Corella, 1995, 19(1): 18-23

A CHOICE OF METHODS FOR ESTIMATING SEXES OF BIRDS USING MORPHOMETRIC MEASUREMENTS: A REPLY TO ROGERS AND ROGERS (1995)

GRAHAM H. PYKE

Australian Museum, 6 College St, Sydney, NSW 2000

Received 27 July, 1994

INTRODUCTION

Male and female birds often tend to differ with respect to one or more morphological measurements (e.g. Rooke 1976; McFarland 1986; Rogers *et al.* 1986; Pyke and Armstrong 1993). Male New Holland and White-cheeked Honeyeaters, for example, tend to be larger than females in terms of the distance from the back of the skull to the tip of the bill (i.e. headbill length) (Rooke 1976; McFarland 1986; Rogers *et al.* 1986; Pyke and Armstrong 1993). Consequently a frequency histogram of such a measurement for a whole bird population may be broader than that for just one sex and may even be bimodal (e.g. Pyke and Armstrong 1993; Rogers and Rogers 1995). This provides the potential for using the observed frequency histogram to provide a method of estimating the sex of each individual and estimates of the frequency distribution of the measurement for each sex (e.g. Pyke and Armstrong 1993; Rogers and Rogers 1995).

Ideally, any method for sexing birds based on the observed frequency histogram of a morphological measurement, should:

(a) be relatively easy to use;

(b) be based on reasonable assumptions;

(c) produce estimates that are generally accurate and unbiased;

(d) produce estimates with known and reasonably small associated error.

To date three general approaches to such sexing of birds have been proposed. One is based simply on estimating the position of the internodal trough in a bimodal frequency histogram of some morphological measurement (Pyke and Armstrong 1993). A second is based on an examination of the cumulative frequency distribution of the measurement when it is plotted on probability paper (e.g. Harding 1949; Cassie 1954; Griffiths 1968). The third method involves using analytical procedures to derive estimates of the locations and shapes of the frequency distribution for each sex (e.g. Rogers *et al.* 1986; Rogers and Rogers 1995).

In the context of this reply to Rogers and Rogers (1995) it is appropriate to review these alternative methods and to consider the extent to which each satisfies the above criteria.

ALTERNATIVE METHODS

Estimating internodal trough position

Pyke and Armstrong (1993) presented a method for sexing honeyeaters based on the frequency histogram of headbill lengths. Their method could, however, be applied to any morphological measurement that shows a similar bimodal frequency histogram.

The method presented by Pyke and Armstrong (1993) involves two steps. First, an interval size is chosen for the frequency histogram so that the resulting histogram was reasonably smooth with a clear trough. Secondly, the position of the internodal trough is estimated by eye. This value is then used as a threshold to estimate the sex of each individual: if the measurement is larger than the threshold, the individual is estimated to be male; if the measurement is smaller, the individual is taken to be female.

This method is clearly relatively simple. It does, however, have a number of shortcomings with respect to the other criteria above (Rogers and Rogers 1995). These are discussed below.

Firstly, the results of the Pyke and Armstrong (1993) method may depend on the size chosen for the class interval in the frequency histogram since this interval size can alter the histogram appearance (Rogers and Rogers 1995). Large intervals may result in a smooth histogram and hence define the trough, but the threshold may then lie within a relatively large range (Rogers and Rogers 1995). Small intervals are subject to relatively large sampling error (Rogers and Rogers 1995).

The results of the Pyke and Armstrong (1993) method may also depend on both the sex ratio in the sample of measured birds and the variability of the measurement for each sex (Rogers and Rogers 1995). This can most easily be seen by imagining that the frequency histogram of the measurement for the sample of birds is the sum of that for males and that for females (see Rogers and Rogers 1995). It follows that the position of the internodal trough will shift to the left (i.e. towards smaller values) with decreases in either the proportion of the smaller sex in the sample or the variance of the histogram associated with this sex (Rogers and Rogers 1995).

Consequently, the method of Pyke and Armstrong (1993) may only apply when the sex ratio in the bird sample is approximately 1:1 and when the frequency histograms for each sex are similar in shape. These would be reasonable assumptions when the frequency histogram for the bird sample appears to be symmetrical about the observed trough and, in particular, appears to have two peaks of roughly equal height. This can be tested statistically by reversing the observed frequencies to the right of the threshold and comparing them with the frequencies to the left of the threshold.

Use of the Pyke and Armstrong (1993) method requires visual inspection (i.e. 'eyeballing', *sensu* Rogers and Rogers 1995) for estimating the position of the internodal trough and hence the threshold for sexing birds (Rogers and Rogers 1995). Consequently, the achieved accuracy of the method could, in general, be low. However, in the particular case of the bird samples considered by Pyke and Armstrong (1993), the adopted method estimated sexes of birds with good accuracy (Pyke and Armstrong 1993).

The method of Pyke and Armstrong (1993) does not, in general, lead to estimates of the error associated with the estimated sex for a particular individual, the sex ratio in the population, or the shape of the frequency histogram for each sex (Rogers and Rogers 1995). If these are considered necessary then this method will not suffice. It may, however, be more satisfactory within its more modest goal of estimating the sexes of captured honeyeaters (Pyke and Armstrong 1993).

The method of Pyke and Armstrong (1993) leads, in particular, to a single threshold for sexing birds and individuals with measurements close to the threshold may be very likely to be incorrectly sexed (Rogers and Rogers 1995). Consequently, this method may only be useful where the overlap between the sexes is relatively slight and it is considered necessary to have an estimated sex for each observed individual as in behavioural and ecological studies such as those of Pyke, Armstrong and others (e.g. Armstrong 1990; 1991a, 1991b, 1992; Pyke and O'Connor 1989; Pyke *et al.* 1989, 1993; Pyke and O'Connor 1993). In some studies, of course, it may be considered necessary to concentrate on observations taken from only those individuals which can be sexed with confidence (Rogers and Rogers 1995).

In summary, the method of Pyke and Armstrong (1993) is relatively easy to use but requires assumptions that will not be generally satisfied and yields estimates that are generally biased, may not be accurate, and do not have known associated error. It is likely to be useful only in special circumstances.

Plotting cumulative frequency distribution on probability paper

Probability paper has been used to estimate the shapes of the frequency distributions of morphological measurements for different but intermingled groups (e.g. sex) by several authors (e.g. Harding 1949; Cassie 1954; Griffiths 1968; Barter 1985). In all cases the measurements are considered in class intervals.

This method, though not quite as simple as that of Pyke and Armstrong (1993), requires little more than the plotting of the cumulative frequency distribution for a particular measurement on probability graph paper (as devised by Hazen 1913).

The method rests on the assumption that the observed frequency distribution of the measurement for all groups combined is the arithmetic sum of the distributions for each group and the frequency distribution for each group is Normal in shape (e.g. Harding 1949). Under this assumption, the cumulative frequency distribution, when plotted on probability graph paper, is sigmoidal in shape consisting of linear segments with intervening points of inflexion (Harding 1949; Cassie 1954; Griffiths 1968). The location and slope of each linear segment provides estimates of the mean and standard deviation of each of the group distributions, while the positions of the inflexion points provide estimates of the relative abundance of each group in the total sample (Harding 1949).

The validity of the assumption that the component distributions are Normal in shape has not been determined (see below).

The results of using this method will, like the method of Pyke and Armstrong (1993), be sensitive to the size of the class interval chosen for the frequency distribution. With increasing size of the class interval, the frequency distribution will become increasingly smooth and hence its shape increasingly clear. But, at the same time, the location of the inflexion points and the parameters for each component distribution will become decreasingly precise.

This method also involves 'eyeballing' and therefore has similar problems in terms of accuracy to the Pyke and Armstrong (1993) method. The best-fitting sigmoidal curve is drawn by eye through the cumulative frequency distribution and the position of the point of inflexion determined by visual inspection (Cassie 1954; Griffiths 1968).

The means and standard deviations for each component group are then calculated numerically as explained in Harding (1949) and Cassie (1954). However, this component of the method requires the further assumption that, at least in the vicinity of the point of inflexion, the cumulative frequency distribution is hyperbolic in shape (Harding 1949; Cassie 1954; Griffiths 1968).

These means and standard deviations can then be used to derive, with a predetermined level of accuracy, criteria for estimating the groups to which individual birds belong. If, for example, there were two groups (such as males and females), then a threshold could be found such that an individual with a measurement greater than the threshold has a specified probability of being a member of one of the groups (Harding 1949; Cassie 1954; Griffiths 1968).

This method, like that of Pyke and Armstrong (1993), does not lead to estimates of the errors associated with the various parameter estimates and hence with any estimate of an individual's sex. Only with analytical methods can such error values be obtained (see below).

However, unlike the method of Pyke and Armstrong (1993), this method produces results that are not affected by either unequal numbers of each group or unequal variances of each component distribution.

In summary, the graphical approach based on the cumulative frequency distribution provides a reasonably easy method to use and yields unbiased estimates. However, the validity of its underlying assumption has not been determined, it may not always be accurate, and it does not yield estimates of any associated error values.

Analytical methods

Analytical methods for deriving component frequency distributions from frequency distributions that represent mixtures of these components have been discussed by many authors (e.g. Pearson 1915; Rao 1948; Wessels 1964; Hasselblad 1966; Bhattacharya 1967; Day 1969; Macdonald 1969; Fryer and Robertson 1972; Tan and Chang 1972; Dick and Bowden 1973; Hosmer 1973; James 1978; Macdonald and Pitcher 1979). In addition, similar methods have been relatively recently developed by K. Rogers (Rogers *et al.* 1986; Rogers and Rogers 1995) and used for some Australian birds (e.g. Rogers *et al.* 1986; Barter 1989, 1990; Fry 1990). These methods are all considerably more complex than those discussed above.

These methods all assume that the observed frequency distribution of measurements for the sample of animals considered is a random sample from the frequency distribution for the population as a whole (e.g. Rogers *et al.* 1986; Rogers and Rogers 1995). They also assume that the population consists of a known number of component groups, that the population frequency distribution is the arithmetic sum of the distributions for each component group of the sample and that each of these distributions has a Normal shape (Wessels 1964; Hasselblad 1966; Bhattacharya 1967; Day 1969; Dick and Bowden 1973; Hosmer 1973; James 1978; Macdonald and Pitcher 1979).

This approach involves the estimation of large numbers of variables. In general, assuming there are k component groups, there are then 3k–1 parameters to be estimated. For each component group it is necessary to estimate three parameters, namely the mean, standard deviation and proportion of the whole sample. However, these proportions must sum to 1, and so the total number of parameters to be estimated is reduced from 3k by 1. For two component groups, as, for example, when considering differences between the sexes, there will therefore be 5 variables to be estimated. As other parameters such as age are added the number of variables to be estimated increases rapidly.

Two general analytical methods have been used to estimate these parameters from a sample of measurements. One is based on comparing the moments (i.e. mean, variance, third moment, etc) of a possible mixture of distributions with the observed moments for the sample. A search is made for the parameters of the possible mixed distribution that result in the equivalent moments being identical (Pearson 1915; Rao 1948; Fryer and Robertson 1972; Tan and Chang 1972). The other is based on the probability (or 'likelihood') of obtaining the observed sample after a random sample of a population with particular parameters. In this case, a search is made for the parameter values which maximize this likelihood.

Other possible methods that may be applied to this problem include those of 'least squares' and 'minimum Chi square' (Sokal and Rohlf 1981). The least squares method involves finding the parameter values that minimize the sum of the squared differences between the observed frequency distribution and that expected for each set of parameter values. The minimum Chi square method is also based on the differences between the expected sample frequency distribution, given a particular choice of the parameters, and the observed sample frequency distribution. In this case a search is made for the parameter values that result in the minimum value for a Chi-square statistic (see Day 1969; Sokal and Rohlf 1981) calculated from the two distributions.

After some calculation, these analytical methods lead to estimates of the errors associated with the various parameters and hence to confidence intervals for these parameters (e.g. Hasselblad 1966; Day 1969; Dick and Bowden 1973; Hosmer 1973).

For all the above methods, the search for appropriate parameter values will be a difficult and time-consuming mathematical exercise. This exercise is made simpler, however, by two alternative assumptions concerning the magnitudes of the standard deviations for the component distributions. On the one hand, it may be reasonable to assume that these standard deviations are all equal (Macdonald and Pitcher 1979). On the other hand, since standard deviations often increase with the size of the mean, it may be reasonable to assume that the standard deviations are proportional to the means, or, in other words, that the coefficients of variation are equal. In both cases, the number of parameters to be estimated is reduced from 3k–1 to 2k.

To further ease the problem, high-speed computers have been programmed to carry out the search process (Macdonald 1969; Brassard and Correia 1977; Clark 1977; Macdonald and Pitcher 1979).

There is apparently no easy way to estimate the number of component groups in the population (Macdonald and Pitcher 1979). In some cases the number of component groups can be estimated if the component groups in a relatively small sub-group can be identified (Macdonald and Pitcher 1979). In other cases the only guide may be the number of peaks in the overall frequency distribution.

It is not appropriate, in the present paper, to review the statistical literature on the estimation of components of mixed distribution. It seems clear, however, that any mathematical and computer-based approach to estimating the population parameter values must be based on correct mathematical formulae and an accurate and efficient computer algorithm for locating the appropriate parameter values. Achieving this is a challenge in itself (e.g. Macdonald and Pitcher 1979). The statistical literature in this area has a long history and is now quite extensive (e.g. Pearson 1915; Rao 1948; Wessels 1964; Hasselblad 1966; Day 1969; Fryer and Robertson 1972; Tan and Chang 1972; Dick and Bowden 1973; Hosmer 1973; James 1978; Macdonald and Pitcher 1979).

In summary, these various analytical methods are not easy to use and are based on assumptions that have not yet been validated for the sexing of birds. However, they produce parameter estimates that are unbiased and have a known associated error. They are probably more accurate than the graphical methods but this has not been demonstrated.

General comments on alternative methods

Both the second and third of the above methods make the assumption that the component distributions are Gaussian or Normal in shape. Surprisingly, however, this assumption was not tested in papers reporting the results of using these methods (e.g. Barter 1985, 1986, 1989, 1990; Fry 1990; Rogers *et al.* 1986) and there are, in fact, apparently no published tests of this assumption for morphological measurements of Australian birds.

All three methods would benefit from information regarding the measurements for known component groups of the population. This can provide an estimate of the accuracy of the method being used (e.g. Pyke and Armstrong 1993), or it may provide help in estimating how many component groups there are in the population.

The usefulness of all three methods should increase with increases in the size of the sample considered.

RESPONSE TO COMMENTS BY ROGERS AND ROGERS (1995)

In this issue of Corella, Rogers and Rogers (1995) have published a critical commentary on the earlier paper by Pyke and Armstrong (1993). A few comments in reply seem appropriate.

Most importantly, Rogers and Rogers (1995) describe what they see as 'serious problems' with our approach in terms of its potential for inaccuracy and bias. We agree, as discussed above, that the method has shortcomings in these areas. However, as is also indicated above, no method is without its attendant problems and each worker will have to choose the method that is most appropriate to his/her needs. In the above discussion I have attempted to describe the nature of this choice.

Rogers and Rogers (1995) argue that our 'procedure does not produce results which can be used by other workers' and imply that other methods do. However, whatever method is used, the results are just as likely to be location or region specific and use of them by other workers will depend on the question being asked. If it is geographic variation in some morphological measurement that is of interest, then the method of Pyke and Armstrong (1993) is unlikely to yield useful results. But then it was not intended to do this (Pyke and Armstrong 1993).

Rogers and Rogers (1995) are also critical of the fact that raw data are not provided in Pyke and Armstrong (1993). However, this criticism seems unwarranted given that the publication of raw data is the exception rather than the rule. Like many or most other authors, we would be happy to provide our raw data to anyone who requests them.

Rogers and Rogers (1995) suggest that 'Pyke and Armstrong (1993) could have tested if their histogram of Yellow-faced Honeyeater head-bill lengths concealed slight size dimorphism by comparing it against a normal distribution'. However, even if the frequency distribution for Yellow-faced Honeyeaters revealed a significant departure from normality, this could be due to an underlying non-Normal distribution, just as easily as to the distribution being a composite of two (or more) Normal distributions. I suspect, furthermore, that the statistical power of the proposed test would, for an observed distribution with a single peak, be very low. Further consideration needs to be given to such unimodal distributions before the usefulness of any approach based on a composite of distributions will be apparent.

Rogers and Rogers (1995) also state that Armstrong and Pyke (1993) were in error with respect to statements we made concerning the methods used in Rogers *et al.* (1986) and the geographic location of the study carried out by Congreve and reported in Rogers *et al.* (1986). We regret the latter mistake but are not guilty of the former. We referred to Day (1969) as a reference which shows how a 'combined distribution is separated into two normal distributions' and indicated that the methods of Rogers *et al.* (1986) involve the calculations of thresholds from these normal distributions (see Pyke and Armstrong 1993). We were unable to describe the methods of Rogers *et al.* (1986) because their paper does not indicate what they are.

Rogers and Rogers (1995) also indicate that they have developed 'a suite of user-friendly computer programs to deal with' the separation of two components of a mixed frequency distribution. They do not, however, indicate the mathematical basis for their methods nor how these methods work (Rogers and Rogers 1995). These methods are not, furthermore, described in earlier papers (Barter 1985, 1986, 1989, 1990; Rogers *et al.* 1986; Fry 1990). Hence it is not yet possible to evaluate them.

CONCLUSION

There is a range of possible methods for sexing birds using morphometric measurements (or for separating any population sample into its components) and each method has its own suite of problems. Hence each user will have to choose a method that is appropriate for his/her needs.

Only the method of Pyke and Armstrong (1993) has been evaluated in terms of accuracy. For New Holland and White-cheeked Honeyeaters in heathland near Sydney the achieved accuracy was very good (Pyke and Armstrong 1993). However, for the reasons explained above, such high accuracy cannot necessarily be expected to occur in general. The analytical methods would probably be the most accurate but this has not yet been demonstrated.

The analytical methods would seem to offer much potential. With the development of suitable and appropriate computer software, they may become reasonably easy to use. They may also, as stated above, produce accurate and unbiased parameter estimates with known error values. However, it is not yet clear how useful the available software is, nor how accurate these methods are.

Until the analytical methods are fully developed, I recommend that the graphical approach based on the cumulative frequency distribution be used in general for sexing birds based on morphometric measurements. I also recommend that the method of Pyke and Armstrong (1993) be used in cases where its assumptions are satisfied and where a very easy method is desired.

ACKNOWLEDGMENTS

This research was supported by a grant from the Australian Research Grants Scheme and by the Australian Museum. Helpful comments on earlier drafts were provided by Richard Major.

REFERENCES

Armstrong, D. P. (1990). Co-operative care of fledglings by New Holland Honeyeaters. *Emu* **90:** 132–135.

Armstrong, D. P. (1991a). Aggressiveness of breeding territorial honeyeaters corresponds to seasonal changes in nectar availability. *Behav. Ecol. Sociobiol.* **29:** 103–11 1.

Armstrong, D. P. (1991b). Nectar depletion and its implications for honeyeaters near Sydney. *Aust. J. Ecol.* **16:** 99–109.

Armstrong, D. P. (1992). Correlation between nectar supply and aggression in territorial honeyeaters: causation or coincidence. *Behav. Ecol. Sociobiol.* **30:** 95–102.

Bhattacharya, C. G. (1967). A simple method of resolution of a distribution into Gaussian components. *Biometrics* **23:** 115–135.

Barter, M. (1985). Sex determination by bill length of live adult Curlew Sandpipers *Calidrus ferruginea*. *Stilt* **7:** 8 17.

Barter, M. (1986). Great Knots partly undone. *Stilt* **9:** 5 20.

Barter, M. (1989). Bar-tailed Godwit *Limosa lapponica* in Australia. Part 1: Races, breeding areas and migration routes. *Stilt* **14:** 43–48.

Barter, M. (1990). Morphometrics of the Eastern Curlew *Numenius madagascariensis*. *Stilt* **16:** 36–42.

Brassard, J. R. and Correia, M. J. (1977). A computer programme for fitting multimodal probability density functions. *Comput. Programs Biomed.* **7:** 1–20.

Clark, I. (1977). ROKE. a computer program for nonlinear least squares decomposition of mixtures of distributions. *Comput. Geosci.* **3:** 245 256.

Day, N. E. (1969). Estimating the components of a mixture of normal distributions. *Biometrika* **56:** 463–474.

Dick, N. P. and Bowden, D. C. (1973). Maximum likelihood estimation for mixtures of two normal distributions. *Biometrics* **29:** 781–790.

Fry, G. (1990). Biometrics, moult and migration of Terek Sandpipers *Tringa terek* spending the non-breeding season in North West Australia. *Stilt* **17:** 24–28.

Fryer, J. G. and Robertson, C. A. (1972). A comparison of some methods for estimating mixed normal distributions. *Biometrics* **59:** 639–648.

Hasselblad, V. (1966). Estimation of parameters for a mixture of normal distributions. *Technometrics* **8:** 431–444.

Hazen, A. (1913). Storage to be provided in impounding reservoirs for municipal water supply. *Proc. Amer. Soc. Civil Eng.* **39:** 1943–2044.

Hosmer, D. W. (1973). A comparison of iterative maximum likelihood estimates of the parameters of a mixture of two normal distributions under three different types of sample. *Biometrics* **29:** 761 770.

James, I. R. (1978). Estimation of the mixing proportion in a mixture of two normal distributions from simple rapid measurements. *Biometrics* **34:** 265–275.

Macdonald, P. D. M. (1969). FORTRAN programmes for statistical estimation of distribution mixtures: some techniques for statistical analysis of length-frequency data. *Fish. Res. Board Can. Tech. Rep.* **129:** 1–45.

Macdonald, P. D. M. and Pitcher, T. J. (1979). Age-groups from size frequency data: A versatile and efficient method of analysing distribution mixtures. *J. Fish. Res. Board Can.* **36:** 987–1001.

McFarland, D. C. (1986). Breeding behaviour of the New Holland Honeyeater *Philidonyris novaehollandiae*. *Emu* **86:** 161–167.

Pearson, K. (1915). On the problem of sexing osteometric material. *Biometrika* **6:** 59–68.

Pyke, G. H. and Armstrong, D. P. (1993). Estimating sexes of New Holland and White-cheeked Honeyeaters from head-bill measurements. *Corella* **17:** 43–46.

Pyke, G. H. and O'Connor, P. J. (1989). Corroboree behaviour of New Holland and White-cheeked Honeyeaters. *Emu* **89:** 55 57.

Pyke, G. H. and O'Connor, P. J. (1993). Use of heathland and adjoining forest by honeyeaters: Results of a radio-tracking study. *Aust. J. Ecol.* **18:** 269–274.

Pyke, G. H., O'Connor, P. J. and Recher, H. F. (1993). Relationship between nectar production and yearly and spatial variation in density and nesting of resident honeyeaters in heathland near Sydney. *Aust. J. Ecol.* 18: 221–229.

Pyke, G. H., Recher, H. F. and O'Connor, P. J. (1989). Patterns of residency and movement among honeyeaters in heathland near Sydney. *Emu* 89: 30–39.

Rao, C. R. (1948). The utilization of multiple measurements in problems of biological classification. *J. R. Statist. Soc.* 10: 159–193.

Rogers, D. I. and Rogers, K. G. (1995). Commentary: Estimating sexes of honeyeaters from head-bill measurements. *Corella:* 19: 12–17.

Rogers, K. G., Rogers, A., Rogers, D. I., Lane, B. A. and Male, E. B. (1986). 'Bander's Aid: A Guide to Ageing and Sexing Bush Birds.' (A. Rogers: St. Andrews, Victoria.)

Rooke, I. J. (1976). A measurement for sexing New Holland Honeyeaters. *Aust. Bird Bander* 14: 72.

Sokal, R. R. and Rohlf, F. J. (1981). 'Biometry'. (Freeman and Co: San Francisco.)

Tan, W. Y. and Chang, W. C. (1972). Some comparisons of the method of moments and the method of maximum likelihood in estimating parameters of a mixture of normal densities. *J. Amer. Statist. Assoc.* 67: 702–708.

Wessels, J. (1964). Multimodality in a family of probability densities with application to a linear mixture of two normal densities. *Stat. Neerlandica* 18: 267–282.

BOOK REVIEWS

Some Time with Eagles and Falcons

Jerry Olsen, 1994. (Applied Ecology Research Group, University of Canberra: Canberra) 215 × 135 mm, viii and 159 pp, 6 tables, 6 figures, 16 colour plates. $19.95.

When I first read the title and viewed the cover of this book, memories of my own experiences with raptors came flooding back — the capture, a tangled creature completely out of its element, red piercing eyes staring into mine, slender wings catching the breeze then soaring high. These images came alive as my mind recalled the thrills of the encounter and the exhilaration of the release with freedom regained. How privileged I was to enter the world of the raptors for such a short time. But my encounters pale into insignificance compared to those of Jerry Olsen.

Jerry has accomplished what many field researchers have always said they would like to do some day but just never get around to it — publish their experiences! He has been able to weave some good yarns with snippets of research data without compromising either. The reader follows as Jerry's interest in raptors grows from his encounters in the United States of America to a full blossoming in the arid regions of South Australia and Canberra's environs. On my initial reading I pondered the relevance of his rather morbid first chapter set in the wilds of Canada but realized later that it gave an inkling of the events that would later shape his outlook on the natural world and in particular, birds of prey.

As Jerry leads us along we are introduced to his friend, Les Boyd, and the 'sport' of falconry in the United States of America. He does not make value judgements on any moral issues concerning the capturing of wild individuals or taking young from their nests to train. Whatever the reader's opinion, many aspects of the birds' ecology were able to be examined at close quarters and some additions made to the knowledge base. Besides, on occasions the captured and trained prize simply flew off to take its place in the wild leaving a bewildered handler staring into the distance. His admiration and sensitivity to the birds he handled, if not directly stated, comes shining through.

When he took up a teaching position in South Australia his interest in falcons, particularly the Peregrine, followed him. By researching questions on distribution, diet, method of attack and prey partitioning he was able to strengthen the foundation of basic knowledge necessary for more advanced studies. His interest in the effects of pesticides, especially DDT, on the reproductive success of raptors took him into the world of the oologist (egg collector). Thicknesses of egg shell before and after the introduction of DDT were examined to highlight any perceived threat within the birds' ranges. I was enthralled by his comparison of the Black and Peregrine Falcons' hunting abilities and their respective prey species. I was also intrigued by the various strategies used by prey species to escape capture. That these falcons are thought to single out the smaller or weaker was a pertinent comment on the sparse data given and is certainly worthy of future research.

Jerry's authorised experiences using falconry whilst in South Australia were utilized in trying to solve the Silver Gull problem at Sydney's airport. Readers may judge for themselves if this method could have been successful.

Rehabilitating injured birds can be a very rewarding or disheartening experience for the carer, depending on the eventual outcome. Jerry describes various encounters by tracing the history of several injured birds. This is made all the more interesting by his giving them names as I found I could then personally relate to the life history of individual birds. Jerry's involvement with these injured birds led to an opportunity to educate the general public about raptors through the film media. His charges have appeared on *Earthwatch*, several Leyland Brothers productions and a jeans commercial. They also featured in several movies including *Ground Zero* (about the British nuclear testing at Maralinga) and *Mad Max III: Beyond Thunderdome* — can you remember the scene at the 'children's camp'? To preserve the wild nature of these birds so that they can be released later and to train them to 'perform' for the camera to get that certain shot takes a great deal of patience and skill. Jerry tells how he did this describing several lighter moments but ending on a rather sad note.