5

Phenology and Polar Area Charts (Fantail Phenology)

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Keywords

Phenology; Polar area charts; Fantail phenology; Linear phenology charts; Annular phenology charts; graphical representation; visual information; occurrence aggregates, Excel

Summary

This article presents a novel graphical representation of occurrence phenology utilising a modification of the polar area chart method.

Introduction

Tilt a pie chart of four equal slices and the visual information it is meant to convey is destroyed due to the change in perspective. Misuse of graphical representations of this nature abound and are largely the result of inappropriate cosmetic embellishments in popular charting software such as Excel.

The subject of how best to present data is of interest to many business and scientific communities. Graphical representations should convey information via a shape which indicates patterns, trends and outliers. They should avoid visual content that isn't information and stand out clearly, without distraction (Few, 2012.)

Phenological data is of a specific class, that of values placed on a timeline over the specific period of a year or group of years. Graphical presentation of such data may be made in several different forms, divided into two types: linear and circular. Though phenological diagrams are capable of displaying a range of life-cycle information, this article is concerned solely with unqualified occurrence data.

The diagram must depict an entire year. The resolution of phenological data is frequently as high as a day (though this may be longer when traps are used.) Accordingly phenological charts may be devised to display data to a high degree of accuracy. A balance must be struck however between accuracy and a meaningful graphical display.

Day, week or month

Charts depicting **daily** occurrence numbers may produce a diagram which is difficult to interpret, lacking a clear pattern. **Monthly** aggregates will produce a shape which is readily interpreted but may not convey sufficient information. Such aggregates are also imprecise since month lengths differ and so there is some sacrifice of data integrity in any graphical representations which depict twelve equal sectors. **Weekly** occurrence aggregates result in diagrams which are reasonably straightforward to interpret. These are weeks as defined in Excel, with week 1 being January 1st to January 7th regardless of the day of the week.

Available methods

Methods of depicting phenology can be broadly divided into two types, linear diagrams which display data as a series of bars along an horizontal (x) axis and circular diagrams in which the data is displayed either as shapes or colours in an annular arrangement or radially as bars (since they are sectors, these bars are triangular). The customary method for phenology is the bar chart, this is the standard chart implemented in biological recording applications such as Recorder 6. A range of other charts may be used to present the results of such analyses, summarised as follows:

| Linear | | | |
|-----------------|---|---------------------|-------------|
| Chart | Method | Diagram type | Data driven |
| Vertical bars | Excel etc. | Histograms | Y |
| | | Bar charts | Y |
| Horizontal bars | Excel etc. | Calendar | Y/N |
| | | Multiple bar charts | Y |
| Circular | | | |
| Annular | | | |
| | Powerpoint, Edraw, Smartdraw etc. PhaenUR | Ring charts | Ν |
| | GIS | Ring maps | Y |
| | Excel etc. | Doughnut charts | Y |
| | Hand drawn | Phenology wheels | Ν |
| | Various | Phenology clocks | Ν |
| Radial | | | |
| Polar area | Excel etc. | Radar plots | Y |
| Fantail | Excel etc. | Radar plots | Y |

Histogram vs bar chart

An histogram represents frequency distribution (quantitative variable), the column heights depicting observed frequencies. There should be no spaces between adjacent bars. The method allows other statistical information to be calculated or added to the diagram.

A bar chart represents categorical variables. Such categories could be variables of any nature but in the case of phenology of species occurrences they are of equal sized categories placed on a time axis and so tend to be similar in depiction to an histogram. Spaces between adjacent bars should be present.

Ring maps

This term originates in GIS and is used for a range of applications (Huang, 2008; Stewart, 2011). Nelson (2010) employs ring maps for phenology, constructing a diagram comprising a number of concentric annular rings, each of which is segmented. The vector graphics application Adobe Illustrator is used to create

this and the diagram is then imported into a GIS application which permits each sector to be linked to data and the sectors coloured accordingly. Nelson uses this to visualise changes in water quality of a river throughout the year and across a series of years.

Phenology wheels

A hand-drawn technique used in education (Forbes, 2011)

Phenology clocks

Principally an art form derived from annular methods of depicting seasonal changes.

Radial methods

Polar area diagrams are similar to pie charts, instead of representing data via different angles, they have fixed angles and the data is represented by the distance each sector extends from the centre of the circle (Guerry, 1829.)

In polar area charts, termed "radar plots" in Excel, the simple implementation connects each value together as points resulting in a spiky graphical representation that is difficult to interpret:



Figure 1. Simple radar plot: Snow flea (*Boreus hyemalis*) - data from NBN Atlas download Blakeston (2013) demonstrated an Excel method in which each value is replicated ten times. Modifying this methodology so as to produce a phenological chart results in this more easily interpretable graphic:



Figure 2. Fantail phenology: Snow flea (Boreus hyemalis) - data from NBN Atlas download

4 — Phenology and Polar Area Charts (Fantail Phenology)

Pros and cons

Bar charts: Equal areas and stacked or adjacent bars permit comparisons. Frequently presented with unnecessary numerical values; spacing between bars are not optimised (Few, 2012). The annual timeline is often truncated (e.g. January to September) thus reducing the ability to compare with other charts.

Fantails: The clock-face depiction is readily interpretable, even without clear legends; very small images are thus meaningful. The 52 weeks are not divisible by the familiar twelve sectors, making the placing of month labels somewhat difficult - though it can be contrived (Fig 2.); areas are visually skewed with highest values being strongly emphasised and low values less obvious. Stacked and adjacent elements are not possible.

Both waste a lot of space on the diagram, particularly for species with low occurrence numbers.

Fantail phenology: term & conditions

A good number of possible terms for phenology charts depicted in a circular pattern are already used to describe different treatments. A distinctive chart requires a distinctive name and so "fantail" is proposed.

The fantail phenology chart is a particular style of polar area diagram, depicting radial sectors of equal time periods on a circular diagram which depicts an entire year. Sector extents are of species occurrence sums expressed as a fraction of the maximum sum. Actual numbers are not displayed on the axes (though the total may be added to the title). Normally used to depict adult occurrences, with current methodology different stages cannot be shown on the same diagram. If used for other stages then separate diagrams should be used, coloured distinctively differently and consistently and labelled appropriately.

Examples







Figure 3. Neria cibaria (Diptera: Micropezidae) Monthly occurrence aggregates

Figure 4. Neria cibaria (Diptera: Micropezidae) Weekly occurrence aggregates



Figure 5. *Neria cibaria* (Diptera: Micropezidae) Fantail of weekly occurrence aggregates Sectors represented as a proportion of the maximum value, accordingly at least one sector meets the circumference no matter how few occurrence records are available.



2. Selection of Fantail Phenology diagrams

Resources

There are many applications available which are capable of producing charts, most are to be found amongst the statistical analysis software applications such as SPSS and Minitab. Some, such as STEM can output to Powerpoint. There are also free solutions: PAST (https://folk.uio.no/ohammer/past/), PhaenUR (https://sourceforge.net/projects/phaenuhr/?source=typ_re%ADdirectproduces) and others in the R package.

Add to this plethora of applications a large number of drawing and charting applications such as Powerpoint, Edraw Max, Smartdraw and the like and the search for the means to produce good graphical presentations and charts in this rather specialist area can become expensive and very time consuming.

Applications dedicated purely to phenology are few, PhaenUR is designed to compare two sets of values using ring charts and both Recorder 2002 and Recorder 6 have an addon which produces bar charts of a single taxon.

To produce diagrams as in Figs 3, 4 & 5, download the Excel file from [], add data from your Global Biodiversity Gateway of choice (GBIF, NBN Atlas) and follow the guide in the spreadsheet file. Take care to exclude records in such downloads which default to a date of 1st January, this is a Darwin Core artifact which remains unresolved.

Acknowledgements

References

- Anon. (2018). Nature's Calendar. Woodland Trust. Retrieved from https://naturescalendar.woodlandtrust. org.uk/
- Blakeston, A. (2013). How to display survey results in a Polar Area chart. Retrieved from https://alesandrab.wordpress.com/2013/03/28/how-to-display-survey-results-in-a-polar-area-chart/
- Few, S. (2005). Effectively Communicating Numbers Selecting the Best Means and Manner of Display. , (November).
- Few, S. (2006). Visual Pattern Recognition: Meaningful Patterns in Quantitative Business Information. Cognos. Retrieved from www.PerceptualEdge.com
- Few, S. (n.d.). The Encyclopedia of Human-Computer Interaction. In The Encyclopedia of Human-Computer Interaction (p. Ch 35). Retrieved from https://www.interaction-design.org/literature/ book/the-encyclopedia-of-human-computer-interaction-2nd-ed/data-visualization-for-humanperception
- Few, S. (2012). Designing Effective Tables and Graphs. Retrieved from www.PerceptualEdge.com
- Few, S. (2007). Save the Pies for Dessert. Visual Business Intelligence Newsletter, 1–14. Retrieved from http://www.perceptualedge.com/articles/visual_business_intelligence/save_the_pies_for_dessert.pdf
- Forbes, A. (n.d.). Phenology Wheels: Earth Observation Where You Live. Retrieved from https://earthzine. org/2011/02/14/phenology-wheels-earth-observation-where-you-live/
- Forrest, J., & Miller-Rushing, A. J. (2010). Toward a synthetic understanding of the role of phenology in ecology and evolution. Philosophical Transactions of the Royal Society B, 365, 3101–3112. http://doi.org/10.1098/rstb.2010.0145
- Guerry, A. M. (1829). Tableau des variations météorologique comparées aux phénomènes physiologiques, d'aprés les observations faites à l'obervatoire royal, et les recherches statistique les plus récentes. Annales d'Hygiène Publique et de Médecine Légale, 1, 228-.
- Huang, G., Govoni, S., Choi, J., Hartley, D., & Wilson, J. (2008). Geovisualizing data with ring maps. ArcUser, 54–55. Retrieved from http://scholar.google.com/scholar?hl=en&btnG=Search&q=int itle:Geovisualizing+Data+with+Ring+Maps#0

- Kosara, R., & Skau, D. (2016). Judgment Error in Pie Chart Variations. Proceedings of the Eurographics/ IEEE VGTC Symposium on Visualization (EuroVis), 91–95. http://doi.org/10.2312/eurovisshort.20161167
- Nelson, F. A. (2010). Ring Maps: A useful way to visualize temporal data. Missouri Department of Conservation, 5(7).
- Stewart, J. E., Battersby, S. E., Lopez-De Fede, A., Remington, K. C., Hardin, J. W., & Mayfield-Smith, K. (2011). Diabetes and the socioeconomic and built environment: Geovisualization of disease prevalence and potential contextual associations using ring maps. International Journal of Health Geographics, 10, 1–10. http://doi.org/10.1186/1476-072X-10-18
- Sumner, D. P. (2017). Dipterists Forum Recording Scheme Stilt & Stalk Flies. Occurrence Dataset. http://doi.org/https://doi.org/10.15468/mwjnku