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An Investigation of the Effectiveness of Rehabilitation of Birds as shown by Ringing Recoveries

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EXECUTIVE SUMMARY

1. This report aims to assess *post-release survival* of rehabilitated birds and compare this to the survival of non-rehabilitated birds using distance and time elapsed between ringing and finding. Comparisons are made between selected species and ecological groups of species to enable an assessment of rehabilitation success. From this it is possible to prioritise species best suited for rehabilitation in terms of post-release survival if resources available are limited. This report does not consider the moral, ethical or conservation value of rehabilitating individuals of a species.

2. The BTO National Ringing Scheme is concerned with the analysis and collation of reports (recoveries) of ringed birds, both healthy wild birds and those ringed following rehabilitation. Recoveries include both live recaptures and birds found dead. Details of ringing: species, age, sex, date (day, month, year), place of ringing (latitude and longitude) and details for finding; finding condition (dead, alive, alive and released etc), finding circumstances (natural causes, predation, shot etc) and finding status (unknown, nesting, roost, colony etc) are recorded. From these it is possible to assess the distance travelled and the duration (time elapsed) between ringing and finding.

3. After removal of records deemed inaccurate, a total of 1,483 recoveries of dead adults or juvenile birds were available from the BTO National Ringing database for rehabilitated birds (RH). These covered 73 species of which only 17 had more than 10 recoveries. Mute Swan, Guillemot and Kestrel had more than 100 recoveries each. Time elapsed and distance travelled from ringing to recovery were compared between RH and non-rehabilitated recoveries (non-RH). The two datasets were mutually exclusive. Sample sizes for non-RH birds were considerably larger than RH samples.

4. Analyses focused on 11 selected species with more than 20 RH recoveries each, these were: Barn Owl, Buzzard, Gannet, Guillemot, Herring Gull, Kestrel, Little Owl, Mallard, Mute Swan, Sparrowhawk and Tawny Owl. Where RH sample sizes for a species were less than 20 birds, these species were placed in seven groups of ecologically similar species. The groups were: corvids, seabirds, wildfowl, raptors, herons, passerines and gulls. In addition to the 11 species comparisons, RH recoveries for Common Scoter were compared with non-RH for eider (an ecologically similar species), as there were only eight non-RH recoveries for Common Scoter.

5. Mann-Whitney U tests showed that there were significant differences in median time elapsed and distance travelled between RH and non-RH birds for the majority of the 11 species. Median time elapsed and distance travelled was greater for non-RH recoveries. Buzzard was the only species not to show a significant difference in median time elapsed and distance travelled. The seven of species groups also showed a significant difference in median time elapsed between RH and non-RH recoveries. Non-RH recoveries had a longer time elapsed between ringing and finding. Less clear cut differences existed between RH and non-RH for median distance, but differences were most pronounced for seabirds and wildfowl.

6. The significance of the differences in distribution of recoveries against time elapsed between RH and non-RH birds were tested using the Kolmogorov-Smirnov 2-sample test. This was conducted for three time periods of recoveries:
   (1) all recoveries;
   (2) all recoveries excluding the first two months and
   (3) those within the first year only.
   For all recoveries within species comparisons, large differences between RH and non-RH birds occur within the first year, especially the first two months post-release (highest number for RH birds) and differences are significant for all species except Buzzard, Mallard, juvenile Kestrel and juvenile Tawny Owl. Beyond two months, the distribution is more similar between RH and non-RH bird. At least 90% of the RH recoveries for Gannet, Guillemot, Common Scoter, Little Owl and adult Barn Owl occur within the first year.

7. Where a species sample size was sufficient, separate analysis of juveniles and adults showed recoveries of RH were broadly similar between the two. However, despite the rehabilitation success of adults and juveniles being similar, the maximum difference between RH and non-RH occurred with adults as non-RH juveniles had a greater percentage of rapid recoveries than adults. This was especially true for Barn Owl, Tawny Owl and Kestrel. Gannet, Guillemot and Little Owl have approximately twice the number of recoveries within the first year for RH compared to non-RH, as do adult and juvenile Herring Gull, adult Kestrel and adult Tawny Owl. Species with little difference between RH and non-RH include Sparrowhawk, Mallard and Mute Swan. There was also little difference between RH and non-RH for juvenile Barn Owl and juvenile Kestrel. Relationships are similar when the first two months are excluded, except that significance of the differences between RH and non-RH are reduced, although the difference for Guillemot is still apparent.

8. Within the first year only, recoveries of RH and non-RH are similar for Mallard, Kestrel, Tawny Owl and Mute Swan. In contrast, recoveries of RH are higher compared to non-RH recoveries for Buzzard, Gannet, Guillemot, Common Scoter, Herring Gull, Little Owl, Sparrowhawk and Barn Owl, especially within the first two months. The percent of recoveries for RH birds in the first year is three times that of non-RH recoveries for Guillemot, with nearly 90% of the recoveries in the first year occurring within the first month.

9. Small sample sizes for RH recoveries relative to non-RH recoveries for the species groups meant analysis of percentage of recoveries with time elapsed was restricted to adults and juveniles combined. For these groups of species, similar results were obtained when considering all recoveries and exclusion of those recovered within the first two months. All groups of species had significant differences (Kolmogorov-Smirnov 2-sample test) in cumulative percentage of recoveries with time elapsed when considering all recoveries. Most of the RH recoveries occur within the first year and the difference in percentage of recoveries between RH and non-RH birds is greatest within the first two months. Approximately 90% of the total recoveries for RH for corvids, herons, passerines, raptors and seabirds occur within the first year, the difference between RH and non-RH being most marked in seabirds and corvids. Wildfowl and herons show the least difference between RH and non-RH recoveries.

10. The vastly different sample sizes between RH and non-RH recoveries, especially for the species groups, suggests that caution should be used in interpreting the results. However, for some of the species and groups where differences between RH and non-RH are large, these differences are likely to be ‘real’ and act as a useful indicator of the post-release survival of rehabilitated birds.

11. The report has shown that for some species, such as Guillemot and Common Scoter, post release survival is so low that the majority of the rehabilitated individuals are unlikely to re-enter the wild population. While for other species such as Mute Swan a high percentage enter the wild population. Birds can only be classed as ‘successfully rehabilitated’ in the long term if they re-enter the population and have a similar chance of survival to wild birds.

1 INTRODUCTION

1.1 Background to the BTO National Ringing Scheme

The BTO organises the Ringing Scheme covering Britain and Ireland, collates the data gathered and carries out analyses of those data. Approximately 2,000 volunteer ringers throughout Britain and Ireland ring around 750,000 birds of a wide variety of species each year, with a total ringed to the end of 2001 of over 30 million. Annually there are about 10,000 subsequent reports of ringed birds (recoveries) that have either been found dead or have been recaught at least five km from their original capture site; nearly 600,000 recoveries had been received by the end of 2001. All recoveries of birds ringed in Britain and Ireland have been computerised to facilitate analyses.

When a bird is ringed the species, age, sex, date (day, month, year) and place of ringing are recorded. Additionally, measurements are recorded for some individuals. The same information is recorded when a bird is recovered as well as details of what happened to it, both its condition (dead, alive, released etc) and the circumstances in which it was found (natural causes, predation, shot etc). The straight-linedistance and direction travelled by the bird between ringing and recovery is calculated and held on the database, as is the elapsed time.

Although almost all birds ringed by BTO ringers are healthy wild birds, a small number of rehabilitated birds are ringed each year. The elapsed time of recoveries of these birds can be compared to that for healthy wild birds to assess the level of success of rehabilitation.

Oil spills receive a lot of media coverage and in turn generate considerable public interest and awareness surrounding the rehabilitation of these oiled birds. Oil spills are just one of many causes for which birds may be rehabilitated. Rehabilitation may be seen to have two main roles, which are not necessarily mutually exclusive and consist of animal welfare and conservation of the species concerned. For some species post-release survival is low, not only is this extremely wasteful of resources and of uncertain benefit to the bird's welfare, it has low conservation value. Post-release monitoring is important to assess the effectiveness of the rehabilitation methods and may also help indicate the impact of such events as oil spills. It is probable that post-release survival rates of rehabilitated birds may differ between rehabilitation centres and analysis of recovery data may be one method to assess various rehabilitation techniques and continue to develop the codes of best practice, aimed at maximising post-release survival.

The results of an analysis of ring recoveries of North American seabirds rehabilitated after oil spills suggested the need to urgently assess the cost and effectiveness of rehabilitation efforts as post-release survival was very low (Sharpe 1996). The very low life expectancy of Guillemots *Uria aalge* in North America (Sharpe 1996) was supported by analysis of post-release survival rates for Guillemots from Britain and Ireland (Wernham *et al.* 1987). Physiological effects and physiological damage were likely to be the main reasons for the poor survival following rehabilitation (Sharpe 1996). However for other species, such as the African Penguin *Spheniscus demersus*, it has been shown that rehabilitation may indeed play a population and conservation role (Whittington 1999). Time elapsed between ringing and recovery did not differ significantly between cleaned oiled penguins and non-oiled penguins (Whittington 1999).

Drawing comparisons between rehabilitated (RH) and non-rehabilitated (non-RH) birds may however be hindered by the lack of comparable data for ringing and later recovery. This is likely to be species

specific, with some species having many more records in one or other of the categories (RH versus non-RH). This is likely to be the case for some seabirds, where there may exist more oil spill RH birds, compared to recoveries from non-RH birds. There may also be differences in the age, sex and year of ringing and recovery between RH and non-RH birds. Recovery rate is based on two probabilities: the survival of the individual and also the probability of the individual being encountered and subsequently reported. Sample sizes were small for some species and the large differences between those for RH and non-RH birds precluded detailed survival analyses in this report. Analyses will be focused on time elapsed and differences in the number of recoveries (expressed as a percentage of total recoveries) between RH and non-RH birds.

1.2 Aims

The report aims to assess differences in *post-release survival* of rehabilitated and non-rehabilitated birds, using distance and time elapsed between ringing and finding for recoveries of *dead* birds. Comparisons are made between species and ecological groups of species to enable an assessment of the relative likelihood of success between species and groups. This report does not consider the survival of the species during the rehabilitation stage, prior to their release back into the wild.

2 METHODS

2.1 Selection of RH and non-RH recoveries

The RH recoveries were extracted from the BTO National Ringing database by selecting all the recoveries where birds had been held for *more than* 24 hours (ringing condition; category 6) prior to ringing. This is used as an indicator of the birds having been rehabilitated and includes birds rehabilitated for a wide range of reasons, including oil spills. In contrast, the non-RH birds were selected by excluding all those recoveries where the birds had been held for *more than* 24 hours prior to ringing. Thus the datasets were mutually exclusive.

2.2 Cleaning of the dataset for analysis

For both the RH and non-RH birds the same screening procedures were used to ensure the analyses were comparable and based on reliable records in terms of ringing and finding accuracy. These selection criteria are outlined below:

Age and sex
Recoveries for birds ringed in the nest (EURING age code 1) were excluded from the analyses as these are likely to show a different post-release survival compared to those that have already left the nest. These accounted for approximately 4% of the 1,878 recoveries and the majority of these related to Mute Swan *Cygnus olor*, Barn Owl *Tyto alba*, Lesser Black-backed Gull *Larus fuscus* and Herring Gull *Larus argentatus*. For the analyses, all recoveries with EURING age code 2 and above were included as these represent fledged. In addition for some of the analyses, data for juveniles and adults were analysed separately as they may to show a different response to rehabilitation. Thus for this purpose, EURING ages codes 3 and 5 (< 1 year old) and codes 4, 6 and above (> 1 year old) were classed as juveniles and adults respectively. For the majority of the cases, the sex of the individual is unknown (70%), but for those where sex is known, male and female are approximately equal (males 56%). All records were included.

Date
Records where either the ringing or finding date were inaccurate (ie not known to within 15 days) were excluded. Note: records are included where the finding date is not recorded explicitly by the finder, but the date of the correspondence reporting the recovery is entered instead as previous investigations have shown that such dates are usually within a few days of the date of finding (Mead pers comm).

Location
Records where ringing and finding co-ordinates were accurate to within six minutes of the given location were included.

Status
Records classed as 'unknown' for both ringing and finding status. This results in the removal of birds recorded at the nest, in a roost, at a colony and in moult for example, which may bias the results. In the case of RH recoveries, approximately 99% of the records have unknown finding status, thus removal of records other than unknown will have had a negligible effect on the results.

Finding condition
Only records with a finding condition indicating that the birds were dead were included. Live recaptures are more likely to be subject to spatial biases than dead recoveries as recaptures are dependent on the distribution of ringers, which tends to be aggregated. These recaptures were therefore excluded from all analyses. Note that all finding circumstances were included. For some analyses, especially where distance between ringing and finding location is important, it is desirable to exclude records that have been recorded as 'moved before finding'. However, in this report, as a large number of the recoveries relate to seabirds, a large proportion of recoveries (24%) which are

indeed 'moved by water' before finding. As none of the records were moved by means other than water and this is regular for seabirds found on the shoreline (Wernham *et al.* 2002), these records were retained.

2.3 Data analysis

Comparisons were made between RH and non-RH birds for post-release survival in terms of time elapsed and distance travelled from ringing to finding for recoveries (dead only) for single species where samples were large enough (at least 20 RH recoveries). For Common Scoter *Melanitta nigra* there were no comparable recoveries for non-RH, so to allow a comparison, RH recoveries for Common Scoter were compared with non-RH recoveries for Eider *Somateria mollissima*. Eider is the most ecologically similar species for which sufficient recoveries were available. Due to the problems inherent in drawing conclusions from a comparison between Common Scoter and Eider, not all analyses were performed.

Species for which there were less than 20 RH recoveries were combined in groups to give a reasonable sample size. Groups were formed by combining those species with similar ecology, lifestyle and physiology. Species which adopt similar lifestyles and have similar physiology are more likely to respond to rehabilitation in the same manner. The groupings chosen for this report are not 'final' in any sense and should be viewed as exploratory.

All analyses were carried out using SAS (SAS Institute 1989). Data on the numbers of birds ringed at rehabilitation centres were not available, thus the analyses are limited to the looking at those birds which were recovered, ie known to have died, and been reported as such. As positively determining survival of individual birds is impractical, we measure overall mortality rates (*Survival rate* = 1 – *mortality rate*). We also assume throughout that the pattern of mortality (and hence survival) of recovered birds is representative of those not recovered.

2.3.1 Simple comparison between RH and non-RH birds for time elapsed and distance travelled by the species between ringing and finding

Medians were used to make comparisons between RH and non-RH recoveries for time elapsed and distance travelled due to the non-normality (strong positive skew) of the distribution of the data. Mann-Whitney U tests were used to assess the statistical significance of these differences in median time elapsed and distance travelled between RH and non-RH birds for the selected species and groups of species.

2.3.2 Analysis of time elapsed between ringing and recovery

Differences in the number of recoveries between RH and non-RH birds were expressed as the cumulative percentage against time elapsed. Three comparisons were made between recoveries for RH and non-RH birds. Firstly, the percentage of recoveries was plotted against elapsed time in six month periods for all recoveries. The other two comparisons involved a subset selected from all the recoveries; one using six month periods as before, but excluding those recoveries within the first two months since ringing and the other using recoveries within the first year only (365 days, expressed as 12 'monthly' periods ie approximately 30 days each). As the majority of RH recoveries occurred in the first two months after ringing, exclusion of this period enabled a closer comparison between those RH birds which had survived the initial critical post-release stage with non-RH birds. Where sample size allowed, analyses were carried out for juveniles and adults separately. Juveniles and adults were combined for those species where sample sizes were insufficient.

To test the statistical significance of the difference in distribution of the recoveries for time elapsed between RH and non-RH records, the Kolmogorov-Smirnov 2-sample non-parametric test was used. A non-parametric test was used due to the small sample sizes and the failure of the data to conform to normality.

2.3.3 Comparison of time elapsed for rehabilitated Guillemot recoveries between those recovered prior to 1996 and those after 1996

To assess if the rehabilitation of Guillemots has improved since rehabilitation techniques have been changed and hopefully improved after 1996, a comparison was made between records prior to 1996 and those after 1996 for time elapsed with (a) six month periods with all recoveries and (b) 30 day periods within the first year only. This was done for the adults and the juveniles combined as sample sizes were small, but enabled an assessment of any improvement in the rehabilitation procedures used by rehabilitation centres since 1996.

2.3.4 Index of the degree of rehabilitation success

The degree of skew and kurtosis of the distribution of number of recoveries for time elapsed was used to indicate the degree of success of rehabilitation (post-release survival) and allow a comparison across species. Skewness indicates the symmetry of the distribution and kurtosis concerns the peakedness of the distribution. In a normal distribution, skewness and kurtosis are both zero. Both measures can be used to indicate the difference between the RH and the non-RH distribution for time elapsed. Values of positive skewness and kurtosis will indicate a distribution with a strong peak of recoveries immediately following post-release, with a smaller number of recoveries being found in the long term. By taking a ratio from the statistic for RH and non-RH (dividing non-RH by RH), it is possible to get an indicator of the rehabilitation or post-release success. This can then be used to compare across species and rank them in order of rehabilitation success with the more positive values indicating the best post-release success. The standard measure of skew and kurtosis were obtained from the descriptive statistics provided by SAS (see Sokal & Rolf 1981 for detailed descriptions of how skew and kurtosis are calculated). Two indices were calculated for each species, the first based on skew and the second on kurtosis.

3 RESULTS AND DISCUSSION

3.1 Descriptive statistics for the RH data after 'cleaning' of inaccurate recoveries

After data selection (see section 2.2) there was a total of 1,483 recoveries of 73 species. There were 17 species with more than 10 recoveries, but 52 for which there fewer than five recoveries (Table 3.1.1). Only three species (Mute Swan, Guillemot and Kestrel *Falco tinnunculus*) had more than 100 recoveries. Raptors, seabirds and gulls generally dominate the number of recoveries. There were few live recaptures of RH birds so excluding these will have had little effect on reducing available sample sizes for the RH birds.

3.2 Simple comparison between RH and non-RH birds for median time elapsed and median distance travelled for selected species

For those species with at least 20 recoveries, Table 3.2.1 compares the median distance travelled and median time elapsed between RH and non-RH birds for all birds (adults and juveniles combined), for the 11 species with 20 or more recoveries: Barn Owl, Buzzard *Buteo buteo*, Gannet *Morus bassanus*, Guillemot, Herring Gull, Kestrel, Little Owl *Athene noctua*, Mallard *Anas platyrhynchos*, Mute Swan, Sparrowhawk *Accipiter nisus* and Tawny Owl *Strix aluco*. In addition, as there are only eight non-RH records for Common Scoter *Melanitta nigra*, RH recoveries for this species were compared with non-RH recoveries for Eider *Somateria mollissima*, an ecologically very similar species. Caution should, of course, be used when considering the results of the comparison between Common Scoter and Eider.

Although comparisons were made for all recoveries and also for adults and juveniles separately, it should be noted that for some species sample sizes are small for adults and/or juveniles.

For all species except Buzzard, the number of recoveries for adults and juveniles combined is greater for non-RH birds (Table 3.2.1). There is no clear pattern of median distance travelled amongst RH and non-RH birds whether for all birds combined or when the age classes were analysed separately. However, of the species for which significant differences were found non-RH birds generally moved further from the release location. This difference was most marked for species inhabiting marine environments. By contrast, there is always a greater median time elapsed for non-RH birds and 30 of 36 comparisons (11 of 12 for combined ages and 19 of 24 for separate ages) are significant. Buzzard was the only species to show no significant differences amongst the combined ages. Amongst juveniles only, no significant differences were found for Buzzard, Gannet and Guillemot. Amongst adults only, no significant differences were found for Mallard or Sparrowhawk.

3.3 Analysis of time elapsed between ringing and recovery for selected species

The percentage of recoveries for non-RH birds that occur within the first year varies from species to species. This will reflect the lifespan of the species, amongst other factors concerned with the probability of recovery for each species. In this report we consider the difference between RH and non-RH birds within a species.

All recoveries

When all recoveries grouped by six-month period were considered, significant differences in the distribution of recoveries with time elapsed were found for 10 of 11 species comparisons (Table 3.3.1a). Note that no statistical test was performed for the comparison between Common Scoter (RH) and Eider (non-RH) because of the potential biases. Amongst juveniles only, four of six comparisons showed significant differences as did five of six comparisons for adults. The graphs (Figs 3.3.1 & 3.3.2) show that the greatest differences between the RH and the non-RH birds occur within the first year (marked by a dashed line on Figs 3.3.1 & 3.3.2). Beyond one year, for the majority of the species, the number of recoveries shows a similar trend with time elapsed. Exceptions to this include those species where at least two thirds of the recoveries for RH occur within the first year (eg Gannet,

Guillemot, Little Owl, Common Scoter). The percentage of recoveries in the first year is higher for RH birds than non-RH birds for all species except Buzzard, which show a very similar trend in recoveries from RH and Non RH with time elapsed. Species which show least difference between RH and non-RH are Buzzard, juvenile Barn Owl and juvenile Kestrel. The differences are significant for all species except Buzzard, juvenile Kestrel, juvenile Tawny Owl and both juvenile and adult Mallard. However, failure to find significance using these tests does not necessarily imply there is no biological difference and in some cases may reflect the small sample size of RH birds.

For species where the sample size allowed separate analysis of juveniles and adults, recoveries of RH birds were broadly similar between the two age groups, but recoveries of non-RH birds differed between juveniles and adults with juveniles having a greater percentage of recoveries within a shorter time period. However, despite the rehabilitation success of adults and juveniles being similar, the maximum difference between RH and non-RH birds occurs within adults. Adults for Barn Owl, Kestrel and Tawny Owl show a bigger difference between RH and non-RH birds compared to juveniles (Table 3.3.1a).

Excluding the first two months
For the RH birds (11 species) removal of recoveries within the first two months (<60 days) results in the total number of recoveries decreasing by 46%. For the non-RH birds this resulted in a decrease of 13%. Patterns of recoveries and differences between RH and non-RH birds with time elapsed (six month periods) with exclusion of the first two months are, however, broadly similar to those when all recoveries are included (Figs 3.3.3 & 3.3.4), although the percentage of recoveries within the first year is naturally lower. The main exception to this is Guillemot, with the large difference between the number of RH and non-RH recoveries reduced compared to the consideration of all recoveries. The number of significant differences between RH and non-RH birds is reduced (for all birds combined seven of 11 comparisons are significant, for juveniles two of five and for adults three of five) (Table 3.3.1b). The level of significance of these differences is also reduced.

Within the first year only
There is a significant difference between RH and non-RH in the distribution of the percentage recoveries against 30 day periods 'month' within the first year for eight of the eleven species tested, with Kestrel, Mallard and Tawny Owl showing no significant difference (Table 3.3.1c, Fig 3.3.5). For both juveniles and adults only two of the five tests are significant (Table 3.3.1b & c, Fig 3.3.6). The graphs show little difference for RH and non-RH for Mallard (juvenile), and both adults and juveniles separately for Kestrel and Tawny Owl. For those species with a large difference in percentage of recoveries with time elapsed between RH and non-RH birds (Barn Owl, Buzzard, Gannet, Guillemot, Herring Gull, Common Scoter/Eider, Sparrowhawk), this difference largely occurs in the first two months. Interestingly Buzzard, which had a very similar percentage of recoveries for both RH and non-RH birds with six month periods, has a larger difference when expressed with 30 day periods. This again seems to be due to the number of recoveries in the first two months. The percentage of recoveries for RH Guillemots occurring in the first year is three times that of non-RH Guillemots, with nearly 90% of the recoveries in the first year occurring within the first month. This is similar for the Common Scoter/Eider comparison and Barn Owl. The results for the Guillemot are comparable with those from the work of Wernham *et al.* (1997), which used a subset of the data considered here.

Mute Swan and adult Herring Gull had the lowest percentage of recoveries within the first year (approximately 50% of the total), although there were still 20% more RH recoveries than non-RH recoveries. Gannet, Guillemot and Little Owl had approximately twice the percentage of recoveries occurring within the first year for RH compared to non-RH birds, along with adult Tawny Owl and Herring Gull (adult and juvenile combined).

Improvements since 1996
For Guillemot, cumulative percentage of number of RH recoveries with time elapsed was compared between pre-1996 and post-1996 for all recoveries with 6 month periods and those within the first

year only with 30 day periods (Fig 3.3.7). Sample size for number of recoveries was small for post-1996 relative to pre-1996 and there appears little difference in the trend of recoveries between these two periods. No significant difference was found either for all recoveries or those in the first year only (Ksa = 0.61 & 0.47, P = 0.85 & 0.98 respectively).

3.4 Comparison between RH and non-RH birds for median time elapsed and median distance travelled for groups of species

Table 3.4 compares the median distance travelled and median time elapsed between RH and non-RH birds for adults and juveniles combined for the seven groups: corvids, gulls, herons, passerines, raptors, seabirds and wildfowl. In all the groups there was a significant difference in median time elapsed between RH and non-RH recoveries with non-RH having a higher proportion of birds with a longer time elapsed between ringing and finding compared to the RH birds for all seven groups. The results for median distance travelled are mixed, with non-RH birds moving further in four of seven comparisons. The only significant differences found are for seabirds and wildfowl for which the non-RH birds move further than the RH birds.

3.5 Analysis of time elapsed between ringing and recovery for the group of species

All recoveries
Comparison of the percentage of recoveries with time elapsed between ringing and finding of RH and non-RH birds for the species groups was restricted to adults and juveniles combined due to the considerably larger sample sizes for the non-RH birds compared to the RH birds. Significant differences were found for all groups in the cumulative percentage of recoveries with six month periods (Kolmogorov-Smirnov 2-sample test, Table 3.5.1a, Fig 3.5.1). For all the groups, the cumulative percentage of recoveries is higher for RH than non-RH at an equivalent time point. For the RH birds, most recoveries occur within the first year (approximately 90% of the total recoveries for RH birds for corvids, herons, passerines, raptors and seabirds). Indeed as the sample sizes are small for RH birds, it is possible that only one or two recoveries are responsible for the trend after the first year. There is approximately a 30% difference between RH and non-RH after one year for all the groups, with the difference being greatest for seabirds. Wildfowl perhaps shows the least difference for comparison between RH and non-RH recoveries.

Excluding the first two months
Exclusion of the first two months of recoveries reveals similar trends in the pattern of RH and non-RH recoveries to those from an analysis of all recoveries (Figure 3.5.2), with the difference is only significant for passerines. The cumulative percentage of recoveries tends to be higher for RH than non-RH at an equivalent time point. However, as sample sizes are very small for the RH relative to non-RH recoveries, little emphasis can be placed on these results.

Within the first year only
For all the seven groups, the difference in percentage of recoveries between RH and non-RH tends to be greatest within the first year (Figure 3.5.3). Corvids and herons have a similar trend in RH and non-RH recoveries and are the only two groups for which the Kolmogorov-Smirnov 2-sample test is non-significant. Difference in sample size between RH and non-RH recoveries is greatest for passerines.

3.6 Index of rehabilitation success for selected species and groups

Species
Table 3.6.1 gives the measures of normality (skewness and kurtosis) and the index of skewness and kurtosis for time elapsed for the 11 selected species. There are strong significant correlations between skewness and kurtosis for the RH recoveries. This is consistent for all recoveries, excluding the first two months and within the first year only (r_s = 0.96, 0.97 & 0.99 respectively; P <0.0001, n=11 in all cases). This is also the case for non-RH recoveries; (a) for all recoveries, (b) excluding the first two

months and (c) within the first year only (r_s = 0.99, 0.99 & 0.87; P <0.001, n=11). It is to be expected then that there will be a strong significant correlation between the ratio of skewness and ratio of kurtosis for all recoveries, excluding the first two months and within the first year only (r_s = 0.86, 0.84 & 0.47; P=<0.001, 0.001 & 0.14 respectively; n=11). This is indeed the case for all recoveries and excluding the first two months, but not for those recoveries within the first year.

The more positive the index, the better RH birds survive by comparison to non-RH birds for that species. Ranking of the species differs between inclusion of all recoveries, excluding the first two months and within the first year only for the ratio of skewness and kurtosis (Table 3.6.2). Species which are generally consistently near the bottom of the table, which would suggest they have good post-release survival are Mallard and Sparrowhawk. In contrast those that are found at the top of the table (indicating poor post-release survival) include Guillemot, Gannet, Herring Gull and Little Owl.

Groups

Skewness, kurtosis and index of skewness and kurtosis for the groups of species are found in Table 3.6.3. Ranking of the species for the two indices are given in Table 3.6.4. As with the consideration of species, the groups of species rankings differ between skewness and kurtosis index and the various combinations of recoveries. Generally, groups with a poor post-release survival include seabirds, wildfowl and corvids, whilst passerines seem to do better from rehabilitation. As sample sizes are small for RH birds little emphasis can be placed on these results.

3.7 General conclusions, limitations of the results and recommendations for further work

For rehabilitation to be classed as successful from an individual's standpoint it must be re-established back into the wild population and have a similar chance to those of wild birds of entering the breeding pool. It is clear from this analysis that the treatment of birds during rehabilitation and ultimate release of birds back into the wild, should not be taken alone as successful rehabilitation as for the majority of individuals of some species, survival after release is, however, limited. For these species, many rehabilitated birds do *not* re-enter the population. Rehabilitation of the individual is undertaken for a variety of reasons. For many we feel that we have a moral obligation to rehabilitate them. This could be because they have been found injured but is often because their condition is the result of mans actions, for example, if birds are oiled as a result of oil spills or birds injured by being hit by cars. For others where the species is in decline an endangered rehabilitation of an individual may contribute to the survival of the species.

It is only ethical to attempt to rehabilitate birds if any suffering that the bird endures is alleviated and its rehabilitation has a good chance of giving it a reasonable quality of life on release.

Analyses such as these are crucial at providing information, which will enable a better understanding of the chances of rehabilitation of the individual back into the wild population. It will also inform decisions which have to be made on which individual should be given priority in situations where there are too many birds entering rehabilitation centres for all to be treated effectively.

The study found variations between species in post-release survival. Results from the 11 species with sample sizes of at least 20 recoveries for time elapsed and indices of skewness and kurtosis suggest that Mallard, Mute Swan, Buzzard and Sparrowhawk have relatively good post-release survival following rehabilitation whereas Guillemot, Gannet, Herring Gull, Little Owl and Barn Owl have relatively poor post-release rehabilitation survival. Differences between the groups of species appear less clear cut but this may reflect variation within these group of species. Amongst the groups, seabirds and corvids had the greatest difference between RH and non-RH recoveries with time elapsed. This agrees with previous studies suggesting poor post-release survival of seabirds when considering individual species like Guillemot, Gannet and Common Scoter.

In a situation where an influx of sick or injured birds to a rehabilitation centre meant that not all birds could be rehabilitated, it would be best to concentrate on those specie most likely to survive when released back into the wild. This study makes suggestions as to which are most likely to survive, but there are limitations to the data and further work would be able to investigate the differences and the reasons for them more closely.

There are likely to be a number of factors which may help explain this apparent discrepancy, including differences related to feeding and availability of suitable food, susceptibility to stress, waterproofing, grooming behaviour/technique, physiology, body size and release weight. It has been suggested that Guillemots rehabilitated in some of the earlier events may have been released back into the wild underweight, reducing their chance of survival, especially if birds are released in unfamiliar surroundings and during times of food shortage.

Comparisons are frequently drawn between the poor post-release survival of Guillemots and good post-release survival of African Penguins. Plumage characteristics differ between Guillemots and African Penguins and differences in grooming behaviour and time spent grooming may affect the amount of oil ingested and any adverse effects associated with this. Clearly these explanations are purely speculative and can only be substantiated with further detailed studies.

The comparisons in this study were restricted by the availability of sufficient recoveries within the BTO National Ringing database especially of rehabilitated birds. Generally, recoveries are limited for RH birds, but for Common Scoter this was the reverse, with very few recoveries available for non-RH birds as very few wild Scoters have been ringed as they winter at sea where it is not possible to catch

them. The difference in RH and non-RH sample sizes is likely to be species specific, with some species having many more records in one or other of the categories (RH versus non-RH). Differences in sample size between RH and non-RH recoveries are also greatest when considering the groups of species.

Although all recoveries were treated as comparable across species/groups, it is likely that the individual birds may have been rehabilitated for different reasons. Thus the severity of the condition of individual birds may have differed, posing a problem for analysis if this showed a species bias. For example, individuals rehabilitated for minor reasons and released are more likely to survive than those treated for instance from oil spill incidents. This may explain the poor record of rehabilitation for seabirds compared to the other groups considered and should be investigated further.

Because of small sample sizes, the finding circumstance on recoveries was not taken into account in the analyses. Where sample size allows, further exploration of the effect finding circumstances may have on the difference in time elapsed between RH and non-RH recoveries for the selected species would be interesting. Better comparison between RH and non-RH may be possible using similar categories for the finding circumstances although these are unlikely to change the general conclusions.

In these analyses, the probability at a dead bird being found and reported was considered to be equivalent for RH and non-RH recoveries. It is likely that many of the RH birds are released close to the rehabilitation centres, rather than the initial point of capture. As rehabilitation centres may be closer to denser areas of human habitation where birds are more likely to be found when they die, the recovery rates for these RH birds may be higher than those for the non-RH birds. Individuals released in unfamiliar surroundings are also more likely to suffer from competition with resident birds, which may decrease their ability to survive in the short-term immediately following release. Further information on release areas may help to understand if this potential bias would have a significant effect on the results.

No seasonal differentiation between recoveries was made, but it is possible that there may have been seasonal differences in both ringing and recovery. As 'natural' survival is probably influenced by time of year, seasonal influences may have biased the results if differences were apparent between RH and non-RH recoveries in terms of initial ringing and hence recovery. For some of the species with larger sample sizes for RH birds, it would be possible to show the number of recoveries within a recovery matrix (recoveries are displayed by ringing and finding year). This would be useful to assess any differences in ringing and finding from year to year. For example it is likely that records of RH seabirds would be erratic and be concentrated within a few years corresponding to major oil spill incidents.

The differences in sample size between RH and non-RH recoveries, especially for the groups of species, implies caution should be used in interpreting the results. Despite this, it is probable that the large differences seen between RH and non-RH recoveries for guillemots and seabirds are likely to be representative of the true pattern. Identifying significant results in a statistical sense will be difficult for such small sample sizes unless the magnitude of difference is large. A non-significant result does not however mean that there is no biological difference, or that one would not be detected with a larger sample size.

The current analysis has looked at survival by considering the median time between ringing and recovery. For species with larger sample sizes, this could be extended to carry out full survival analyses (see Wernham *et al.* 1997), this would give a much clearer picture of any difference between RH and non-RH birds. For this, and for other possible future analyses discussed above, it is important that as many RH birds as of many species as possible are ringed to increase the sample sizes. These ringing data should be associated with information of the reason that each bird needed to be rehabilitated and its treatment history so that in future research can focus rehabilitation more closely

with a high chance of success. It will also show which species and type of treatments need to be developed further to improve the chances of survival of the individual.

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Table 3.1.1 Number of 'dead' recoveries of rehabilitated birds for each species and membership for the groups of species (species in bold were considered individually).

Species	Total no. of recoveries	Group membership	Species	Total no. of recoveries	Group membership
Mute Swan	384		Red-breasted Merganser	2	Wildfowl
Guillemot	345		Robin	2	Passerine
Kestrel	104		Siskin	2	Passerine
Common Scoter	88		White Stork	2	Heron
Barn Owl	84		Woodcock	2	
Tawny Owl	79		Woodpigeon	2	
Mallard	63		Barnacle Goose	1	Wildfowl
Buzzard	42		Carrion/Hooded Crow	1	Corvid
Gannet	36		Chaffinch	1	Passerine
Herring Gull	28		Collared Dove	1	
Sparrowhawk	27		Coot	1	Wildfowl
Little Owl	24		Cuckoo	1	
Razorbill	15	Seabird	Goldeneye	1	Wildfowl
Eider	13	Wildfowl	Goldfinch	1	Passerine
Grey Heron	13	Heron	Goosander	1	Wildfowl
Blackbird	11	Passerine	Great Skua	1	Seabird
Black-headed Gull	10	Gull	Gyrfalcon	1	
Jackdaw	6	Corvid	Hen Harrier	1	Raptor
Shag	6	Seabird	Hooded Crow	1	Corvid
Fulmar	5	Seabird	Jay	1	Corvid
Starling	5	Passerine	Kittiwake	1	Seabird
Bittern	4	Heron	Linnet	1	Passerine
Cormorant	4	Seabird	Long-eared Owl	1	Raptor
Red-throated Diver	4	Wildfowl	Peregrine	1	Raptor
Short-eared Owl	4	Raptor	Raven	1	Corvid
Great Crested Grebe	3	Wildfowl	Red-necked Grebe	1	Wildfowl
Merlin	3	Raptor	Snow Goose	1	Wildfowl
Moorhen	3	Wildfowl	Swallow	1	Passerine
Pink-footed Goose	3	Wildfowl	White-fronted Goose	1	Wildfowl
Shelduck	3	Wildfowl			
Carrion Crow	2	Corvid			
Common Gull	2	Gull			
Great Black-backed Gull	2	Gull			
Greenfinch	2	Passerine			
Greylag Goose	2	Wildfowl			
House Sparrow	2	Passerine			
Lesser Black-backed Gull	2	Gull			
Magpie	2	Corvid			
Manx Shearwater	2	Seabird			
Oystercatcher	2				
Pintail	2	Wildfowl			
Pochard	2	Wildfowl			
Puffin	2	Seabird			
Red Kite	2	Raptor			

Note : Oystercatcher, Woodpigeon, Woodcock, Collared Dove, Cuckoo and Gyrfalcon were NOT included in any groups.

Table 3.2.1 Simple comparison between rehabilitated and non-rehabilitated data of median time elapsed and median distance travelled (a) adults and juveniles combined and (b) adults and juveniles separately.

a) Adults and juveniles combined

	No. of recoveries		Median distance travelled (km)			Median time elapsed (days)		
Species	RH	Non-RH	RH	Non-RH	Z value[a]	RH	Non-RH	Z value[a]
Barn Owl	84	302	6	6	0.24	32.5	272	7.95***
Buzzard	42	38	18.5	12.5	0.39	158	268.5	1.46
Gannet	36	213	42.5	170	3.90***	17	596	6.12***
Guillemot	345	595	11	235	15.48***	7	1,377	22.36***
Herring Gull	28	3,587	23	39	2.40*	115.5	1,012	4.94***
Kestrel	104	580	11.5	7	2.39*	93	267	5.04***
Little Owl	24	117	3.5	0	1.77	33	372	3.99***
Mallard	63	17,175	12	27	2.86*	158	356	3.01**
Mute Swan	385	13,210	10	10	1.69	292	621	10.09***
Sparrowhawk	27	935	6	4	0.44	55	321	4.29***
Tawny Owl	79	260	2	0	2.86**	141	487	5.50***
Common Scoter/Eider	88	1,312	4	4	0.24	8	1,71	15.14**

[a] = P value of Mann-Whitney U test: * = <0.05; ** = <0.01; *** = <0.001

b) Juveniles and adults separately

	Age	No. of recoveries		Median distance travelled (km)			Median time elapsed (days)		
Species		RH	Non-RH	RH	Non-RH	Z value[a]	RH	Non-RH	Z value[a]
Barn Owl	Juv	40	106	9	11	2.17*	60	175.5	3.42**
	Ad	44	196	6	4	1.09	31.5	364.5	7.00***
Buzzard	Juv	5	21	4	18	0.59	33	138	1.43
	Ad	37	17	20	9	1.04	231	310	2.05*
Gannet	Juv	7	49	34	128	1.46	22	25	0.37
	Ad	29	164	43	172	3.70***	15	986.5	6.44***
Guillemot	Juv	18	6	13	349.5	1.04	7	67	0.10
	Ad	327	589	11	235	15.48***	7	1,408	22.21***
Herring Gull	Juv	17	1,113	22	60	2.81**	103	986	3.33**
	Ad	11	2,474	27	32	1.01	313	1,027	3.41**
Kestrel	Juv	66	317	10.5	13	0.02	95	158	2.20*
	Ad	38	263	12.5	4	3.48***	83.5	475	4.92***
Little Owl	Juv	17	47	4	3	0.33	33	290	2.12*
	Ad	7	70	2	0	1.11	18	389.5	2.88**
Mallard	Juv	51	10,515	6	27	4.07***	107	332	2.71*
	Ad	12	6,660	50.5	26	1.30	309	404	0.29
Mute Swan	Juv	144	7,257	10	11	0.45	301.5	533	5.27***
	Ad	241	5,953	9	9	2.17*	281	762	9.62***
Sparrowhawk	Juv	20	642	6	5	0.72	38	249	3.83***
	Ad	7	293	4	3	0.58	115	406	1.84
Tawny Owl	Juv	47	88	2	1.5	1.38	137	275.5	2.98**
	Ad	32	172	1	0	1.72	199.5	606.5	3.91***
Common Scoter/Eider	Juv	5	196	10	0	1.32	29	834.5	3.24**
	Ad	83	1,116	4	6	0.82	8	1,830	14.77***

[a] = P value of Mann-Whitney U test comparing RH with non-RH value: * = <0.05; ** = <0.01; *** = <0.001

Table 3.3.1 Comparison between rehabilitated & non-rehabilitated of the distribution of the number of dead recoveries for time elapsed between ringing and recovery for fledged birds using the Kolmogorov-Smirnov 2-sample test (statistics are only provided where sample sizes allowed).

a) All recoveries

	Juveniles and adults combined				Juveniles only				Adults only			
			Sample size				Sample size				Sample size	
Species	KSa	P value[a]	Non-RH	RH	KSa	P value[a]	Non-RH	RH	KSa	P value[a]	Non-RH	RH
Barn owl	4.0	***	302	84	2.0	**	106	40	3.6	***	196	44
Buzzard	1.2	NS	38	42								
Gannet	3.1	***	213	36								
Guillemot	11.9	***	595	345								
Herring gull	2.2	***	3,587	28	1.6	**	1,113	17	1.6	**	2,474	11
Kestrel	2.5	***	580	104	1.3	NS	317	66	2.4	***	263	38
Little owl	2.2	***	117	24								
Mallard	1.7	**	17,175	63	1.7	**	10,515	51	0.6	NS	6,660	12
Mute swan	4.6	***	13,210	385	2.6	***	7,257	144	4.3	***	5,953	241
Sparrowhawk	2.2	**	935	27								
Tawny owl	2.8	***	260	79	1.3	NS	88	47	2.6	***	172	32

[a] P value *** <0.0001 ** <0.01 * <0.05

b) Excluding the first two months after ringing

	Juvenile and adults				Juveniles only				Adults only			
			Sample size				Sample size				Sample size	
Species	KSa	P value[a]	Non-RH	RH	KSa	P value[a]	Non-RH	RH	KSa	P value[a]	Non-RH	RH
Barn owl	1.1	NS	268	34	0.6	NS	86	20	0.9	NS	182	14
Buzzard	0.8	NS	34	26								
Gannet	1.6	*	154	8								
Guillemot	2.5	***	550	46								
Herring gull	1.4	*	3,308	17								
Kestrel	2.0	**	446	61	1.2	NS	255	40	1.9	**	221	21
Little owl	1.1	NS	93	8								
Mallard	1.7	**	14,210	49	1.6	*	8,364	37	0.9	NS	5,846	12
Mute swan	3.5	***	12,165	302	2.1	**	6,578	112	3.1	***	5,587	190
Sparrowhawk	1.2	NS	786	13								
Tawny owl	2.3	***	226	55	1.0	NS	77	32	2.3	***	149	23

[a] P value *** <0.0001 ** <0.01 * <0.05

Table 3.3.1 continued

c) Within the first year after ringing only

	Juveniles and adults				Juveniles only				Adults only			
			Sample size				Sample size				Sample size	
Species	KSa	P value[a]	Non-RH	RH	KSa	P value[a]	Non-RH	RH	KSa	P value[a]	Non-RH	RH
Barn owl	3.5	***	175	74	2.0	**	77	34	3.2	***	98	40
Buzzard	1.5	*	25	27								
Gannet	1.5	*	96	34								
Guillemot	5.9	***	138	322								
Herring gull	1.6	**	867	17								
Kestrel	1.0	NS	327	86	0.6	NS	207	53	1.1	NS	120	33
Little owl	1.4	*	57	22								
Mallard	0.7	NS	8,789	43	0.8	NS	5,662	36	0.9	NS	3,127	7
Mute swan	2.3	***	4,632	215	1.5	*	2,845	82	2.1	**	1,787	133
Sparrowhawk	1.5	*	507	23								
Tawny owl	0.8	NS	109	59	1.2	NS	51	34	0.7	NS	58	25

[a] P value *** <0.0001 ** <0.01 * <0.05

Table 3.4.1 Simple comparison between rehabilitated and non-rehabilitated data of median time elapsed and median distance travelled for adults and juveniles combined for groups of species.

Group	No. of recoveries		Median distance travelled (km)			Median time elapsed (days)		
	RH	Non-RH	RH	Non-RH	Z value[a]	RH	Non-RH	Z value[a]
Corvids	14	2,099	4	1	1.59	65	596	3.69***
Gulls	16	8,796	54	301	2.02	58	958	3.07**
Herons	19	58	7	11	0.23	62	272	2.60**
Passerines	28	103,208	1	0	0.14	31.5	387	5.75***
Raptors	12	153	53.5	34	0.19	30	280	3.52**
Seabirds	36	4,122	7	60	2.51**	5	1,160.5	8.80***
Wildfowl	44	13,117	7.5	158	4.43***	37.5	716	5.39***

[a] = P value of Mann-Whitney U test: * = <0.05; ** = <0.01; *** = <0.001

Table 3.5.1 Comparison between rehabilitated & non-rehabilitated of the distribution of the number of recoveries for time elapsed between ringing and recovery using the Kolmogorov-Smirnov 2-sample test for each group juveniles and adults combined.

a) All recoveries

	Juveniles and adults			
			Sample size	
Group	KSa	P value[a]	Non-RH	RH
Corvids	1.99	**	2,099	14
Gulls	2.05	**	8,796	16
Herons	1.37	*	58	19
Passerines	2.70	***	103,208	28
Raptors	2.04	**	153	12
Seabirds	4.86	***	4,122	36
Wildfowl	3.07	***	13,117	44

b) Excluding the first two months after ringing

	Juveniles and adults			
			Sample size	
Group	KSa	P value[a]	Non-RH	RH
Corvids	1.26	NS	1,862	7
Gulls	0.69	NS	8,177	8
Herons	1.15	NS	48	10
Passerines	1.51	*	87,20	11
Raptors	0.67	NS	125	3
Seabirds	0.87	NS	3,876	5
Wildfowl	0.76	NS	11,886	20

c) Within the first year after ringing only

	Juveniles and adults			
			Sample size	
Group name	KSa	P value[a]	Non-RH	RH
Corvids	1.24	NS	792	12
Gulls	1.91	**	2,141	10
Herons	0.98	NS	31	16
Passerines	2.15	**	49,694	25
Raptors	1.77	**	84	11
Seabirds	4.10	***	859	32
Wildfowl	3.45	***	4,375	26

[a] P value *** <0.0001 ** <0.01 * <0.05

Table 3.6.1 Comparison of descriptive statistics between rehabilitated and non-rehabilitated recoveries for time elapsed from ringing to recovery. Comparison includes both juveniles and adults and statistics are for: a) all recoveries, b) all recoveries excluding those in the first two months (60 days) and c) those recovered within the first year (365 days). For all those species with >20 recoveries.

a) All recoveries

Species	No. of recoveries		Skewness		Kurtosis		Median time elapsed (days)		Index kurtosis	Index skewness
	RH	NON-RH	RH	NON-RH	RH	NON-RH	RH	NON-RH		
Barn owl	84	308	5.0	2.3	28.1	5.3	32.5	272	0.19	0.45
Buzzard	42	42	3.4	2.5	12.5	6.0	158	281.5	0.48	0.74
Gannet	36	213	4.1	1.0	16.0	-0.1	17	537	-0.01	0.25
Guillemot	345	523	4.8	0.8	25.1	-0.5	7	952	-0.02	0.16
Herring gull	28	3,957	2.3	0.8	6.5	-0.2	115.5	940	-0.03	0.36
Kestrel	104	619	4.0	1.8	17.0	3.1	93	258	0.18	0.45
Little owl	24	125	3.9	1.3	16.4	0.8	33	374	0.05	0.32
Mallard	63	17,647	2.2	2.0	4.8	4.1	158	356	0.86	0.88
Mute swan	385	17,225	2.8	1.4	10.1	1.3	292	581	0.13	0.48
Sparrowhawk	27	1,047	2.6	1.9	6.4	3.4	55	323	0.54	0.72
Tawny owl	79	263	3.1	1.6	10.9	1.7	141	484	0.16	0.51

b) All recoveries excluding those within the first two months (60 days)

Species	No. of recoveries		Skewness		Kurtosis		Median time elapsed (days)		Index kurtosis	Index skewness
	RH	NON-RH	RH	NON-RH	RH	NON-RH	RH	NON-RH		
Barn owl	34	273	3.3	2.2	11.2	4.6	252	333	0.41	0.65
Buzzard	26	38	2.7	2.4	7.5	5.3	400.5	302.5	0.70	0.88
Gannet	8	154	1.5	0.7	0.6	-0.7	170.5	988.5	-1.04	0.44
Guillemot	46	474	1.2	0.7	0.6	-0.6	351	1,045.5	-1.03	0.60
Herring gull	17	3,640	1.9	0.8	4.6	-0.3	672	1,055	-0.06	0.41
Kestrel	61	473	3.0	1.5	9.4	2.1	229	465	0.22	0.51
Little owl	8	98	2.3	1.1	5.7	0.3	318	703	0.05	0.45
Mallard	49	14,622	2.0	1.8	3.5	3.5	259	438	1.01	0.92
Mute swan	302	15,936	2.6	1.3	8.4	1.1	428	651	0.13	0.50
Sparrowhawk	13	878	1.6	1.7	1.5	2.8	194	433.5	1.82	1.09
Tawny owl	55	228	2.6	1.4	7.5	1.3	254	594.5	0.17	0.55

Table 3.6.1 continued

Species	c) Recoveries within the first year since ringing (365 days)									
	No. of recoveries		Skewness		Kurtosis		Median time elapsed (days)		Index kurtosis	Index skewness
	RH	NON-RH	RH	NON-RH	RH	NON-RH	RH	NON-RH		
Barn owl	74	178	1.5	0.3	1.1	-1.0	24.5	138.5	-0.85	0.23
Buzzard	27	29	1.2	-0.1	0.3	-1.5	48	237	-5.31	-0.12
Gannet	34	98	2.8	1.1	7.7	-0.2	14.5	34	-0.03	0.40
Guillemot	322	149	4.5	0.1	22.2	-1.4	7	164	-0.06	0.01
Herring gull	17	993	1.9	0.4	3.7	-1.1	32	131	-0.31	0.20
Kestrel	86	353	1.2	0.9	0.3	-0.2	61	75	-0.78	0.80
Little owl	22	60	1.7	0.7	1.3	-1.1	26.5	70	-0.80	0.41
Mallard	43	9,053	0.8	0.8	-0.3	-0.7	91	99	2.01	0.97
Mute swan	215	6,226	0.6	0.2	-0.9	-1.1	97	154	1.29	0.39
Sparrowhawk	23	567	1.6	0.5	2.6	-0.9	43	127	-0.35	0.30
Tawny owl	59	112	0.7	0.6	-0.8	-1.0	74	100.5	1.28	0.77

The standard measure of skew and kurtosis was obtained from the descriptive statistics provided by SAS. The index for skew was calculated by dividing the skew of the non-rehabilitated recoveries by the skew of the rehabilitated recoveries. This was repeated using kurtosis of the rehabilitated and the non-rehabilitated recoveries for the kurtosis measure.

Table 3.6.2 Species rankings of the 11 selected species based on skewness index and kurtosis index for a) inclusion of all recoveries, b) within the first year and c) excluding the first two months. Species with poor post-release survival occur at the top of the table.

Species rankings (negative to positive/poor to good)					
Kurtosis index			Skewness index		
a) All recoveries	b) Excluding 1st two months	c) Within 1st year	a) All recoveries	b) Excluding 1st two months	c) Within 1st year
Herring Gull	Gannet	Buzzard	Guillemot	Herring Gull	Buzzard
Guillemot	Guillemot	Barn Owl	Gannet	Gannet	Guillemot
Gannet	Herring Gull	Little Owl	Little Owl	Little Owl	Herring Gull
Little Owl	Little Owl	Kestrel	Herring Gull	Mute Swan	Barn Owl
Mute Swan	Mute Swan	Sparrowhawk	Barn owl	Kestrel	Sparrowhawk
Tawny Owl	Tawny Owl	Herring Gull	Kestrel	Tawny Owl	Mute Swan
Kestrel	Kestrel	Guillemot	Mute Swan	Guillemot	Gannet
Barn Owl	Barn Owl	Gannet	Tawny Owl	Barn Owl	Little Owl
Buzzard	Buzzard	Tawny Owl	Sparrowhawk	Buzzard	Tawny Owl
Sparrowhawk	Mallard	Mute Swan	Buzzard	Mallard	Kestrel
Mallard	Sparrowhawk	Mallard	Mallard	Sparrowhawk	Mallard

Table 3.6.3 Comparison of descriptive statistics between rehabilitated and non-rehabilitated recoveries for time elapsed from ringing to recovery for each group. Comparison includes both juveniles and adults and statistics are for: a) all recoveries, b) all recoveries excluding those in the first two months (60 days) and c) those recovered within the first year (365 days).

a) All recoveries

Group	No. of recoveries		Skewness		Kurtosis		Median time elapsed (days)		Index kurtosis	Index skewness
	RH	NON-RH	RH	NON-RH	RH	NON-RH	RH	NON-RH		
Corvids	14	2,099	3.5	1.9	12.8	5.0	65	596	0.39	0.54
Gulls	16	8,796	1.8	1.5	3.8	2.4	58	958	0.62	0.80
Herons	19	58	3.2	2.6	11.7	7.5	62	272	0.64	0.84
Passerines	28	103,208	3.0	2.5	10.8	16.8	31.5	387	1.55	0.81
Raptors	12	153	2.2	1.9	4.6	4.0	30	280	0.88	0.89
Seabirds	36	4,122	4.4	1.8	20.4	4.4	5	1,160.5	0.22	0.42
Wildfowl	44	13,117	3.8	2.1	16.7	6.8	37.5	716	0.41	0.56

b) All recoveries excluding those within the first two months (60 days)

Group	No. of recoveries		Skewness		Kurtosis		Median time elapsed (days)		Index kurtosis	Index skewness
	RH	NON-RH	RH	NON-RH	RH	NON-RH	RH	NON-RH		
Corvids	7	1,862	2.5	1.8	6.5	4.8	299	699	0.73	0.73
Gulls	8	8,177	1.2	1.5	2.5	2.3	1,367.5	1,088	0.92	1.25
Herons	10	48	2.7	2.4	8.0	6.1	283	440	0.77	0.90
Passerines	11	87,820	2.2	2.4	5.3	17.5	231	488	3.29	1.11
Raptors	3	125		1.7		3.2	273	474		
Seabirds	5	3,876	1.2	1.8	0.2	4.4	493	1,357	18.80	1.52
Wildfowl	20	11,886	2.8	2.1	8.4	6.6	742	826	0.79	0.75

c) Recoveries within the first year since ringing (365 days)

Group	No. of recoveries		Skewness		Kurtosis		Median time elapsed (days)		Index kurtosis	Index skewness
	RH	NON-RH	RH	NON-RH	RH	NON-RH	RH	NON-RH		
Corvids	12	792	1.3	0.3	0.2	-1.3	41	135	-8.00	0.22
Gulls	10	2,141	1.4	0.4	2.9	-1.0	41	130	-0.34	0.29
Herons	16	31	0.8	0.5	-1.4	-0.4	46.5	124	0.28	0.65
Passerines	25	49,694	1.2	0.5	0.1	-0.9	25	114	21.90	0.44
Raptors	11	84	1.9	0.6	1.9	-0.7	21	111.5	-0.40	0.30
Seabirds	32	859	4.7	-0.1	24.0	-1.6	4	206	-0.07	-0.02
Wildfowl	26	4,375	2.5	0.6	7.2	-0.8	12	113	-0.12	0.23

Note: Raptors have no skew index due to the small sample size.

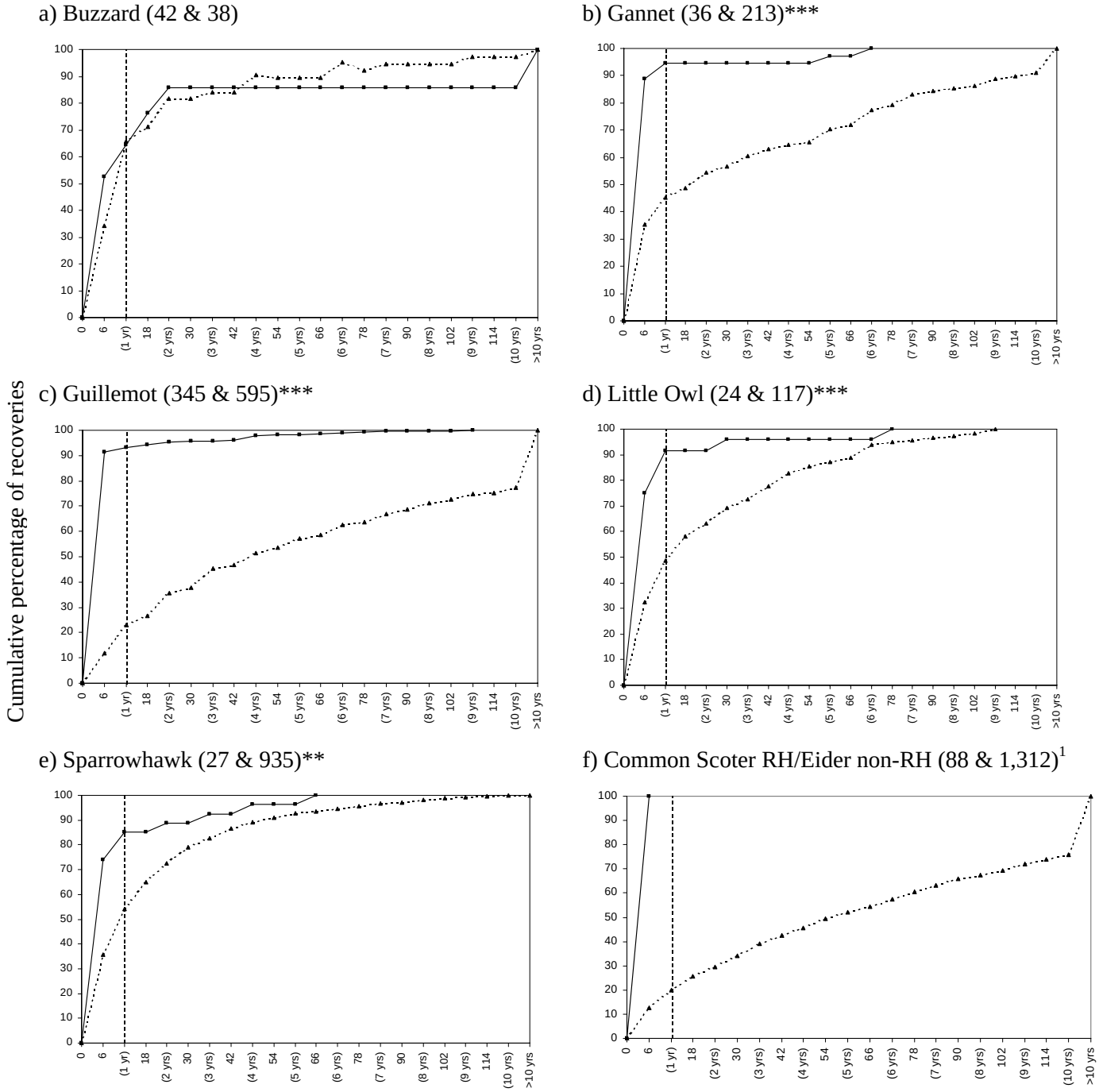
The standard measure of skew and kurtosis was obtained from the descriptive statistics provided by SAS. The index for skew was calculated by dividing the skew of the non-rehabilitated recoveries by the skew of the rehabilitated recoveries. This was repeated using kurtosis of the rehabilitated and the non-rehabilitated recoveries for the kurtosis measure.

Table 3.6.4 Rankings of the seven groups based on skewness index and kurtosis index for a) inclusion of all recoveries, b) within the first year and c) excluding the first two months. Groups of species with poor post-release survival occur at the top of the table.

Groups of species rankings (negative to positive/poor to good)					
Kurtosis index			Skewness index		
a) All recoveries	b) Excluding 1st two months	c) Within 1st year	a) All recoveries	b) Excluding 1st two months	c) Within 1st year
Seabirds	Corvids	Seabirds	Seabirds	Corvids	Corvids
Corvids	Herons	Corvids	Corvids	Wildfowl	Raptors
Wildfowl	Wildfowl	Wildfowl	Wildfowl	Herons	Gulls
Gulls	Gulls	Gulls	Gulls	Raptors	Wildfowl
Herons	Passerines	Raptors	Passerines	Passerines	Seabirds
Raptors	Seabirds	Passerines	Herons	Gulls	Herons
Passerines		Herons	Raptors	Seabirds	Passerines

Note : Raptors have no skew index due to the small sample size

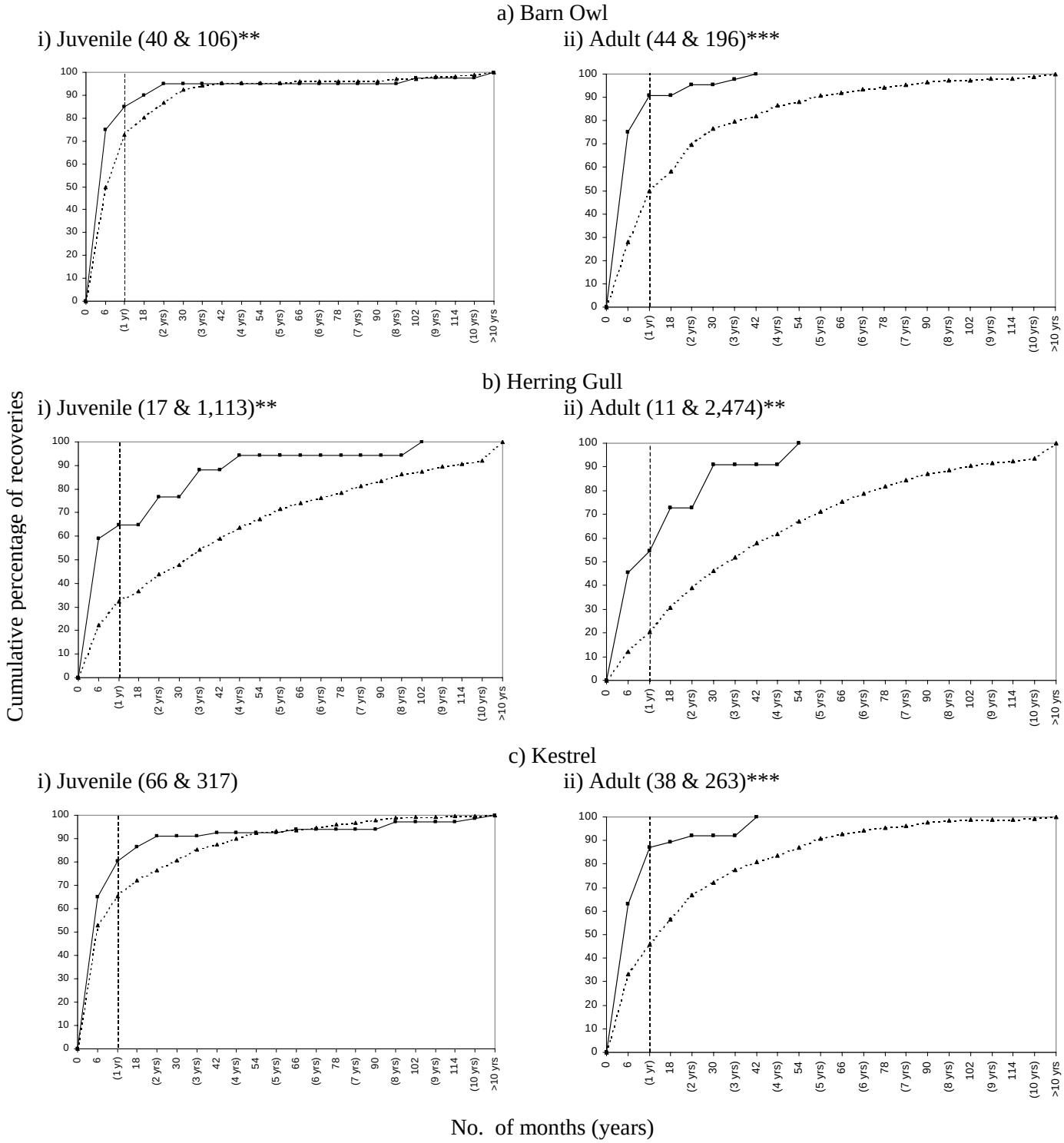
Figure 3.3.1 Comparison between rehabilitated and non-rehabilitated birds of the number of dead recoveries for time elapsed from ringing to recovery for fledged birds. All recoveries, juveniles and adults combined.



[1] = No Kolmogorov-Smirnov 2-sample test was done as it was deemed inappropriate

Solid lines joining squares are RH birds and dashed lines joining triangles are non-RH birds. The vertical dashed line marks a recovery period of one year. Sample sizes are given in parentheses for RH and non-RH birds respectively. ***, ** and * denotes P<0.0001, P<0.001 and P<0.05 respectively for Kolmogorov-Smirnov 2-sample test between RH & non-RH (see Table 3.3a for respective values of KSa and P). Note that for these species there were >10 recoveries for at least one of the age codes for RH and/or non-RH birds.

Figure 3.3.2 Comparison between rehabilitated and non-rehabilitated birds of the number of dead recoveries for time elapsed from ringing to recovery for fledged birds. All recoveries, juveniles and adults separated.

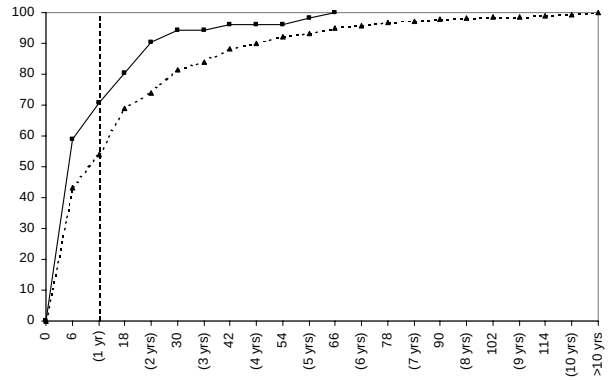


Solid lines joining squares are RH birds and dashed lines joining triangles are non-RH birds. The vertical dashed line marks year one. Sample sizes are given in parentheses for RH and non-RH birds respectively. ***, ** and * denotes P<0.0001, P<0.001 and P<0.05 respectively for Kolmogorov-Smirnov 2-sample test between RH & non-RH (see Table 3.3a for respective values of KSa and P). Note that for these species there were >10 recoveries for all the age codes for RH and non-RH birds.

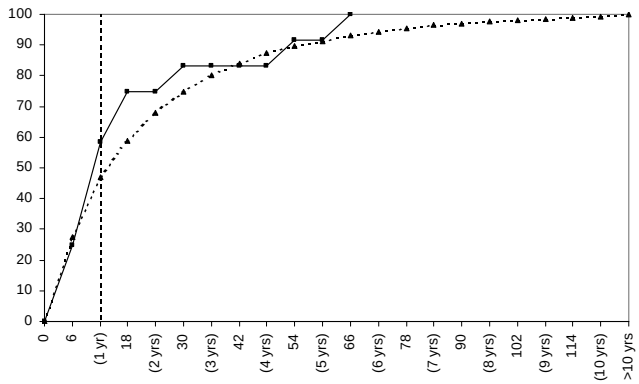
Figure 3.3.2 Continued

d) Mallard

i) Juvenile (51 & 10,515)



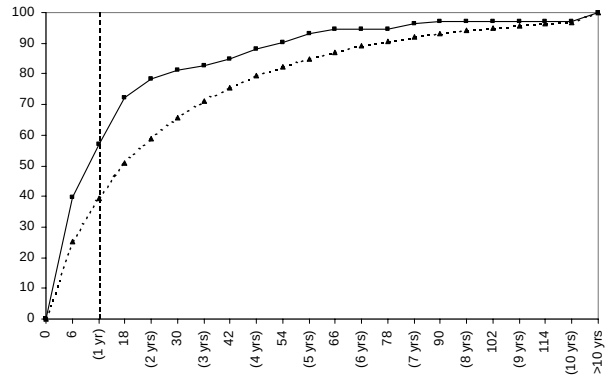
ii) Adult (12 & 6,660)



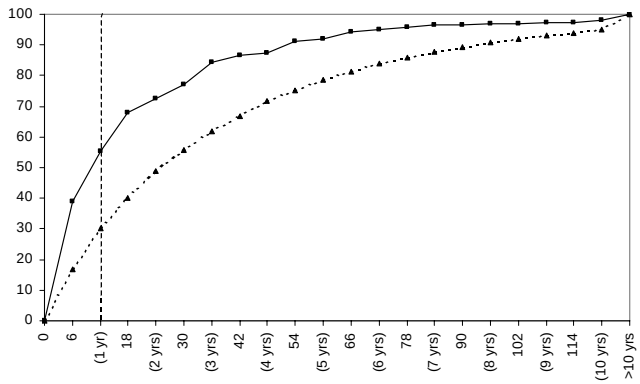
e) Mute Swan

Cumulative percentage. of recoveries

i) Juvenile (144 & 7,257)***

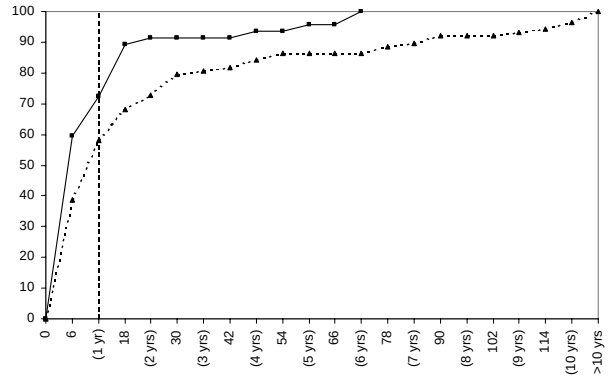


ii) Adult (241 & 5,953)***

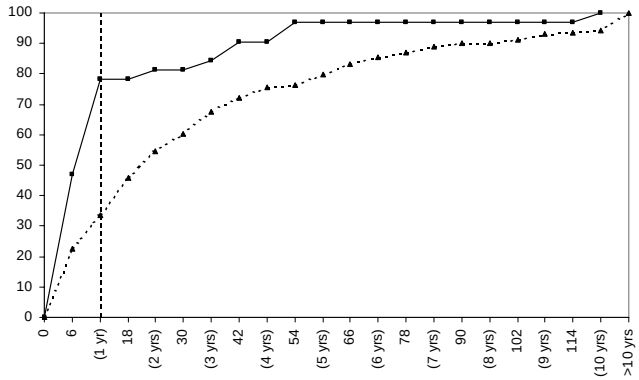


f) Tawny Owl

i) Juvenile (47 & 88) (P<0.05)



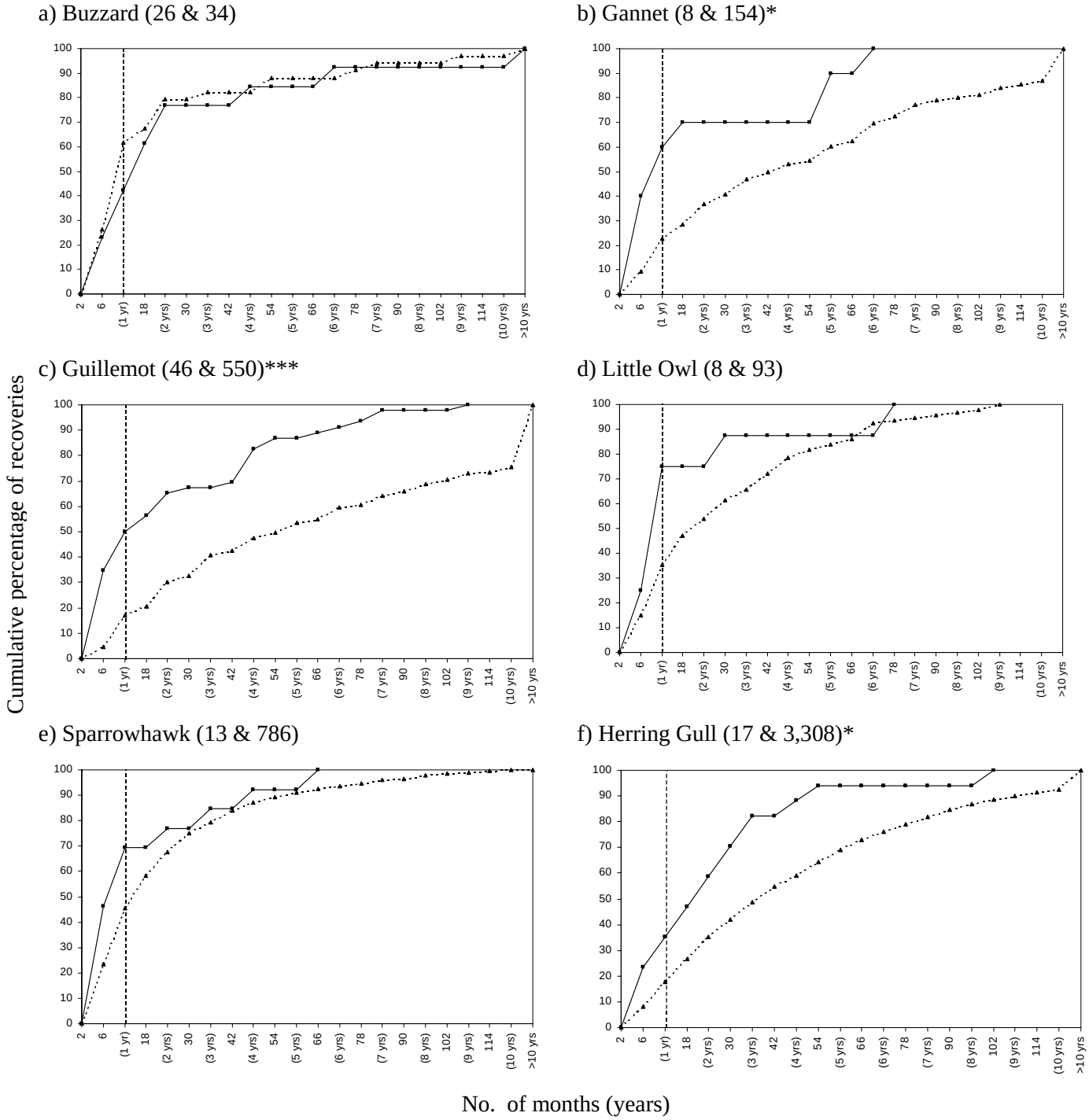
ii) Adult (32 & 172) ***



No. of months (years)

Solid lines joining squares are RH birds and dashed lines joining triangles are non-RH birds. The vertical dashed line marks year one. Sample sizes are given in parentheses for RH and non-RH birds respectively. ***, ** and * denotes P<0.0001, P<0.001 and P<0.05 respectively for Kolmogorov-Smirnov 2-sample test between RH & non-RH (see Table 3.3a for respective values of KSa and P). Note that for these species there were >10 recoveries for all the age codes for RH and non-RH birds.

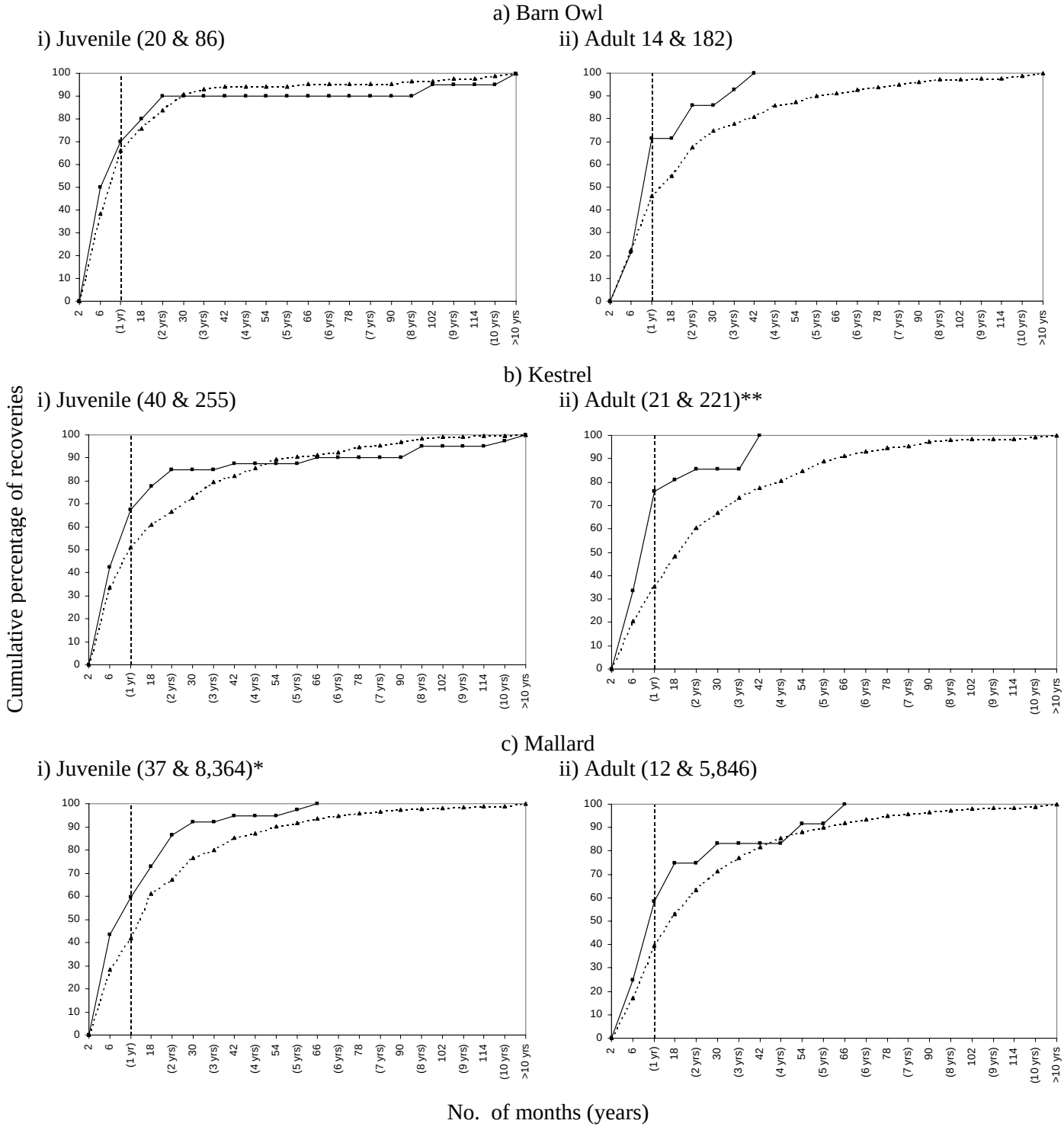
Figure 3.3.3 Comparison between rehabilitated and non-rehabilitated birds of the number of dead recoveries for time elapsed from ringing to recovery for fledged birds. Juveniles and adults combined. Recoveries within the first two months after ringing are excluded.



Solid lines joining squares are RH birds and dashed lines joining triangles are non-RH birds. The vertical dashed line marks year one. Sample sizes are given in parentheses for RH and non-RH birds respectively. ***, ** and * denotes P<0.0001, P<0.001 and P<0.05 respectively for Kolmogorov-Smirnov 2-sample test between RH & non-RH (see Table 3.3b for respective values of KSa and P). Note that for these species there were <10 recoveries for at least one of the age codes for RH and/or non-RH birds.

Note that Common Scoter/Eider is excluded from this comparison due too small sample size for RH birds.

Figure 3.3.4 Comparison between rehabilitated and non-rehabilitated birds of the number of dead recoveries for time elapsed from ringing to recovery for fledged birds. Juveniles and adults separately. Recoveries within the first two months after ringing are excluded.

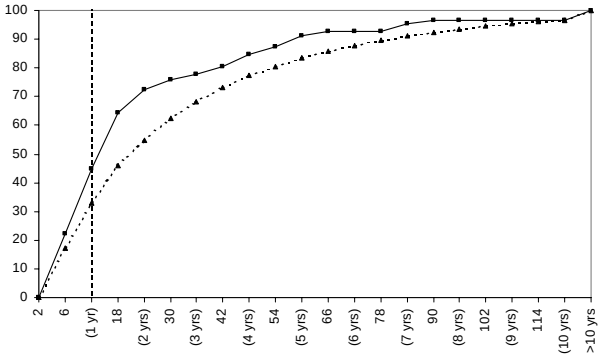


Solid lines joining squares are RH birds and dashed lines joining triangles are non-RH birds. The vertical dashed line marks year one. Sample sizes are given in parentheses for RH and non-RH birds respectively. ***, ** and * denotes P<0.0001, P<0.001 and P<0.05 respectively for Kolmogorov-Smirnov 2-sample test between RH & non-RH (see Table 3.3b for respective values of KSa and P). Note that for these species there were >10 recoveries for all the age codes for RH and non-RH birds.

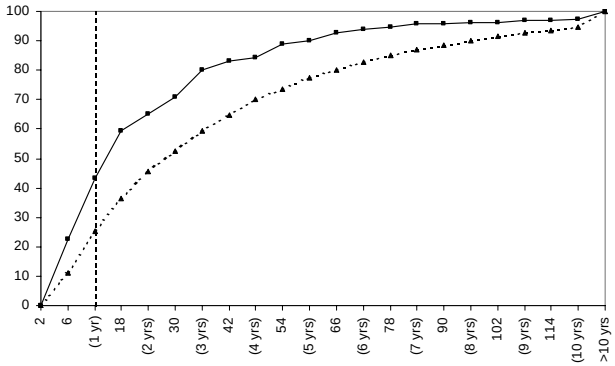
Figure 3.3.4 Continued

d) Mute Swan

i) Juvenile (112 & 6,578)**

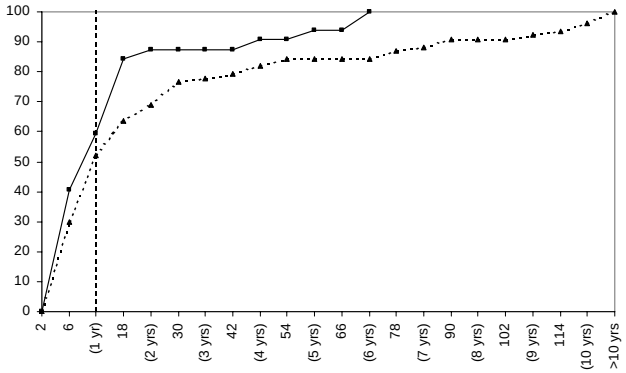


ii) Adult (190 & 5,587)***

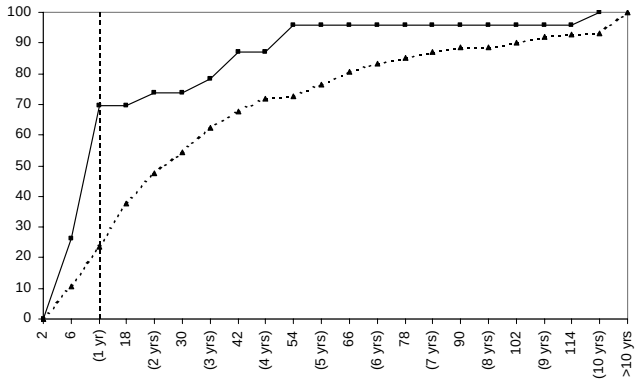


e) Tawny Owl

i) Juvenile (32 & 77)



ii) Adult (23 & 149)***

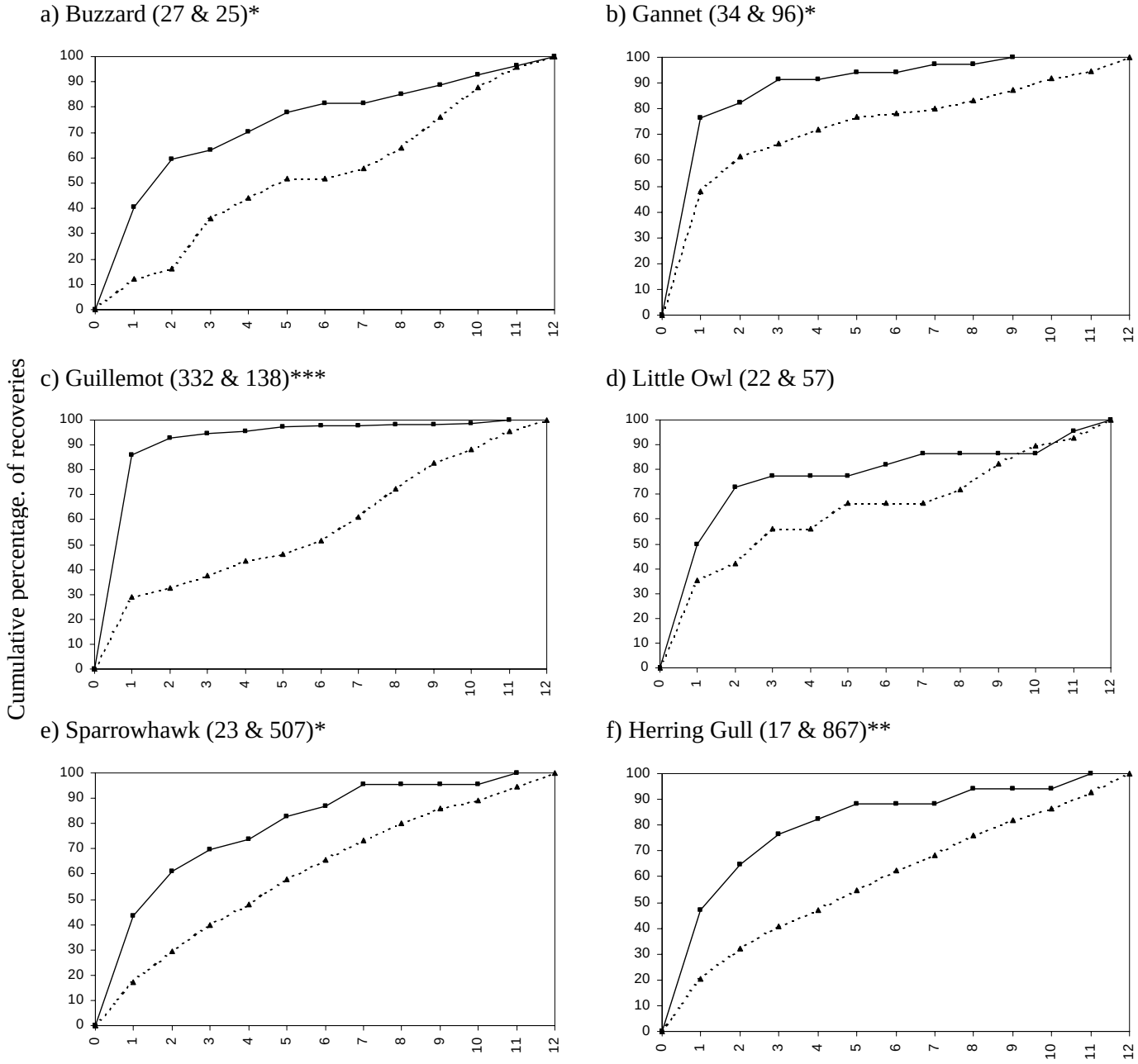


Cumulative percentage of recoveries

No. of months (years)

Solid lines joining squares are RH birds and dashed lines joining triangles are non-RH birds. The vertical dashed line marks year one. Sample sizes are given in parentheses for RH and non-RH birds respectively. ***, ** and * denotes P<0.0001, P<0.001 and P<0.05 respectively for Kolmogorov-Smirnov 2-sample test between RH & non-RH (see Table 3.3b for respective values of KSa and P). Note that for these species there were >10 recoveries for all the age codes for RH and non-RH birds.

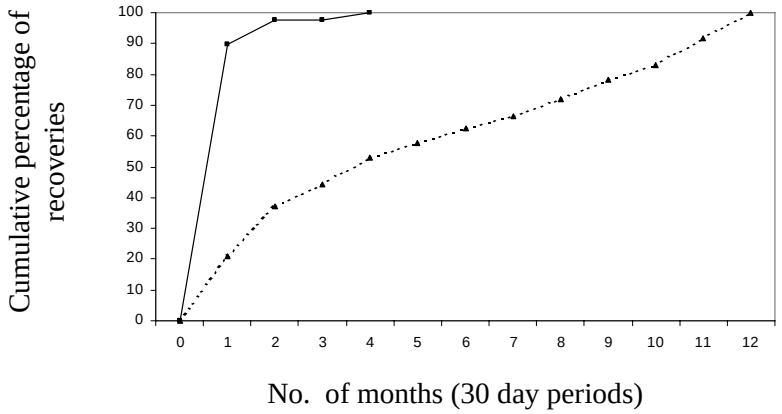
Figure 3.3.5 Comparison between rehabilitated and non-rehabilitated birds of the number of dead recoveries for time elapsed from ringing to recovery for fledged birds. Juveniles and adults combined. Recoveries within the first year after ringing only.



Solid lines joining squares are RH birds and dashed lines joining triangles are non-RH birds. The vertical dashed line marks year one. Sample sizes are given in parentheses for RH and non-RH birds respectively. ***, ** and * denotes P<0.0001, P<0.001 and P<0.05 respectively for Kolmogorov-Smirnov 2-sample test between RH & non-RH (see Table 3.3c for respective values of KSa and P). Note that for these species there were >10 recoveries for at least one of the age codes for RH and non-RH birds.

Figure 3.3.5 Continued

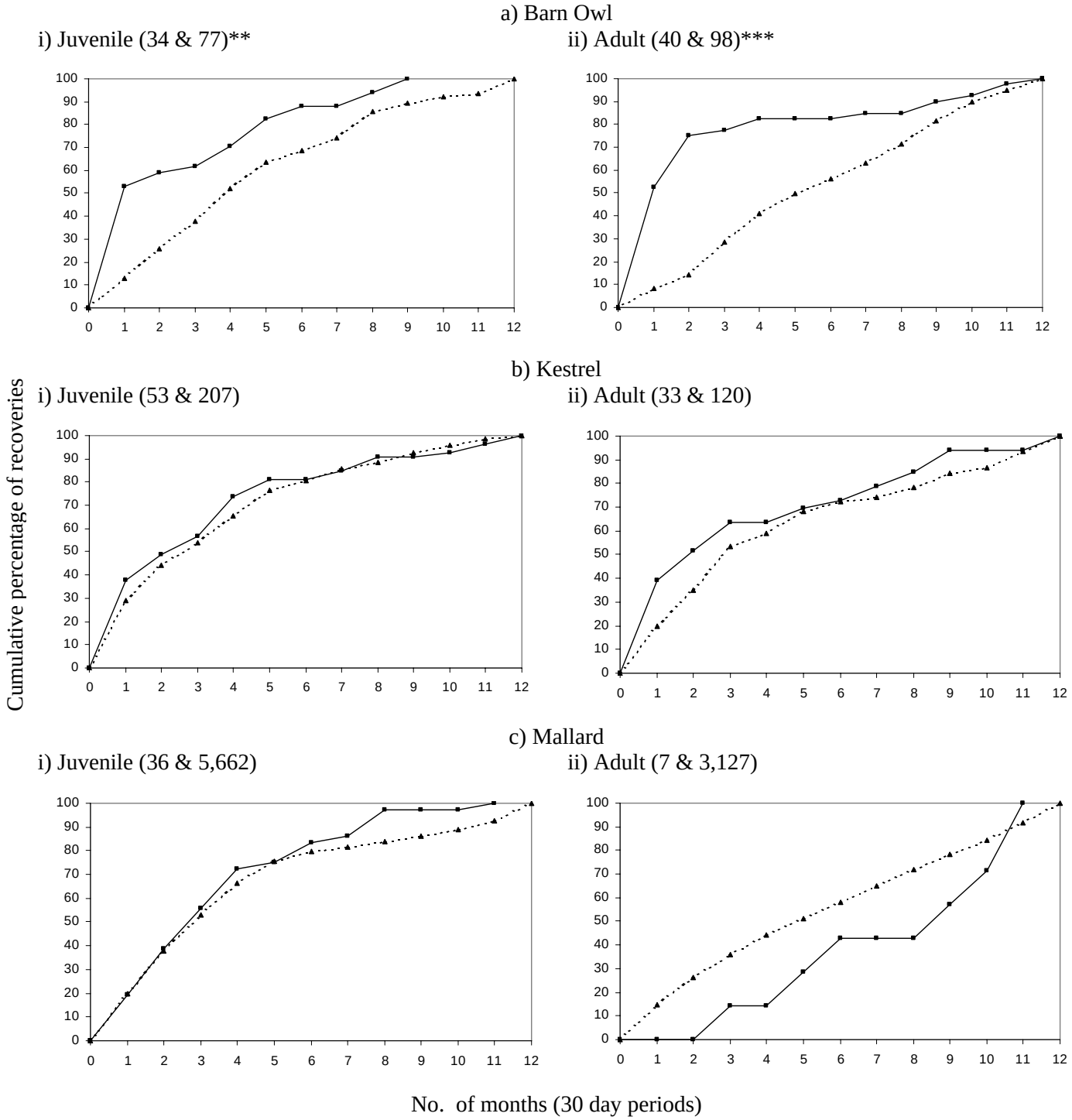
g) Common Scoter RH/Eider non-RH (86 & 262) [1]



[1] = No Kolmogorov-Smirnov 2-sample test was done as it was deemed inappropriate

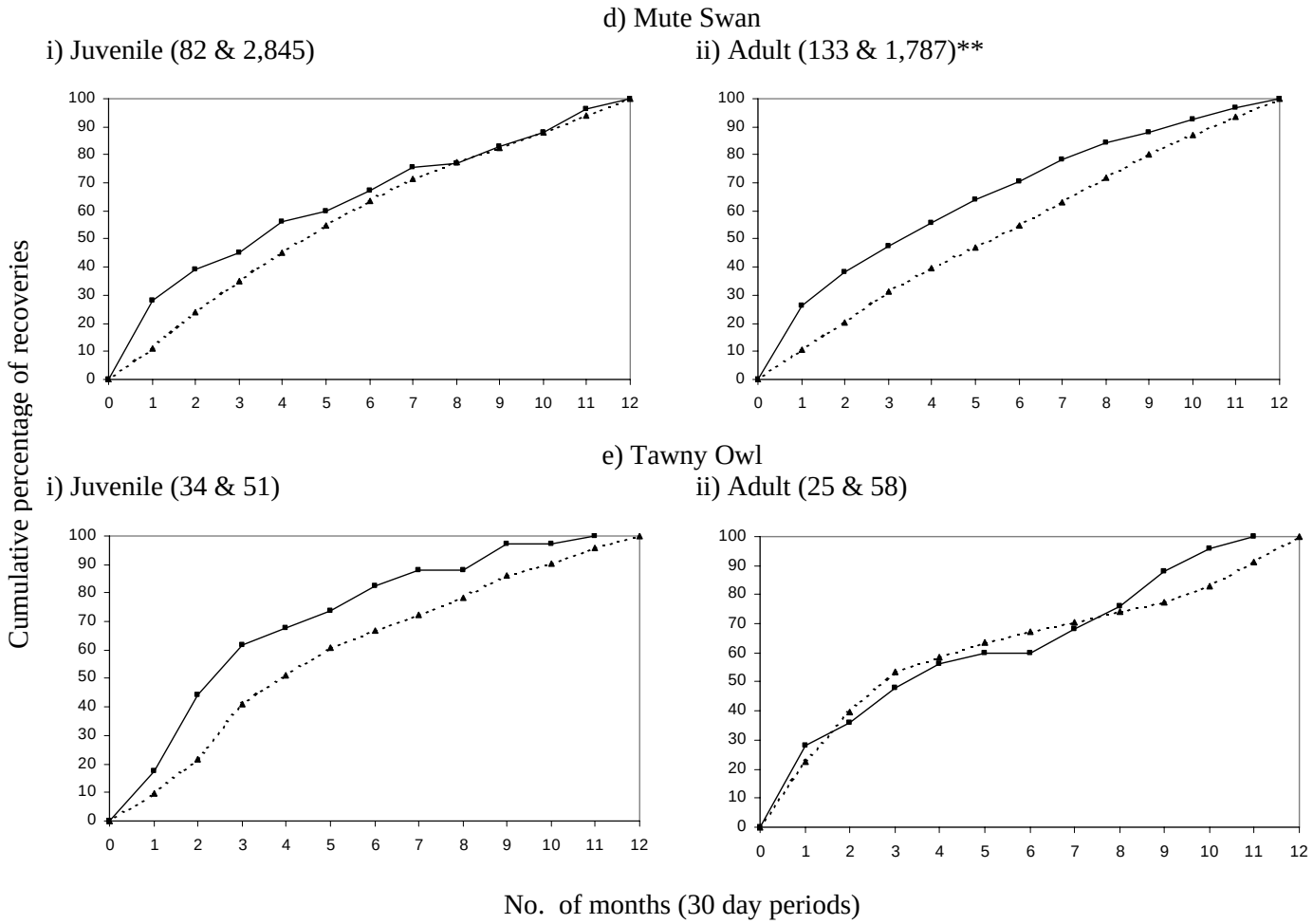
Solid lines joining squares are RH birds and dashed lines joining triangles are non-RH birds. The vertical dashed line marks year one. Sample sizes are given in parentheses for RH and non-RH birds respectively. ***, ** and * denotes P<0.0001, P<0.001 and P<0.05 respectively for Kolmogorov-Smirnov 2-sample test between RH & non-RH (see Table 3.3c for respective values of KSa and P). Note that for these species there were >10 recoveries for at least one of the age codes for RH and non-RH birds.

Figure 3.3.6 Comparison between rehabilitated and non-rehabilitated birds of the number of dead recoveries for time elapsed from ringing to recovery for fledged birds. Juveniles and adults separately. Recoveries within the first year after ringing only.



Solid lines joining squares are RH birds and dashed lines joining triangles are non-RH birds. The vertical dashed line marks year one. Sample sizes are given in parentheses for RH and non-RH birds respectively. ***, ** and * denotes P<0.0001, P<0.001 and P<0.05 respectively for Kolmogorov-Smirnov 2-sample test between RH & non-RH (see Table 3.3c for respective values of KSa and P). Note that for these species there were >10 recoveries for all the age codes for RH and non-RH birds.

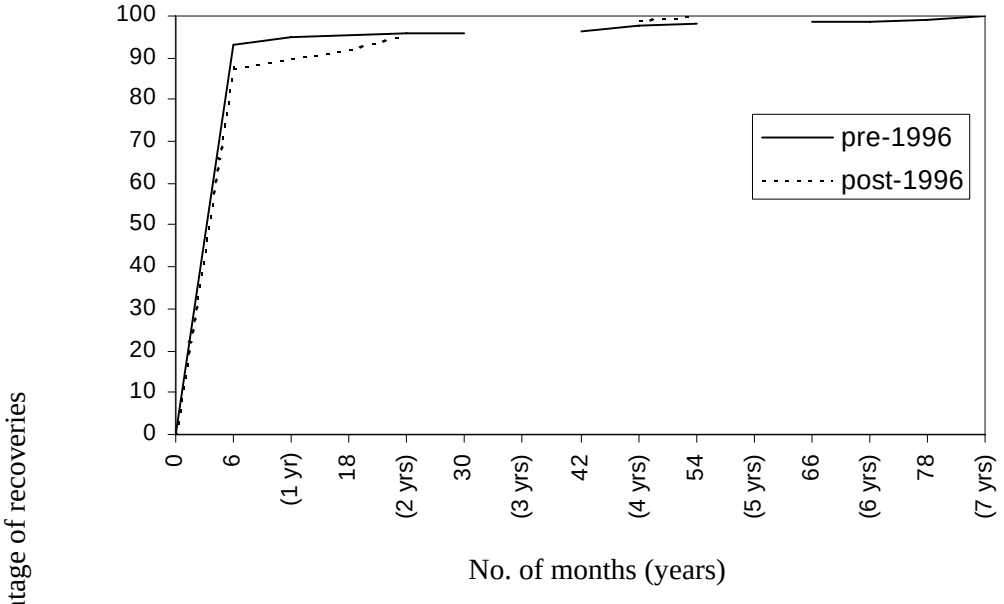
Figure 3.3.6 Continued



Solid lines joining squares are RH birds and dashed lines joining triangles are non-RH birds. The vertical dashed line marks year one. Sample sizes are given in parentheses for RH and non-RH birds respectively. ***, ** and * denotes P<0.0001, P<0.001 and P<0.05 respectively for Kolmogorov-Smirnov 2-sample test between RH & non-RH (see Table 3.3c for respective values of KSa and P). Note that for these species there were >10 recoveries for all the age codes for RH and non-RH birds.

Figure 3.3.7 Comparison of cumulative percentage of dead recoveries with time elapsed between those recovered before and those recovered after 1996 for rehabilitated guillemots: (a) 6 month periods and (b) 30 day periods within the first year only. Sample sizes are given in parentheses for pre-1996 and post-1996 respectively. Adults and juveniles combined.

a) All recoveries six month periods (255 & 89)



b) First year 30 day periods (242 & 80)

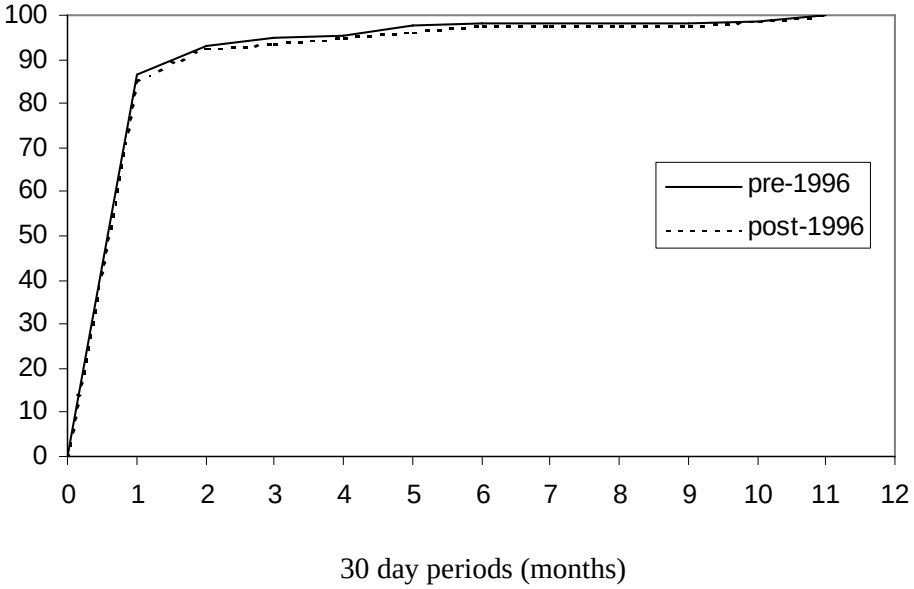
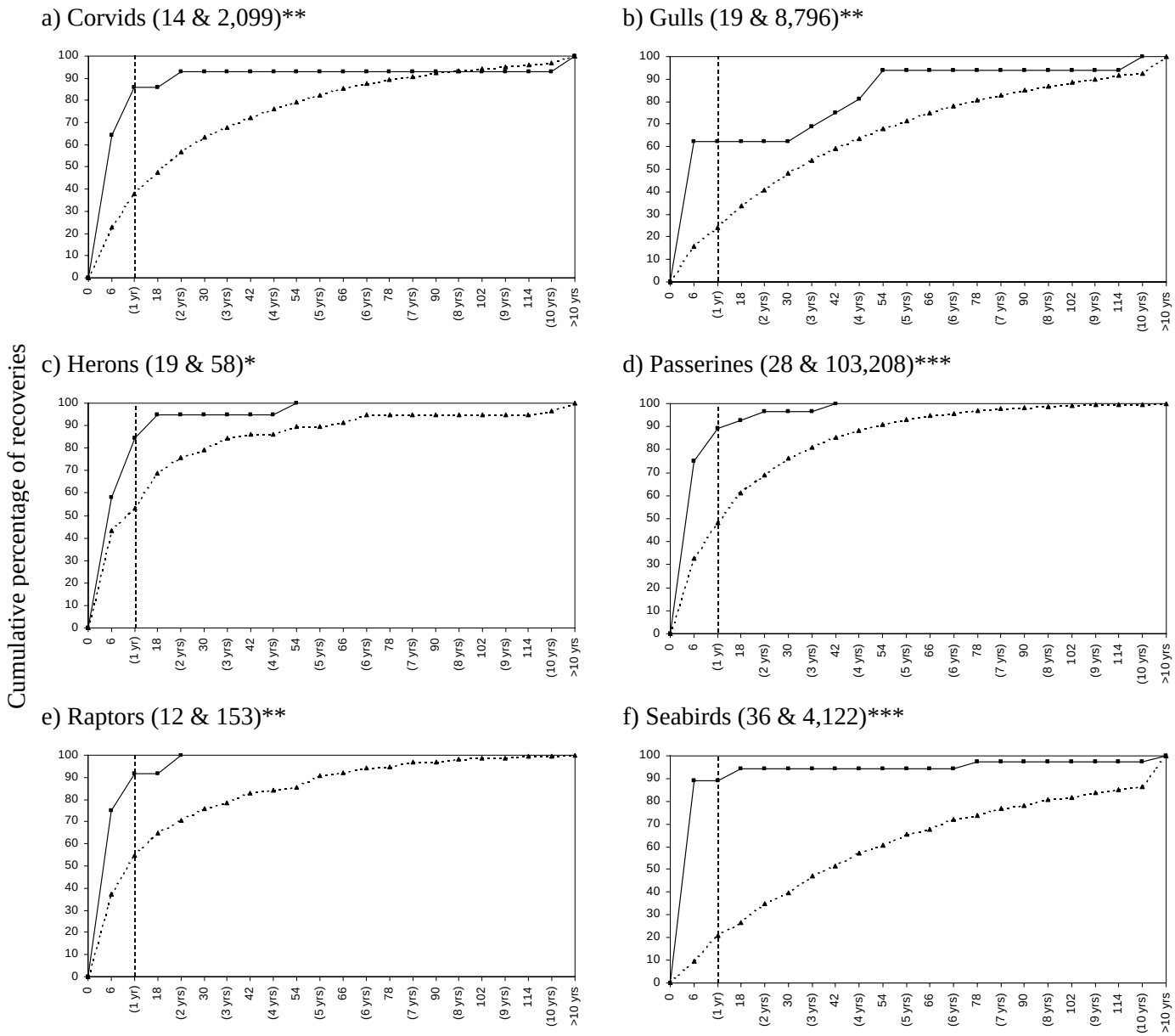


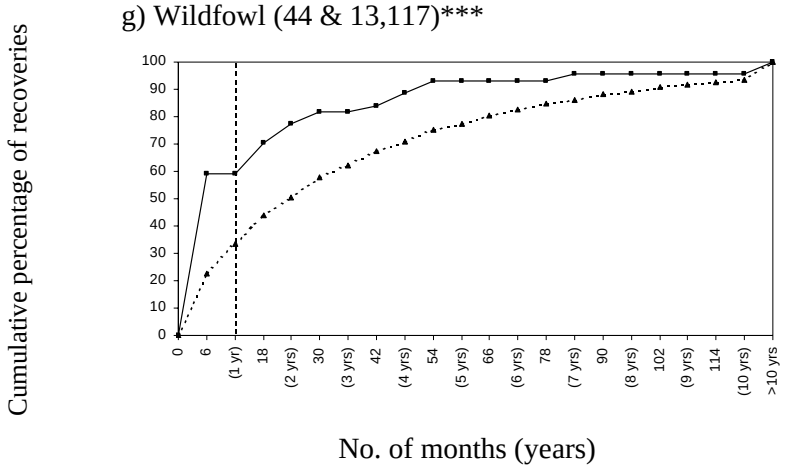
Figure 3.5.1 Comparison between rehabilitated and non-rehabilitated birds combined into groups for the number of dead recoveries for time elapsed from ringing to recovery for fledged birds. All recoveries, adults and juveniles combined.



Solid lines joining squares are RH birds and dashed lines joining triangles are non-RH birds. The vertical dashed line marks year one. Sample sizes are given in parentheses for RH and non-RH birds respectively. ***, ** and * denotes P<0.0001, P<0.001 and P<0.05 respectively for Kolmogorov-Smirnov 2-sample test between RH & non-RH (see Table 3.5a for respective values of KSa and P).

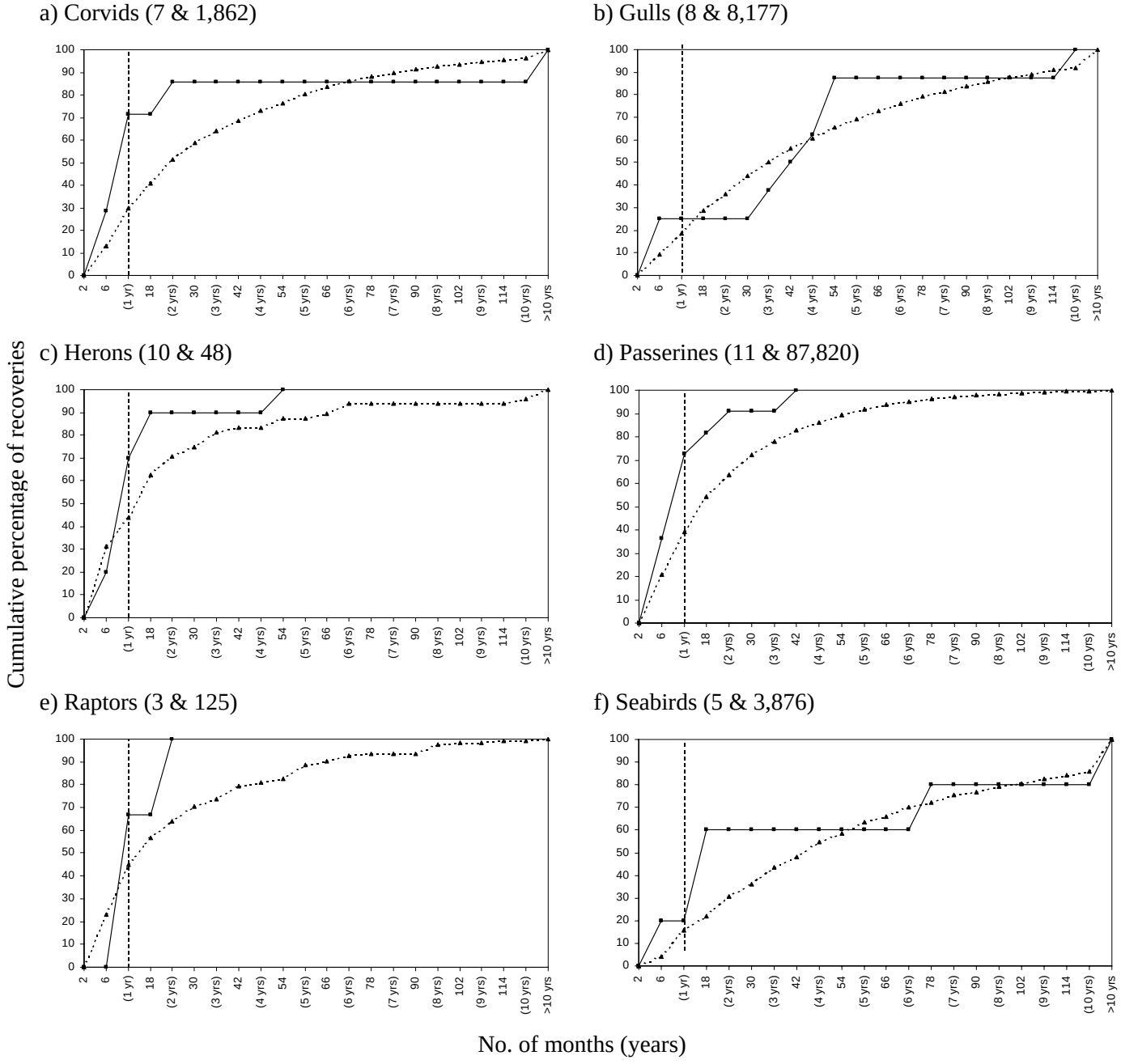
Figure 3.5.1 continued

g) Wildfowl (44 & 13,117)***



Solid lines joining squares are RH birds and dashed lines joining triangles are non-RH birds. The vertical dashed line marks year one. Sample sizes are given in parentheses for RH and non-RH birds respectively. ***, ** and * denotes P<0.0001, P<0.001 and P<0.05 respectively for Kolmogorov-Smirnov 2-sample test between RH & non-RH (see Table 3.3a for respective values of KSa and P).

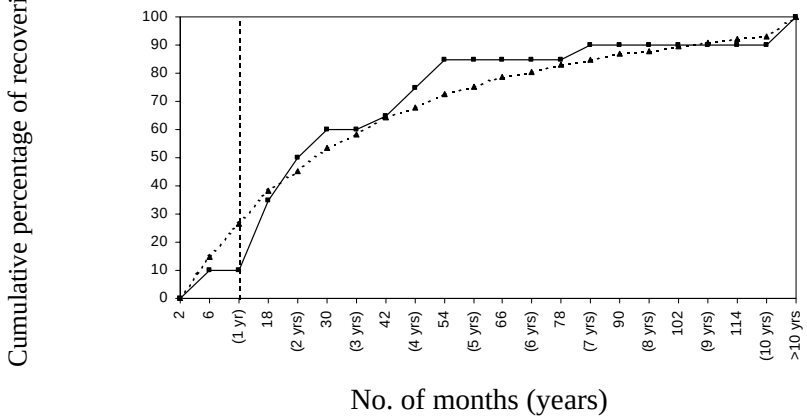
Figure 3.5.2 Comparison between rehabilitated and non-rehabilitated birds combined into groups of the number of dead recoveries for time elapsed from ringing to recovery for fledged birds. Juveniles and adults combined. Recoveries within the first two months after ringing are excluded.



Solid lines joining squares are RH birds and dashed lines joining triangles are non-RH birds. The vertical dashed line marks year one. Sample sizes are given in parentheses for RH and non-RH birds respectively. ***, ** and * denotes P<0.0001, P<0.001 and P<0.05 respectively for Kolmogorov-Smirnov 2-sample test between RH & non-RH (see Table 3.5b for respective values of KSa and P).

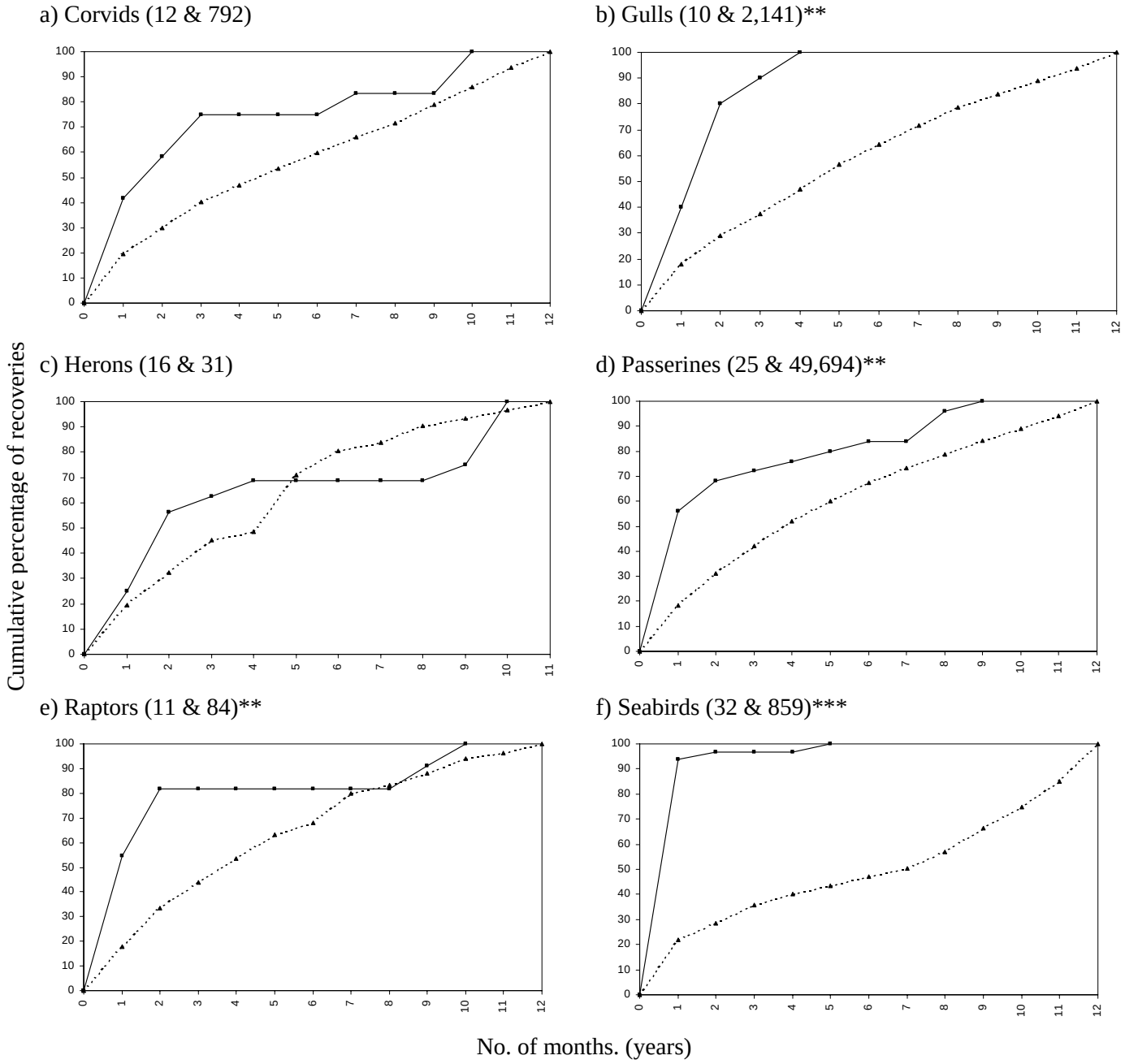
Figure 3.5.2 continued

g) Wildfowl (20 & 11,886)



Solid lines joining squares are RH birds and dashed lines joining triangles are non-RH birds. The vertical dashed line marks year one. Sample sizes are given in parentheses for RH and non-RH birds respectively. ***, ** and * denotes P<0.0001, P<0.001 and P<0.05 respectively for Kolmogorov-Smirnov 2-sample test between RH & non-RH (see Table 3.5b for respective values of KSa and P).

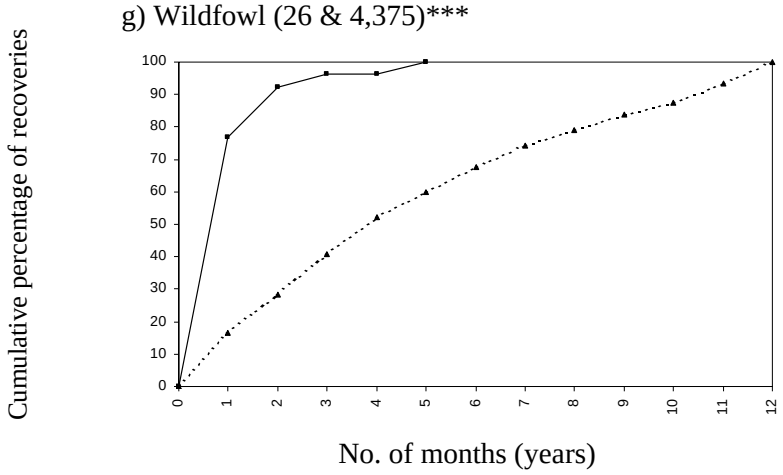
Figure 3.5.3 Comparison between rehabilitated and non-rehabilitated birds combined into groups of the number of dead recoveries for time elapsed from ringing to recovery for fledged birds. Juveniles and adults combined. Recoveries within the first year after ringing only.



Solid lines joining squares are RH birds and dashed lines joining triangles are non-RH birds. The vertical dashed line marks year one. Sample sizes are given in parentheses for RH and non-RH birds respectively. ***, ** and * denotes P<0.0001, P<0.001 and P<0.05 respectively for Kolmogorov-Smirnov 2-sample test between RH & non-RH (see Table 3.5c for respective values of KSa and P).

Figure 3.5.3 continued

g) Wildfowl (26 & 4,375)***



Solid lines joining squares are RH birds and dashed lines joining triangles are non-RH birds. The vertical dashed line marks year one. Sample sizes are given in parentheses for RH and non-RH birds respectively. ***, ** and * denotes P<0.0001, P<0.001 and P<0.05 respectively for Kolmogorov-Smirnov 2-sample test between RH & non-RH (see Table 3.3 C for respective values of KSa and P).