A statistical examination of the Hastings Rarities

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THIS PAPER IS an attempt to establish the consistency or otherwise of the great flood of rarities from east Sussex and west Kent during the first two decades of this century, from the internal evidence presented by the statistical aspects of the records themselves. The consequences of various hypotheses which assume the validity of all the records will be tested against the numerical evidence.

METHODS

For the analysis, all records of rarities for the counties of Kent and Sussex for the years 1895-1954 inclusive have been extracted from Walpole-Bond (1938), Harrison (1953), the *South-Eastern Bird Reports* for 1936-47, the *Kent Bird Reports* for 1952-54 and the *Sussex Bird Reports* for 1948-54. Between them these publications cover the period and region required.

The region has been split up into three parts: area X is contained inside a circle with centre Hastings Pier and radius 20 miles, except that the whole of Romney Marsh (apart from Hythe) is included; area YS is the rest of Sussex not in area X and area YK is the rest of Kent similarly. The inclusion of the whole of Romney Marsh in X is necessary because a number of records in the sources do not specify exact places in the Marsh, and the allocation of these records to the correct area would be problematical if the 20-mile radius definition were strictly adhered to.

The 60-year span has been divided into two eras, 1895-1924 inclusive, called A, and 1925-1954 inclusive, called B. The records dealt with here thus fall into one of six categories, XA, XB, YSA, YSB, YKA or YKB. These six combinations of areas and eras will be termed area-eras for short.

For the purposes of this paper a rarity is defined as a species whose recorded occurrences have been completely enumerated in the books and reports mentioned, and which has not occurred on the average more than once per year in any of the six area-eras.

The reduction to tabular form of such a heterogeneous collection of data as these reports of occurrences of bird rarities over the 60 years is not easy. The records exhibit all gradations from virtual certainty about the identity of the bird to considerable vagueness, and some rules for their acceptance or rejection are essential. Within the limits necessarily imposed by the "strictness" or "leniency" of the sources, I have tended towards strictness and the reduction of acceptances to a minimum. No record has been accepted for the purpose of the following analysis unless all the following conditions are satisfied:

(i) The name of the observer in the field or identifier (if bird dead) must be given in the source.

(ii) The date must be given to within a year.

(iii) No doubt must be expressed by the author (or editor) about the validity of the record; if a record occurs in more than one source no doubt must be expressed by any of the authors (or editors). All square-bracketed records have thus been rejected. (In a few cases it was not quite obvious whether the author was expressing doubt or not, but, in accordance with the general principle, such records were rejected.)

(iv) The bird must have been *seen*; records based on birds heard but not seen have been rejected.

(v) The bird must have been seen or taken from the land; no records of birds observed from ships (including lightships) have been admitted.

Since occurrences of rarities other than singly are important in these data, some formal definition of an occurrence is required. In this paper, two birds are said to have occurred together (and so to constitute one occurrence) if they were seen or taken within five miles and within seven days of each other. A set of more than two records of individual birds forms a single occurrence, if, when arranged in chronological order, every adjacent pair satisfies the condition for a single occurrence. A set of records also forms a single occurrence if the birds were specifically recorded as having come from a flock, even though successive records were not all within seven days of each other. Occurrences relating to one bird, two birds and more than two birds will be called *singular, dual* and *plural* respectively, while *multiple* will be used to cover dual and plural combined. Sometimes reports are vague about numbers and in such cases the minimising rule is brought into play: thus "several" is taken to mean "three" (i.e., the smallest integer greater than two), "a small flock" is taken as "four", and if the author or editor expresses a belief that several records refer to the same individual, this is taken to be so and only a single occurrence is allowed.

For the purpose of analysis an index of the rarity of a species is required. In this paper the number given for England in *The Handbook* is used as an index and, as before, when any doubt is expressed there about numbers the smaller one is taken. Again records from sea-based observers have been rejected. Certain objections to this

TABLE 1—HYPOTHETICAL EXAMPLES OF TWO-WAY TABLES (SEE TEXT BELOW)

	(a) Exact proportionality		(b) With random errors added (not significantly different from proportionality)		(c) Significant departure from proportionality	
	Winter	Summer	Winter	Summer	Winter	Summer
Class II	100	300	98	310	100	200
Class I	50	150	54	145	50	150
	$\chi^2_1=0$		$\chi^2_1=0.21$ $(0.7>P>0.5)$		$\chi^2_1=7.94$ $(P<0.01)$	

index can be raised; in particular, it does not cover the whole period under investigation, and hence weights records in favour of the earlier period. Its main advantage is that it was compiled by one man, independently of the present investigation, and is, therefore, consistent and objective. In the main, species and subspecies will be divided into three classes: class I rarities, which have less than 20 accepted English examples in *The Handbook*; class II, with 20-99 examples (inclusive); and class III, consisting of those whose occurrences are not enumerated in *The Handbook*. It is possible that some class III species have actually less than 100 records over the period covered by *The Handbook*, and so overlap class II, because *The Handbook* does not appear to be entirely consistent in this matter. However, this overlap, if it exists, is small and unimportant.

The only statistical, in the sense of probabilistic, techniques used in the following analysis are the χ^2 (chi-squared) goodness-of-fit test and the Poisson distribution. The χ^2 test is applied here mostly to frequencies arranged in two-way tables, for example the frequencies of the occurrence of rarities of different classes in different seasons. The simplest situation in such a table occurs when the relative frequencies in one set of categories (e.g. rarity classes) are the same for all categories in the other set (seasons). The first part (a) of Table 1 shows such an ideal situation. Each rarity group has three times as many summer records as winter, and each season has twice as many class II records as class I. The hypothesis that the relative frequencies are of this simple type is called in statistical parlance the *null hypothesis*. Of course in any particular sample the frequencies would almost never be exactly proportional, even if the null hypothesis were true, because of random errors in them. These random errors might give rise to something like Table 1(b). Here the hypothesis of proportionality is not disproved. However, these random errors can only distort the picture to a certain degree and χ^2 can be regarded as a measure of whether this distortion has reasonably been exceeded in any particular case.

Under certain conditions the relative frequencies of different values of χ^2 turning up can, if the null hypothesis is true, be calculated. The average value of χ^2 equals a quantity called the number of degrees of freedom, which itself depends only on the form of the table, not on the numbers in it. A value of χ^2 much in excess of the average value means that a very unlikely event has taken place, if the null hypothesis is true, and hence that it should be discarded for some other hypothesis more in accordance with the facts. Thus in Table 1(c) while class I has three times as many summer as winter records, class II has only twice as many. This gives a large χ^2 and tends to discredit the null hypothesis. Similarly, for a χ^2 with two degrees of freedom (written χ^2_2), a value of six would be exceeded in only 5% of cases if the null hypothesis were true. Thus values of χ^2_2 greater than six are said to be significant at the 5% level, or significant $P=0.05$, and provide considerable evidence that the null hypothesis is false. It should be pointed out that the null hypothesis can fail to be true in two rather different ways. In one situation, the true frequencies may not be proportional, so that occurrences among class III rarities might have a relatively greater frequency in winter than occurrences in the other two classes; this is a systematic deviation from the null hypothesis. The other situation occurs when the random deviations are unusually large, but the true frequencies are still proportional; this may occur if the thing being measured comes from a heterogeneous population, made up of several sub-populations with unequal chances of being represented. Thus our class III rarities comprise a number of species of which some are relatively much commoner than others, and this may produce a random deviation larger than average. In practice it is often possible to distinguish the two kinds of deviations, since one has a pattern while the other has not. In the analysis which follows we shall meet examples where the null hypothesis is well supported, and where there are deviations both random and systematic from it.

The Poisson distribution is a theoretical probability distribution, often useful in the description of the frequencies of rare events. It is completely specified by its mean value. For a general description of χ^2 and this distribution a standard statistical textbook should be consulted (e.g. Snedecor 1946).

THE RESULTS

The results to be discussed embrace 1,015 occurrences, involving 1,360 birds of 168 species and subspecies. Subspeciation is as given in *The Handbook*. This is generally satisfactory for our purposes, but the Yellow Wagtail (*Motacilla flava*) complex has presented difficulties. In particular the "Sykes" type (resembling *beema*) must be a class I rarity

TABLE 2—TOTAL OCCURRENCES IN DIFFERENT RARITY CLASSES

An explanation of the area-eras will be found on page 283, and of the rarity classes on page 285

Area-era	Class I	Class II	Class III	Total
XA	243	108	165	516
XB	54	51	103	208
YSA	15	16	45	76
YSB	19	13	32	64
YKA	11	11	22	44
YKB	26	28	53	107
Total	368	227	420	1,015

by our definition, though modern records make it much commoner and this bird actually makes up nearly 10% of the class I records for the rest of Kent in the years 1925-54 (YKB). However, since *The Handbook* is being used for the rarity index, no exceptions are made to its classification of subspecies and records.

The complete list of records used (which is not given in full here, but is being deposited at the Edward Grey Institute, Oxford) has been split up in various ways for the investigation, and the following aspects will be presented and discussed: the relative frequencies of singular, dual, plural and total occurrences in the three rarity classes for the six area-eras; also the distribution of occurrences in the various seasons of the year and in different years throughout the periods concerned.

The distribution of the total number of occurrences

We consider first the total number of occurrences in each rarity class for each area-era, the relevant figures being shown in Table 2. The most obvious feature of these figures is that the distribution of the occurrences among the rarity classes in the Hastings Area for the period 1895-1924 (XA) is quite different from the distribution in the remaining area-eras. A χ^2 test carried out on these remaining area-eras gives $\chi^2_8 = 3.55$, showing no significant difference in the proportions of the three rarity classes. Considering the heterogeneous nature of the data, the agreement is remarkably good. Table 3, however, compares Hastings (XA) with the total of the remaining area-eras and it will be seen immediately that XA has nearly twice the proportion of class I rarities that the remainder has, balanced by a deficiency of class III

TABLE 3—TOTAL OCCURRENCES FOR HASTINGS 1895-1924 COMPARED WITH ALL OTHER AREA-ERAS COMBINED

Area-era	Class I	Class II	Class III	Total
Hastings (XA)	243	108	165	516
Remainder	125	119	255	499

rarities. In contrast to the homogeneity of the remainder of the area-eras, these discrepancies are highly significant, producing the enormous χ^2_2 value of 57.40.

So far we have considered only the distribution of the numbers in the different rarity classes, without looking at the total number of occurrences in the different area-eras. It is clear from inspection of the figures for the rest of Sussex and Kent (YS and YK) that the trend in the two regions over the period of time concerned is quite different. While the total number of records for YS has actually declined slightly for era B compared with era A, that for YK has markedly increased. (It should not be assumed from the YS figures that the amount of bird-watching has gone down in that area over the period considered, because if a species has too many records in the second period for it to be enumerated completely in the sources, or if there are more than 30 records in that period, its contribution is automatically eliminated from these figures by the rules previously laid down. This tends to minimize the number of records for the second era, but does not bias the other comparisons we are making.) In the absence of agreement between the trends for these two areas we cannot say, with any conviction, what the figures for XA ought to be. Incidentally, even if YS and YK had agreed in their trends over the two eras, no significance test comparing them with X would have been valid, since we have deliberately chosen XA for investigation on account of its unusually large total of rarities (the fact of this choice does not invalidate significance tests on the other aspects we are considering). It is fair to note, however, that the trend for the Hastings Area does not agree with either of the other areas. It is nearer to YS, but to be comparable the XA figure should be about 247 instead of the 516 actually recorded.

The distribution of numbers at each occurrence

Considering class I rarities first, and dividing occurrences into singular and multiple (there being insufficient records in most area-eras to divide the multiple occurrences into dual and plural), we get Table 4. The proportion of multiple records in XA (25.1%) is much higher than in the other area-eras (average 12.0%). A χ^2 test excluding XA gives $\chi^2_4=2.00$, indicating homogeneity among the "remainder" group, while comparison of XA with the remainder gives $\chi^2_1=8.65$ ($P<0.01$), showing that XA disagrees with the remainder. This is even more marked if we divide the multiples into duals and plurals as shown in Table 5. Here $\chi^2_2=12.76$, a more extreme value than the previous $\chi^2_1=8.65$. The remainder group has only one plural occurrence for class I rarities—the Paddock Wood Snow Finches* of 1906 (*Handbook*, 1: 155).

*All scientific names are given in the final appendix on pages 382-384.

TABLE 4—DISTRIBUTION OF SINGULAR AND MULTIPLE OCCURRENCES FOR CLASS I RARITIES

An explanation of the area-eras will be found on page 283, of singular and multiple occurrences on page 284 and of the rarity classes on page 285 (see Appendix on pages 297-298)

Area-era	Singular	Multiple	Total
XA	182	61	243
XB	46	8	54
YSA	14	1	15
YSB	18	1	19
YKA	10	1	11
YKB	22	4	26
Total	292	76	368

The situation with class II rarities is very much the same as with class I; the proportion of multiple records for XA is 26.9%, while for the remainder group it is 12.6%, with YSA the highest at 18.8%. Again the remainder group gives a low $\chi^2_4=1.20$, indicating homogeneity, while comparison of XA with the remainder gives a significant $\chi^2_2=7.36$ ($P<0.05$).

With class III rarities the situation is less clear cut, for the XA proportion of multiple records, here 22.8%, is slightly less than that for YSA, which has 24.4%. This difference of YSA from the rest of the remainder group is almost entirely due to records for one species, the Glossy Ibis, which contributes four out of the 15 multiple occurrences for YSA. The same species contributes three out of the 38 multiple occurrences for XA. The result of this is that XA and YSA do not differ significantly, though XA differs from the remaining four area-eras ($\chi^2_2=7.29$). One other aspect of the data deserves mention. In the remainder group, the percentages of plural occurrences for class III, II, and I rarities are 5.1, 2.5, and 0.8 respectively; that is, they fall steadily, being greatest in the least rare class. This is what one might expect *a priori*. However, in the XA group, the percentages (in the same order) are 9.1, 5.6 and 9.9, and show no such trend.

TABLE 5—DISTRIBUTION OF SINGULAR, DUAL AND PLURAL OCCURRENCES FOR CLASS I RARITIES

Area-era	Singular	Dual	Plural	Total
Hastings (XA)	182	37	24	243
Remainder	110	14	1	125
Total	292	51	25	368

The distribution of occurrences by season

For nearly 97% of the occurrences, the month of the occurrence is given in the source. Where it is not given, the occurrence is excluded from the analysis in this section. Where a single bird stayed for several months, the first month is taken. If a flock was present and members were shot from it or seen in more than one month, then the month of the first record is again used. The numbers for most of the months in most of the area-eras are too small to allow any accurate comparisons, so they have been grouped in four seasons of winter (December-

TABLE 6—DISTRIBUTION OF OCCURRENCES BY SEASONS

An explanation of the area-eras will be found on page 283, and of the rarity classes on page 285

Area-era and rarity class		Number of occurrences				
		Spring (Mar/May)	Summer (Jun/Aug)	Autumn (Sep/Nov)	Winter (Dec/Feb)	Total
XA	I	101	42	63	36	242
	II	25	38	29	13	105
	III	42	35	56	27	160
	Total	168	115	148	76	507
XB	I	16	15	16	4	51
	II	12	11	27	1	51
	III	35	16	41	10	102
	Total	63	42	84	15	204
YSA	I	5	0	7	3	15
	II	6	1	7	2	16
	III	7	3	18	7	35
	Total	18	4	32	12	66
YSB	I	6	4	9	0	19
	II	3	2	6	2	13
	III	9	11	8	3	31
	Total	18	17	23	5	63
YKA	I	2	3	3	3	11
	II	4	2	3	0	9
	III	1	3	6	7	17
	Total	7	8	12	10	37
YKB	I	11	9	3	3	26
	II	12	8	7	1	28
	III	20	6	14	10	50
	Total	43	23	24	14	104

February), spring (March-May), summer (June-August) and autumn (September-November). The frequency of occurrences for all area-eras, rarity classes and seasons is given in Table 6.

The distribution by seasons is much more variable in the remainder group than the previous distributions considered. A remarkable feature is the growth of spring records in the rest of Kent from 18.9% in era A to 41.3% in era B, while the rest of Sussex shows no such change though summer records have increased there. Both these areas agree, however, in showing a decline in the proportion of autumn and winter records as we pass from era A to era B. YS shows a fall of 22.3% from 66.7% to 44.4%, and YK a fall of 23.0% from 59.5% to 36.5%. By contrast, the autumn and winter records for the Hastings Area rise slightly from 44.2% to 48.5%. It is also noticeable that, while the seasonal distributions of total occurrences for XB and YSB are very similar (giving $\chi^2_3=1.26$), those for XA and YSA are quite unlike each other ($\chi^2_3=15.70$). The XA records have another property not shared by any of the other area-eras in that they have a considerably greater proportion of spring records for class I rarities than for classes II and III.

The distribution of records by years

The relevant data on distribution by years are given in Table 7 for all area-eras and rarity classes. Considering first the earlier era A, we find that for both YS and YK the distribution of the number of class I rarities is very close to a Poisson; the actual frequencies and the theoretical ones of the Poisson distributions with the same means are shown in Table 8.

These good fits to the theoretical distributions suggest strongly that there were no large differences in the numbers of class I rarities reaching these areas each year during this period, or in the intensity of observations made on them; for, if there had been any such large differences, the actual frequency distributions would have had longer "tails" and the Poisson model would no longer have fitted well. The distribution of class I rarities in XA is obviously quite unlike the last two considered. In the first place it shows strong time trends, there being a sharp increase in the early 1900s followed by an equally sharp decrease after 1916. In such circumstances it is unreasonable to expect a theoretical distribution to fit well and, in fact, the Poisson distribution is a very bad fit here. It is somewhat surprising that the peak years in X, namely 1905, 1914 and 1915, do not correspond with any peaks in the other two regions.

Differences between regions are much less remarkable for classes II and III. In YSA and YKA the Poisson fits less well, due doubtless to increasing heterogeneity in the population sampled, while the distributions for XA are less extreme than that for XA class I.

TABLE 7—DISTRIBUTION OF OCCURRENCES BY YEARS

An explanation of the area-eras will be found on page 283, and of the rarity classes on page 285

Era A

Area-era and rarity class		1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	Total
	I	2	4	2	0	1	4	7	7	10	7	19	9	13	8	15	6	14	14	8	27	22	15	6	4	3	5	0	3	6	2	243
XA	II	3	2	0	2	1	1	7	3	4	8	7	4	3	3	3	2	3	2	7	9	7	5	1	5	2	3	2	4	2	3	108
	III	3	2	5	4	3	6	3	9	11	9	16	9	3	6	4	7	10	5	5	5	5	4	4	4	4	4	1	5	2	7	165
	Total	8	8	7	6	5	11	17	19	25	24	42	22	19	17	22	15	27	21	20	41	34	24	11	13	9	12	3	12	10	12	516
	I	0	0	0	1	0	1	0	1	1	0	1	0	0	1	3	1	1	0	2	0	0	1	0	0	0	0	0	1	0	0	15
YSA	II	0	0	1	1	0	0	1	0	0	3	3	1	2	0	0	0	0	0	0	0	0	0	0	1	0	0	1	2	0	0	16
	III	0	1	1	0	4	1	3	1	3	1	0	3	3	4	5	2	1	3	0	1	0	0	1	1	1	1	0	2	0	2	45
	Total	0	1	2	2	4	2	4	2	4	4	4	4	5	5	8	3	2	3	2	1	0	1	1	2	1	1	1	5	0	2	76
	I	0	1	1	0	1	0	0	2	0	1	1	1	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	11
YKA	II	0	0	0	1	2	0	0	0	0	1	0	0	3	1	0	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0	11
	III	1	3	1	1	0	0	0	0	2	0	0	4	1	1	1	0	0	1	1	0	1	1	0	0	1	2	0	0	0	0	22
	Total	1	4	2	2	3	0	0	2	2	2	1	5	6	2	1	0	2	2	1	0	1	1	0	0	1	2	1	0	0	0	44

Era B

		1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	
XB	I	0	1	0	0	0	0	2	1	2	3	3	6	3	1	0	0	0	1	0	1	0	3	3	3	2	4	5	4	3	3	54
	II	2	1	1	1	1	0	2	2	0	1	1	0	2	2	0	1	2	0	2	0	0	0	2	3	2	5	7	4	2	5	51
	III	5	1	0	3	1	0	1	0	2	3	3	6	5	4	2	1	0	2	0	1	1	2	6	1	6	11	7	10	7	12	103
	Total	7	3	1	4	2	0	5	3	4	7	7	12	10	7	2	2	2	3	2	2	1	5	11	7	10	20	19	18	12	20	208
YSB	I	0	1	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	4	2	1	2	2	19
	II	0	0	0	0	0	0	1	0	0	2	0	0	0	1	0	0	0	1	0	0	0	1	0	3	1	2	0	1	0	0	13
	III	0	1	1	2	3	0	2	2	2	0	0	1	4	0	0	0	0	0	0	1	0	0	1	2	3	2	1	2	1	1	32
	Total	0	2	1	3	3	0	4	3	2	2	0	1	4	1	0	0	0	1	0	1	0	1	3	7	4	8	3	4	3	3	64
YKB	I	0	0	0	0	0	0	0	0	1	1	0	1	0	1	1	0	0	2	2	0	1	0	0	0	1	4	2	1	4	4	26
	II	0	1	1	0	0	0	0	1	0	2	1	1	1	0	0	1	0	0	1	0	0	2	0	3	0	2	1	1	4	5	28
	III	0	0	0	1	1	0	0	2	0	0	2	2	1	0	1	0	2	2	2	3	1	1	1	0	1	5	6	3	10	6	53
	Total	0	1	1	1	1	0	0	3	1	3	3	4	2	1	2	1	2	4	5	3	2	3	1	3	2	11	9	5	18	15	107

TABLE 8—THE NUMBER OF CLASS I RARITIES PER YEAR IN THE REST OF SUSSEX AND KENT DURING 1895-1924

	Number per year	Years with this number	Poisson frequencies
Rest of Sussex (YSA)	0	18	18.2
	1	10	9.1
	2	1	2.3
	3	1	0.4
Rest of Kent (YKA)	0	21	20.8
	1	7	7.6
	2	2	1.4
	3	0	0.2

In era B, we see a number of trends in time which make any agreement with a simple theoretical model out of the question. The major factor is the post-war increase in bird-watching, with its resulting effect on the number of rarities seen from 1946 onwards. Conversely, the war itself has depressed the number of records in X and YS below that of the pre-war years (although YK does not seem to show this), while during the period 1925-1939 there seems to be a trend towards an increasing number of records. In spite of these effects of the number of observers (for that is what they most likely are), the figures show two points of interest. One is that the post-war boom in bird-watching has increased total records in all regions by much the same proportion when compared with the 1925-1939 period. The figures are 3.3 to 1 for X, 3.0 to 1 for YS and 3.9 to 1 for YK. The other point is that, although the post-war records for class III rarities in the X area are now running at a level higher than the mean for era A, while class II rarities are about equal, the post-war bird watchers have not managed to average even half the number of class I rarities per year that XA shows, while their best effort, five in 1951, is less than a fifth of the peak year (1915) in XA.

DISCUSSION

We began this investigation by noting the remarkable number of rarities recorded from the Hastings Area during the earlier part of this century. No attempt has been made to assess the intrinsic probability of obtaining so many rarities from a relatively small area in such a short time, for the obvious reason that the information necessary to determine such a probability—such as numbers of observers, intensity of observation and actual totals of rare birds to be seen—is almost wholly lacking. Instead we have classified the records in various ways and compared the distributions for the Hastings Area so obtained with those for two neighbouring areas, and during two eras. A number of striking differences in these distributions has been obtained, and most of them have been in the direction of making XA, the Hastings Area for 1895-1924, the odd one out. We now consider what hypotheses would have to be adopted to explain these differences, assuming the validity of all the records.

For the total number of occurrences in the three rarity classes, we found XA to be quite different from the remainder of the area-eras which did not differ significantly among themselves. This discrepancy in XA is unlikely to be due simply to more or more enthusiastic observers, since the effect of this in YK, as shown in the differences between YKA and YKB, has been to leave the proportions in the rarity classes almost unchanged. Nor can X be a specially good area for class I rarities, judging by its performance during era B and since (when, in spite of the establishment of an observatory at Dungeness, there has still been no exceptional proportion of class I rarities). We must thus postulate observers who failed to report many class II and III rarities while recording all class I rarities. Also the evidence from the distribution by years shows that, to obtain the number of class I rarities actually recorded for XA, something more than twice the activity of post-war observers would be required. Whether there is any direct evidence either of the suppression of lesser rarities or of this enormously increased activity in the XA area-era I must leave others better qualified to say, but the possibility seems inherently unlikely.

The distribution of the numbers at each occurrence for class I and class II rarities shows XA to have an excessive number of multiple occurrences when compared with the rest of the area-eras. Here again a mere change in the number of observers cannot account for it, since the proportion of multiple occurrences has remained effectively unchanged for YS and YK in both eras, even though the type of observation has largely changed from shooting to watching and the number of observers has greatly increased. Again to judge by the performance of XB, X has not recently been a specially good area for multiple occurrences. Hence we must suppose XA to have had observers exceptionally skilled in detecting and collecting multiple occurrences. Now although our definition allows a certain separation in both space and time for the birds in a multiple occurrence, in fact the birds in most multiple occurrences were from the same place and date, or from what was stated to be the same flock at different dates. It is difficult to conceive of an observer who will produce markedly more multiple occurrences than average. For if a person is skilled enough to track down one rarity he surely will not omit to look around for the possible presence of others of the same species. Nevertheless, the presence of such unlikely types seems to be the only suitable explanation, assuming that we can discard the possibility, even among class I rarities, that some single occurrences were suppressed.

The changes in the distribution of rarities by seasons, although not exactly the same for YS and YK, are in one respect similar: the percentage of spring and summer records has risen as we pass from era A to era B. This might perhaps be the expected consequence of a changeover from shooting, which is primarily an autumn and winter activity, to bird-watching, which is much more an all-the-year-round activity. The greater rise of spring records in Kent than in Sussex is probably a reflection of a real difference in the numbers of spring migrants passing through the two counties, which seems likely for reasons of geography. From the position of the X area, one would expect it to behave more like the rest of Sussex than the rest of Kent. This is so in era B where, as we have shown above, the distribution by seasons of records in XB and YSB do not differ significantly. In era A, by contrast, the spring and summer percentages are both greater for X than for YS, and slightly greater for XA than for XB. Thus, once again, the XA records need a special hypothesis to account for them. The agreement between XB and YSB suggests, also once again, that it is the observers whose activities must be different. For their era they were more active in the spring and summer than observers in the rest of the two counties.

The distribution of records by years adds a further anomaly to the XA records, in that the frequencies for yearly numbers of class I rarities fit well to a simple theoretical distribution for YSA and YKA, but not to XA. The YSA and YKA records thus suggest a more or less static situation with regard to both numbers of rarities and numbers and activities of observers, while XA suggests violent fluctuations in one or the other or both. The era B records are interesting in showing that a trend like the post-war increase in bird-watching is reflected very similarly in all three areas, which we might expect *a priori*, in contrast to the situation in era A when area X is so different from the other two regions.

It will now be clear from the foregoing discussion that if we accept all the XA records as genuine we are led to postulate an extraordinary situation regarding the activities of observers operating in this area-era. While the apparent results of their activities cannot be proved to be impossible, they appear so inherently unlikely as to call very seriously in question the basic assumption that all the XA records are genuine. I conclude that the data themselves constitute a strong *prima facie* case for a thorough investigation into the circumstances in which the Hastings Rarities came into existence.

SUMMARY

(1) A statistical investigation has been made of certain aspects of the many rare birds recorded in east Sussex and west Kent in the era 1894-1924 (the "Hastings Rarities"), using other areas in Kent and Sussex and a later era (1925-1954) for comparison.

(2) The basic unit for the analysis is an occurrence, which may involve one, two or more birds. Species and subspecies are classified into three rarity classes based on the number of English occurrences given in *The Handbook*. The distribution of the total number of occurrences of birds in three different classes of rarity shows the Hastings records in the era 1895-1924 to be anomalous, the remaining area-eras being consistent with one another.

(3) The distribution of the numbers at each occurrence for species of the greatest rarity is also shown to be anomalous for Hastings 1895-1924 when compared with the remaining area-eras.

(4) The proportion of spring and summer records for the two areas excluding Hastings is shown to have increased from era 1895-1924 to era 1925-1954, but to have decreased for Hastings. Other anomalous results involving the Hastings 1895-1924 records are pointed out.

(5) The distribution of occurrences year-by-year over the period 1895-1924 is shown to fit a simple theoretical distribution for the two areas excluding Hastings, but not to fit any such distribution for Hastings. Certain trends common to all areas for the period 1925-1954 are pointed out and the results compared with those for the earlier period.

(6) Auxiliary hypotheses necessary to account for these anomalous results are considered, on the assumption that all the records are genuine.

(7) It is concluded that these hypotheses are exceedingly unlikely to be true and that the basic assumption of the validity of all the records must be questioned.

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Appendix—Rarity classes of species and subspecies analysed

A full explanation of the rarity classes will be found on page 285. Scientific names are given in the final appendix on pages 382-384

CLASS I (rarities with 1-19 English examples accepted in *The Handbook*)

Wilson's Petrel
Madeiran Petrel
Madeiran Little Shearwater
Cape Verde Little Shearwater
Audubon's Shearwater
Mediterranean Shearwater
North Atlantic Shearwater
Bulwer's Petrel
Little Egret
Great White Heron
American Bittern
Blue-winged Teal
King Eider
Kite
Lesser Kestrel
Sociable Plover
Semipalmated Ringed Plover
Killdeer
Caspian Plover
American Golden Plover
Asiatic Golden Plover
Dowitcher

Upland Sandpiper
Slender-billed Curlew
Solitary Sandpiper
Spotted Sandpiper
Greater Yellowlegs
Lesser Yellowlegs
Marsh Sandpiper
Grey-rumped Sandpiper
Terek Sandpiper
Baird's Sandpiper
White-rumped Sandpiper
Semipalmated Sandpiper
Buff-breasted Sandpiper
Broad-billed Sandpiper
Black-winged Pratincole
Ivory Gull
Great Black-headed Gull
Mediterranean Black-headed Gull
Bonaparte's Gull
Sooty Tern
Bridled Tern
Yellow-billed Cuckoo
Black Lark
Calandra Lark
White-winged Lark
Short-toed Lark
Crested Lark
Red-rumped Swallow
Thick-billed Nutcracker
Wallcreeper
Dusky Thrush
Black-throated Thrush
Alpine Ring Ouzel
Rock Thrush
Desert Wheatear
Western Desert Wheatear
Western Black-eared Wheatear
Eastern Black-eared Wheatear
Isabelline Wheatear
Black Wheatear
North African Black Wheatear
Siberian Stonechat
Thrush Nightingale
White-spotted Bluethroat
Cetti's Warbler
Savi's Warbler
Moustached Warbler
Great Reed Warbler
Eastern Great Reed Warbler
Melodious Warbler
Icterine Warbler
Olivaceous Warbler
Orphean Warbler
Rüppell's Warbler
Sardinian Warbler
Rufous Warbler
Brown-backed Warbler
Dusky Warbler
Brown Flycatcher
Collared Flycatcher
Masked Wagtail
Grey-headed Wagtail
Black-headed Wagtail
"Sykes's" Wagtail
South European Grey Shrike
Lesser Grey Shrike
Corsican Woodchat Shrike
Masked Shrike
Pine Grosbeak
Black-headed Bunting
Rock Bunting
Rustic Bunting
Little Bunting
Western Large-billed Reed Bunting
Eastern Large-billed Reed Bunting
Snow Finch

CLASS II (rarities with 20-99 English examples accepted in *The Handbook*)

Balearic Shearwater
Purple Heron
Squacco Heron
Surf Scoter
Red-footed Falcon
Little Crake
Pectoral Sandpiper
Pratincole
Cream-coloured Courser
Whiskered Tern
Gull-billed Tern
Caspian Tern
Scops Owl
Snowy Owl
Tengmalm's Owl
Slender-billed Nutcracker
White's Thrush
Aquatic Warbler
Barred Warbler
Yellow-browed Warbler
Red-breasted Flycatcher
Alpine Accentor
Richard's Pipit
Tawny Pipit
Red-throated Pipit
Woodchat Shrike
Serin

CLASS III (rarities with occurrences not enumerated in *The Handbook*)

Great Shearwater
Night Heron
White Stork
Glossy Ibis
Red-crested Pochard
Ferruginous Duck
Ruddy Shelduck
Goshawk
White-tailed Eagle
Gyr Falcon
Baillon's Crake
Eastern Little Bustard
Great Snipe
Black-winged Stilt
Red-necked Phalarope
Pomarine Skua
Long-tailed Skua
Iceland Gull
Sabine's Gull
White-winged Black Tern
Roseate Tern
Black Guillemot
Pallas's Sandgrouse
Bee-eater
Roller
Golden Oriole
Chough
British Dipper
Red-spotted Bluethroat
Scandinavian Chiffchaff
Siberian Chiffchaff
Water Pipit
Rose-coloured Starling
Northern Bullfinch
Two-barred Crossbill
Ortolan Bunting