A statistical analysis of temporal trends in detection rates of birds in the Rangelands, using Atlas of Australian Birds data, 1999 – 2006

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Executive summary

- This report provides results which may be incorporated into the second Australian Collaborative Rangelands Information System (ACRIS) report on tracking change in the Rangelands.
- We used Atlas of Australian Birds data from repeatedly visited sites, 1998-2007, to examine temporal and regional change in 60 species of Rangeland birds. We had sufficient data to compare trends for up to ten IBRA regions.
- We fitted smoothing splines to the grouped data, and generated statistics to examine temporal and regional variation. We also conducted a Principal Components Analysis on the derived temporal parameters in an attempt to classify species according to trend profiles.
- Smoothed curves of relative abundance over time showed high inter-year and high intra-year variability, which seems common to most long-term bird data.
- We used rigorous criteria to determine change, and for 49 species we confidently assigned a change status during for the period examined. Of these, 22.4% decreased, 36.7% remained stable and 40.8% increased.
- Many species show a marked peak during the relatively wet 2000-2001 period, and some showed troughs during the peak of the drought of 2002-2004.
- Neither assignment of guilds nor Principal Component Analysis provided any insights into species-specific differences in temporal trend.
- 75% of species showed regional variation in trend, and it was common for the trend in at least one IBRA to be substantially different from overall trends. IBRA-specific trends are presented and at times conflict with overall trends.
- We make recommendations about what aspects of the results may best be incorporated into the ACRIS report.

Introduction

Birds are promising environmental indicators. Features which underpin their utility as indicators include:

- they live in almost every type of environment in Australia and in almost every niche within those environments;
- they tend to be at the top of the food chain;
- they have varied diets;
- they are easy to see and observe;
- they are very well-catalogued, and their taxonomy is reasonably well-known;
- the distributions and general biology of most birds are already relatively well documented (compared with other taxa), providing a good baseline against which change can be monitored; and,
- birds are also loved by the public, which ensures a ready pool of skilled volunteers willing to go into the field to monitor them.

In Australia the status of birds is used in environmental reports such as the State of the Environment, published every five years by the Department of Environment and Water Resources. The State of Australia's Birds reports also described change in birds, and are partly funded by the Australian Government's Natural Heritage Trust (e.g. Olsen and Weston 2004; Olsen et al. 2003). Much of the information used in these reports is gathered by the Birds Australia Atlas of Australian Birds, one of the largest wildlife databases in the world, in terms of both number of records and breadth of geographical scope. The Atlas is now in its thirtieth year, and this fact, combined with its continent-wide coverage, make it an ideal vehicle for examining changes in bird populations over time.

The first Australian Collaborative Rangelands Information System (ACRIS) report was on a pilot study in five IBRA regions from 1992-2002. A second ACRIS report is under preparation and this report provides information which may be included in the new ACRIS report.

Drawing on data collected as part of Birds Australia's ongoing Atlas of Australian Birds project, The Department of Environment and Water Resources sought this report. The specific aim of this report is to statistically analyse temporal trends in rangelands birds between 1999 and 2006, based on changes in the detection rates of 50 common and widespread rangeland species.

Methods

Birds Australia's ongoing Atlas of Australian Birds

In 1974 the decision was made by the Birds Australia (RAOU) to go ahead with a national Bird Atlas Scheme, and in 1976 the first grants were received from the Australian Government's Australian Biological Resources Study (ABRS) and the Australian National Parks and Wildlife Service (ANPWS). This first atlas was published in 1984 as The Atlas of Australian Birds (Blakers et al. 1984). In 1998, the second atlas commenced, and it was funded by the Australian Government's Natural Heritage Trust (Barrett et al. 2003). Since 2002, Birds Australia has funded the atlas, using a variety of funding sources.

For the second atlas, the two hectare (2-ha) search was heavily promoted as the most useful search method, and observers were encouraged to visit the outback and contact designated local regional organisers for details on where to go atlassing. A major effort was also put into remote atlassing with the assistance of committed individuals, wildlife agencies, Aboriginal Land Councils, universities, regional bird groups, station owners and tourism operators. In particular, *Desert Discovery*, a non-profit organization that co-ordinates expeditions and promotes scientific research in remote and difficult terrain, played a major role in organizing expeditions to a number of remote regions between 1999 and 2001. Organisers aimed for at least 20 surveys per 1º grid, visiting as many different types of habitat as possible. With the exception of Arnhem Land where a helicopter was used, all expeditions were vehicle-based.

The Atlas now contains six million bird records from 400,000 surveys, making it a major resource for those wishing to understand change in birds.

Detailed methods are presented in Barrett et al. (2003) and information on the volunteers that contributed is presented in Weston et al. (2006).

Atlas survey methods: *2-ha search*

The *2-ha Search* for 20 minutes was the method atlassers were encouraged to use, and while the recommended shape of the search area was 100 m × 200 m, the area could be any shape. Only birds within the two hectares were recorded, including birds seen flying over the area. People were asked to survey their selected areas once each season for at least one year, ideally during the middle month of each season: January (summer), April (autumn), July (winter) and October (spring). However, once-off surveys where observers had no intention of returning to the site were still considered valuable and encouraged. Observers were encouraged to complete a *Record Form* for all *2-ha Searches*, even if no bird species were recorded. Observers were instructed to choose *2-ha Search* areas that were representative of one type of habitat or land management. For example, selecting *2-ha Search* areas that were half grassland and half forest, or part

grazed and part ungrazed, was discouraged. While surveys are undoubtedly biased towards the better bird watching areas, observers were encouraged to survey all types of habitat, regardless of the birds present.

In this report, the place where a *2-ha Search* for 20 minutes occurred is termed a 'site'.

Atlas data: error sources and data vetting

Variation in observer capability presents one problem in the integrity of data gathered by multitudes of volunteers. These differences were minimized by keeping the survey methods simple and making sure the tasks were not too onerous. Some sources of error include bird identification errors, form recording errors, and positional information errors. Multiple-stage vetting procedures were in place to minimise all of these error sources, and a great deal of ongoing effort is made to ensure that a very low proportion of errors enter the database and remain undetected.

Reporting rate

In this report, the 'reporting rate' is the frequency with which a given species or group of species was recorded. It is calculated as:

$$\frac{\text{The number of surveys in which the taxon/taxa were recorded}}{\text{The total number of surveys conducted}}$$

The reporting rate is often expressed as a percentage.

Selection of data for analysis

We defined the Rangelands according to Figure 1.

For this study, Atlas data from 1,111 sites in 29 IBRA[3] regions in the Rangelands from June 1998 to January 2007, a total of 10,011 observations, were made available for analysis.

Table 1: The number of Atlas surveys in the Rangelands during each year.

Year	Number of Atlas surveys in the Rangelands
1998	422
1999	2,138
2000	2,336
2001	1,374
2002	969

[3] Interim Biogeographical Regionalisation of Australia.

Year	Number of Atlas surveys in the Rangelands
2003	736
2004	724
2005	737
2006	557
2007[4]	18
Total	10,011

Rangeland IBRAs with fewer than five sites were excluded as were sites with no repeat surveys. Further data exclusion criteria were:

- Surveys from before September 1998 and after August 2006;
- Sites where no birds from the species list (Table 3) were seen; and,
- Sites with repeat observations only from the same year. That is, sites having surveys in at least two different years were included.

After data selection, 8,655 observations from 623 sites in 28 IBRAs remained in the data subset which was analysed. These data are summarised in Table 2.

Table 2: The number of sites in each of the Rangeland IBRAs. The number of observations (surveys) is provided for those IBRAs where at least one species was observed on at least 40 of the 96 months (i.e., for those IBRAs included in the restricted data set).

IBRA region[5]	Number of sites	Number of observations
BBN	19	922
BRT	14	
CAR	9	
CHC	8	
CK	5	
CP	7	
CYP	8	265
DL	33	242
DRP	25	168
EIU	4	
FIN	17	191
FLB	37	1,249
GAS	21	
GAW	26	237

[4] This number is low primarily because this report was written early in 2007 and there is often a delay in the submission of survey forms.

[5] IBRA abbreviations are presented. The full names of IBRAs where enough data were available for analysis is provided in the caption to Figure 1.

IBRA region[5]	Number of sites	Number of observations
GSD	51	
GUP	4	
MAC	32	813
MDD	125	2,678
MGD	21	
ML	32	
MUR	8	
NK	13	
OVP	16	
PIL	6	
RIV	65	630
SSD	6	
TAN	3	
VB	8	

Selection of species for analysis

We required species that were relatively frequently recorded for analysis of trends, and we had *a priori* determined that would analyse about 50 species. Thus, we needed to select the most appropriate taxa for analysis.

It was decided to select 60 species, a few more than originally intended, in case a few species fell out during analysis. A threshold level of 2% mean reporting rate in the study area was set for inclusion of species in the analysis. Of 462 species recorded in the Rangelands from 2-ha surveys, 138 (29.9%) exceeded the threshold reporting rate (Table 3).

Several other selection criteria were used:

- Selected species were reported in a minimum of 16 IBRA regions;
- Typical rangeland/arid country species were selected;
- Most waterbirds were excluded as it was felt that they weren't typical Rangeland species and would only use the area if conditions were favourable. Two exceptions were the Grey Teal and Pacific Black Duck, which were retained as they occur routinely in the Rangelands; and,
- Species which observers had difficulty in identifying were mostly left out of the analysis. This included the Ravens and Crows, though Torresian Crow was selected as it is readily identifiable.

Table 3: Species selected for analysis of trends in the Rangelands.

Common name	Scientific name
Emu	*Dromaius novaehollandiae*
Peaceful Dove	*Geopelia striata*
Diamond Dove	*Geopelia cuneata*
Common Bronzewing	*Phaps chalcoptera*
Crested Pigeon	*Ocyphaps lophotes*
Masked Lapwing	*Vanellus miles*
Pacific Black Duck	*Anas superciliosa*
Grey Teal	*Anas gracilis*
Wedge-tailed Eagle	*Aquila audax*
Whistling Kite	*Haliastur sphenurus*
Black Kite	*Milvus migrans*
Brown Falcon	*Falco berigora*
Nankeen Kestrel	*Falco cenchroides*
Little Corella	*Cacatua sanguinea*
Galah	*Cacatua roseicapilla*
Cockatiel	*Nymphicus hollandicus*
Red-winged Parrot	*Aprosmictus erythropterus*
Australian Ringneck	*Barnardius zonarius*
Budgerigar	*Melopsittacus undulatus*
Red-backed Kingfisher	*Todiramphus pyrrhopygia*
Sacred Kingfisher	*Todiramphus sanctus*
Rainbow Bee-eater	*Merops ornatus*
Horsfield's Bronze-Cuckoo	*Chrysococcyx basalis*
Welcome Swallow	*Hirundo neoxena*
Tree Martin	*Hirundo nigricans*
Fairy Martin	*Hirundo ariel*
Willie Wagtail	*Rhipidura leucophrys*
Jacky Winter	*Microeca fascinans*
Red-capped Robin	*Petroica goodenovii*
Rufous Whistler	*Pachycephala rufiventris*
Grey Shrike-thrush	*Colluricincla harmonica*
Magpie-Lark	*Grallina cyanoleuca*
Crested Bellbird	*Oreoica gutturalis*
Black-faced Cuckoo-Shrike	*Coracina novaehollandiae*
White-winged Triller	*Lalage sueurii*
Grey-crowned Babbler	*Pomatostomus temporalis*
Weebill	*Smicrornis brevirostris*
Inland Thornbill	*Acanthiza apicalis*
Chestnut-rumped Thornbill	*Acanthiza uropygialis*
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*
Rufous Songlark	*Cinclorhamphus mathewsi*
White-winged Fairy-wren	*Malurus leucopterus*

Common name	Scientific name
Variegated Fairy-wren	*Malurus lamberti*
Masked Woodswallow	*Artamus personatus*
Black-faced Woodswallow	*Artamus cinereus*
Mistletoebird	*Dicaeum hirundinaceum*
Brown Honeyeater	*Lichmera indistincta*
Singing Honeyeater	*Lichenostomus virescens*
White-plumed Honeyeater	*Lichenostomus penicillatus*
Yellow-throated Miner	*Manorina flavigula*
Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*
Little Friarbird	*Philemon citreogularis*
Richard's Pipit	*Anthus novaeseelandiae*
Singing Bushlark	*Mirafra javanica*
Zebra Finch	*Taeniopygia guttata*
Torresian Crow	*Corvus orru*
Pied Butcherbird	*Cracticus nigrogularis*
Grey Butcherbird	*Cracticus torquatus*
Australian Magpie	*Gymnorhina tibicen*
Restless Flycatcher	*Myiagra inquieta*
Striated Pardalote	*Pardalotus striatus*

Statistical analysis

Data for each species were first grouped by Year and Month and observed reporting rates were calculated. To these proportions a smoothing spline of order 5 (5 d.f.) was fitted and plotted (see Figure 2). The method used was a weighted least squares for overdispersed proportions data (the dispersion parameter is estimated rather than set to 1, as would be the case for Binomial data). This modelling framework is widely known as a Generalised Additive Model (GAM).

Unsurprisingly, these proportions data showed extensive variation according to intra-year and inter-year variability and other factors, and they did not generally provide useful information on longer-term temporal trends. As the interest here was in long-term trends, no attempt was made to fit a seasonal component. As well as this initial analysis other methods of smoothing were explored and, as they gave similar results to the above, are not presented here.

Possible serial dependence arising from the fact that data are repeated measures data was ignored. Attempts to fit a random site effect to account for intra-site dependence usually fail due to the extreme imbalance in the data arising from the haphazard nature of data collection. In any case we assume the grouping of data and likely detection errors will obscure this feature.

Several analyses are presented graphically as follows:

Analysis 1: All IBRA regions

The pattern in the reporting rate over time was plotted, using data from all 29 Rangeland IBRAs regardless of whether the taxon was recorded within that IBRA or not. These were plotted together with a 'smooth fit', obtained by fitting a smoothing spline of order 5 (d.f. = 5) by weighted least squares, within a framework known as generalised linear models (GLM) for proportional data with the dispersion parameter estimated.

This analysis is presented in the top left panel of the results shown in Appendix 1.

Analysis 2: IBRAs where taxon was present

For the second analysis, only data from IBRAs where the taxon had been recorded were included for analysis. The reporting rate was plotted over time, along with a fitted smooth trend of order 5 and a smooth trend of order 1 (a linear trend).

The straight-line fit should be viewed with extreme caution; trends are usually not linear, as can be seen for most taxa. From the fitted lines we calculated the predicted values at July 1999 and July 2006 based on the high order smooth fit and also on the linear fit. From these we derived the percentage change, which represents the predicted change over seven years, from July 1999 to July 2006. The p-value for linear trend is a test of whether the slope of the line is different from zero (i.e. a flat line).

The above analysis is presented in the top right panel of the results shown in Appendix 1. The lower right panel presents: 1) the predicted reporting rates for July 1999 and July 2006 and the associated percentage change based on the 5 d.f. smoothed curve and 2) the percentage change based on the linear fit, together with the observed significance level (p-value) for the linear trend (see Figure 2).

Analysis 3: Regional (IBRA) variation in trends

Trends in the occurrence of birds over time show regional variations (Barrett *et al*. 2003). The Rangelands is a huge area, sampling used in this study was from a relatively small number of widely spread IBRAs, and therefore regional variation was probable. Thus we wished to examine any regional variation in temporal trends.

We selected IBRAs with at least 100 surveys and excluded data from IBRAs where the species had not been observed in at least 40 of the possible 96 months. A maximum of ten IBRAs remained for analysis (see Table 2). This analysis is intended to be indicative of a full between-IBRA comparison of trends.

For these data we assessed heterogeneity of temporal trends across IBRA regions. This was done by fitting a smoothing spline of order 3 to data for each included IBRA and constructed a test statistic for 'parallelism' of these trends. The p-value for this test is given in the lower right panel (see Figure 2). A low p-value ($p<0.05$) indicates some heterogeneity in trend i.e. the trends vary between IBRA regions. High p-values indicate a degree of parallelism in trends across IBRAs.

We graphed the trends for IBRAs for which we had enough data.
This analysis is presented in the bottom left right panel of the results shown in Appendix 1. The lower right panel provides: 1) a colour-key for the IBRA displayed in the lower left panel graph and 2) results of the test for heterogeneity of slopes between IBRA regions and predicted values and % change figures.

Analysis 4: Principal components analysis

Principal Components Analysis (PCA) is a statistical method which may provide insight into structure within multivariate data and so may assist in identifying patterns in data. Since patterns can be hard to find in data of high dimension, PCA is a powerful tool for expressing the data in such a way as to highlight their similarities and differences among species.
In the present case, we wished to examine the similarities and differences in species-specific temporal trends in our data using PCA. We conducted a PCA which derived two principal components of the parameters associated with the six dimensional curve fitted to the temporal data for each species analysed. These components seem to relate to year to year patterns (excluding the first and last years). Species scores were plotted; birds close together on the plot show similar patterns in terms of the first two principal components.

Presentation of results

Figure 2 provides a key to the presentation of results in Appendix 1, and which have been explained in greater detail in the text above.

Interpretation

Determining and classifying change

Our results describe a complex set of relationships, which involve principally temporal components. A key question is how we should differentiate change over time from circumstances where no change has occurred. Our approach is to define what we consider constitutes ‘change’.

We have defined change as meeting all of the following circumstances:

- The linear trend is significantly different from zero (based on the p-value), and the percentage change (linear) is of a magnitude greater than 30% (the linear trend must be interpreted with a high degree of caution);
- The percentage change figure (which is based on the spline) is of a magnitude greater than 30%;
- The percentage change (linear) is in the same direction as the percentage change derived from the spline; and,

- Examination of the graphs (top panels) reveals a consistent pattern (see 'Consensus assessment' below).

Where trends did not meet our criteria for change, they were defined as "stable", which in fact means there was not sufficient enough evidence to confidently assign a trend. We have done this so that the designation of change is as conservative as possible.

Consensus assessment

Three investigators (James O'Connor, Andrew Silcocks and Michael Weston), met to assess and categorise each species-specific graph, with a view to obtaining a consensus characterisation of the temporal patterns. To achieve this, the group examined the reporting rate and spline derived from IBRAs where species were recorded (the upper right panel in Appendix 1). We made the following assessments:

- We categorised trends as increasing, decreasing or remaining stable;
- We identified obvious, clear-cut troughs and peaks in the spline, and characterised these as slight or large, according to their magnitude (and accounting for the scale on the graphs). The apex year of peaks and troughs was recorded for each species.

This proved particularly informative, particularly as statistical summaries did not indicate the temporal occurrence of peaks and troughs.

Regional variation in temporal patterns

Change over time also varies regionally (see, for example, Barrett et al. 2003). Thus consideration of localised change is then best performed at the IBRA level. Under these circumstances, the trend in particular region/s can be dissimilar or even opposite, thus some regional trends may appear to contradict the overall results. Several factors may explain this:

- Only up to 10 of the 29 Rangeland IBRAs are included in this analysis;
- Estimates of overall trends are intrinsically weighted proportional to survey effort (number of surveys); and,
- Trends derived here are highly smoothed.

We also wished to categorise regional change. One of us (JOC) examined the graphs showing regional variation and classified the number of IBRA regions that were going against the general trend (those with very flat or slight slopes were disregarded). We then calculated the proportion of IBRA regions analysed and calculated the percentage of IBRA trend that went against the overall trend.

Inference

This study was only able to examine trends over a seven year period. We were constrained to this period because of available data. It is not possible to infer longer-term trends from an examination of a seven-year period, especially given the highly variable climate of the Rangelands, and the fact that the ecologies of many species will be responsive to irregular and unpredictable drought and rains, fire and many other factors. Nevertheless, the results of this study flag changes in the relative occurrence of bird species that provide information on the current trends in bird populations in the Rangelands. Placing these in the context of longer-term climatic or other variation will require more years of data collection.

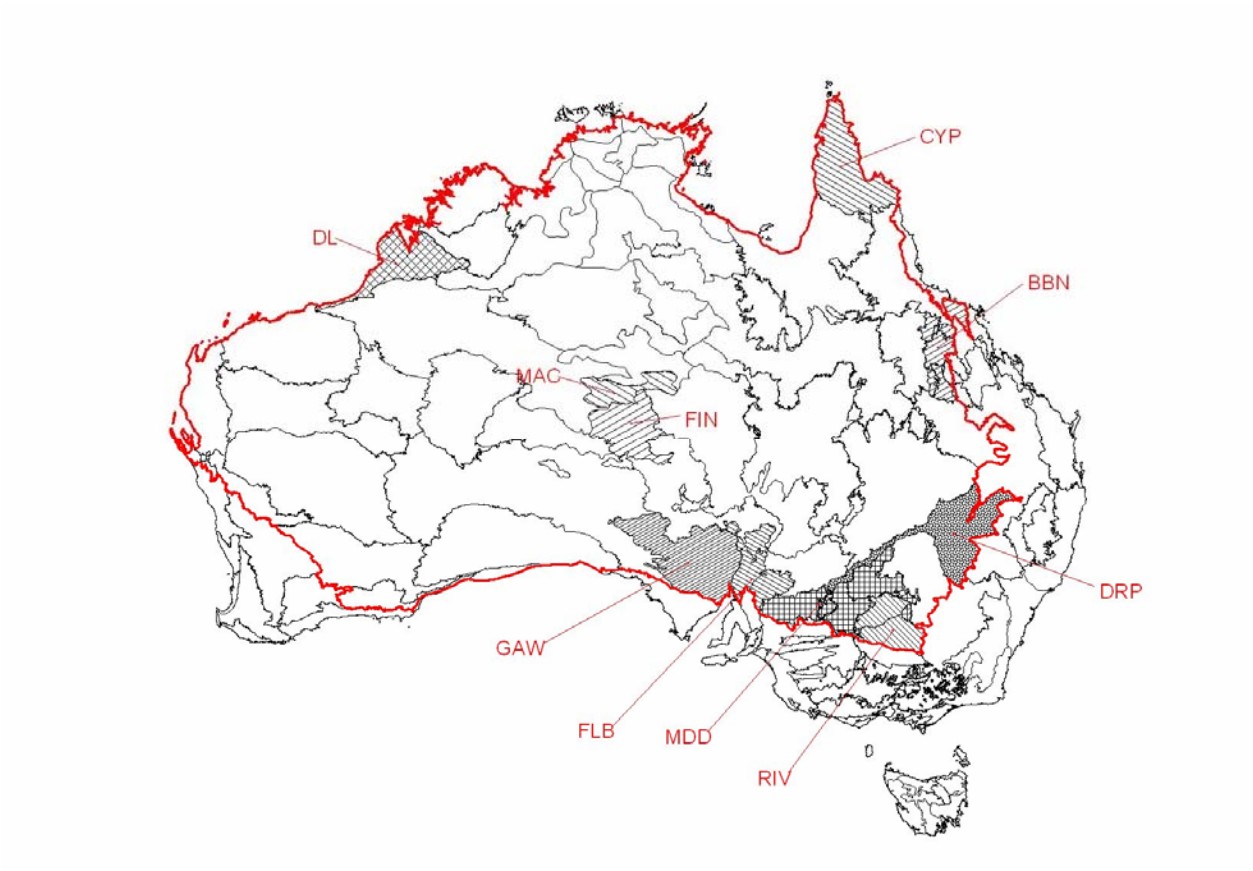


Figure 1: Map of Australia showing IBRA regions. The Rangelands are demarcated by the red line and IBRAs that were used in this analysis are shaded and labelled. CYP = Cape York Peninsula, BBN = Brigalow Belt North, DRP = Darling Riverine Plain, RIV = Riverina, MDD = Murray-Darling Depression, FLB = Flinders Lofty Block, GAW = Gawler, FIN = Finke, MAC = MacDonnell Ranges, DL = Dampierland.

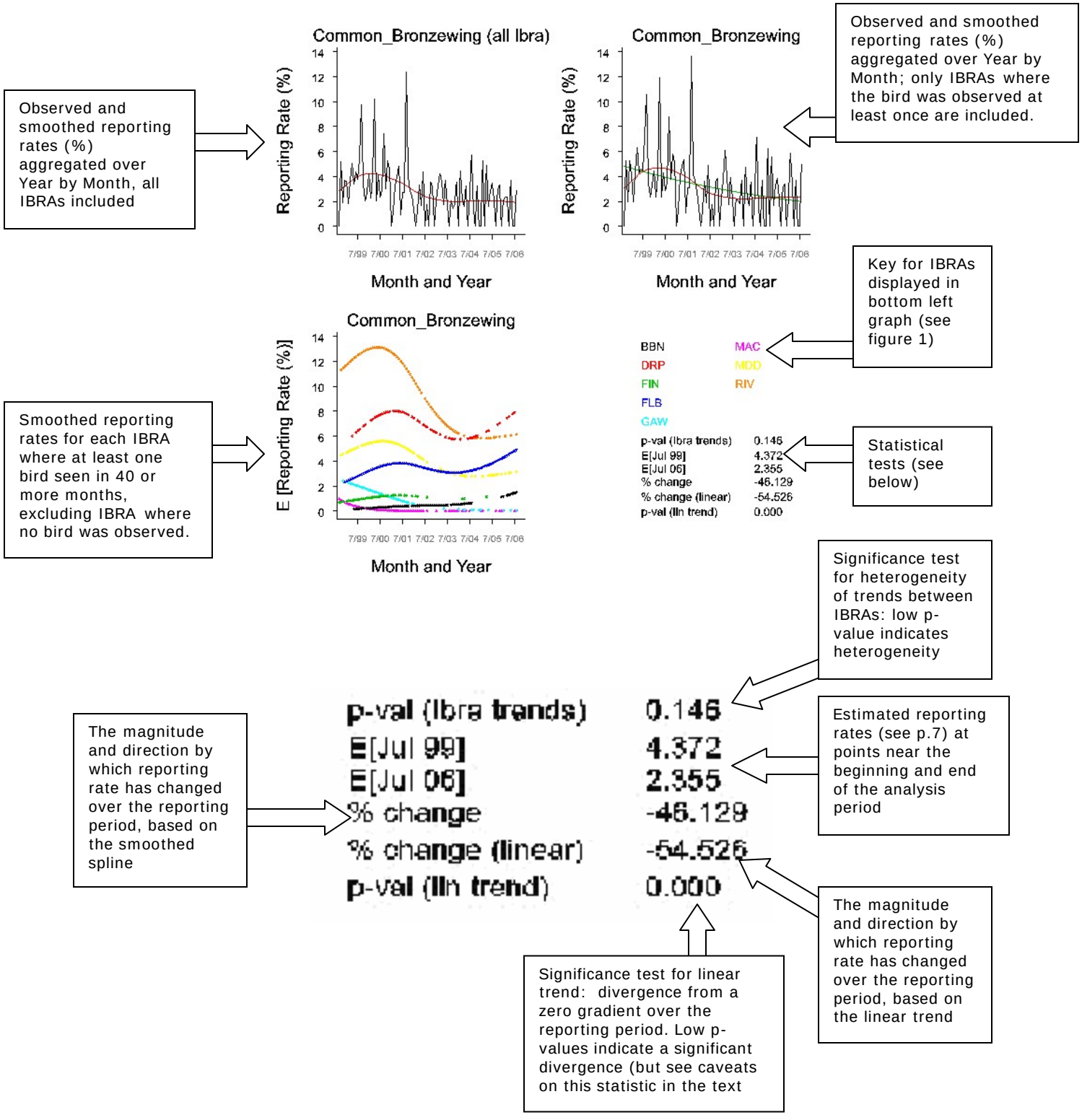


Figure 2: Guide to the interpretation of species-specific results

Results

Sixty common Rangelands bird species were analysed. Detailed results are presented for each species in Appendix 1. These are summarised in tabular form in Table 3.

Overall temporal changes

Statistical results

We consider the most useful single statistic is the percentage change derived from the spline curve for those IBRAs where a species was recorded. Percentage change estimated from the spline varied -89.3 - 552.9% (49.1± 147.5% [mean standard±deviation]). Overall, 31 species (51.7%) had a negative percentage change; the remainder had positive percentage changes.

The spline also permitted us to generate an estimate of the reporting rate at the beginning of the period (July 1999) and at the end of the period (July 2006). On change in the average of these estimates was 2.061% (see Table 4).

Table 4: Summary of the estimated report rates (as percentages) in July 1999 and July 2006.

Statistic	Estimated reporting rate in July 1999	Estimated reporting rate in July 2006
Minimum	1.344	0.652
Maximum	31.779	29.627
Mean	8.189	8.358
Standard Deviation	6.662	6.802

Here, we have decided not to present the linear regression results because trends are usually more complex than can be described by a straight line (see Methods).

Consensus approach – temporal trends

The consensus approach allowed us to classify the temporal trends in species occurrence. Table 3 presents the results of this approach, which was featured by high levels of concordance among the experts involved.

Consensus approach – peaks and troughs

The consensus approach proved very useful, and allowed us to identify clear-cut peaks and troughs in the fitted splines. Fifty-two peaks and troughs were identified from 43 species. These are summarised in Figure 3. High concordance was achieved among the experts identifying and categorising peaks and troughs.

Figure 3: The temporal distribution in the number of peaks and troughs in relative abundance among 60 bird species in the Rangelands.

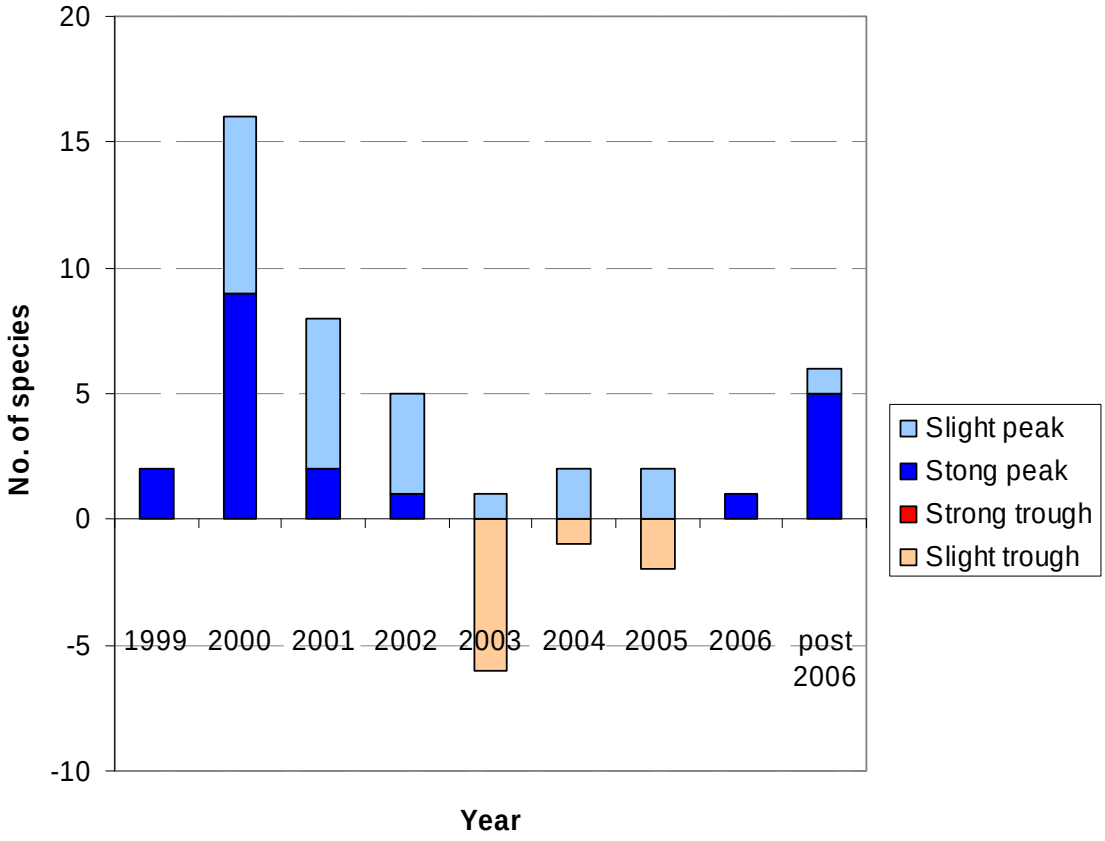


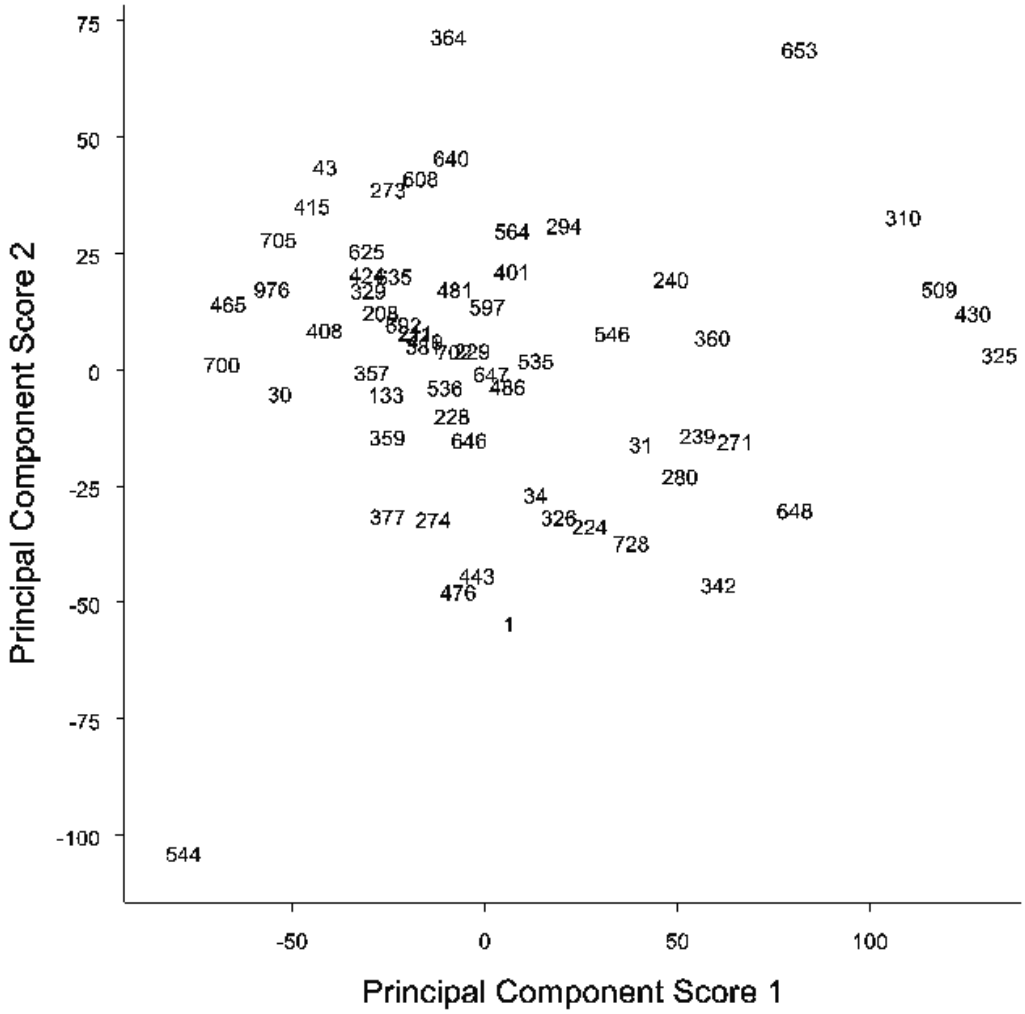
Figure 3 clearly shows that many species showed peaks in occurrence in 2000 and 2001, followed by a less distinct period of troughs in 2003-2005. This broadly corresponds of high rainfall (1998-2001), and the beginning of drought (2001 onwards).

This approach also allowed us to examine similarities in patterns among groups of species. In particular, raptors (birds of prey) showed a distinct double-humped pattern, with a small peak in occurrence around 2001 and the build up to what is presumably a peak (but possibly a plateau) post 2006.

Principal components analysis

The PCA derived components that seem to relate to year to year patterns (excluding the first and last years). Figure 4 shows an ordination derived from the PCA conducted on the temporal trends in bird species. The closer together species occur on the ordination, the more similar they are in terms of their temporal trend.

Figure 4: Ordination derived from the Principal Component Analysis conducted on the temporal trends in bird species. Numbers correspond to RAOU numbers for species as listed in the leftmost column of Table 3.



The ordination revealed that for most species, there was little separation in terms of similarity or difference of temporal trend. However, it did identify a number of species which were dissimilar to most others. These were Willie Wagtail (364), Zebra Finch (653), Budgerigar (310), Rufous Songlark (509), White-winged Triller (430), Red-backed Kingfisher (325) and Masked Woodswallow (544). Most of these species reveal little difference from general trends in their individual graphs (see Appendix 3). The monthly figures for Masked Woodswallow are characterised by long periods of complete absence

punctuated by discrete short-lived 'events' in which the reporting rate skyrockets, which is consistent with the known sporadic and highly unpredictable movements of this species (Higgins *et al*. 2006).

The primary result to be derived from Figure 4 is that there appears to be an overall pattern of similarity in temporal trend between species, and that differences tend to be along a gradient rather than in distinct clusters.

Guilds

We assigned guild classifications to all species analysed. These are provided in Table 3 and summarised in Table 5. Species could not be classified into single guilds, rather they met the criteria for multiple guilds; species occurred in 2-5 guilds (3.2 ± 0.8 guilds). Thus guilds were confounded one with the other, and were not considered a useful method of attempting to characterise temporal patterns in the occurrence of the birds analysed. Certainly the outliers in the PCA were not exclusively associated with particular guilds.

Table 5: The guilds associated with the 60 Rangeland bird species analysed.

Guild	Temperate woodland	Tropical woodland	Grassland	Ground feeder	Non Ground feeders	Wetland species
Number of species	44	44	32	44	29	3
Percentage of species	73.3	73.3	53.3	73.3	48.3	5.0

Summary

Of the 60 species analysed, the consensus determination for change agreed with the statistical determination of change in 81.7% of cases (49 species). Table 6 indicates the results from the statistical classification of change, the consensus approach and the correspondence between the two methods. The last row of Table 6 indicates species which we have classified as 'decreasing', 'stable' or 'increasing' during the period we examined.

Table 6: Classification of temporal changes in Rangeland birds. The number (and percentage) of species classified as 'decreasing', 'stable' and 'increasing', 1999-2006, using statistical results, a consensus approach, and the combination of both (where assigned classifications corresponded between the statistical and consensus approaches).

Approach	Decreaser	Stable	Increaser
Statistical	14 (23.3)	25 (41.7)	21 (35.0)
Consensus	16 (26.7)	22 (36.7)	22 (36.7)
Correspondence	11 (22.4)	18 (36.7)	20 (40.8)

Table 3: Summary of species-specific results. Yellow indicates suggestion of significant decline, light blue indicates suggestion of significant increase, and blank cells indicate circumstances where the analysis did not converge, and non-sensible results were obtained. Red figures indicate the circumstance where the linear trend results were associated with a percentage change figure that was less than 30% in magnitude. Key: A, Temperate woodland; B, Tropical woodland; C, Grassland; D, Ground feeder; E, Non Ground feeders; F, Wetland species; G, Number of guilds in which a species is classified.

Sp. No.	Common name	p-val (Ibra trends)	E (Jul99)	E (Jul06)	% change	% change (lin)	p-val (lin trend)	Strong Peak	Slight peak	Slight trough	Change (Statistics)	Change (Consensus)	Final Classification	Correspondence	A	B	C	D	E	F	G
705	Australian Magpie	0.625	13.270	20.796	56.716	44.236	0.001				Increaser	Increaser	Increaser	Corresponds	1	1	1	1	0	0	4
294	Australian Ringneck	0.000	15.201	8.795	-42.138	-56.785	0.000		2000		Decreaser	Decreaser	Decreaser	Corresponds	1	0	0	1	1	0	3
229	Black Kite	0.003	4.507	14.245	216.050	46.057	0.048	post 2006		2004	Increaser	Increaser	Increaser	Corresponds	0	1	1	1	0	0	3
424	Black-faced Cuckoo-Shrike	0.000	10.919	9.338	-14.482	-31.996	0.005		2000	2005	Stable	Decreaser	Stable	No correspondence	1	1	0	0	1	0	3
546	Black-faced Woodswallow	0.000	5.316	5.635	6.012	-15.717	0.415			2003	Stable	Stable	Stable	Corresponds	1	1	1	0	1	0	4
239	Brown Falcon	0.606	2.055	6.045	194.181	74.715	0.009	post 2006		2003	Increaser	Increaser	Increaser	Corresponds	1	1	1	1	0	0	4
597	Brown Honeyeater	0.000	17.650	9.123	-48.310	-60.229	0.000				Decreaser	Decreaser	Decreaser	Corresponds	1	1	0	0	1	0	3
310	Budgerigar	0.015	4.723	5.175	9.550	-33.787	0.078	2000			Stable	Stable	Stable	Corresponds	0	1	1	1	0	0	3
481	Chestnut-rumped Thornbill	0.000	12.122	9.457	-21.989	-21.167	0.132		2001		Stable	Stable	Stable	Corresponds	0	0	0	1	1	0	2
274	Cockatiel	0.075	1.735	1.582	-8.827	-10.258	0.658		2000		Stable	Stable	Stable	Corresponds	0	0	1	1	1	0	3
34	Common Bronzewing	0.146	4.372	2.355	-46.129	-54.526	0.000		2000		Decreaser	Stable	Stable	No correspondence	1	1	0	1	0	0	3
419	Crested Bellbird	0.000	13.973	6.790	-51.410	-54.559	0.000	2000			Decreaser	Decreaser	Decreaser	Corresponds	1	1	0	1	1	0	4
43	Crested Pigeon	0.000	14.375	28.132	95.695	63.699	0.000				Increaser	Increaser	Increaser	Corresponds	0	0	1	1	0	0	2
31	Diamond Dove													Corresponds	0	1	1	1	0	0	3
1	Emu	0.001	1.946	0.652	-66.487	-59.378	0.001		2001		Decreaser	Stable	Stable	No correspondence	1	1	1	1	0	0	4
360	Fairy Martin	0.000	1.847	10.279	456.434	129.370	0.000	post 2006	2001		Increaser	Increaser	Increaser	Corresponds	1	1	1	0	1	0	4
273	Galah	0.473	9.355	16.007	71.093	97.120	0.000				Increaser	Increaser	Increaser	Corresponds	1	1	1	1	0	0	4

Sp. No.	Common name	p-val (Ibra trends)	E (Jul99)	E (Jul06)	% change	% change (lin)	p-val (lin trend)	Strong Peak	Slight peak	Slight trough	Change (Statistics)	Change (Consensus)	Final Classification	Correspondence	A	B	C	D	E	F	G
702	Grey Butcherbird	0.027	17.518	3.959	-77.402	-81.229	0.000	2000			Decreaser	Decreaser	Decreaser	Corresponds	1	1	0	1	0	0	3
408	Grey Shrike-thrush	0.503	23.196	4.241	-81.717	-79.013	0.000	2000			Decreaser	Decreaser	Decreaser	Corresponds	1	1	0	1	1	0	4
211	Grey Teal	0.046	4.036	7.724	91.383	141.919	0.000				Increaser	Increaser	Increaser	Corresponds	0	0	0	1	0	1	2
443	Grey-crowned Babbler	0.001	9.575	1.769	-81.520	-86.117	0.000				Decreaser	Decreaser	Decreaser	Corresponds	1	1	0	1	1	0	4
342	Horsfield's Bronze-Cuckoo	0.090	1.452	0.873	-39.876	-55.639	0.001		2000		Decreaser	Stable	Stable	No correspondence	1	1	0	1	1	0	4
476	Inland Thornbill	0.000	3.032	0.903	-70.220	8.861	0.719		2002		Stable	Stable	Stable	Corresponds	1	0	0	0	1	0	2
377	Jacky Winter	0.393	14.912	3.344	-77.579	-77.724	0.000	1999			Decreaser	Decreaser	Decreaser	Corresponds	1	1	0	1	0	0	3
271	Little Corella	0.172	2.141	7.935	270.550	182.573	0.000				Increaser	Increaser	Increaser	Corresponds	0	1	1	1	0	0	3
646	Little Friarbird	0.001	3.806	2.039	-46.420	83.112	0.035				Stable	Stable	Stable	Corresponds	1	1	0	0	1	0	3
415	Magpie-Lark	0.000	14.305	16.819	17.578	-8.259	0.538		2001	2005	Stable	Stable	Stable	Corresponds	1	1	1	1	0	0	4
133	Masked Lapwing	0.003	2.960	16.025	441.418	283.019	0.000	post 2006	2002		Increaser	Increaser	Increaser	Corresponds	0	0	1	1	0	1	3
544	Masked Woodswallow	0.152	3.410	2.095	-38.556	-29.998	0.142	2000	2003		Stable	Stable	Stable	Corresponds	1	1	1	1	1	0	5
564	Mistletoebird	0.001	5.280	7.065	33.812	11.164	0.517	2001			Stable	Stable	Stable	Corresponds	1	1	0	0	1	0	3
240	Nankeen Kestrel	0.850	2.431	15.870	552.930	282.072	0.000	post 2006	2001		Increaser	Increaser	Increaser	Corresponds	0	0	1	1	0	0	2
208	Pacific Black Duck	0.001	4.543	7.784	71.325	84.027	0.000		2002		Increaser	Increaser	Increaser	Corresponds	0	0	1	1	0	1	3
30	Peaceful Dove	0.000	5.933	13.985	135.717	118.631	0.000				Increaser	Increaser	Increaser	Corresponds	1	1	0	1	0	0	3
700	Pied Butcherbird	0.014	6.375	8.777	37.691	97.420	0.000	2003			Increaser	Stable	Stable	No correspondence	1	1	1	1	0	0	4
329	Rainbow Bee-eater	0.001	8.964	8.934	-0.339	-6.671	0.663				Stable	Stable	Stable	Corresponds	1	1	1	0	1	0	4
325	Red-backed Kingfisher	0.002	2.309	1.957	-15.224	-58.249	0.001			2003	Stable	Decreaser	Stable	No correspondence	0	1	0	1	0	0	2
381	Red-capped Robin	0.000	8.610	6.905	-19.805	-3.811	0.792	2000			Stable	Stable	Stable	Corresponds	1	0	0	1	0	0	2
280	Red-winged Parrot	0.604	14.835	1.594	-89.255	-85.566	0.000		2004		Decreaser	Decreaser	Decreaser	Corresponds	0	1	0	1	1	0	3
728	Restless Flycatcher	0.261	7.174	2.281	-68.209	-79.213	0.000	2000			Decreaser	Decreaser	Decreaser	Corresponds	1	1	0	1	1	0	4
647	Richard's Pipit	0.005	1.815	6.518	259.144	254.074	0.000		2002		Increaser	Increaser	Increaser	Corresponds	0	0	1	1	0	0	2
509	Rufous Songlark	0.000	1.893	1.846	-2.457	-27.543	0.214	2001			Stable	Stable	Stable	Corresponds	1	1	1	1	0	0	4
401	Rufous Whistler	0.000	5.607	6.135	9.419	24.806	0.175	2000			Stable	Stable	Stable	Corresponds	1	1	0	0	1	0	3

Sp. No.	Common name	p-val (Ibra trends)	E (Jul99)	E (Jul06)	% change	% change (lin)	p-val (lin trend)	Strong Peak	Slight peak	Slight trough	Change (Statistics)	Change (Consensus)	Final Classification	Correspondence	A	B	C	D	E	F	G
326	Sacred Kingfisher	0.016	2.139	1.082	-49.408	9.759	0.740		2004		Stable	Decreaser	Stable	No correspondence	1	1	0	1	0	0	3
648	Singing Bushlark	0.000	3.475	20.660	494.507	1339.812	0.000	2006			Increaser	Increaser	Increaser	Corresponds	0	0	1	1	0	0	2
608	Singing Honeyeater	0.000	13.525	22.220	64.285	47.699	0.016				Increaser	Increaser	Increaser	Corresponds	1	1	0	0	1	0	3
640	Spiny-cheeked Honeyeater	0.052	27.590	11.233	-59.286	-64.470	0.000		2000		Decreaser	Decreaser	Decreaser	Corresponds	1	1	0	0	1	0	3
976	Striated Pardalote	0.001	11.535	6.673	-42.148	-21.359	0.089	2000			Stable	Increaser	Stable	No correspondence	1	1	0	0	1	0	3
692	Torresian Crow	0.201	9.267	7.740	-16.479	0.256	0.989	2002			Stable	Stable	Stable	Corresponds	0	1	1	1	0	0	3
359	Tree Martin	0.000	3.659	4.360	19.149	70.401	0.004				Stable	Increaser	Stable	No correspondence	1	1	1	0	1	0	4
536	Variegated Fairy-wren	0.000	7.500	4.224	-43.679	-24.873	0.061				Stable	Decreaser	Stable	No correspondence	1	0	1	1	0	0	3
224	Wedge-tailed Eagle	0.016	1.344	5.090	278.726	144.217	0.000		post 2006		Increaser	Increaser	Increaser	Corresponds	1	1	1	1	0	0	4
465	Weebill	0.008	31.779	6.971	-78.064	-73.026	0.000	1999			Decreaser	Decreaser	Decreaser	Corresponds	1	1	0	0	1	0	3
357	Welcome Swallow	0.000	4.116	6.448	56.659	91.393	0.001				Increaser	Increaser	Increaser	Corresponds	1	1	1	0	1	0	4
228	Whistling Kite	0.000	6.489	6.222	-4.120	-5.990	0.755				Stable	Stable	Stable	Corresponds	1	1	1	1	0	0	4
625	White-plumed Honeyeater	0.000	11.856	23.418	97.514	66.962	0.002				Increaser	Increaser	Increaser	Corresponds	1	1	0	0	1	0	3
535	White-winged Fairy-wren	0.009	3.012	5.788	92.143	161.676	0.000				Increaser	Increaser	Increaser	Corresponds	0	0	1	1	0	0	2
430	White-winged Triller	0.000	2.822	5.115	81.272	8.031	0.732		2000, 2005	2003	Stable	Stable	Stable	Corresponds	1	1	0	1	1	0	4
364	Willie Wagtail	0.010	19.497	29.627	51.952	33.472	0.003			2003	Increaser	Increaser	Increaser	Corresponds	1	1	1	1	1	0	5
486	Yellow-rumped Thornbill	0.010	4.896	2.486	-49.219	18.059	0.404				Stable	Decreaser	Stable	No correspondence	1	0	1	1	0	0	3
635	Yellow-throated Miner	0.000	8.665	6.661	-23.121	-6.672	0.693		2001		Stable	Stable	Stable	Corresponds	1	0	0	0	1	0	2
653	Zebra Finch	0.000	8.706	13.674	57.054	18.522	0.379		2005	2003	Stable	Stable	Stable	Corresponds	1	0	1	1	0	0	3

Regional variation in temporal trends

Occurrence of regional variation

Of the 60 species analysed, 11 species were classified as showing significant decline across the seven year period (in terms of the criteria specified in the Methods section "Determining and Classifying Change"); 29 species were classified as showing a stable trend; and 20 species were classified as showing a significant increase.

Overall, 45 species (75%) showed significant heterogeneity in trends (p-value <0.05) across the IBRAs in which they were recorded (48 species had $p<0.10$). Fifteen species (25%) returned non-significant p-values for heterogeneity of trend across IBRAs, meaning the trends for these species can be considered consistent across the IBRA regions analysed.

Of the 15 species showing consistent trends across IBRAs, five (33.3%) showed significant decline across the seven year period; these species were Spiny-cheeked Honeyeater, Restless Flycatcher, Jacky Winter, Grey Shrike-thrush and Red-winged Parrot. Five species showed no significant change (Cockatiel, Horsefield's Bronze-cuckoo, Common Bronzewing, Masked Woodswallow and Torresian Crow), and five species showed significant increases (Little Corella, Galah, Brown Falcon, Australian Magpie and Nankeen Kestrel).

Regional variation and temporal change

For all species, we were able to analyse temporal trends for 8.03 ± 1.6 IBRAs per species (3-10 IBRAs); 7.6 ± 1.8 IBRAs for those species where the p value indicated parallelism in regional trends and 8.2 ± 1.5 IBRAs for those species where the p value indicated heterogeneity in regional trends.

Correspondence between overall and regional temporal trends

Overall, within species, 0-60% (0-6) of analysed IBRA regions displayed a trend which went against the overall trend; $31.4 \pm 13.5\%$ (0-60%) of IBRAs went against the overall trend for those species where the p value indicated heterogeneity in regional trends and $12.1 \pm 9.1\%$ (0-25%) of IBRAs went against the trend for those species where the p value indicated parallelism in regional trends.

Of the 60 species, 91.7% had at least one IBRA region which was classified as going against the overall trend, emphasising the high degree of regional variation in temporal trends among birds.

Examples of species where some regional trends went against overall trends include the Nankeen Kestrel and Pied Butcherbird, eight or nine of the IBRA regions show a

downward trend, but the overall estimated reporting rate graph and percentage change figures show an increase. Several factors may explain this:

- Only up to 10 of the 29 original IBRAs are included here;
- Estimates of overall trends are intrinsically weighted proportional to survey effort (number of surveys); and,
- Trends here are highly smoothed.

Discussion

This discussion in not intended to be an exhaustive discussion of all results, but aims to pull out issues of particular importance to the second ACRIS report.

Overall patterns

Smoothed curves show high inter-year and high intra-year variability, which seems common to most long-term bird data. For these reasons, inferences relating to long-term trends based on simple linear effects may not be meaningful. That is, to be able to say anything useful about long-term trends, survey data should be as long-term as possible, in the order of ten years or more.

We detected substantial amounts of change among the bird species analysed (63.3% were not stable). Some increased, some decreased and some remained stable over the period examined. The causes of apparent changes, and indeed whether the trends will persist, are unknown. Many species show a marked peak during the relatively wet 2000-2001 period, and some showed troughs during the peak of the drought of 2002-2004. This is perhaps the most consistent pattern in the results, suggesting that prevailing conditions influence the relative abundance of birds, such that they are more common in wetter periods and less common during droughts.

Options for presentation in ACRIS

The key aim of this report was to provide material on change in birds which can be incorporated into the second ACRIS report. We suggest that mapping change would be difficult, and would oversimplify clearly complex patterns. Rather, we think that the presentation of the following would be more powerful and robust:

- Presentation of selected graphs (encapsulating a decliner (e.g. Grey-crowned Babbler), a stable species (e.g. Magpie-lark), and an increaser (e.g. Crested Pigeon);
- Presentation of a species showing a clear peak during the wet 2000-2001 period (e.g. Budgerigar); and,
- Presentation of the graph (Figure 3) showing the temporal occurrence of peaks and troughs. Ideally, information on rainfall would be provided on the same graph.

Towards improved monitoring and the next ACRIS report

This report has demonstrated that temporal changes can be determined for birds in the rangelands using data collected as part of the Atlas of Australian Birds.

Longitudinal trends suffered from the heterogeneity of survey effort. Scant data at the end of the period could result in extreme behaviour of the smoothed curves. This is due to high leverage of a few observations. Thus it would be advisable to encourage survey

activity at multiple sites (say 20 – 30, spatially spread) at regular intervals throughout the year. It is generally more important to maintain multiple sites than frequent temporal surveys. Survey frequency may be twice a year; in autumn and, in particular, spring. Birds Australia is encouraging repeat-sampling of a number of sites, but this is difficult particularly in the Rangelands where observers are sparse. Another option worthy of investigation is the establishment of “communal” sites, which are defined and promoted to any observers passing through the area. This might result in an increased number of visits to fixed sites.

It is hoped that monitoring will be able to continue and therefore inform future ACRIS reports.

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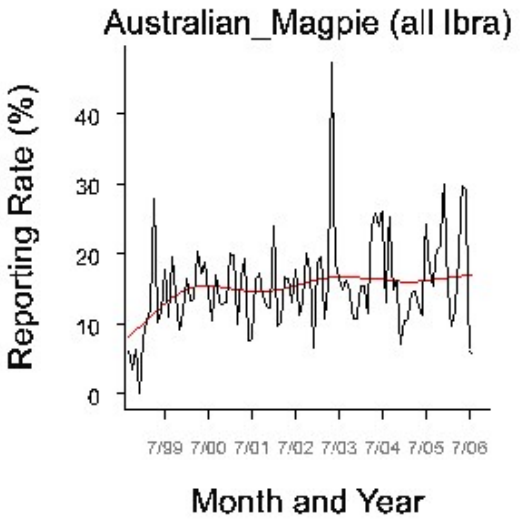
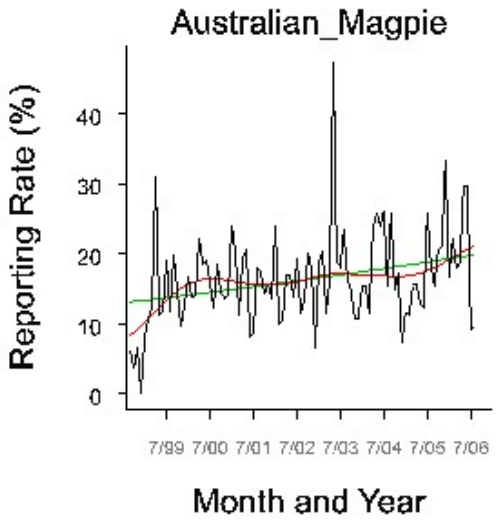
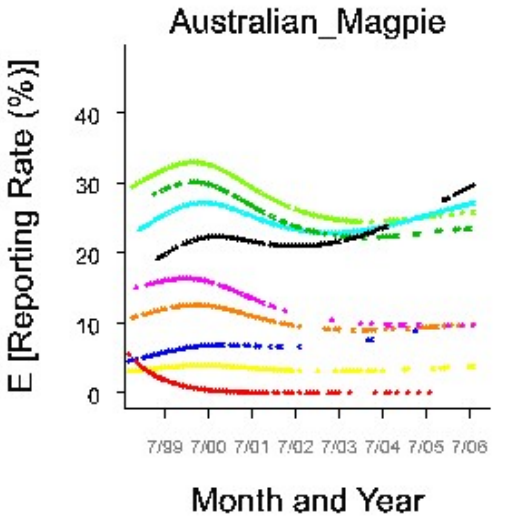
Appendix 1: Species results

Australian Magpie



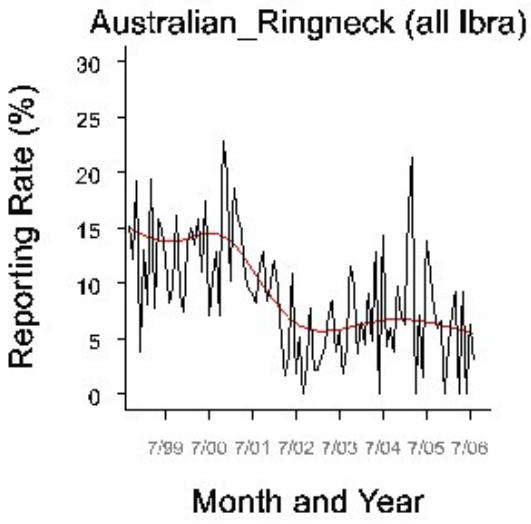


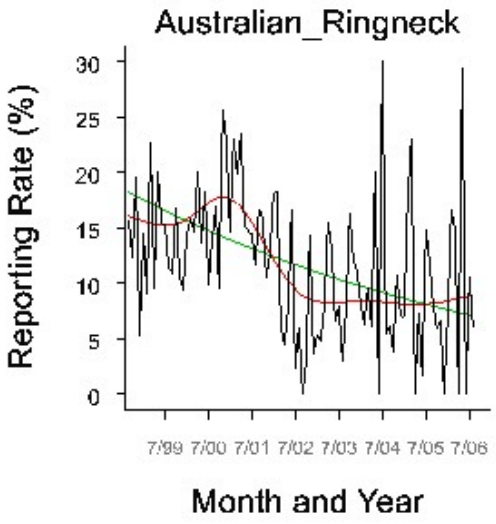


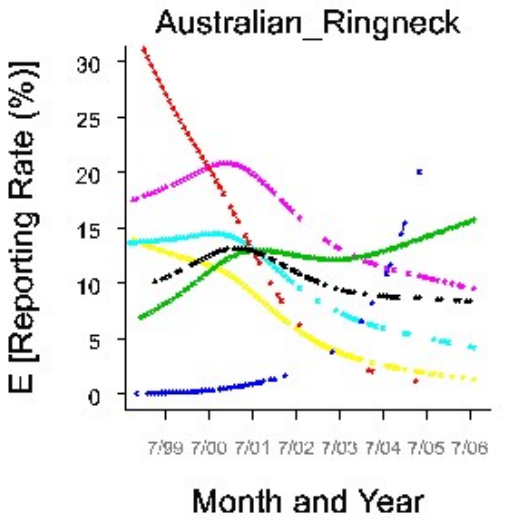
BBN GAW
DL MAC
DRP MDD
FIN RIV
FLB

p-val (Ibra trends)	0.625
E[Jul 99]	13.270
E[Jul 06]	20.796
% change	56.716
% change (linear)	44.236
p-val (lin trend)	0.001

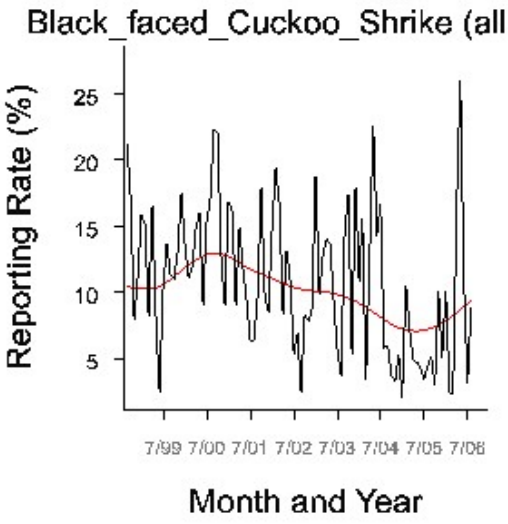
Australian Ringneck

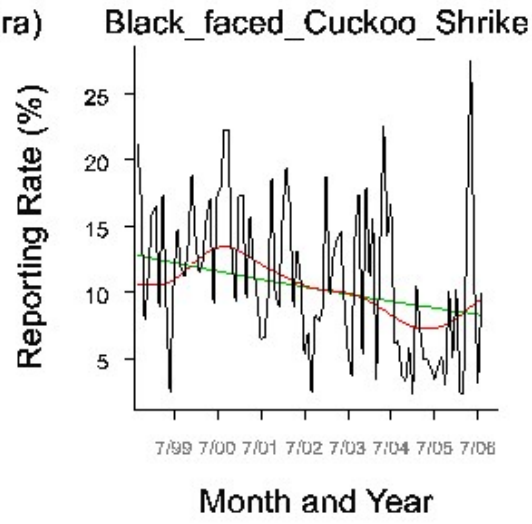


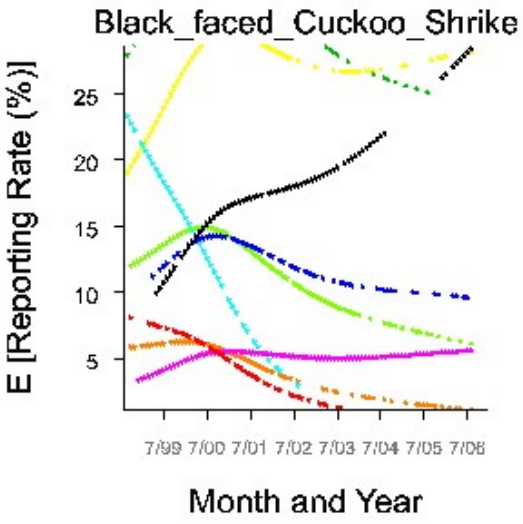




Black-faced Cuckoo-shrike



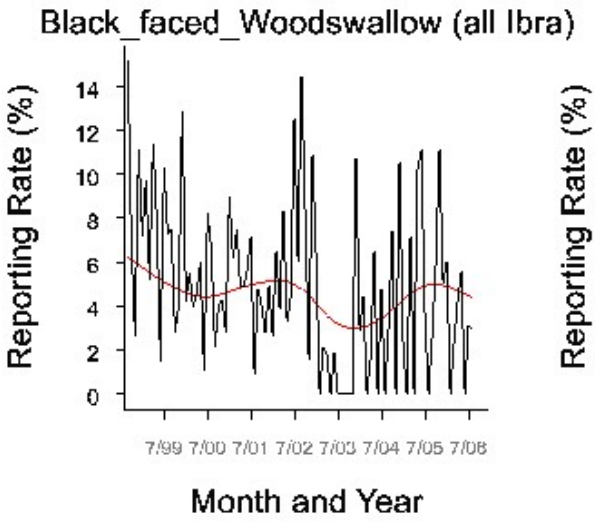


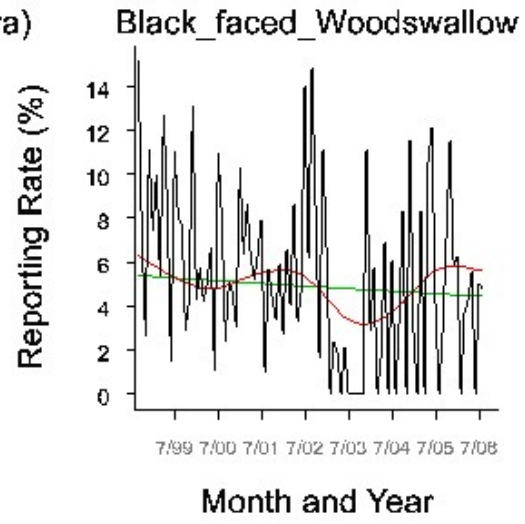


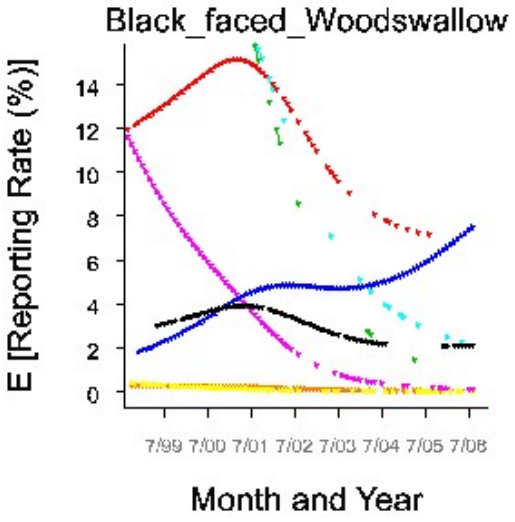
BBN FLB
CYP MAC
DL MDD
DRP RIV
FIN

p-val (Ibra trends)	0.000
E[Jul 99]	10.919
E[Jul 06]	9.338
% change	-14.482
% change (linear)	-31.996
p-val (lin trend)	0.005

Black-faced Woodswallow



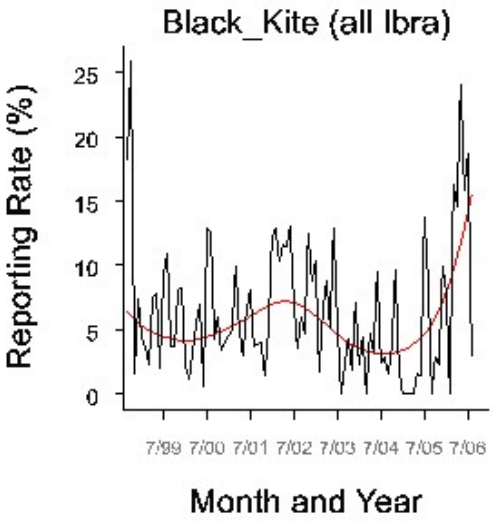


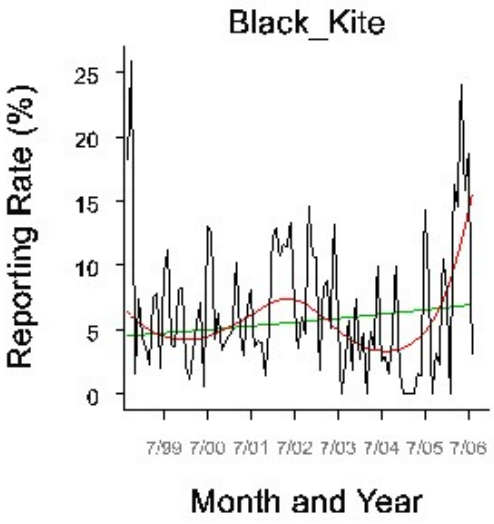


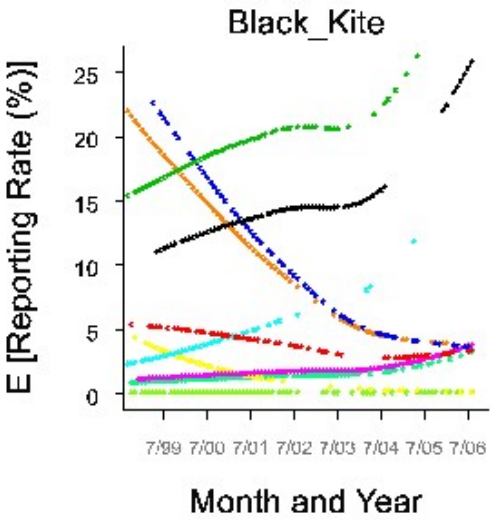
BBN
DL
FIN
FLB
GAW
MAC
MDD
RIV

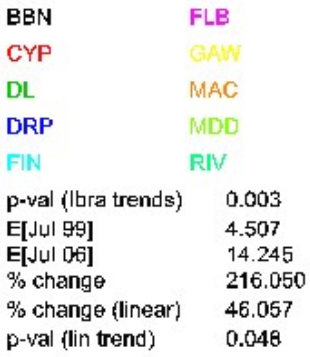
p-val (Ibra trends)	0.000
E[Jul 99]	5.316
E[Jul 06]	5.635
% change	6.012
% change (linear)	-15.717
p-val (lin trend)	0.415

Black Kite

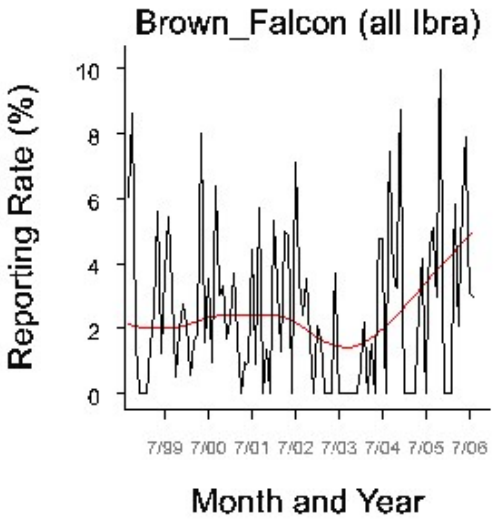

Black_Kite (all Ibra)
Reporting Rate (%)
0
5
10
15
20
25
7/99 7/00 7/01 7/02 7/03 7/04 7/05 7/06
Month and Year

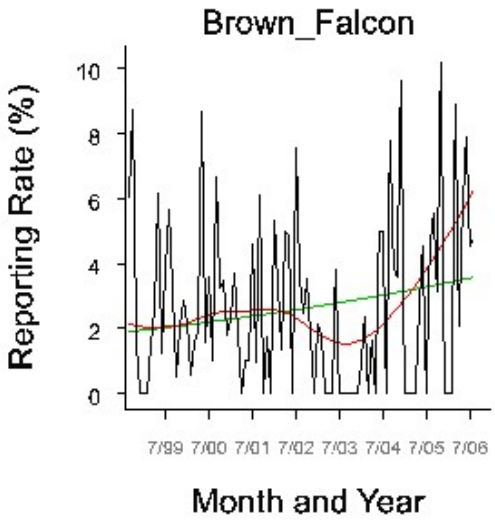

Black_Kite
Reporting Rate (%)
0
5
10
15
20
25
7/99 7/00 7/01 7/02 7/03 7/04 7/05 7/06
Month and Year

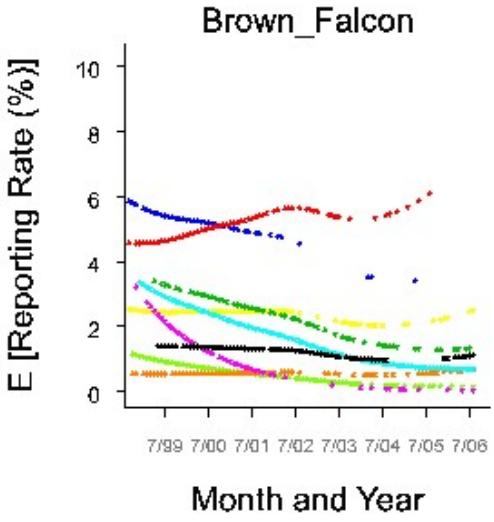

Black_Kite
E [Reporting Rate (%)]
0
5
10
15
20
25
7/99 7/00 7/01 7/02 7/03 7/04 7/05 7/06
Month and Year


BBN
CYP
DL
DRP
FIN
FLB
GAW
MAC
MDD
RIV
p-val (Ibra trends) 0.003
E[Jul 99] 4.507
E[Jul 06] 14.245
% change 216.050
% change (linear) 46.057
p-val (lin trend) 0.048

Brown Falcon



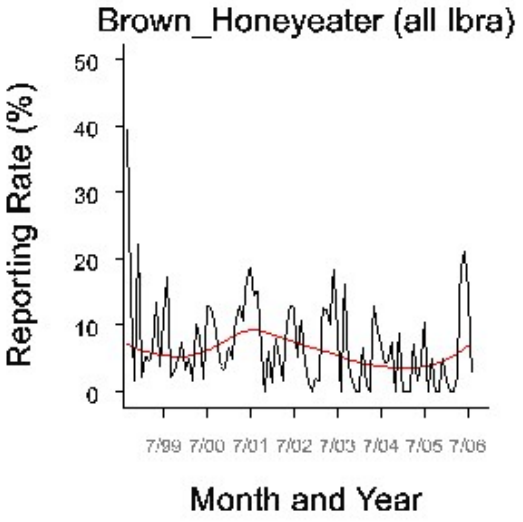


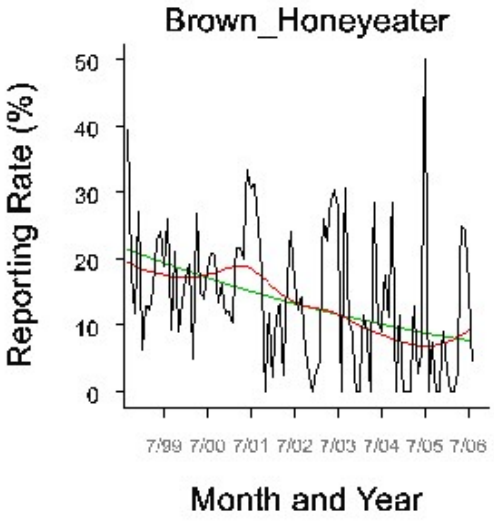


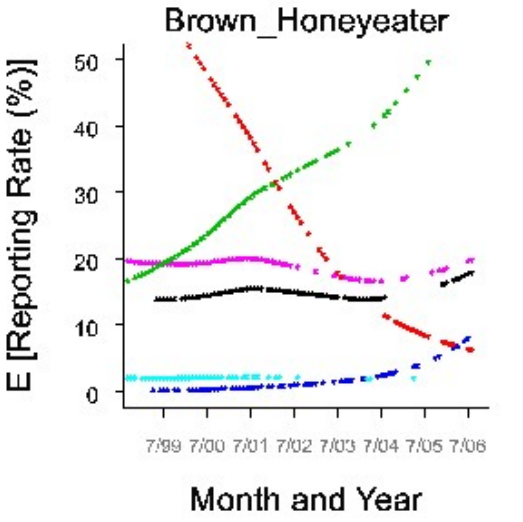
BBN GAW
DL MAC
DRP MDD
FIN RIV
FLB

p-val (Ibra trends)	0.606
E[Jul 99]	2.055
E[Jul 06]	6.045
% change	194.181
% change (linear)	74.715
p-val (lin trend)	0.009

Brown Honeyeater



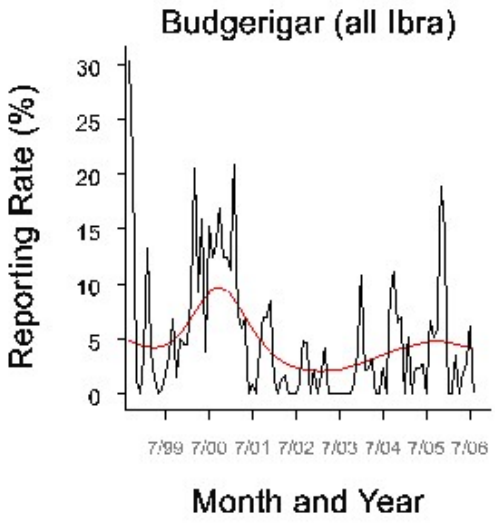


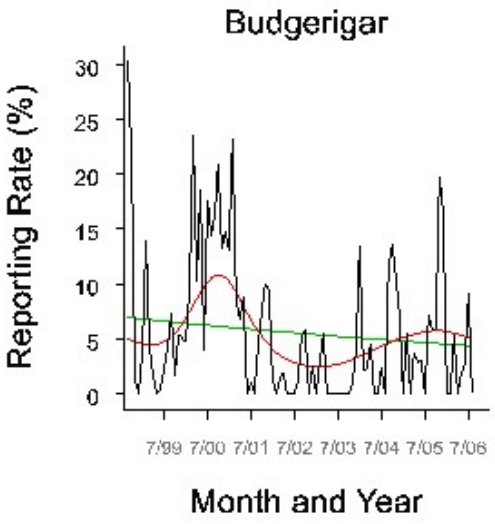


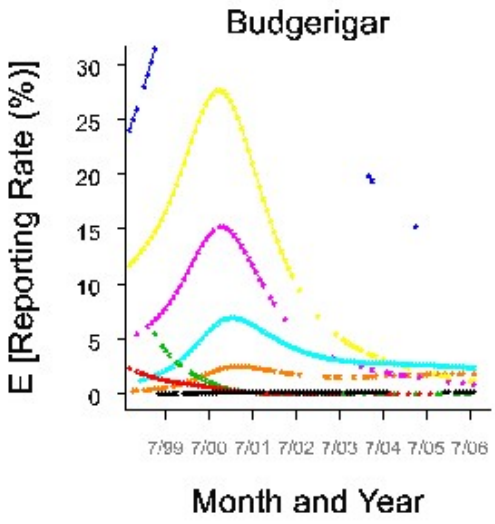
BBN MAC
CYP
DL
DRP
FIN

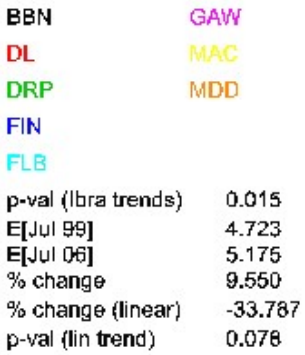
p-val (Ibra trends)	0.000
E[Jul 99]	17.650
E[Jul 06]	9.123
% change	-48.310
% change (linear)	-60.229
p-val (lin trend)	0.000

Budgerigar

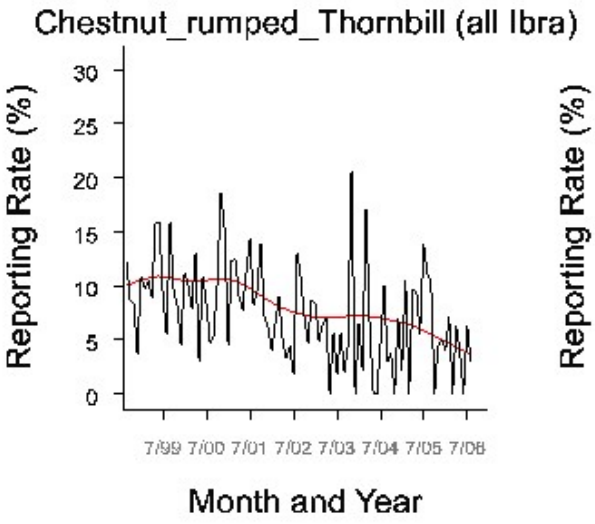

Budgerigar (all Ibra)
Reporting Rate (%)
0
5
10
15
20
25
30
7/99 7/00 7/01 7/02 7/03 7/04 7/05 7/06
Month and Year

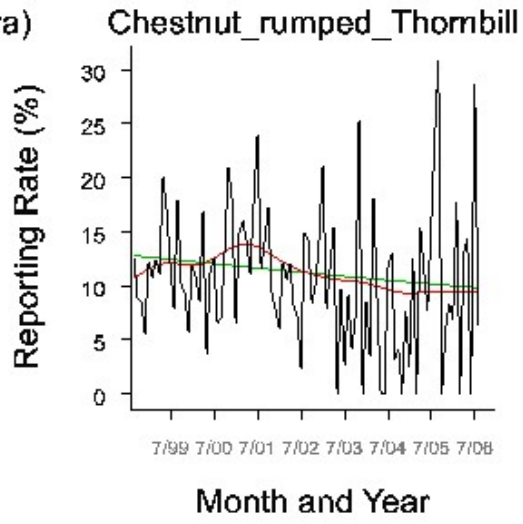

Budgerigar
Reporting Rate (%)
0
5
10
15
20
25
30
7/99 7/00 7/01 7/02 7/03 7/04 7/05 7/06
Month and Year

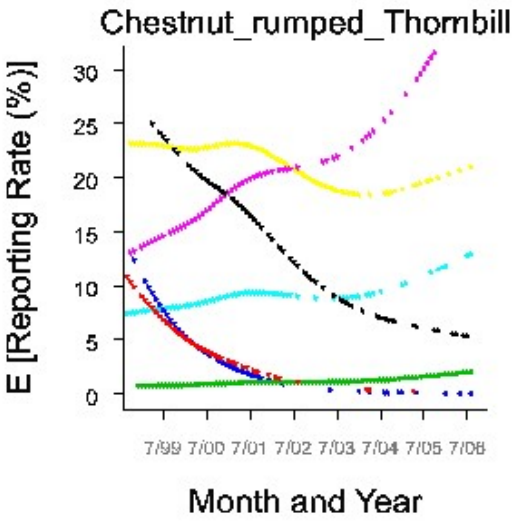

Budgerigar
E [Reporting Rate (%)]
0
5
10
15
20
25
30
7/99 7/00 7/01 7/02 7/03 7/04 7/05 7/06
Month and Year


BBN
DL
DRP
FIN
FLB
GAW
MAC
MDD
p-val (Ibra trends) 0.015
E[Jul 99] 4.723
E[Jul 06] 5.175
% change 9.550
% change (linear) -33.787
p-val (lin trend) 0.078

Chestnut-rumped Thornbill



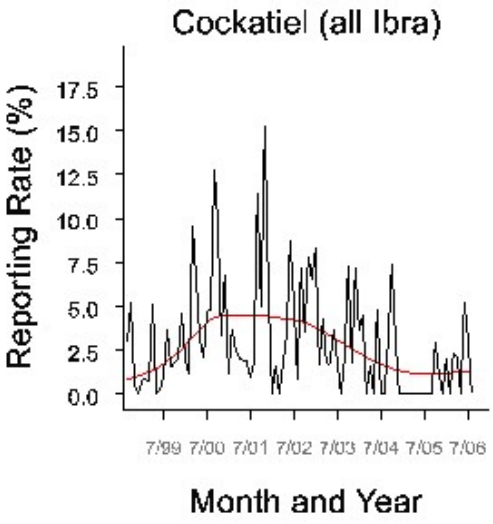


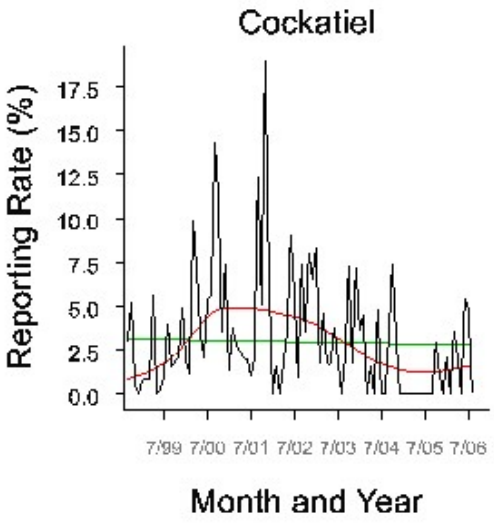


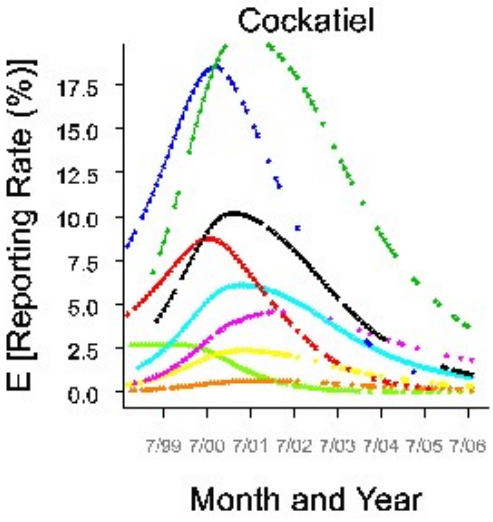
DRP MDD
FIN RIV
FLB
GAW
MAC

p-val (Ibra trends)	0.000
E[Jul 99]	12.122
E[Jul 06]	9.457
% change	-21.989
% change (linear)	-21.167
p-val (lin trend)	0.132

Cockatiel



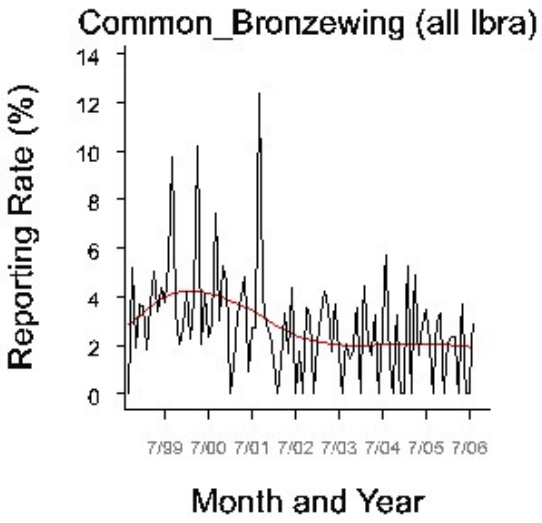


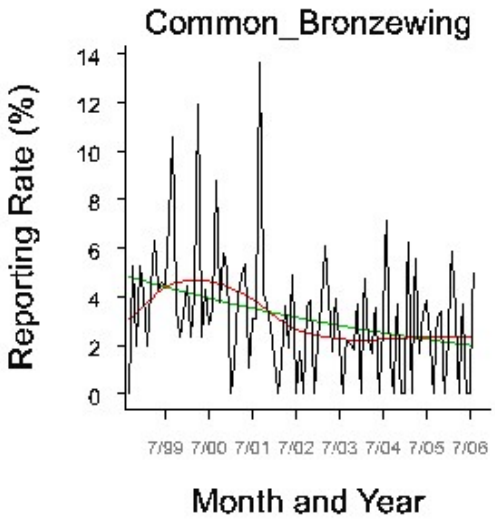


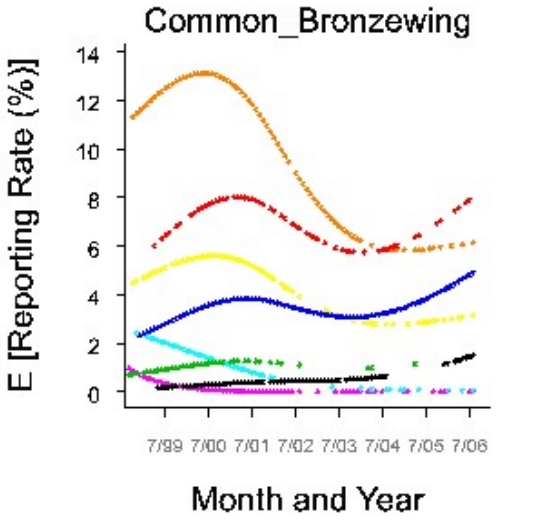
BBN GAW
DL MAC
DRP MDD
FIN RIV
FLB

p-val (Ibra trends)	0.075
E[Jul 99]	1.735
E[Jul 06]	1.582
% change	-8.827
% change (linear)	-10.258
p-val (lin trend)	0.658

Common Bronzewing



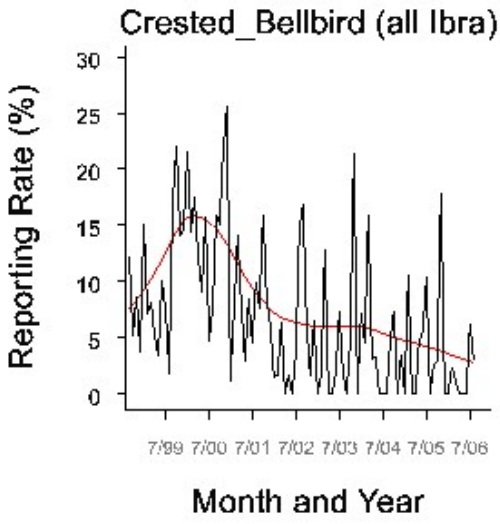


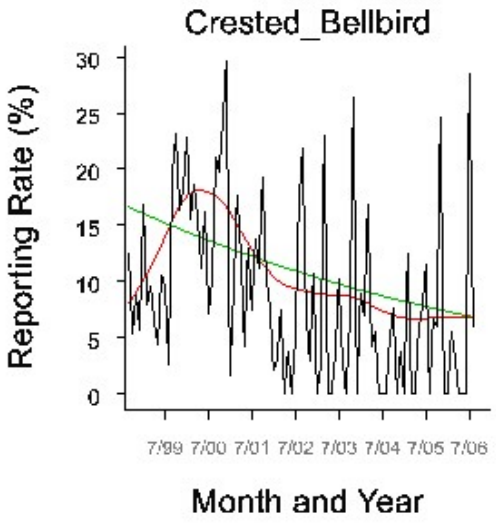


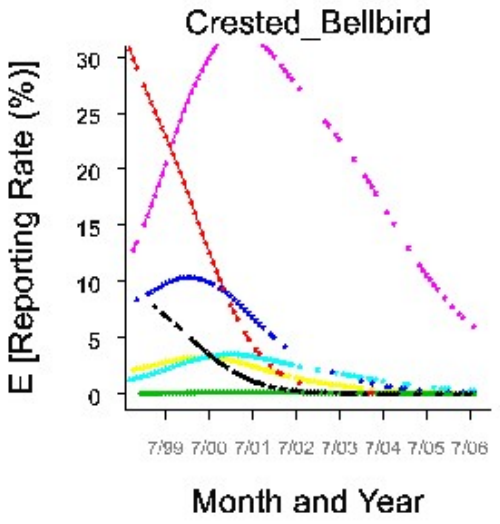
BBN MAC
DRP MDD
FIN RIV
FLB
GAW

p-val (lbra trends)	0.146
E[Jul 99]	4.372
E[Jul 06]	2.355
% change	-46.129
% change (linear)	-54.526
p-val (lln trend)	0.000

Crested Bellbird



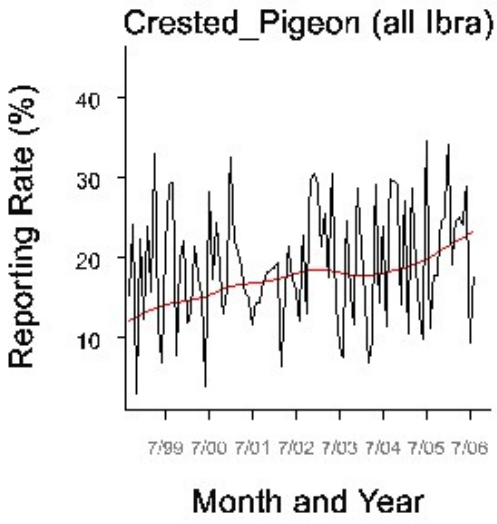


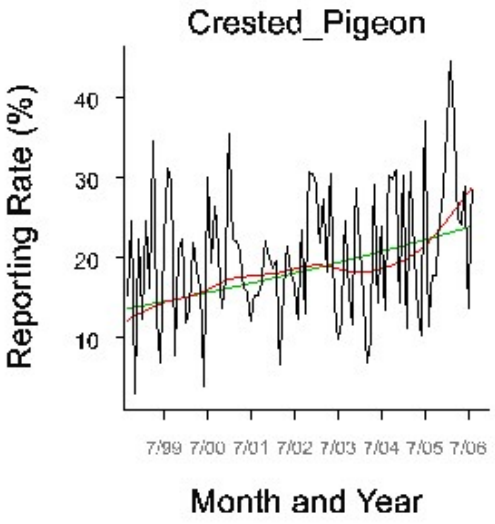


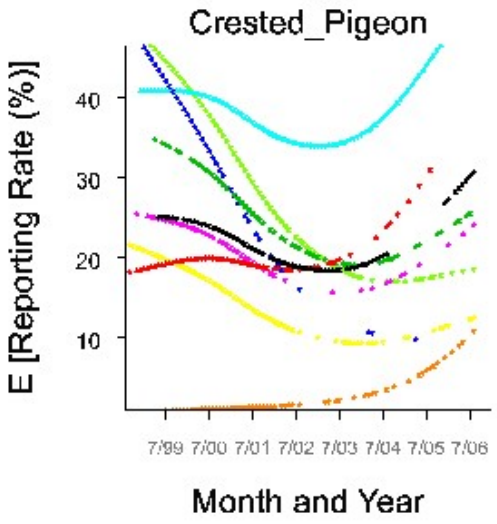
DRP MDD
FIN RIV
FLB
GAW
MAC

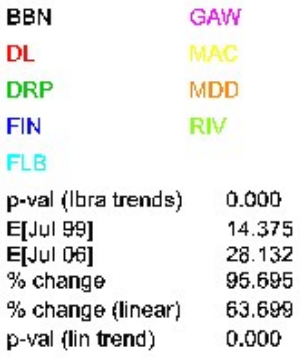
p-val (Ibra trends)	0.000
E[Jul 99]	13.973
E[Jul 06]	6.790
% change	-51.410
% change (linear)	-54.559
p-val (lin trend)	0.000

Crested Pigeon

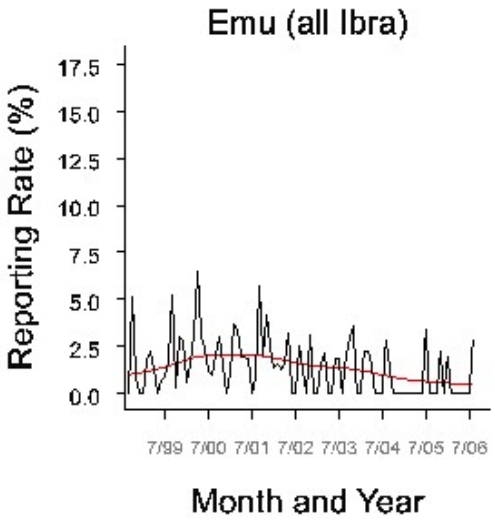


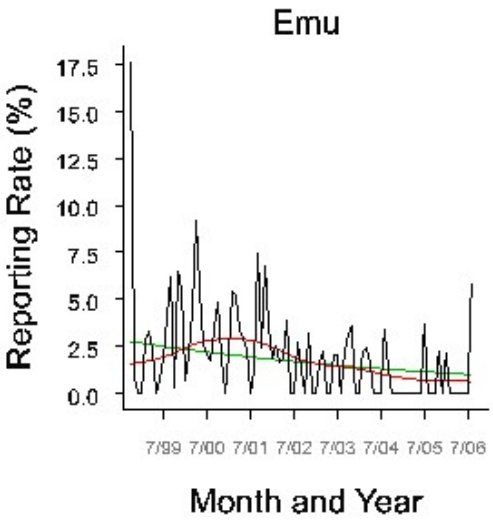


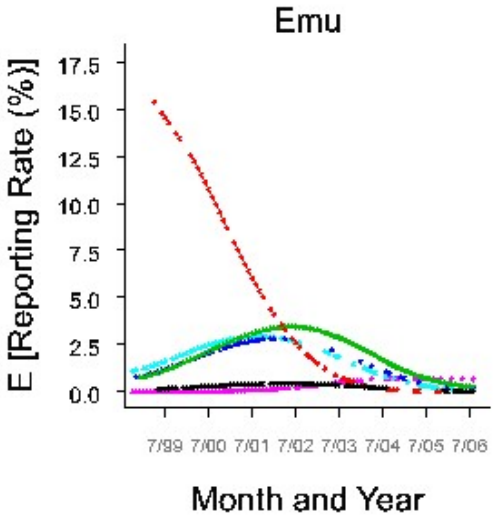




Emu

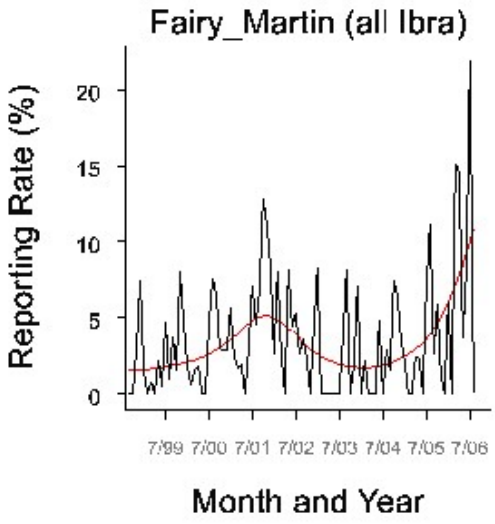

Emu (all Ibra)
Reporting Rate (%)
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
7/99 7/00 7/01 7/02 7/03 7/04 7/05 7/06
Month and Year

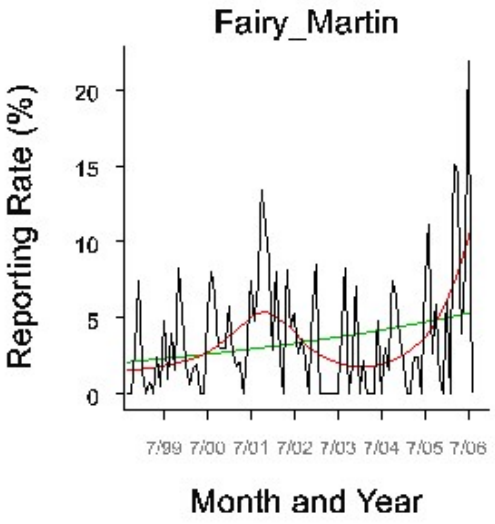

Emu
Reporting Rate (%)
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
7/99 7/00 7/01 7/02 7/03 7/04 7/05 7/06
Month and Year

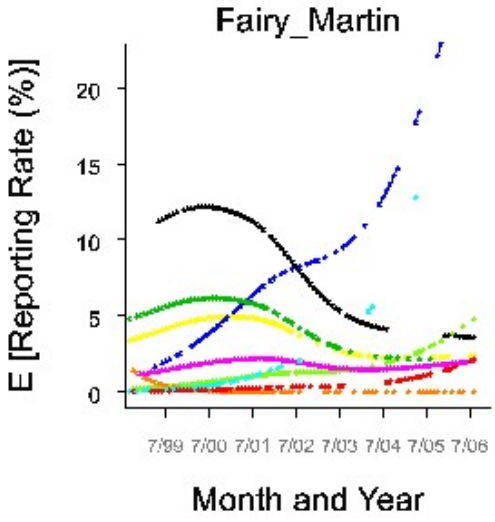

Emu
E [Reporting Rate (%)]
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
7/99 7/00 7/01 7/02 7/03 7/04 7/05 7/06
Month and Year


BBN
RIV
DRP
FLB
GAW
MDD
p-val (Ibra trends) 0.001
E[Jul 99] 1.946
E[Jul 06] 0.652
% change -66.487
% change (linear) -59.378
p-val (lin trend) 0.001

Fairy Martin



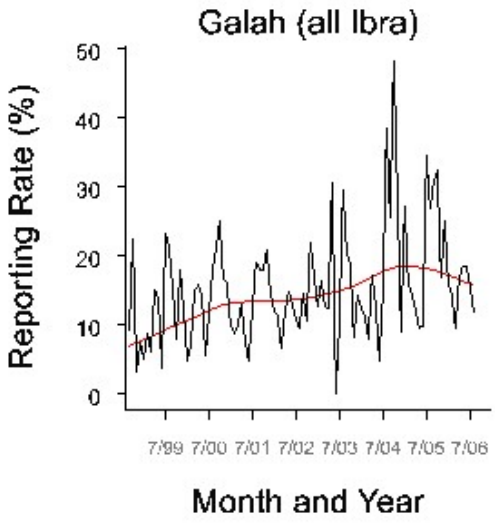


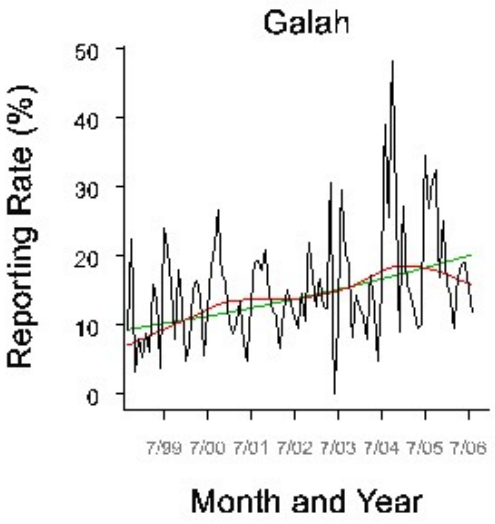


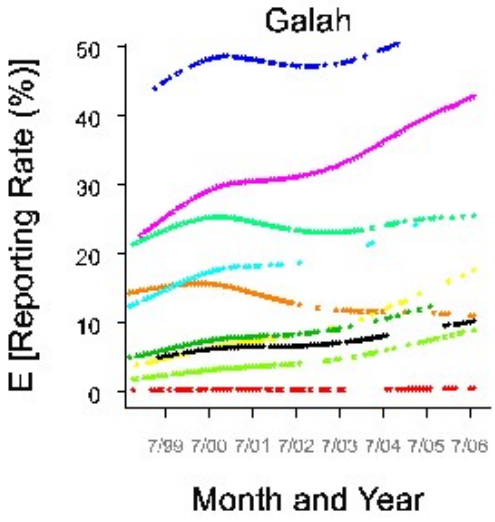
BBN FLB
CYP MAC
DL MDD
DRP RIV
FIN

p-val (Ibra trends)	0.000
E[Jul 99]	1.847
E[Jul 06]	10.279
% change	456.434
% change (linear)	129.370
p-val (lin trend)	0.000

Galah



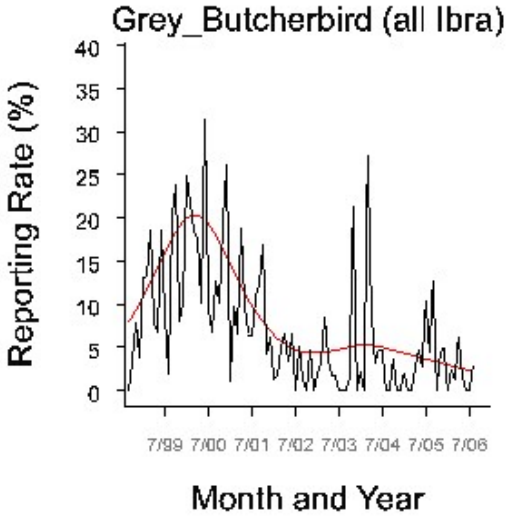


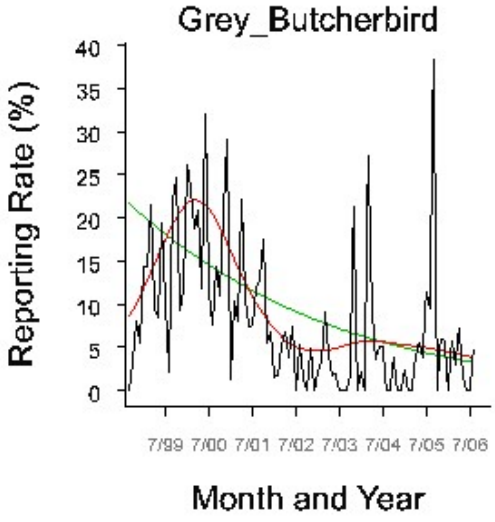


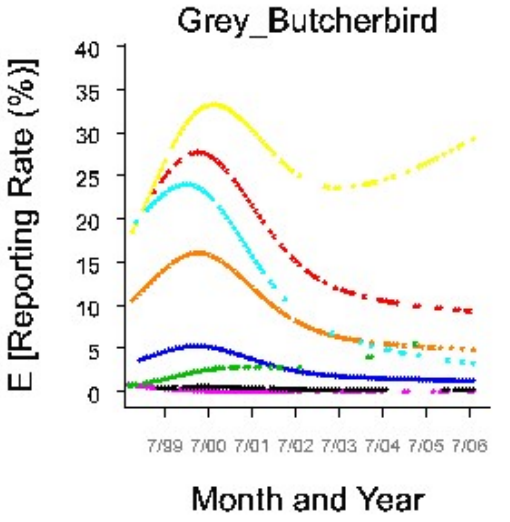
BBN	FLB
CYP	GAW
DL	MAC
DRP	MDD
FIN	RIV

p-val (Ibra trends)	0.473
E[Jul 99]	9.355
E[Jul 06]	16.007
% change	71.093
% change (linear)	97.120
p-val (lin trend)	0.000

Grey Butcherbird



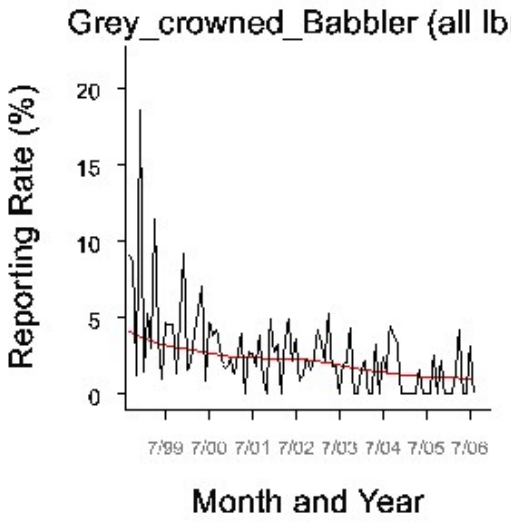


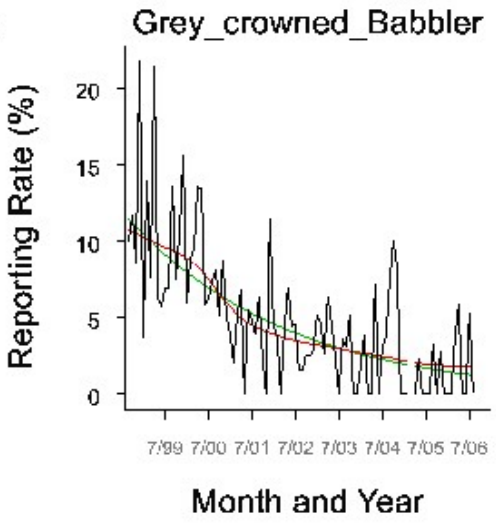


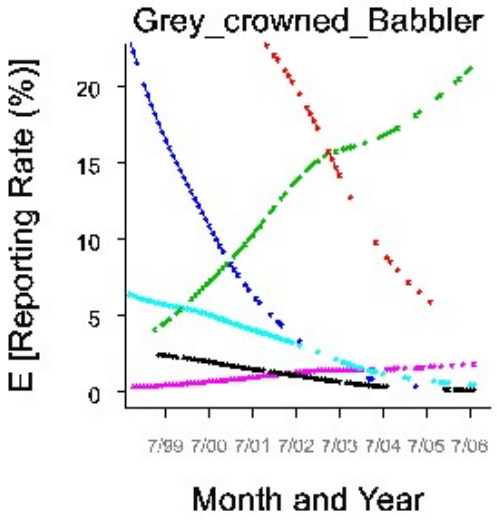
BBN MAC
DRP MDD
FIN RIV
FLB
GAW

p-val (Ibra trends)	0.027
E[Jul 99]	17.518
E[Jul 06]	3.959
% change	-77.402
% change (linear)	-81.229
p-val (lin trend)	0.000

Grey-crowned Babbler



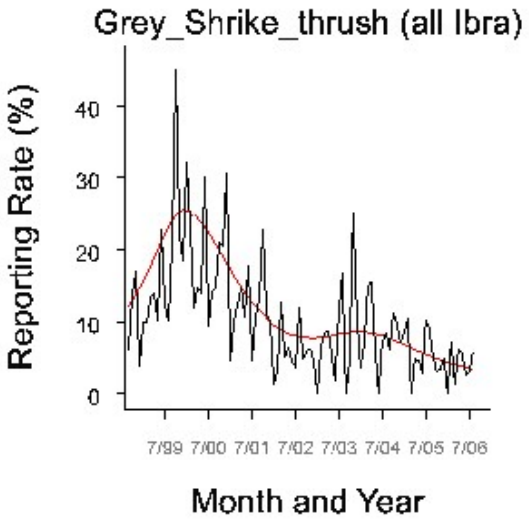


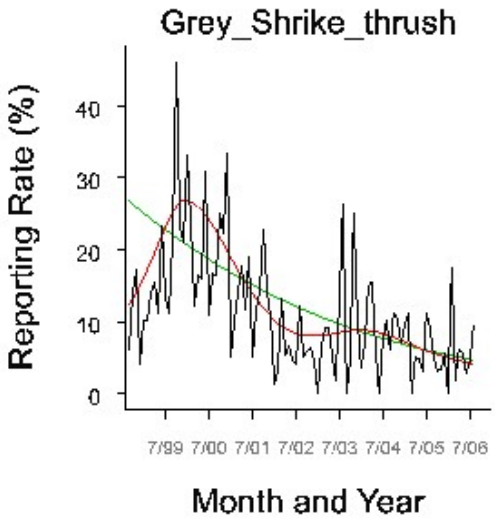


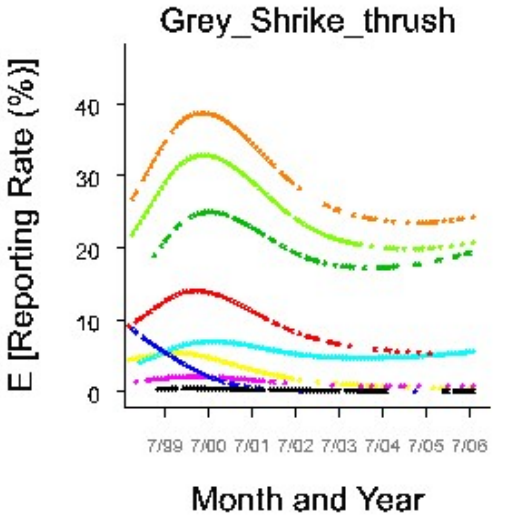
BBN RIV
DL
DRP
FIN
MAC

p-val (Ibra trends)	0.001
E[Jul 99]	9.575
E[Jul 06]	1.769
% change	-81.520
% change (linear)	-86.117
p-val (lin trend)	0.000

Grey Shrike-thrush



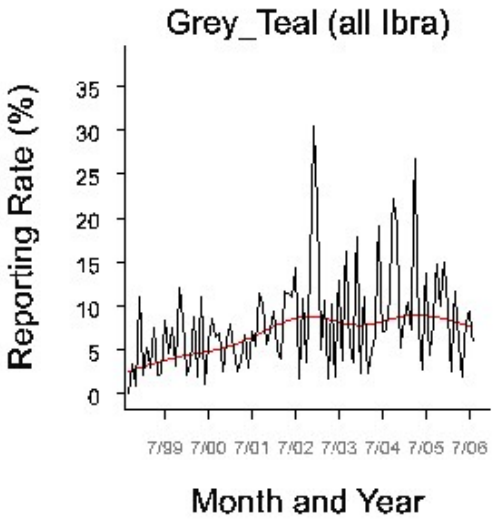


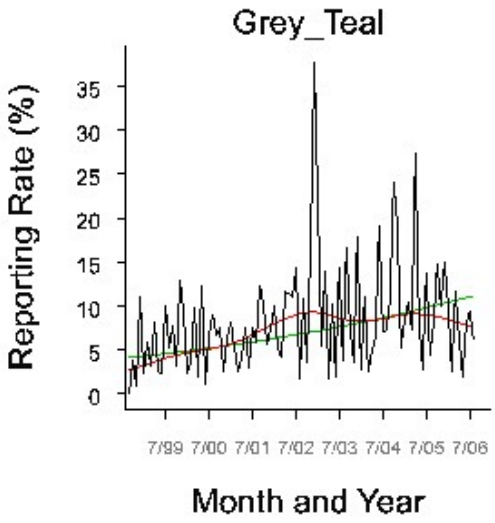


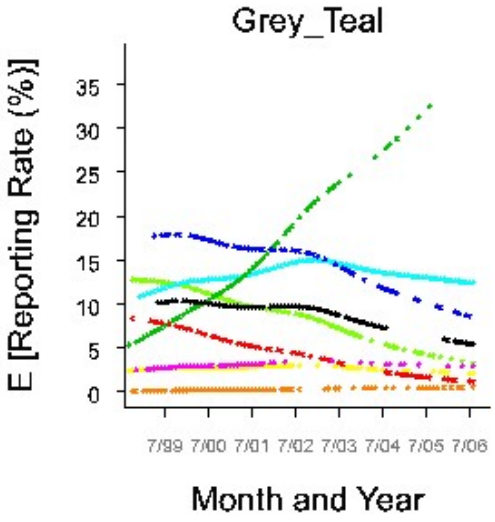
BBN GAW
DL MAC
DRP MDD
FIN RIV
FLB

p-val (Ibra trends)	0.503
E[Jul 99]	23.196
E[Jul 06]	4.241
% change	-81.717
% change (linear)	-79.013
p-val (lin trend)	0.000

Grey Teal



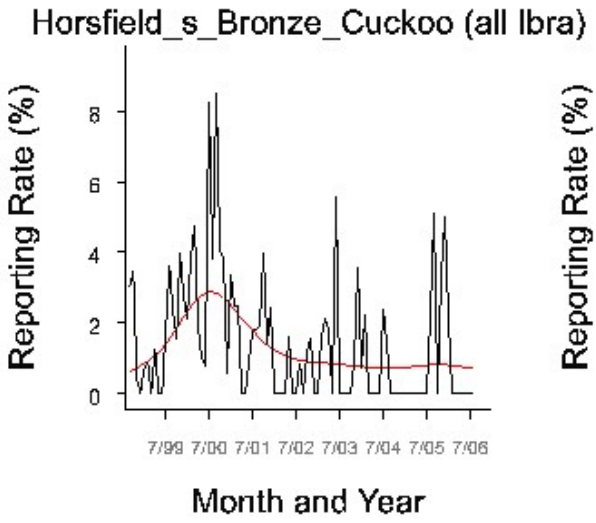


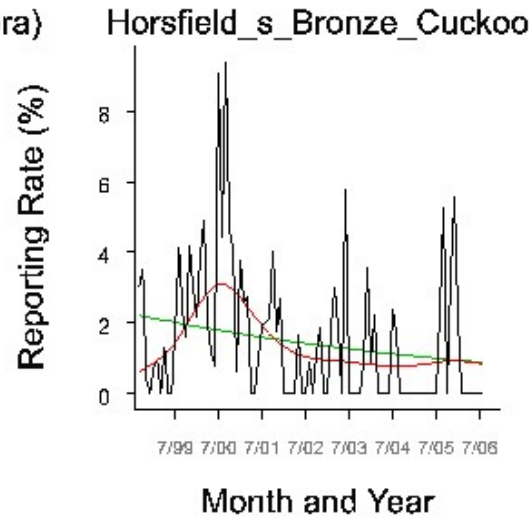


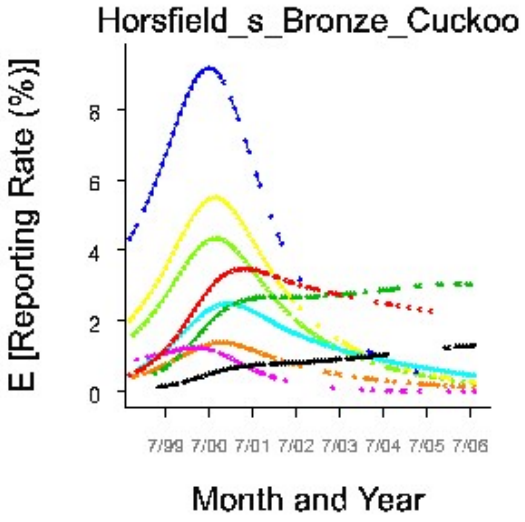
BBN GAW
CYP MAC
DL MDD
DRP RIV
FLB

p-val (Ibra trends)	0.046
E[Jul 99]	4.036
E[Jul 06]	7.724
% change	91.383
% change (linear)	141.919
p-val (lin trend)	0.000

Horsfield's Bronze-cuckoo



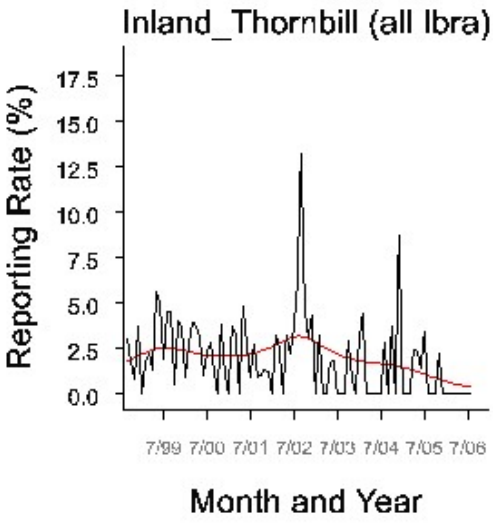


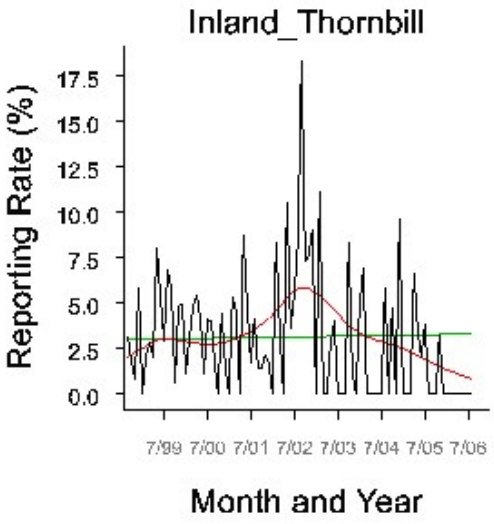


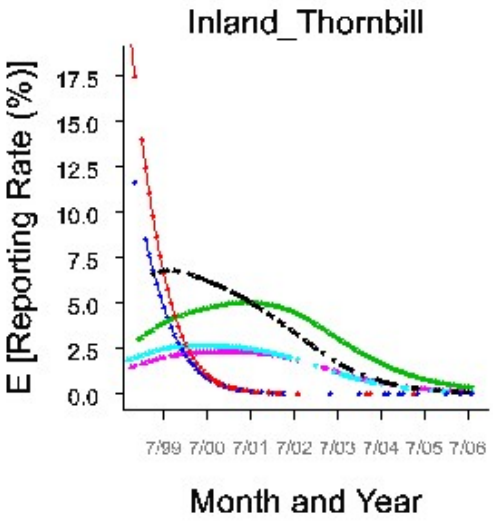
BBN GAW
DL MAC
DRP MDD
FIN RIV
FLB

p-val (lbra trends)	0.090
E[Jul 99]	1.452
E[Jul 06]	0.873
% change	-39.876
% change (linear)	-55.639
p-val (lin trend)	0.001

Inland Thornbill



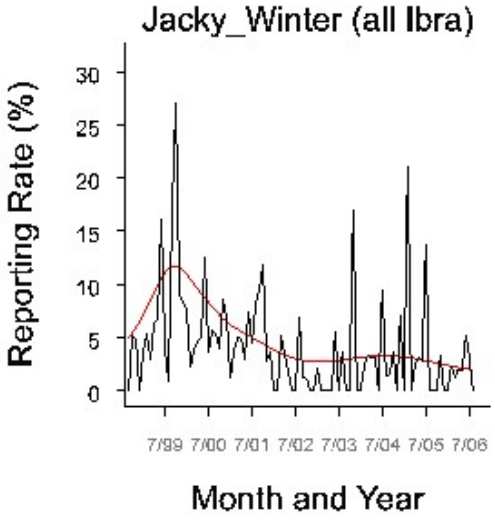


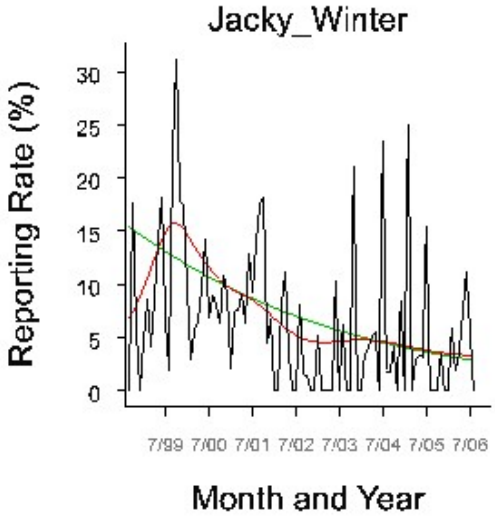


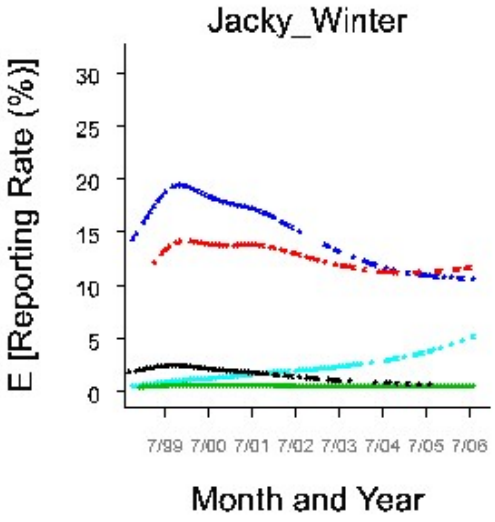
DRP MDD
FIN
FLB
GAW
MAC

p-val (Ibra trends)	0.000
E[Jul 99]	3.032
E[Jul 06]	0.903
% change	-70.220
% change (linear)	8.861
p-val (lin trend)	0.719

Jacky Winter



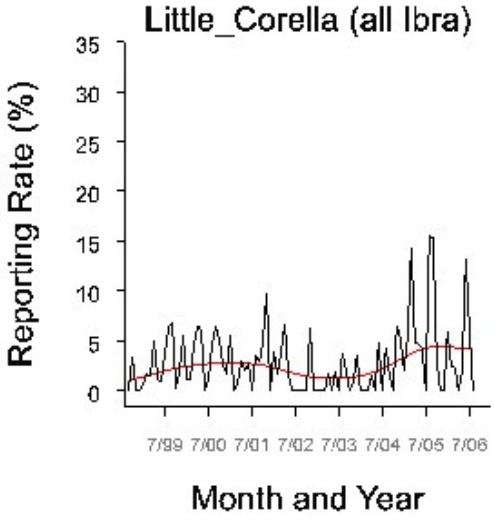


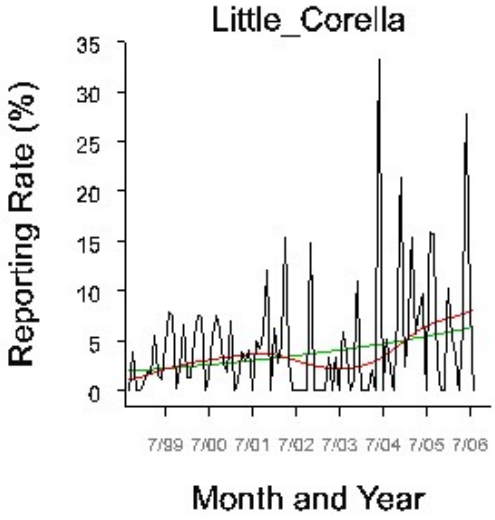


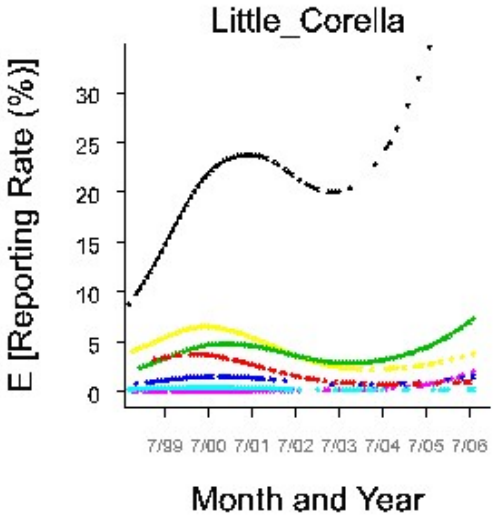
DL
DRP
FLB
MDD
RIV

p-val (Ibra trends)	0.393
E[Jul 99]	14.912
E[Jul 06]	3.344
% change	-77.579
% change (linear)	-77.724
p-val (lin trend)	0.000

Little Corella



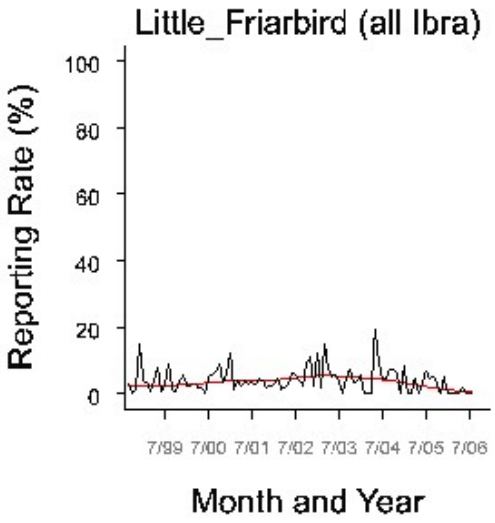


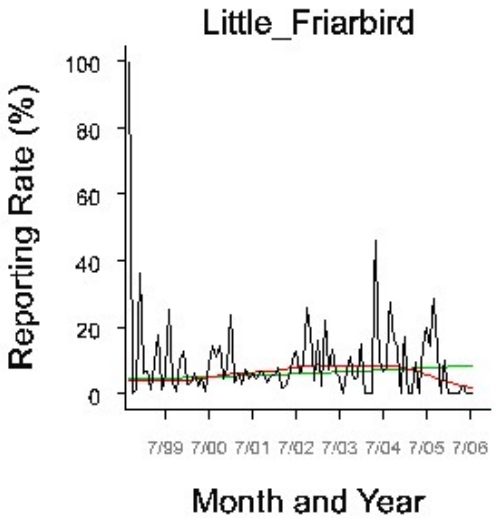


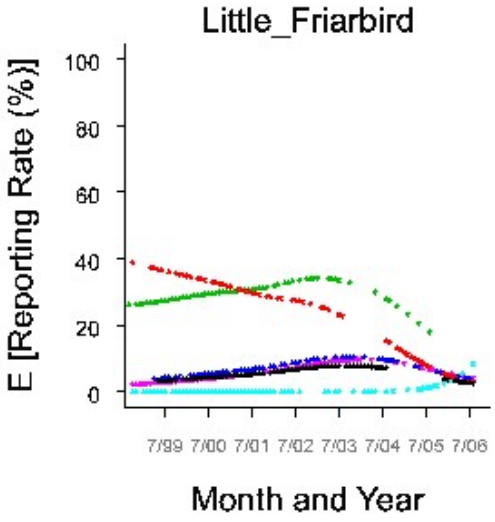
DL
DRP
FLB
GAW
MAC
MDD
RIV

p-val (Ibra trends)	0.172
E[Jul 99]	2.141
E[Jul 06]	7.935
% change	270.550
% change (linear)	182.573
p-val (lin trend)	0.000

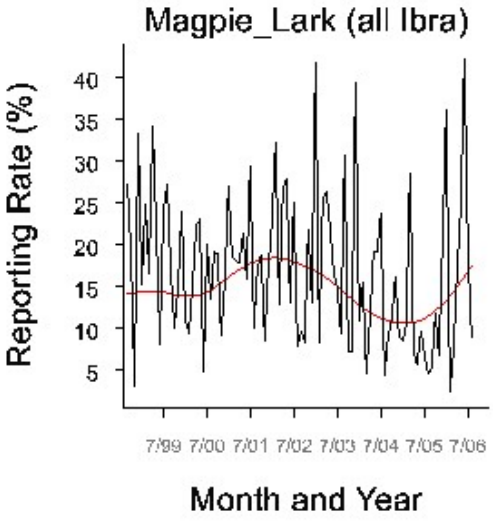
Little Friarbird

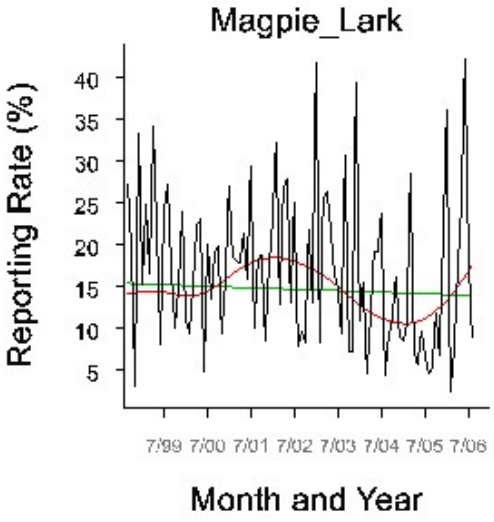


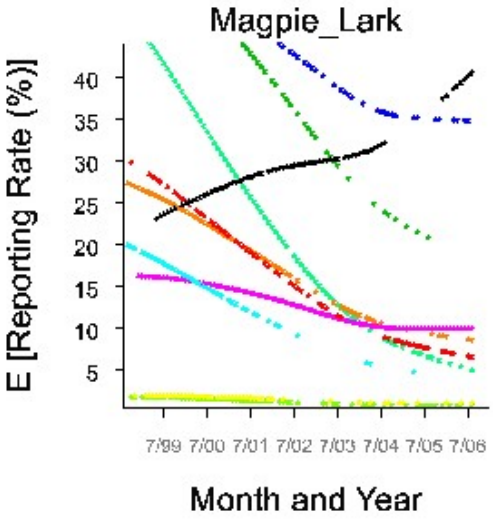




Magpie Lark



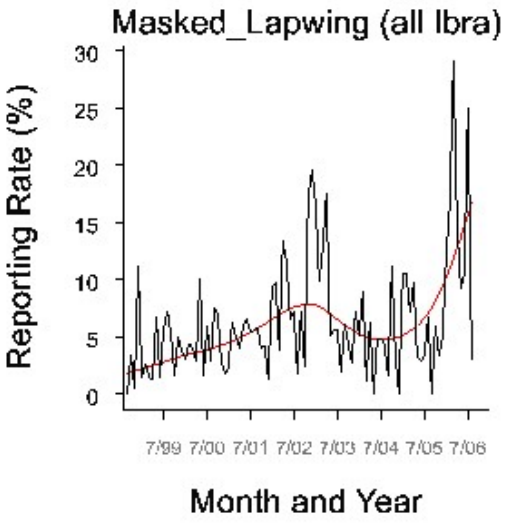


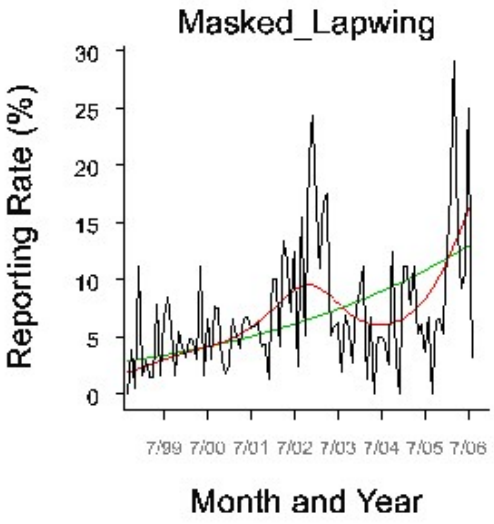


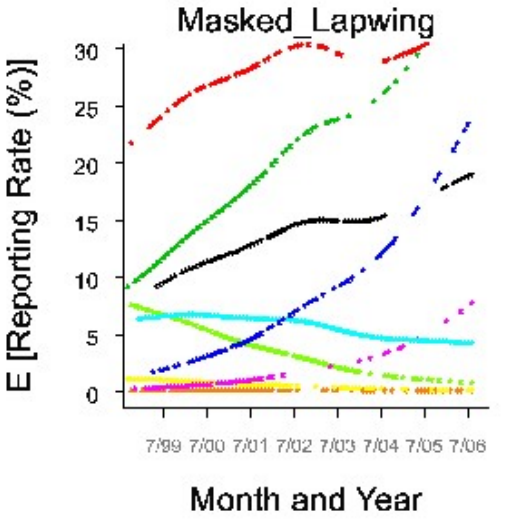
BBN	FLB
CYP	GAW
DL	MAC
DRP	MDD
FIN	RIV

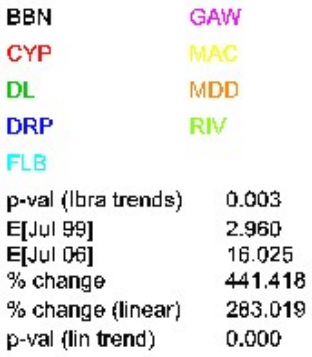
p-val (Ibra trends)	0.000
E[Jul 99]	14.305
E[Jul 06]	16.819
% change	17.576
% change (linear)	-8.259
p-val (lin trend)	0.538

Masked Lapwing

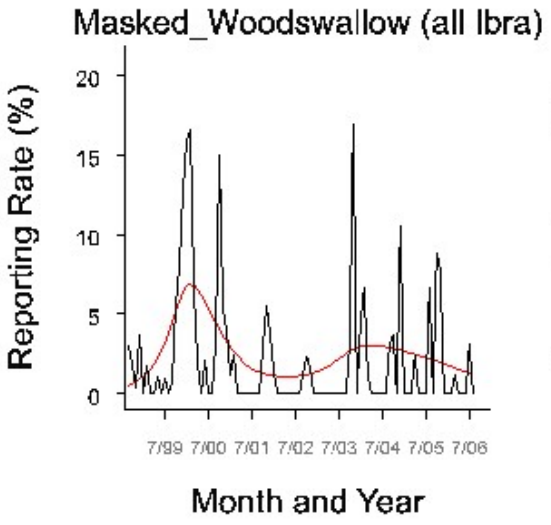


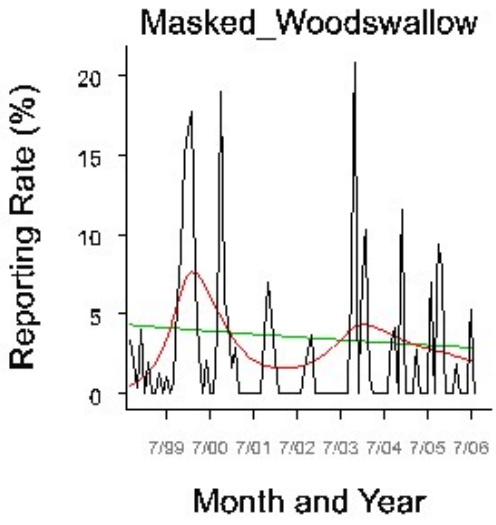


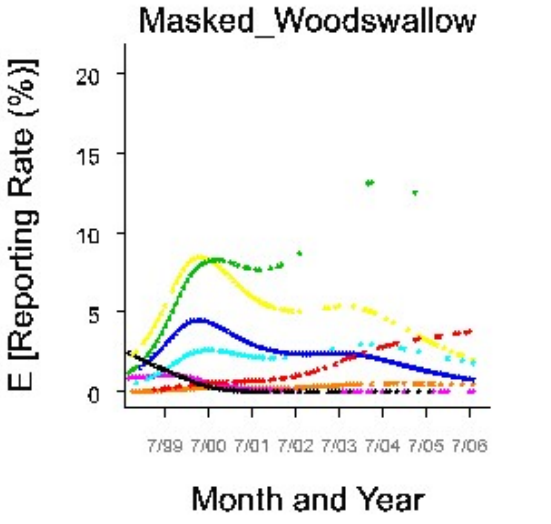


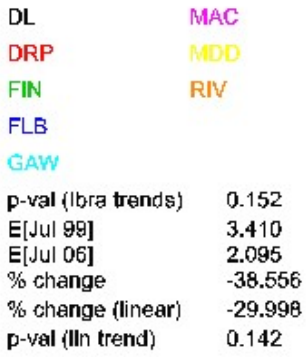


Masked Woodswallow

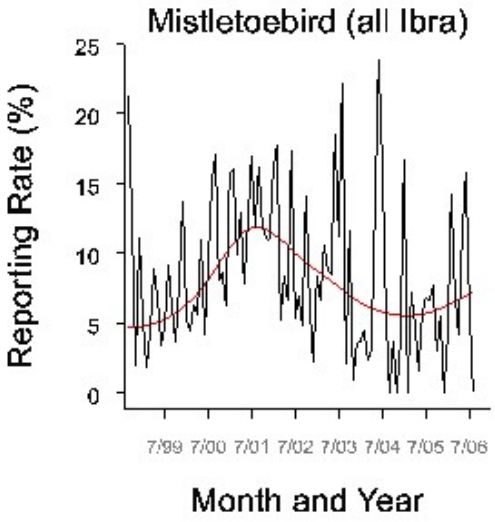


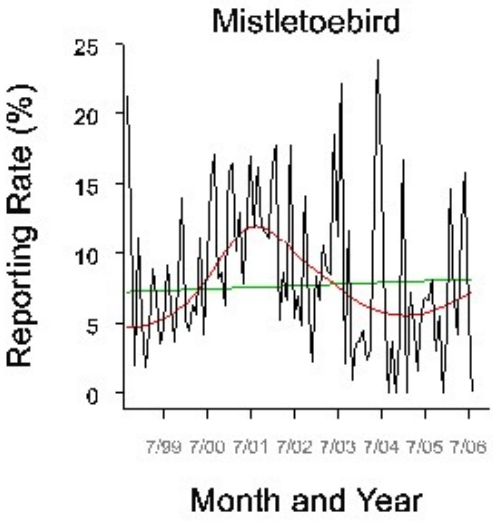


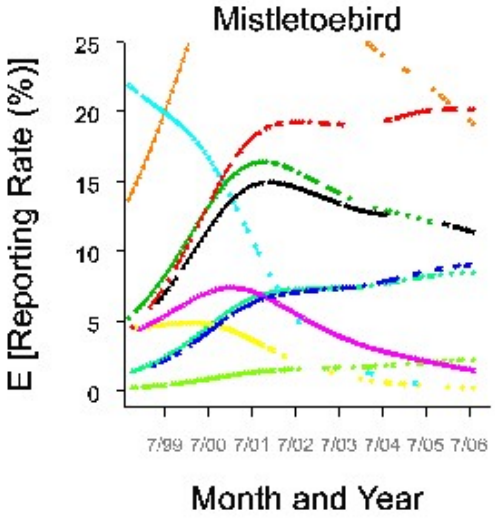




Mistletoebird



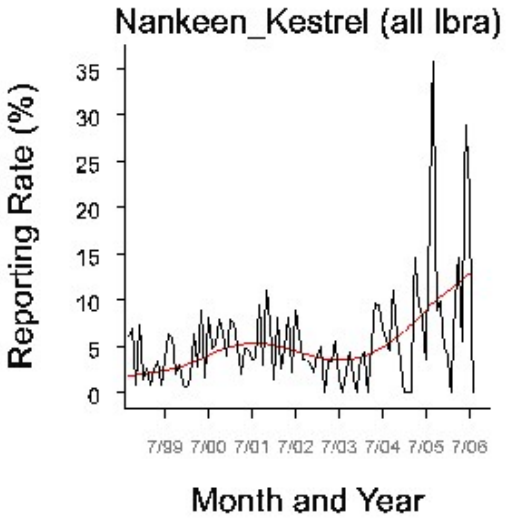


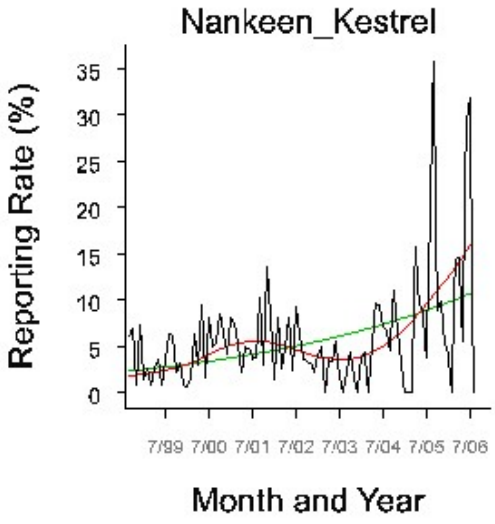


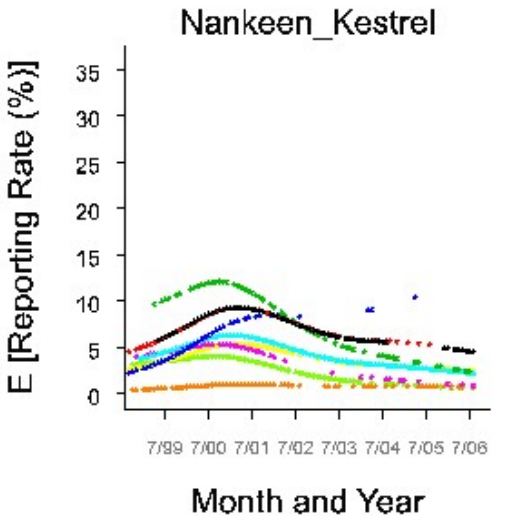
BBN	FLB
CYP	GAW
DL	MAC
DRP	MDD
FIN	RIV

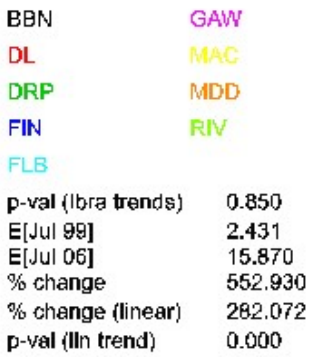
p-val (Ibra trends)	0.001
E[Jul 99]	5.280
E[Jul 06]	7.065
% change	33.812
% change (linear)	11.164
p-val (lin trend)	0.517

Nankeen Kestrel

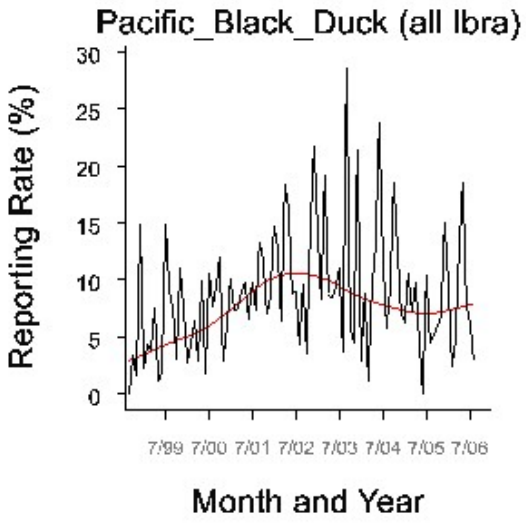


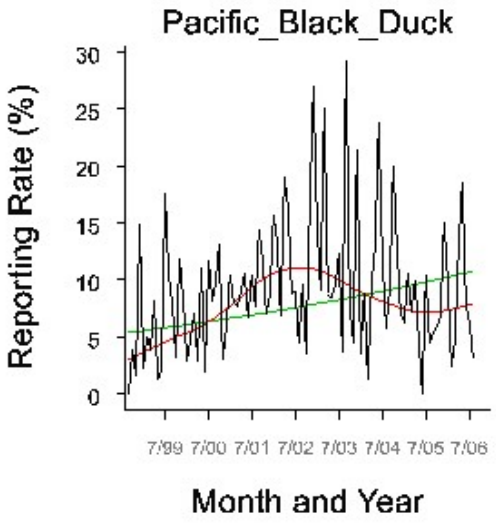


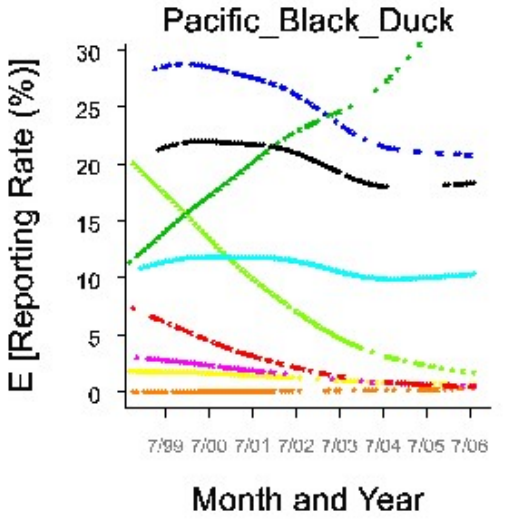




Pacific Black Duck



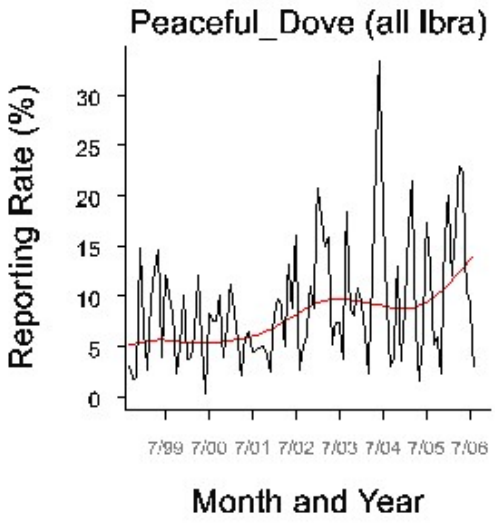


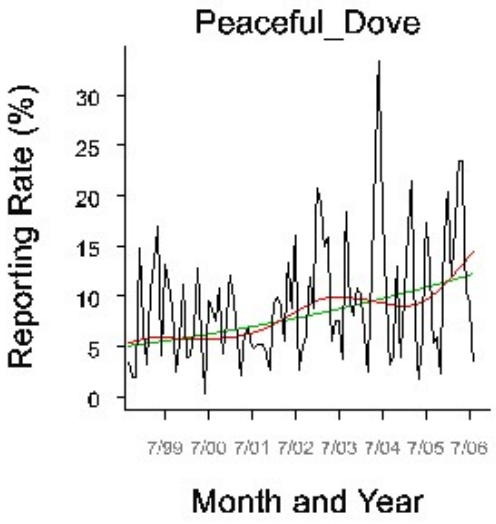


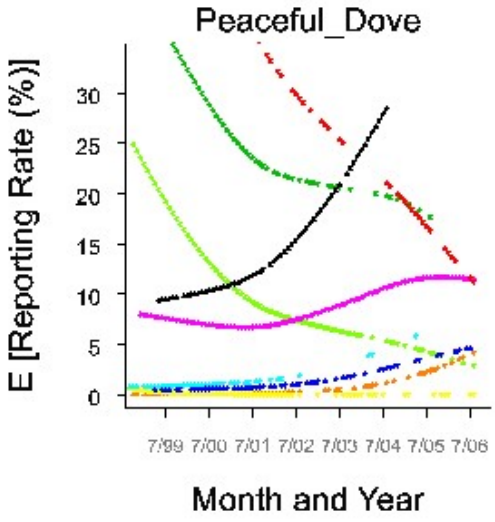
BBN	GAW
CYP	MAC
DL	MDD
DRP	RIV
FLB	

p-val (Ibra trends)	0.001
E[Jul 99]	4.543
E[Jul 06]	7.784
% change	71.325
% change (linear)	84.027
p-val (lin trend)	0.000

Peaceful Dove



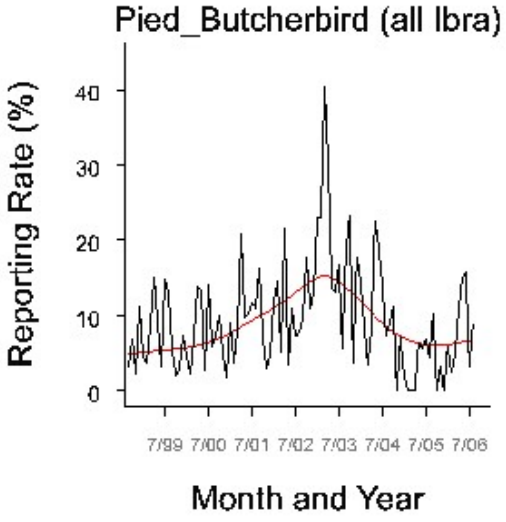


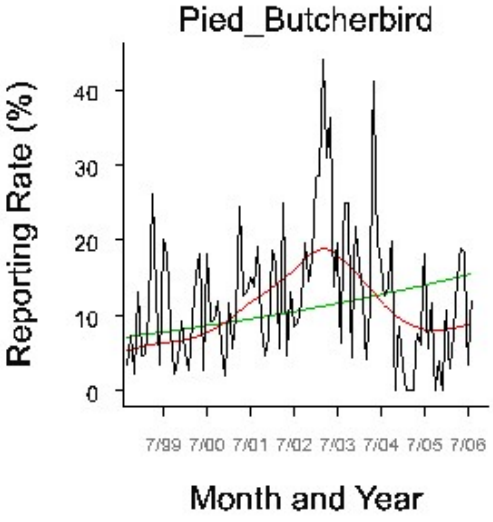


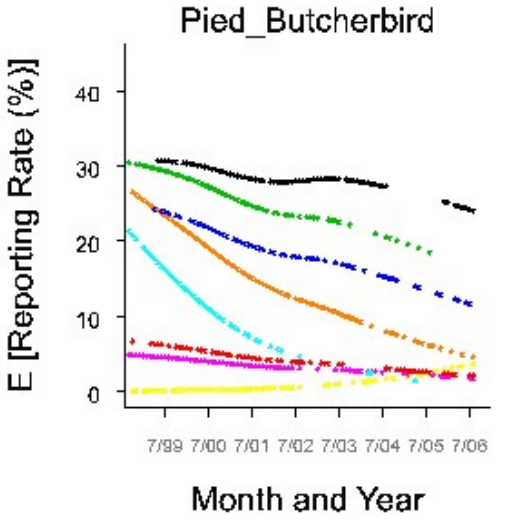
BBN FLB
CYP MAC
DL MDD
DRP RIV
FIN

p-val (Ibra trends)	0.000
E[Jul 99]	5.933
E[Jul 06]	13.985
% change	135.717
% change (linear)	116.631
p-val (lin trend)	0.000

Pied Butcherbird



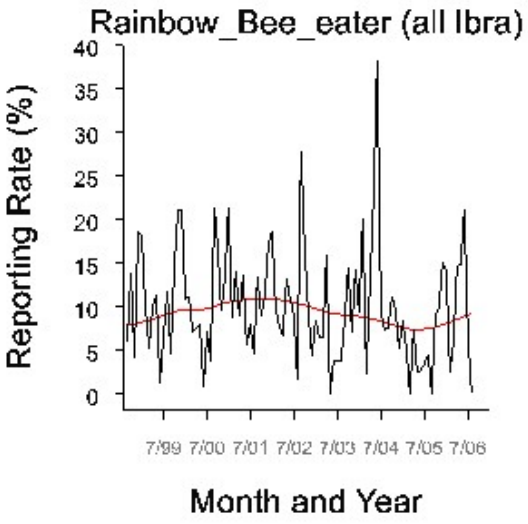


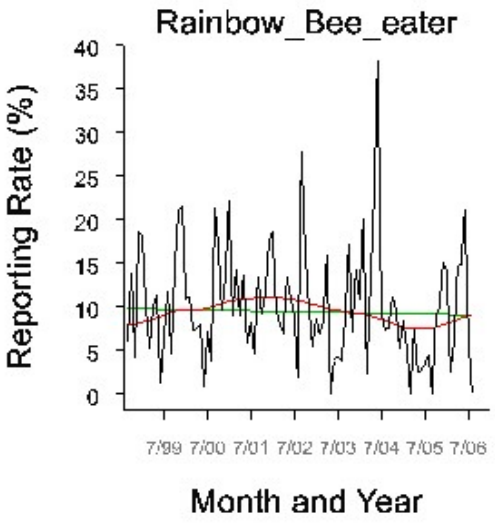


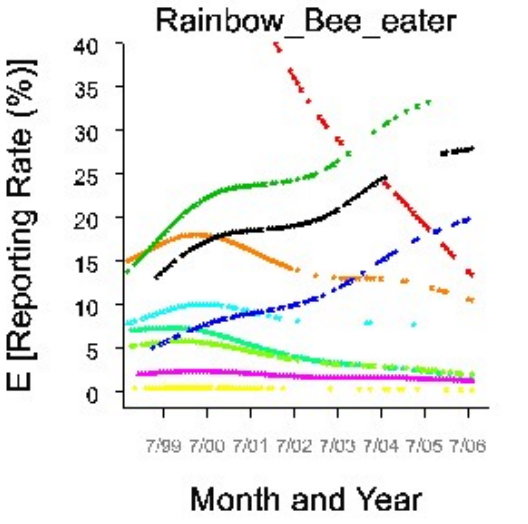
BBN MAC
CYP MDD
DL RIV
DRP
FIN

p-val (Ibra trends)	0.014
E[Jul 99]	6.375
E[Jul 06]	8.777
% change	37.691
% change (linear)	97.420
p-val (lin trend)	0.000

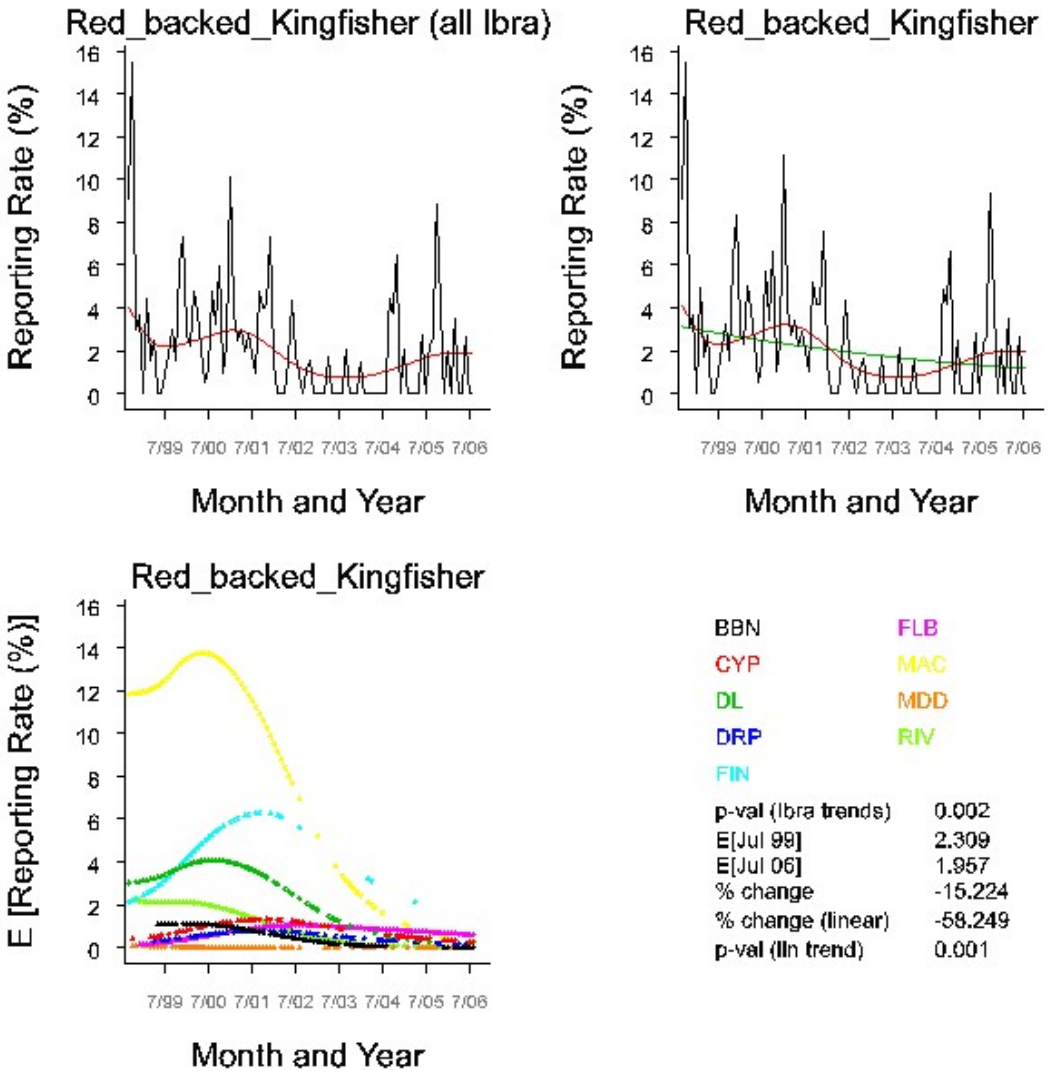
Rainbow Bee-eater



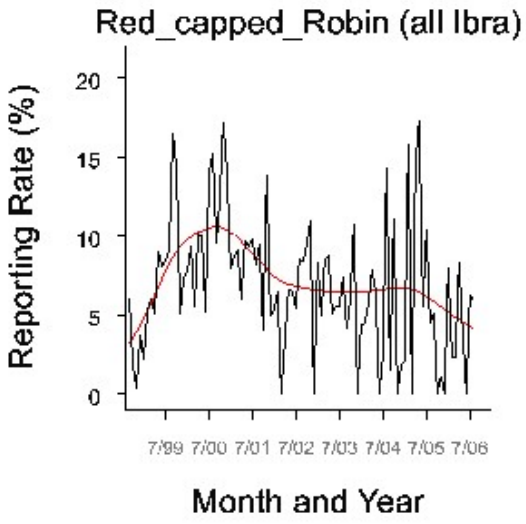


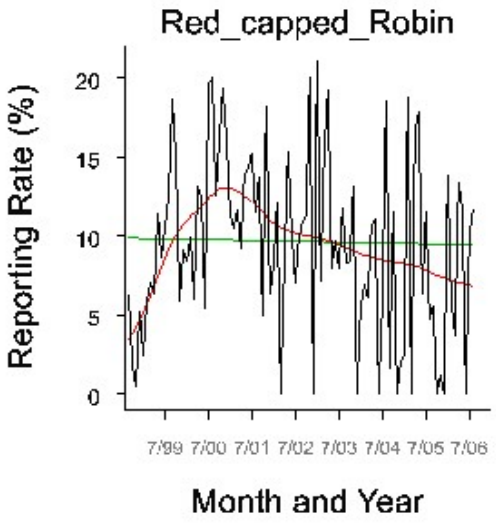


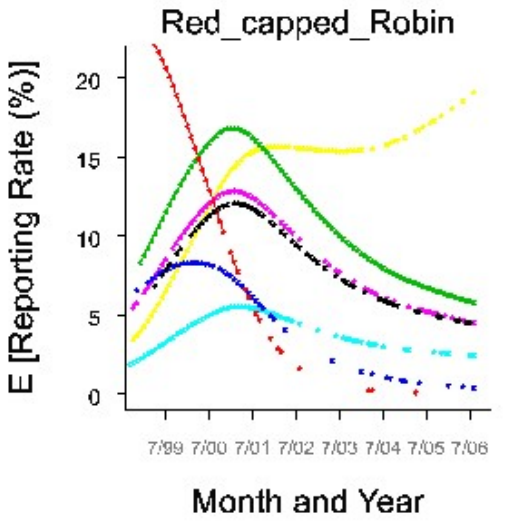
Red-backed Kingfisher



Red-capped Robin



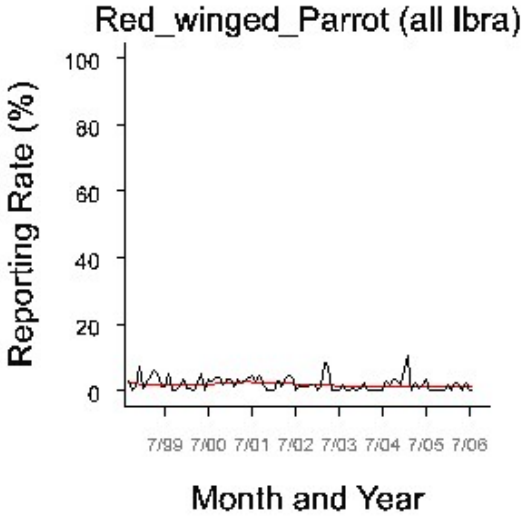


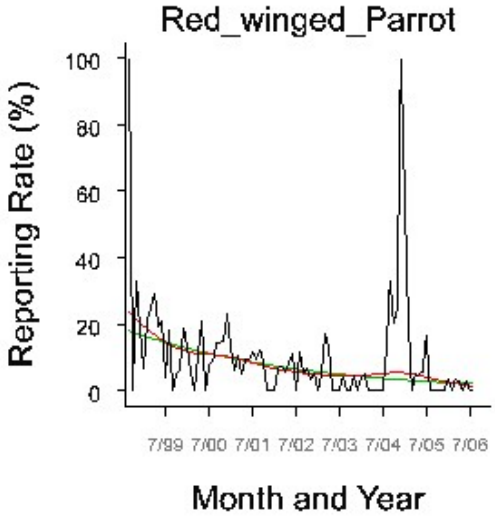


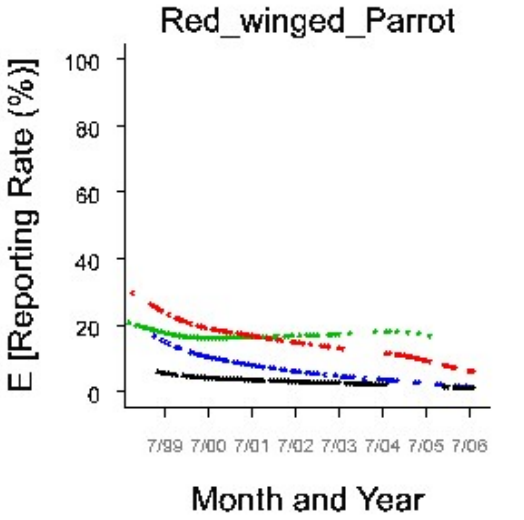
DRP MDD
FIN RIV
FLB
GAW
MAC

p-val (Ibra trends)	0.000
E[Jul 99]	8.610
E[Jul 06]	6.905
% change	-19.805
% change (linear)	-3.811
p-val (lin trend)	0.792

Red-winged Parrot



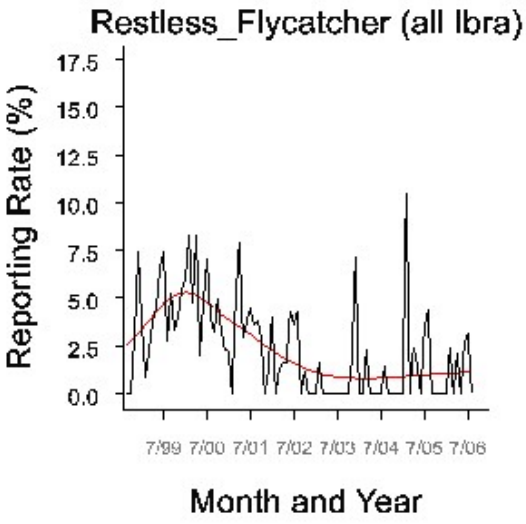


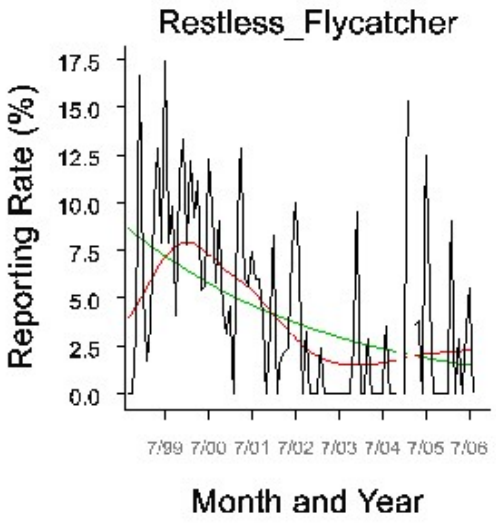


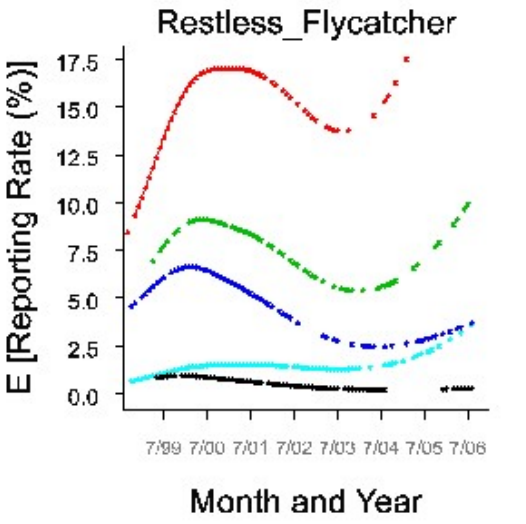
BBN
CYP
DL
DRP

p-val (Ibra trends)	0.604
E[Jul 99]	14.835
E[Jul 06]	1.594
% change	-89.255
% change (linear)	-85.566
p-val (lin trend)	0.000

Restless Flycatcher



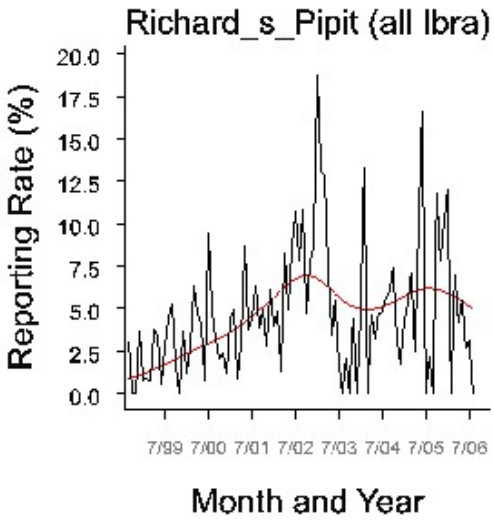


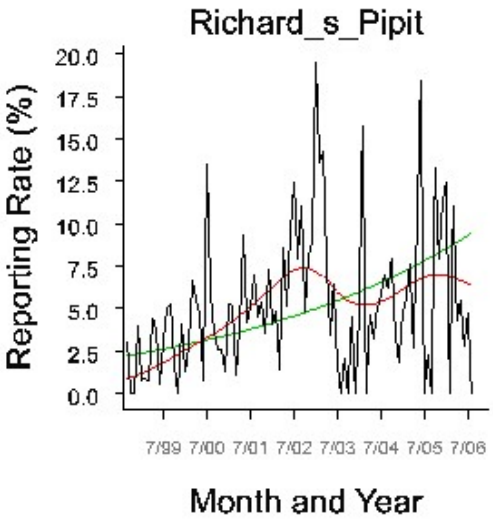


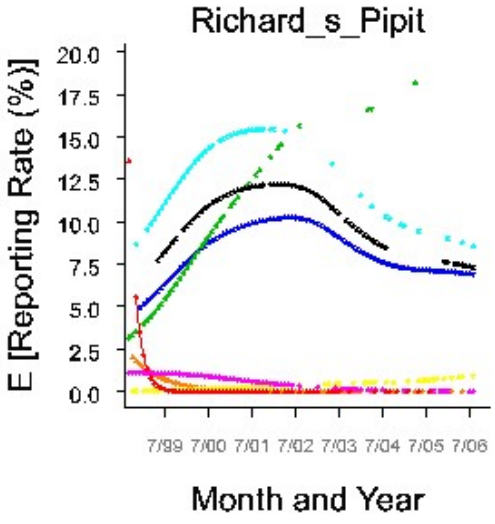
BBN
DL
DRP
MDD
RIV

p-val (Ibra trends)	0.261
E[Jul 99]	7.174
E[Jul 06]	2.281
% change	-68.209
% change (linear)	-79.213
p-val (lin trend)	0.000

Richard's Pipit



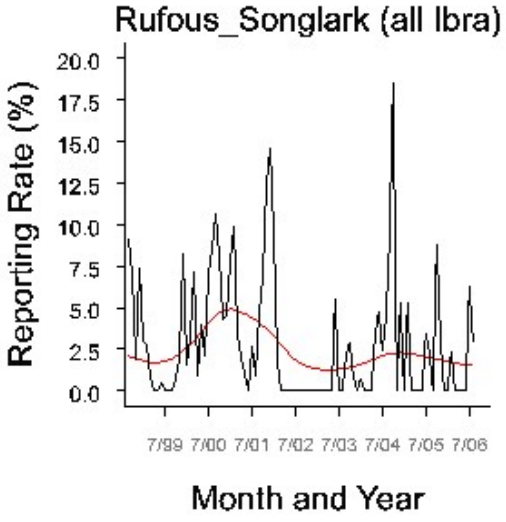


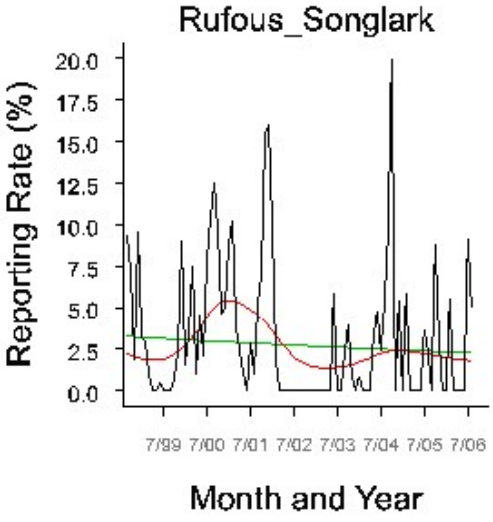


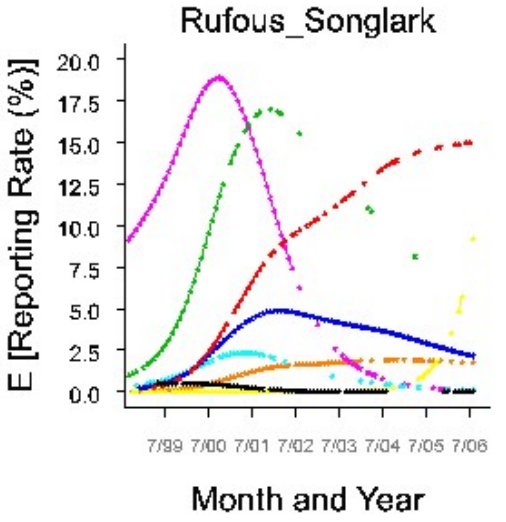
BBN MAC
DL MDD
FIN RIV
FLB
GAW

p-val (Ibra trends)	0.005
E[Jul 99]	1.815
E[Jul 06]	6.518
% change	259.144
% change (linear)	254.074
p-val (lin trend)	0.000

Rufous Songlark



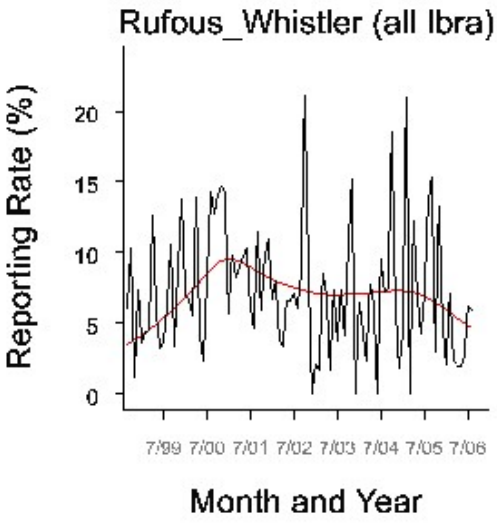


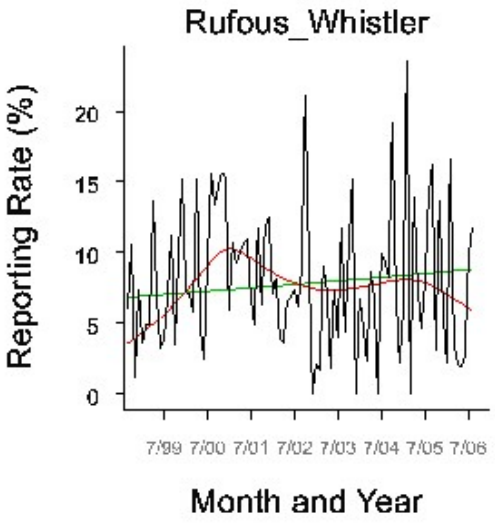


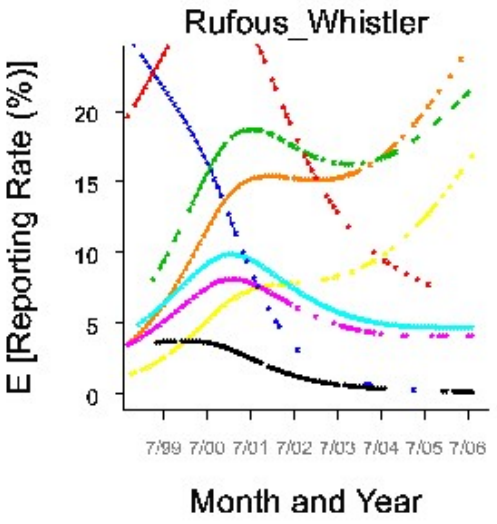
BBN MAC
DRP MDD
FIN RIV
FLB
GAW

p-val (Ibra trends)	0.000
E[Jul 99]	1.893
E[Jul 06]	1.846
% change	-2.457
% change (linear)	-27.543
p-val (lin trend)	0.214

Rufous Whistler



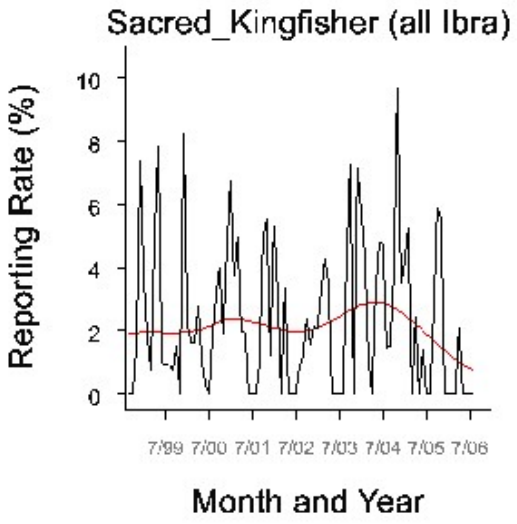


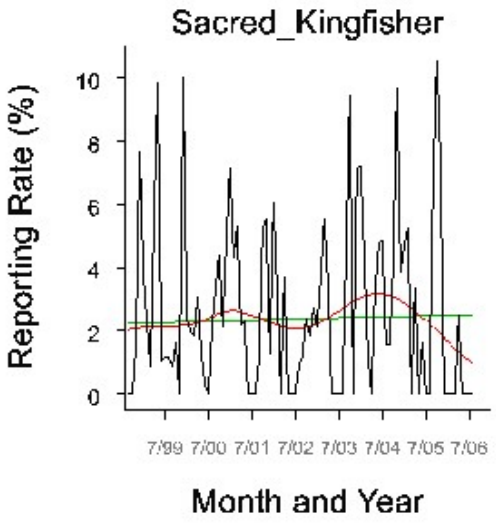


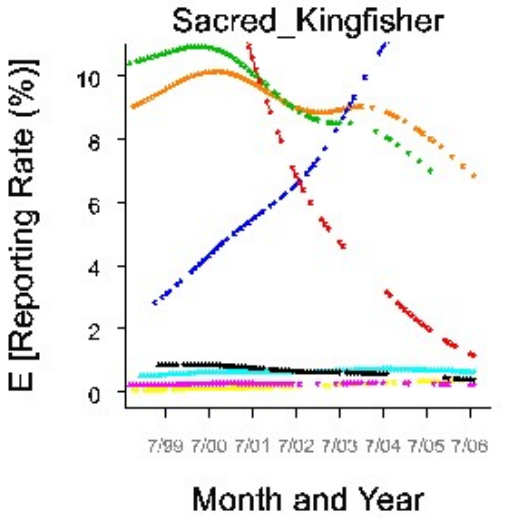
BBN MAC
DL MDD
DRP RIV
FIN
FLB

p-val (Ibra trends)	0.000
E[Jul 99]	5.607
E[Jul 06]	6.135
% change	9.419
% change (linear)	24.806
p-val (lin trend)	0.175

Sacred Kingfisher



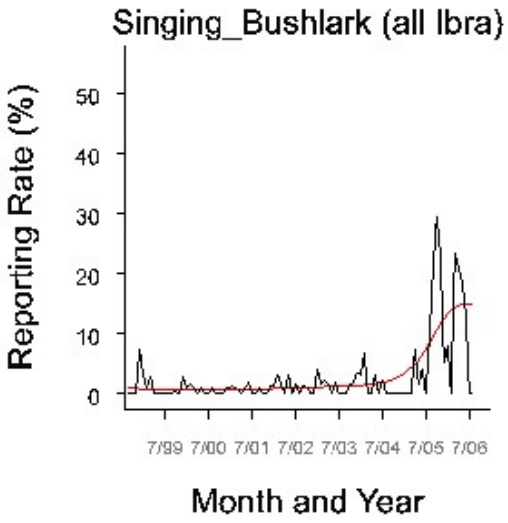


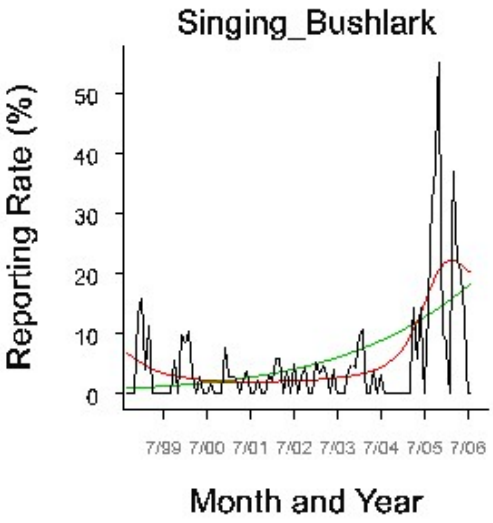


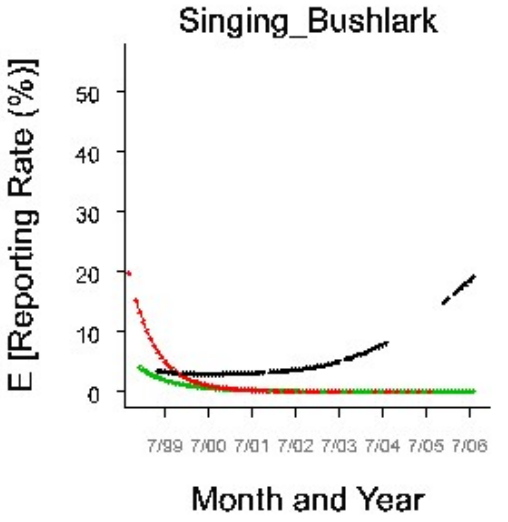
BBN MAC
CYP MDD
DL RIV
DRP
FLB

p-val (Ibra trends)	0.016
E[Jul 99]	2.139
E[Jul 06]	1.082
% change	-49.408
% change (linear)	9.759
p-val (lin trend)	0.740

Singing Bushlark



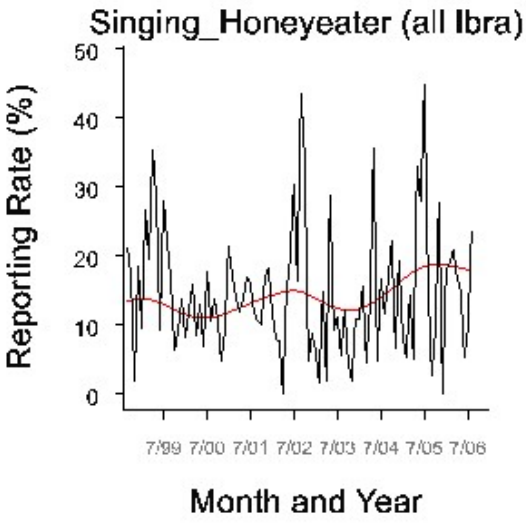


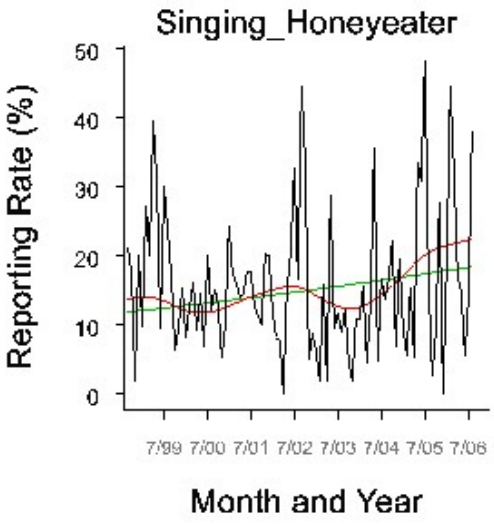


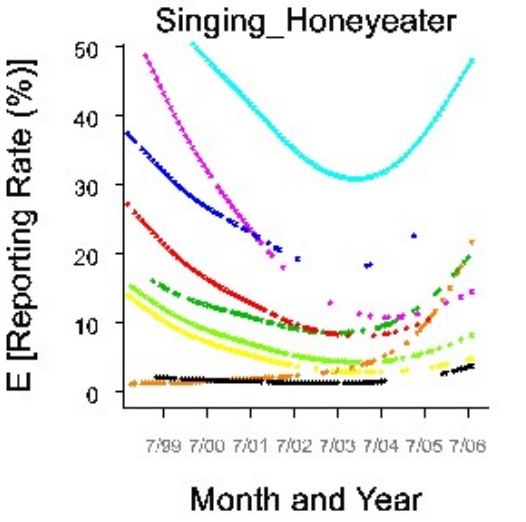
BBN
DL
FLB

p-val (Ibra trends)	0.000
E[Jul 99]	3.475
E[Jul 06]	20.660
% change	494.507
% change (linear)	1339.812
p-val (lin trend)	0.000

Singing Honeyeater



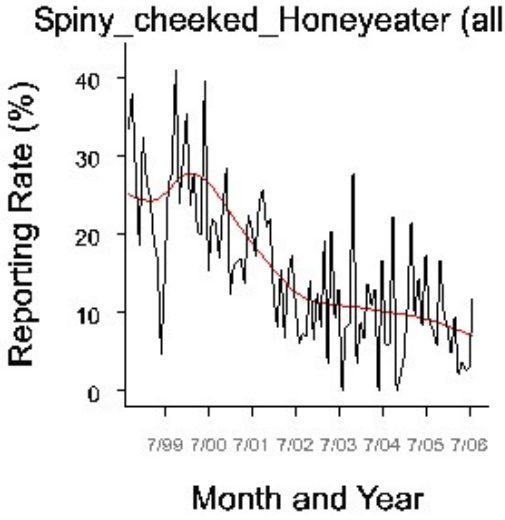


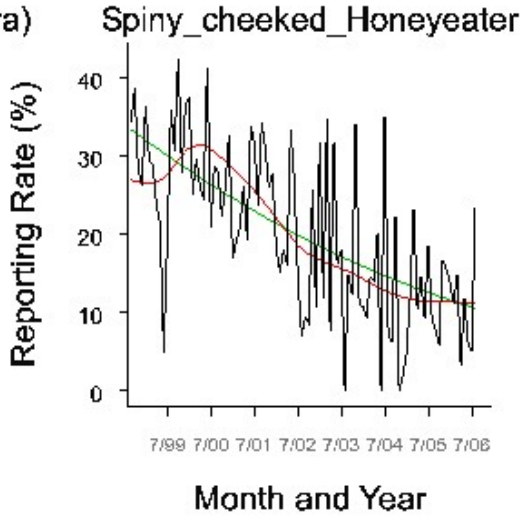


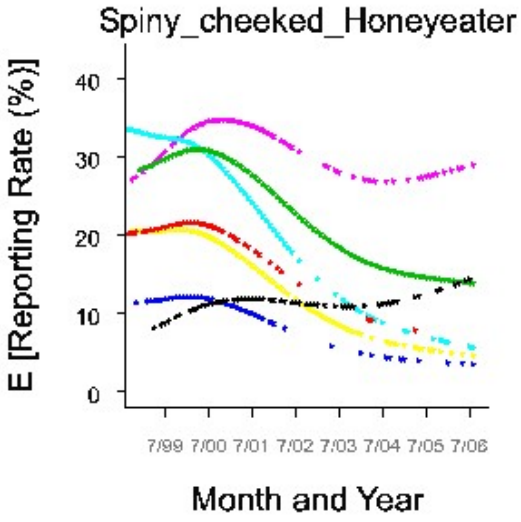
BBN	GAW
DL	MAC
DRP	MDD
FIN	RIV
FLB	

p-val (Ibra trends)	0.000
E[Jul 99]	13.525
E[Jul 06]	22.220
% change	64.285
% change (linear)	47.699
p-val (lin trend)	0.016

Spiny-cheeked Honeyeater



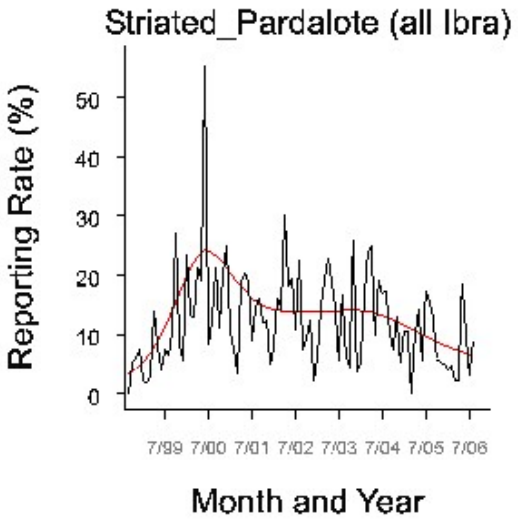


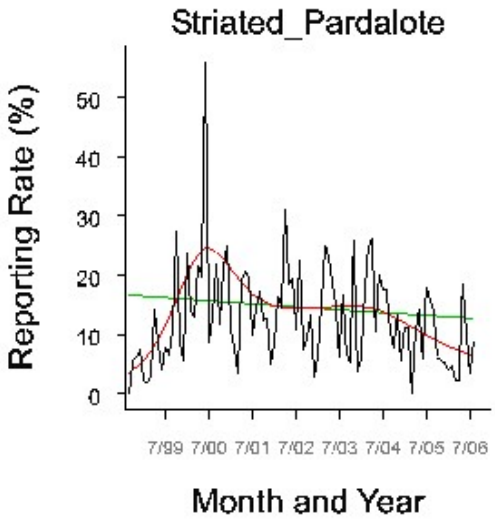


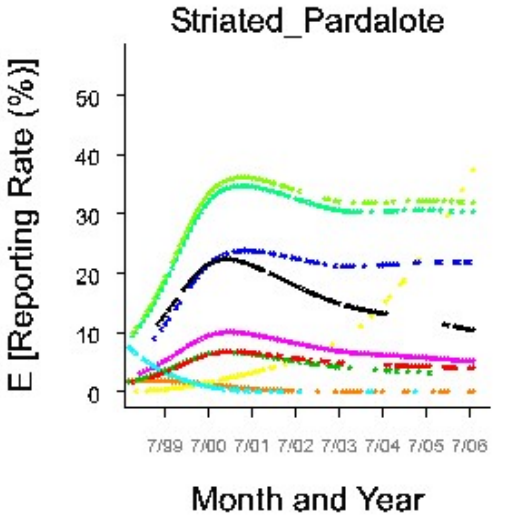
DRP
FIN
FLB
GAW
MAC
MDD
RIV

p-val (Ibra trends)	0.052
E[Jul 99]	27.590
E[Jul 06]	11.233
% change	-59.286
% change (linear)	-64.470
p-val (lin trend)	0.000

Striated Pardalote



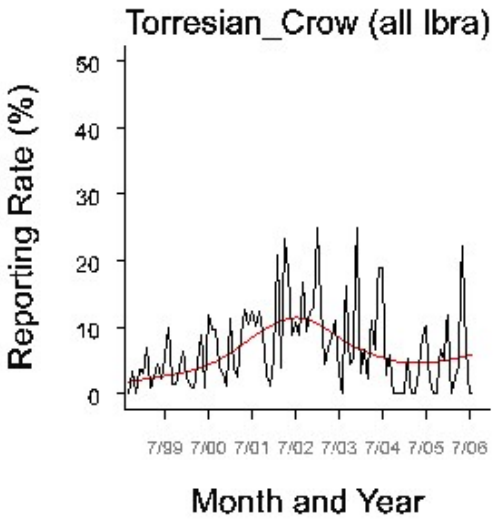


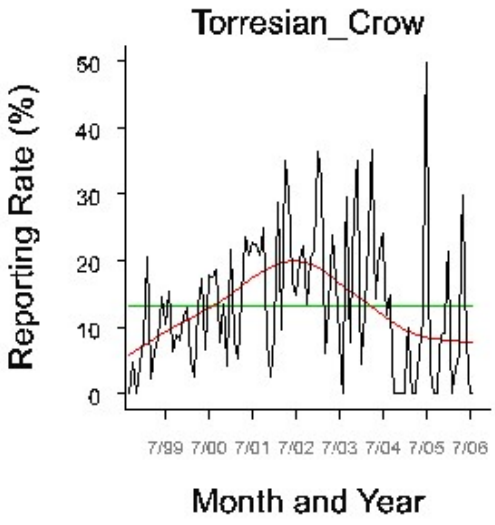


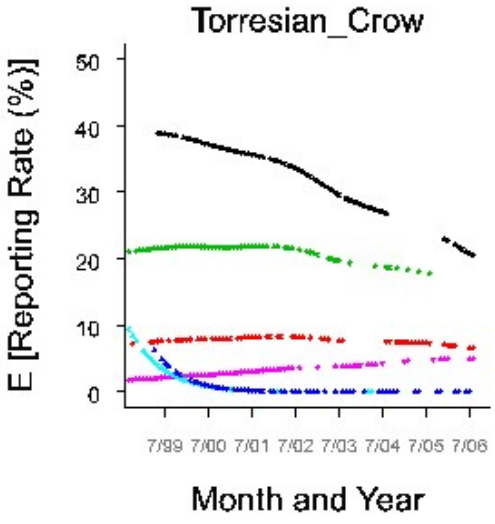
BBN	FLB
CYP	GAW
DL	MAC
DRP	MDD
FIN	RIV

p-val (Ibra trends)	0.001
E[Jul 99]	11.535
E[Jul 06]	6.673
% change	-42.148
% change (linear)	-21.359
p-val (lin trend)	0.089

Torresian Crow



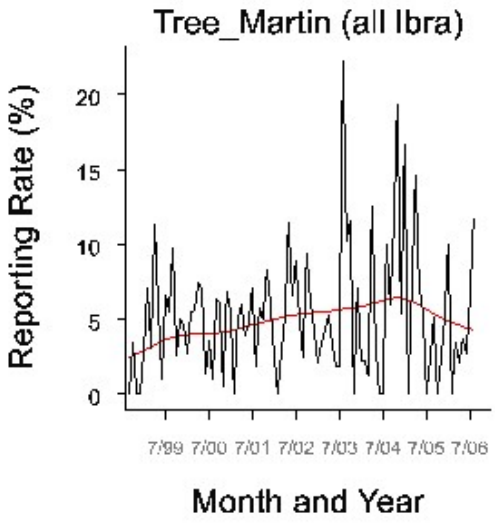


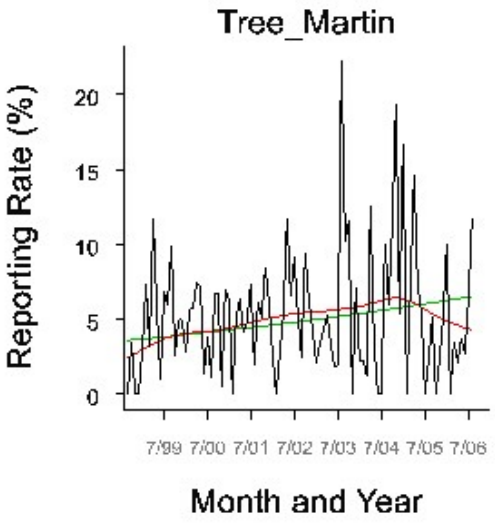


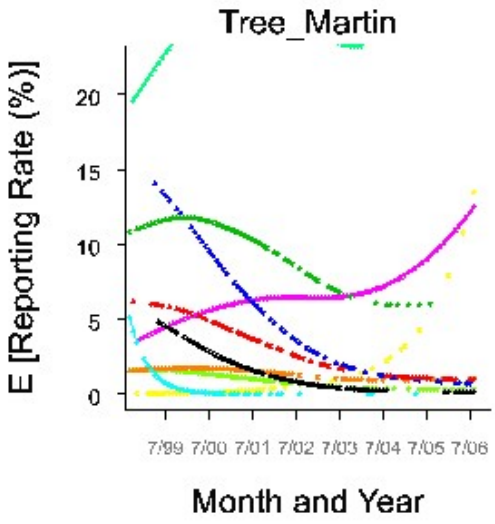
BBN MAC
CYP
DL
DRP
FIN

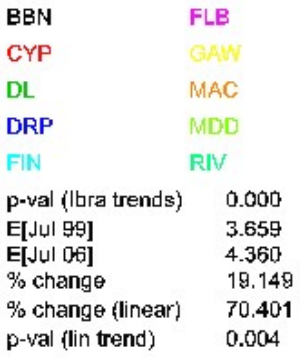
p-val (Ibra trends)	0.201
E[Jul 99]	9.267
E[Jul 06]	7.740
% change	-16.479
% change (linear)	0.256
p-val (lin trend)	0.989

Tree Martin

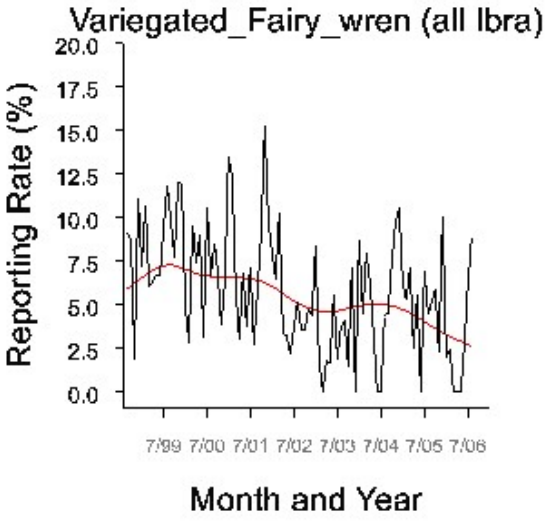

Tree_Martin (all Ibra)
Reporting Rate (%)
0
5
10
15
20
7/99 7/00 7/01 7/02 7/03 7/04 7/05 7/06
Month and Year

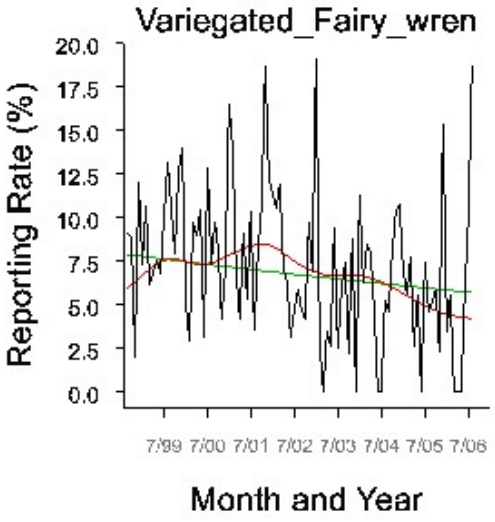

Tree_Martin
Reporting Rate (%)
0
5
10
15
20
7/99 7/00 7/01 7/02 7/03 7/04 7/05 7/06
Month and Year

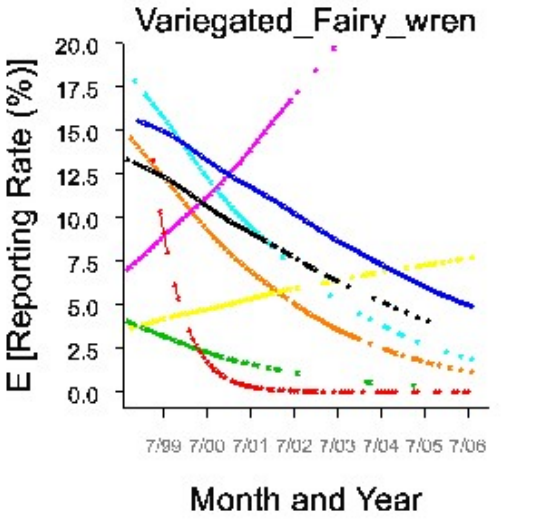

Tree_Martin
E [Reporting Rate (%)]
0
5
10
15
20
7/99 7/00 7/01 7/02 7/03 7/04 7/05 7/06
Month and Year

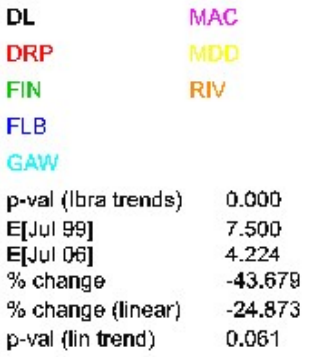

BBN
CYP
DL
DRP
FIN
FLB
GAW
MAC
MDD
RIV
p-val (Ibra trends) 0.000
E[Jul 99] 3.659
E[Jul 06] 4.360
% change 19.149
% change (linear) 70.401
p-val (lin trend) 0.004

Variegated Fairy-wren

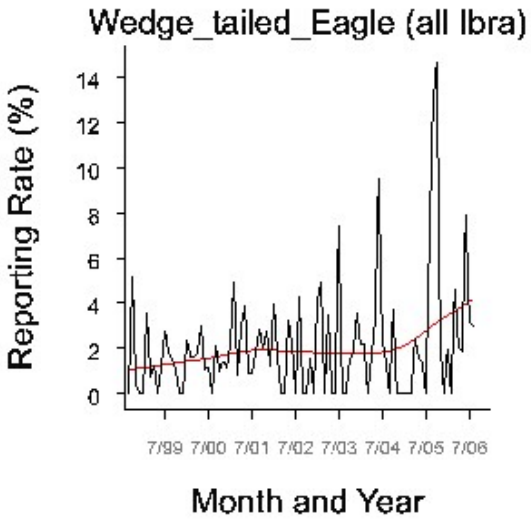


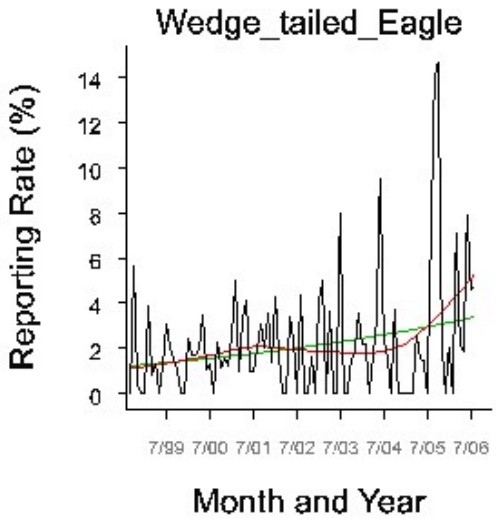


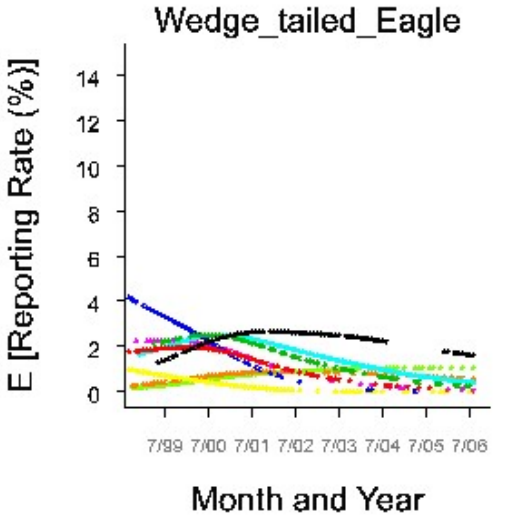




Wedge-tailed Eagle



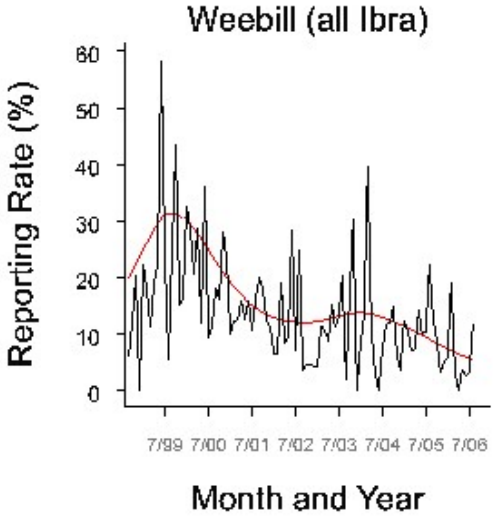


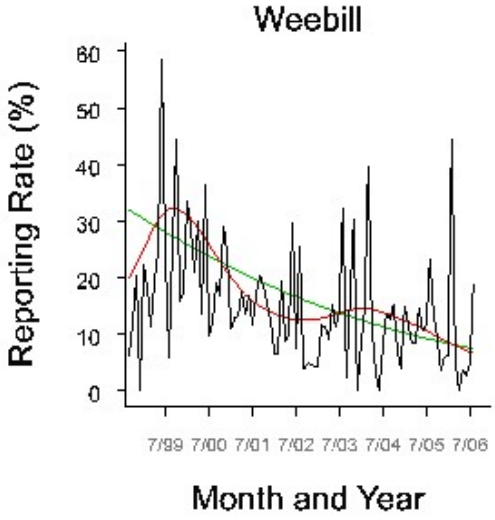


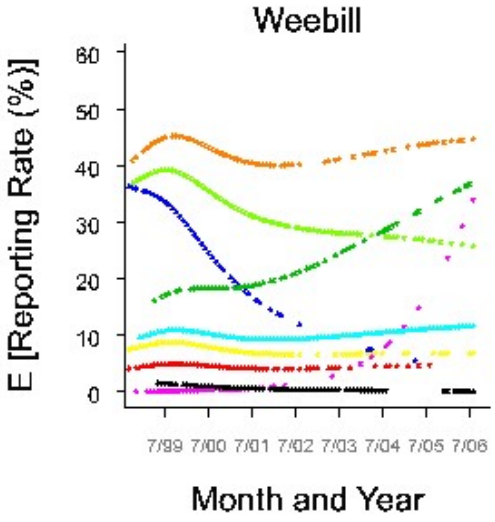
BBN GAW
DL MAC
DRP MDD
FIN RIV
FLB

p-val (Ibra trends)	0.018
E[Jul 99]	1.344
E[Jul 06]	5.090
% change	278.726
% change (linear)	144.217
p-val (lin trend)	0.000

Weebill



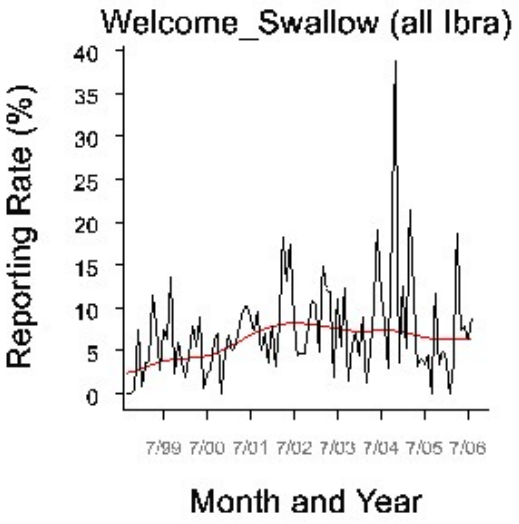


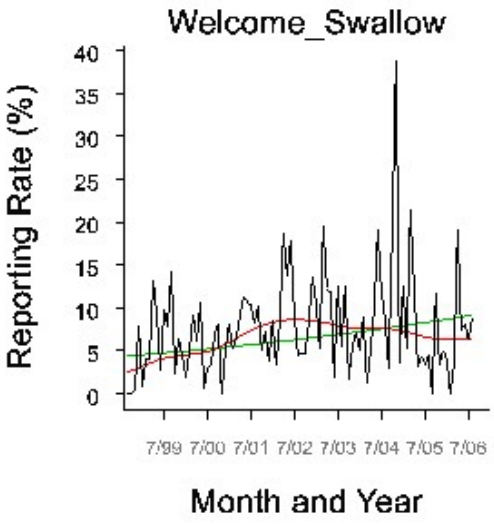


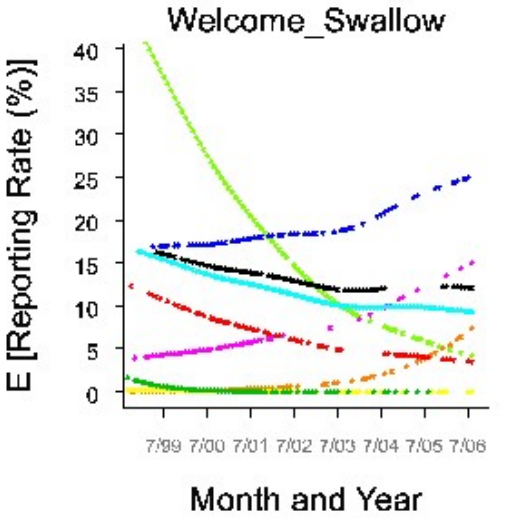
BBN GAW
DL MAC
DRP MDD
FIN RIV
FLB

p-val (Ibra trends)	0.008
E[Jul 99]	31.779
E[Jul 06]	6.971
% change	-78.064
% change (linear)	-73.026
p-val (lin trend)	0.000

Welcome Swallow



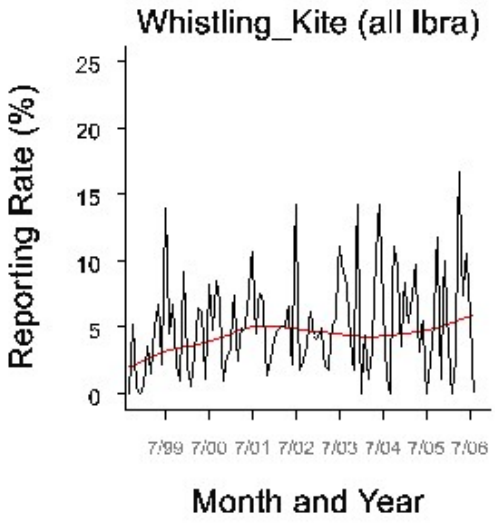


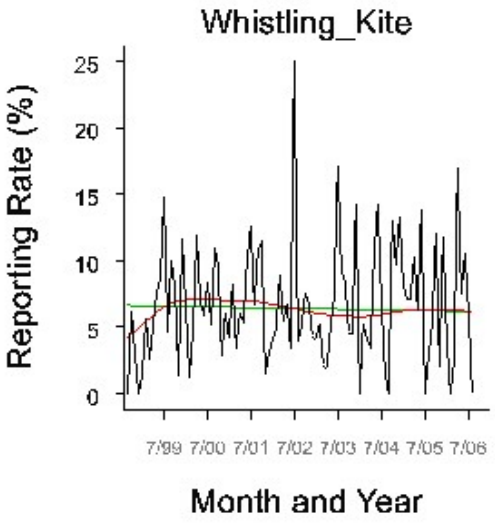


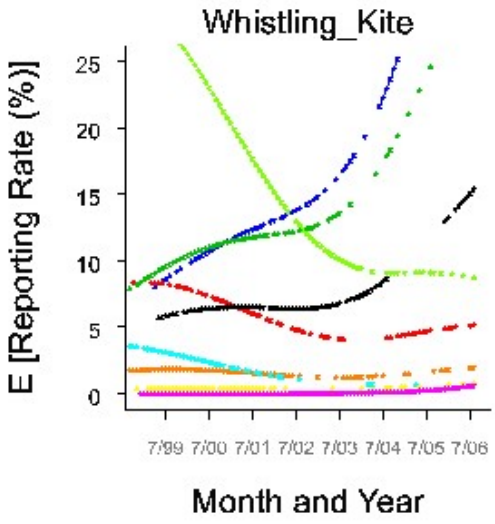
BBN	GAW
CYP	MAC
DL	MDD
DRP	RIV
FLB	

p-val (Ibra trends)	0.000
E[Jul 99]	4.116
E[Jul 06]	6.448
% change	56.659
% change (linear)	91.393
p-val (lin trend)	0.001

Whistling Kite



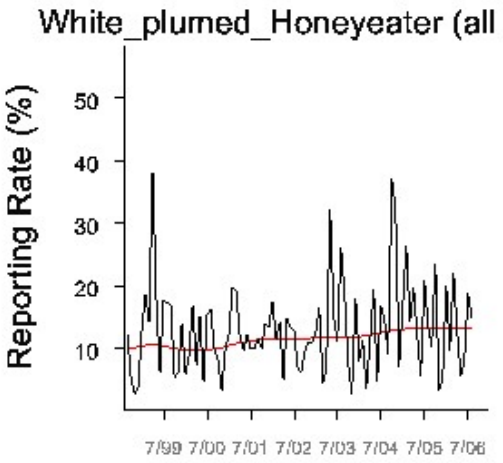


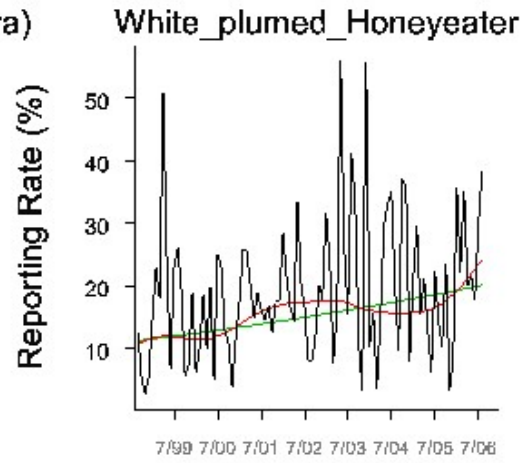


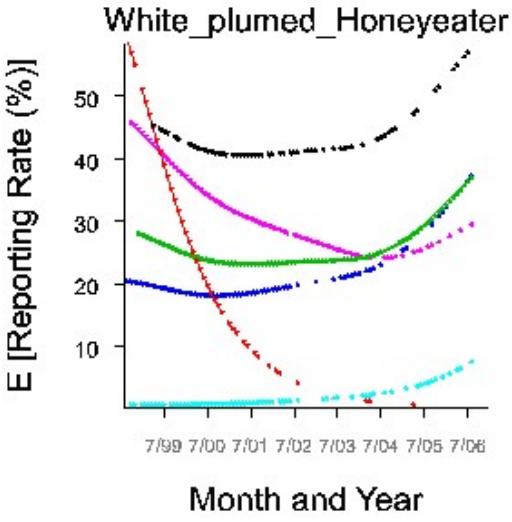
BBN FLB
CYP GAW
DL MAC
DRP RIV
FIN

p-val (Ibra trends)	0.000
E[Jul 99]	6.489
E[Jul 06]	6.222
% change	-4.120
% change (linear)	-5.990
p-val (lin trend)	0.755

White-plumed Honeyeater



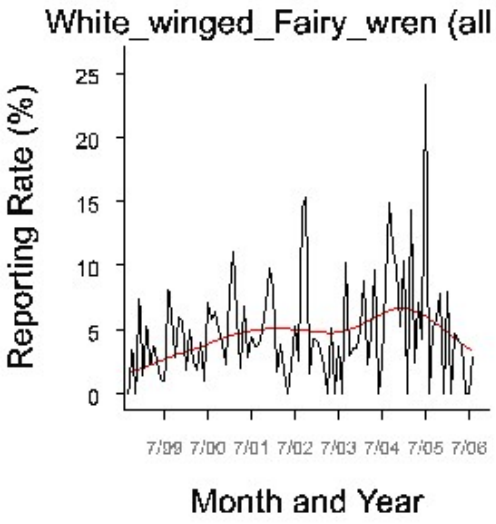


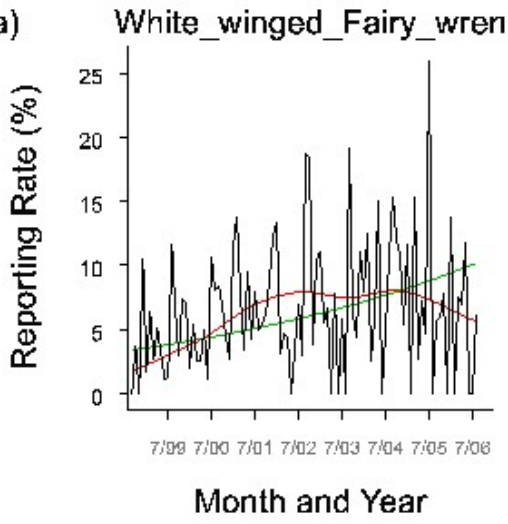


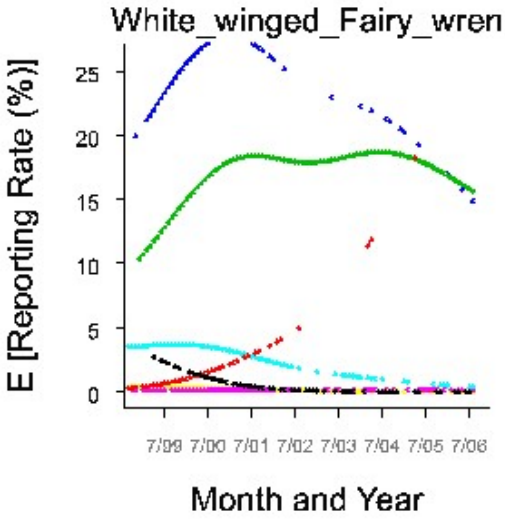
DRP RIV
FIN
FLB
MAC
MDD

p-val (Ibra trends)	0.000
E[Jul 99]	11.856
E[Jul 06]	23.418
% change	97.514
% change (linear)	66.962
p-val (lin trend)	0.002

White-winged Fairy-wren



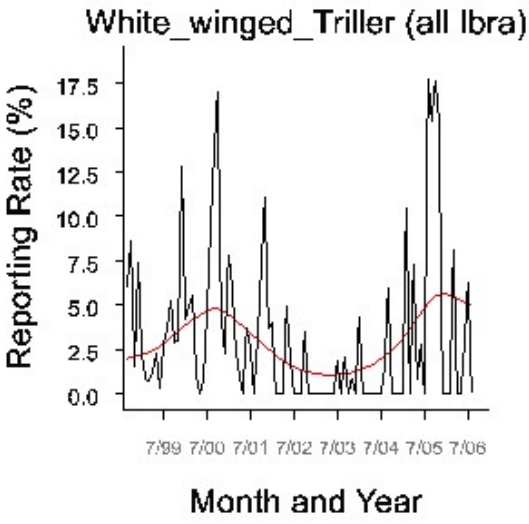


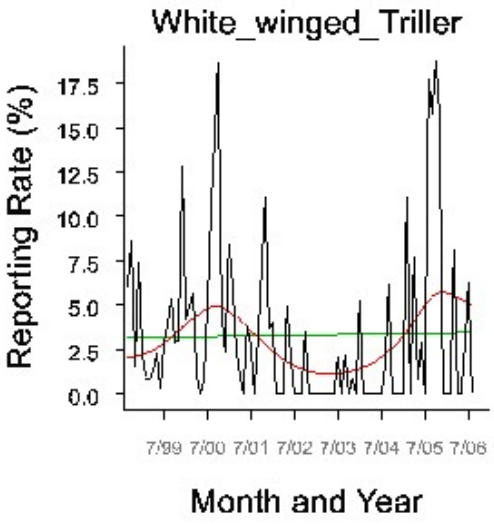


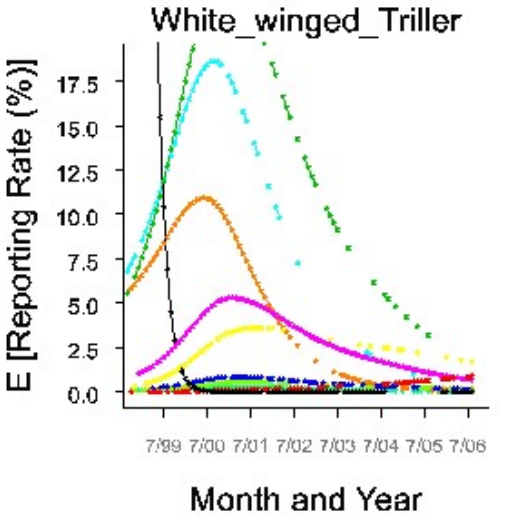
DRP MDD
FIN RIV
FLB
GAW
MAC

p-val (Ibra trends)	0.009
E[Jul 99]	3.012
E[Jul 06]	5.788
% change	92.143
% change (linear)	161.676
p-val (lin trend)	0.000

White-winged Triller



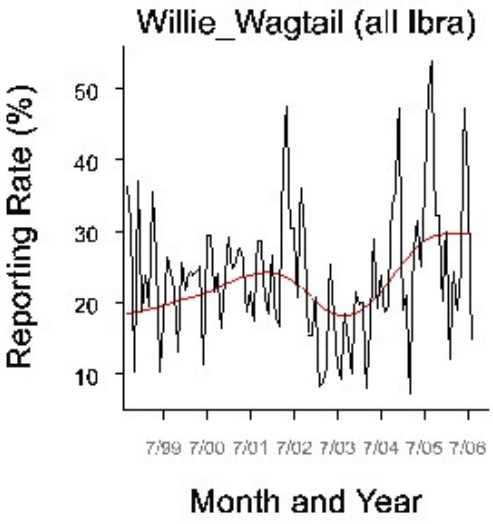


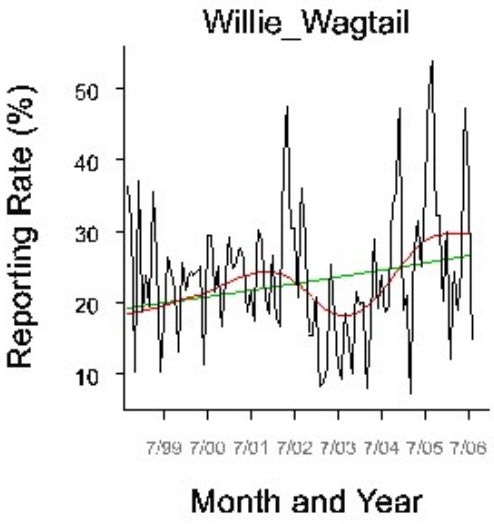


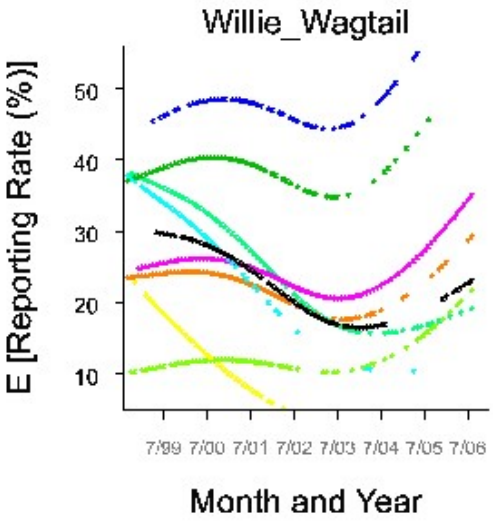
BBN	FLB
CYP	GAW
DL	MAC
DRP	MDD
FIN	RIV

p-val (Ibra trends)	0.000
E[Jul 99]	2.822
E[Jul 06]	5.115
% change	81.272
% change (linear)	8.031
p-val (lin trend)	0.732

Willie Wagtail



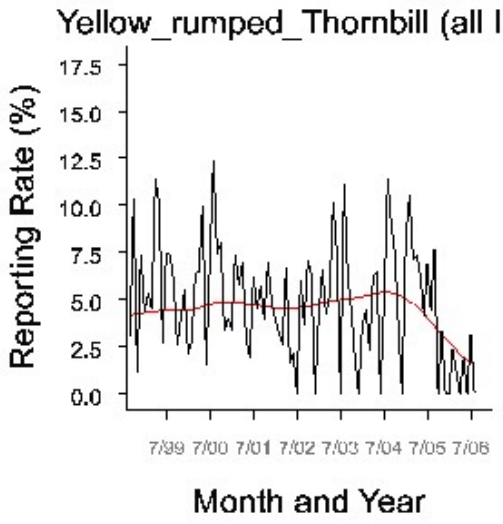


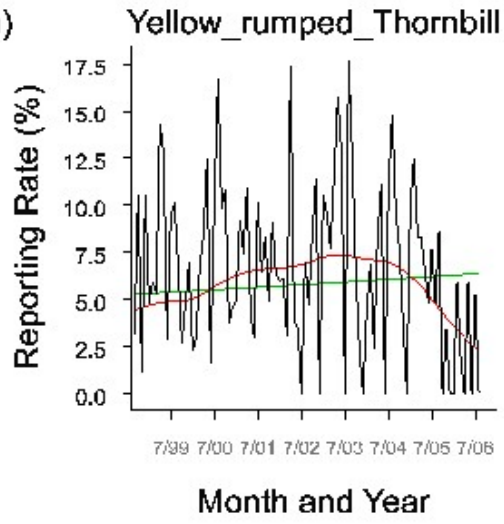


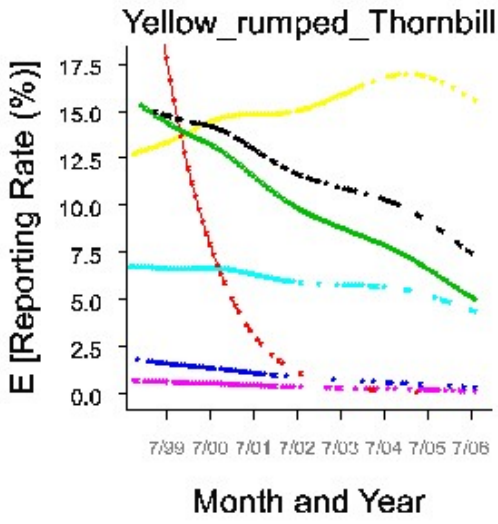
BBN	FLB
CYP	GAW
DL	MAC
DRP	MDD
FIN	RIV

p-val (Ibra trends)	0.010
E[Jul 99]	19.497
E[Jul 06]	29.627
% change	51.952
% change (linear)	33.472
p-val (lin trend)	0.003

Yellow-rumped Thornbill



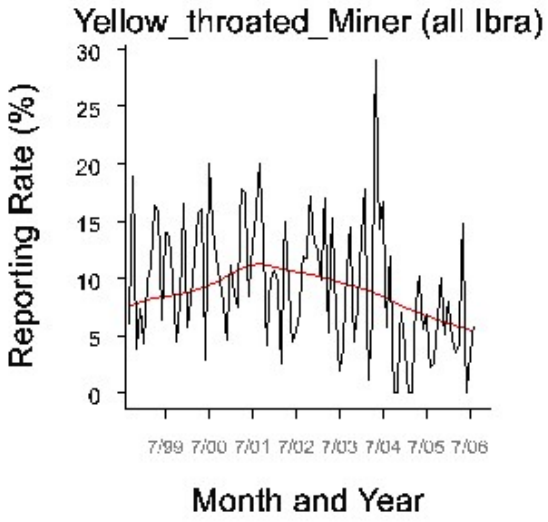


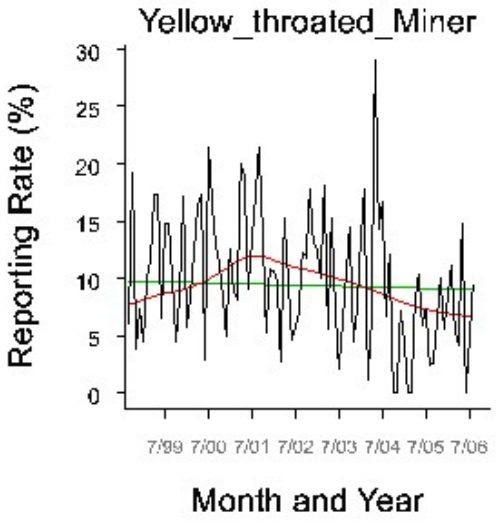


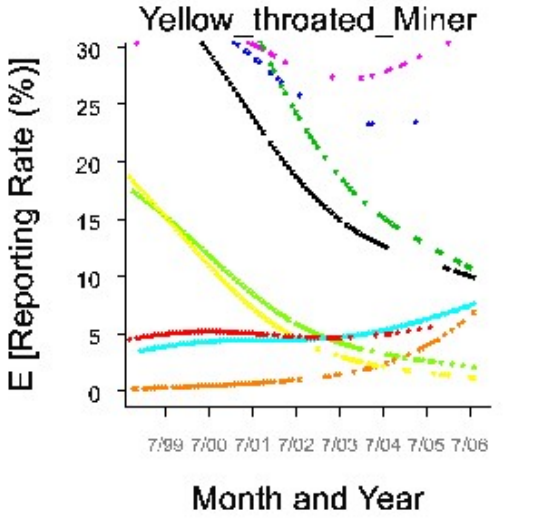
DRP MDD
FIN RIV
FLB
GAW
MAC

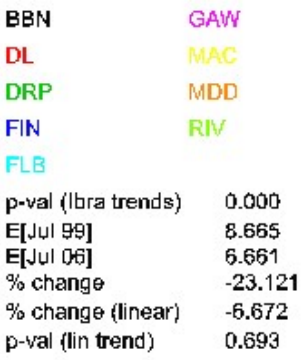
p-val (Ibra trends)	0.010
E[Jul 99]	4.896
E[Jul 06]	2.486
% change	-49.219
% change (linear)	18.059
p-val (lin trend)	0.404

Yellow-throated Miner

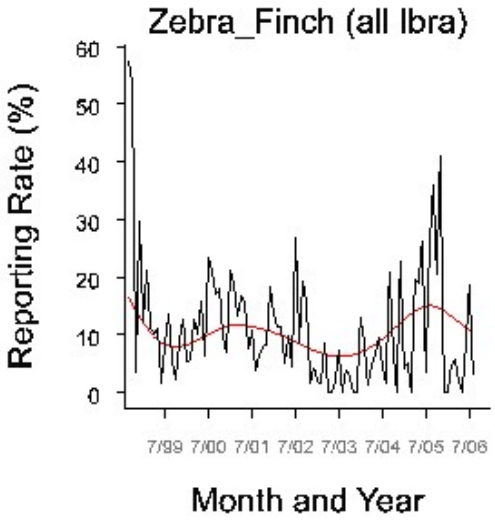


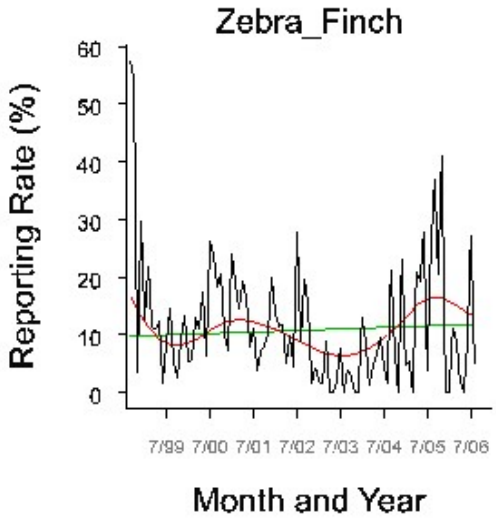


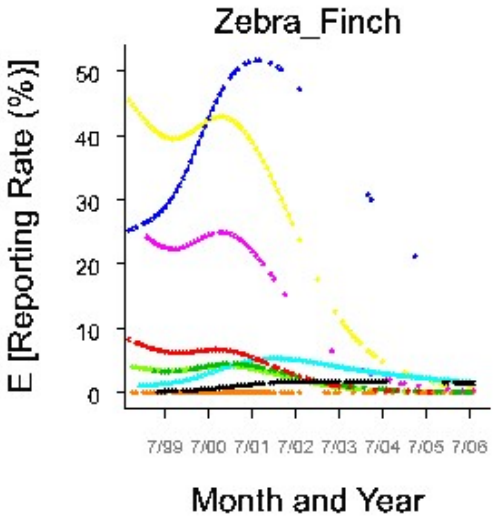




Zebra Finch







BBN GAW
DL MAC
DRP MDD
FIN RIV
FLB

p-val (Ibra trends)	0.000
E[Jul 99]	8.706
E[Jul 06]	13.674
% change	57.054
% change (linear)	18.522
p-val (lin trend)	0.379

Appendix 2: Detailed results of principal component analysis

Latent roots

1	2	3	4	5	6
136049	55571	23315	9164	3796	2131

Percentage variation

1	2	3	4	5	6
59.15	24.16	10.14	3.98	1.65	0.93

Trace

230025

Latent vectors (loadings)

	1	2	3	4	5
coeff[1]	0.00842	0.27345	0.07942	0.13613	-0.22844
coeff[2]	-0.35432	0.07954	-0.78533	0.46177	0.19343
coeff[3]	0.23063	0.79618	0.20128	0.41019	-0.02192
coeff[4]	-0.88339	0.24195	0.25079	-0.19475	-0.21900
coeff[5]	0.17252	0.43796	-0.48959	-0.72352	-0.12278
coeff[6]	-0.10514	0.18614	0.18393	-0.19637	0.92026

	6
coeff[1]	0.92094
coeff[2]	0.02707
coeff[3]	-0.32195
coeff[4]	-0.11092
coeff[5]	-0.01290
coeff[6]	0.18713

Significance tests for equality of final K roots

K	Chi-square	df
2	4.70	2
3	30.91	5
4	91.06	9
5	182.68	14
6	314.02	20