constant over the period, with an increase in 2007 and 2010 and decreasing in 2016 down to similar values of 1929 (figure 4). Mid- altitude area increased in species richness and at high altitudes it decreased.

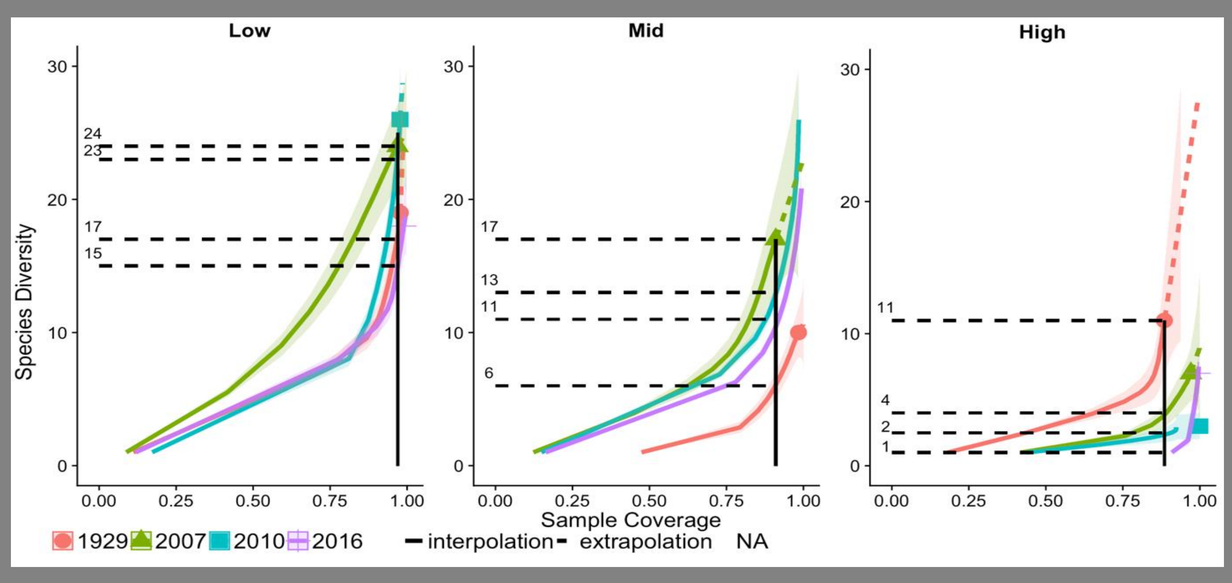

Figure 4. Sample cover estimation over the four survey years between the different habitat bands from iNEXT. The solid vertical line indicates the cut off point for accurate comparison between survey years based on sample coverage. Dashed horizontal lines represent the point at which species diversity values can be compared. Numbers above horizontal dashed lines represent the number of different species that the line is showing.

4. Discussion

This study is in line with previous research that indicates that around 25% of species move down instead of in the expected upwards direction on mountains. Amphibian species' on Mount Kinabalu are moving up to higher altitudes whereas some of the high altitude ones are moving down. Mid-altitude areas now have an increase in species richness in comparison to 1929. The results highlight the need for continuous long-term monitoring of amphibian communities and the need for further work on the effects of environmental change on community composition.

[1]Parmesan, C. *et al. Nature* **421,** 37 (2003).
[2]Walther, G. *et al. Nature* **416,** 389–396 (2002).
[3]Blaustein, A. R. *et al*. *Diversity* **2,** 281–313 (2010)
[4]Bickford, D. *et al. Biodivers. Conserv.* **19,** 1043–1062 (2010)
[5]Smith, M. *Bull. Raffles* **5,** 8–34 (1931).
[6]Chen, I. *et al*. *Proc. Natl. Acad. Sci.* **106,** 1479–1483 (2009).
[7]Chen, I. C. *et al*. *Glob. Ecol. Biogeogr.* **20,** 34–45 (2011).
[8]Chao, A. & Jost, L. *Ecology* **93,** 2533–2547 (2012)
[9]Hsieh, T. C. *et al*. *Methods Ecol. Evol.* **7,** 1451–1456 (2016).

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