Investigating orchid populations across the Sikkim Himalaya - Luke Barnes

Abstract
Field research was carried out in April 2009 to record the altitude of orchid population across the Sikkim Himalaya. Data collected was compared to historical data for the same populations and an increase in altitude for these populations was identified. The altitude increase was compared to that predicted by global climate data for the past 100 years and a close correlation between predicted change and actual change was demonstrated.

Aims
To collect field data on as many species as possible at as many altitudes as possible.
To compile a database from historical, botanical records.
To compare the data sets to identify differences is population distribution.
Link differences in population distributions to human impact and/or global warming.

Methodology
Two main approaches to data collection shall be used;
1. Collection of primary data from Sikkim expedition March/April 2009
2. Extraction of data from botanical records - Primary source – King and Pantling 1898

Details of Methodology
1. Data collection
   • Take part in Sikkim expedition – March 27th to April 10th 2009
   • Record all orchids species found and the altitude at which they were found
2. Botanical records
   • Record every orchid species in King and Pantling 1898 and altitude at which it was found

Data Collection
Data will be collected on the field trip using a variety of techniques. This will ensure that we have the data to answer the hypotheses. The main data that will be collected will be the orchid species and their altitude. This will be done by means of GPS units for altitude. Two GPS units shall be used to increase the reliability of the results. Together with the altitude and the orchids spotted at that location, the amount of time in each location shall be recorded. This is because the amount of time in each location should be proportional to the amount orchid species spotted at each altitude.
Type of forest is also a key piece of data that will be recorded. Primary forest is likely to contain more orchid species as it will have had more time to recruit orchid seedlings, whereas secondary forest is likely to contain fewer orchids as it will have had less time.
Human impact is a very important piece of data. This shall be recorded by photographs showing the extent of the human impact in each location.

Botanical Records
The main botanical record used shall be ‘King and Pantling’1. This is an accurate account of the orchid species in Sikkim in 1898. The data from this shall be loaded into a spreadsheet so that graphs can be compiled. Orchid names are given with their altitude in feet. For easy comparison, the measurements will convert these to
meters. In the case of a point altitude, rather than a range being given, 100m either side shall be added.

**Raw Data**

A spreadsheet was created from data in the botanical records.

Orchid species are identified by their species and genus number in King and Pantling\(^1\). The data in the text was extracted and '1's inserted across the altitude range specified, giving total species identified at each 100m data point from altitude 0m to altitude 4500m.

A second spreadsheet was created for recording field data.

**Data Analysis**

*Fig1 – Data collected in Sikkim Himalayas showing the number of species found at each 100m data point.*

The data from data collection shows a clear peak at 2200m. There are no readings above 2400m. This is likely to be due to seasonal factors. Only verified species were used in this data.

**Botanical Records**

*Fig2 – Data from “King and Pantling” 1898\(^1\) showing number of species identified at each 100m data point.*

This data shows a similar pattern to the data collected on the field trip. Key
differences include the clear peak at 1800m. There are also results for altitudes above 2400m as seasonal change did not affect the results.

**Data comparison**

A number of graphs were plotted to compare the two data sets.

*Fig3 – Comparison of number of species at each 100m data point from expedition and “King and Pantling” - 1898*

When put together, it becomes evident that there is a very similar pattern in both sets of data with a clear peak in both. This peak is at a higher altitude in 2009 than it was in 1898.

*Fig4 – Comparing individual species altitudes, 1898 to 2009*

This graph shows the difference in altitude of individual species between 1898 and 2009. Two anomalous results are easily identified (marked with red rings). These must be discounted before drawing trend-lines. The most likely explanation is that a plant was misidentified on the expedition.

*Fig5 - Comparing individual species’ altitudes, 1898 to 2009 with anomalous results omitted.*

When discounting the anomalous results the (blue) trend-line can be drawn. If no change has occurred in the altitudes of the orchid species, this blue line should follow the dotted line (y=x). As the trend line is y=0.92x+287 and is above the dotted line – orchid species have, on average, been
recorded at higher altitudes in 2009 than 1898. One possible explanation for this pattern is global warming. As the earth’s temperature increases, orchids have to move to higher altitude to stay at the same temperature. This can be checked by working out the temperature difference from global warming data, and comparing it to the temperature change that the orchids would experience by moving to higher altitudes.

Global Warming
Research was focused on determining a reliable estimate of global temperature increase from 1898 to 2009. Graphical data shown in fig6 and fig7 (both from reliable sources) indicate the same 1ºC rise in temperature from 1898 to 2009.

Fig6 – graph from GISS (http://data.giss.nasa.gov/gistemp/graphs/ (15/7/09)) Accepted graphs show this pattern. The change in temperature from 1898 to 2009 is approximately 1ºC. As there is such a large amount of different data on global warming a second source was found for comparison.

Fig7 - graph from “Climate Research unit” (http://www.cru.uea.ac.uk/cru/info/warming/ (15/7/09) It is here estimated that the confidence in this value to be +/- 0.1ºC.
**Orchid Species**
The task now is to check that this 1º change is consistent with what was observed in the Sikkim Himalayas. This graph shows the relationship between altitude and temperature. From this we can work out that for every meter risen, the temperature decreases by approximately 0.0057ºC. From this, we can work out that for every 1ºC decrease in temperature, the altitude must rise by approximately 180m. The plants in Sikkim have risen by an average of 172m.

**Conclusion**
In response to increase in global temperatures, orchid species in the Sikkim Himalayas have moved vertically by 170m. This rise is in line with the expected correlation necessary to compensate for the 1ºC temperature rise. This close correlation indicates that global temperature increase is a plausible mechanism for the altitude shift of recorded orchid populations.

**Alternative Conclusions**
Before accepting a conclusion based on global warming, alternative conclusions must be considered.

1. **Changing land use.** Agriculture is focused at lower altitudes. Agriculture causes a reduction in orchid species and therefore, lower altitude sections of populations that were present in 1898 are now missing. This would result in an apparent altitude rise for species populations. There is some evidence in fig5 with the trend line showing a greater altitude rise effect at lower altitudes than higher altitudes. The data collected at altitudes above 2000m should not have been affected by land use factors but fig5 shows clear evidence of altitude rise in these species. It should also be noted that a large number of orchid species were found at low altitudes, showing that lower altitude parts of populations still exist despite agricultural practice.

2. **Collection effort.** If the majority of collection effort is directed at higher altitudes, it would be expected that mean altitude values would be higher than those generated by an equally spread collection effort. Fig1 shows a very dramatic peak at 2000m which may well reflect increased search effort at this altitude. However, fig5 shown no clear anomaly at this altitude suggesting that search effort has not significantly affected comparative results. This can be explained by considering that at 2000m one will expect to find the lower altitudinal range of some populations and the upper altitudinal range of others.

3. **Effects of plant collectors.** In the past 110 years, a large number of orchids have been wild collected for sale from Sikkim populations. It can be assumed that greater collection would occur from the more accessible lower altitudes than from higher. This would result in apparent population altitude rise. There is no evidence to support this hypothesis as many attractive, collectable species were recorded at lower altitudes.

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**Bibliography**

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3. “**Climate Research unit**” [http://www.cru.uea.ac.uk/cru/info/warming/](http://www.cru.uea.ac.uk/cru/info/warming/) (15/7/09)