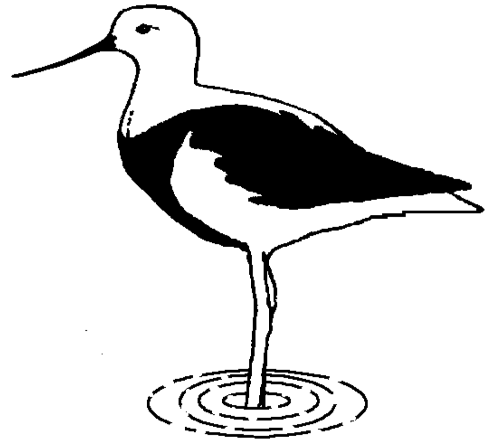
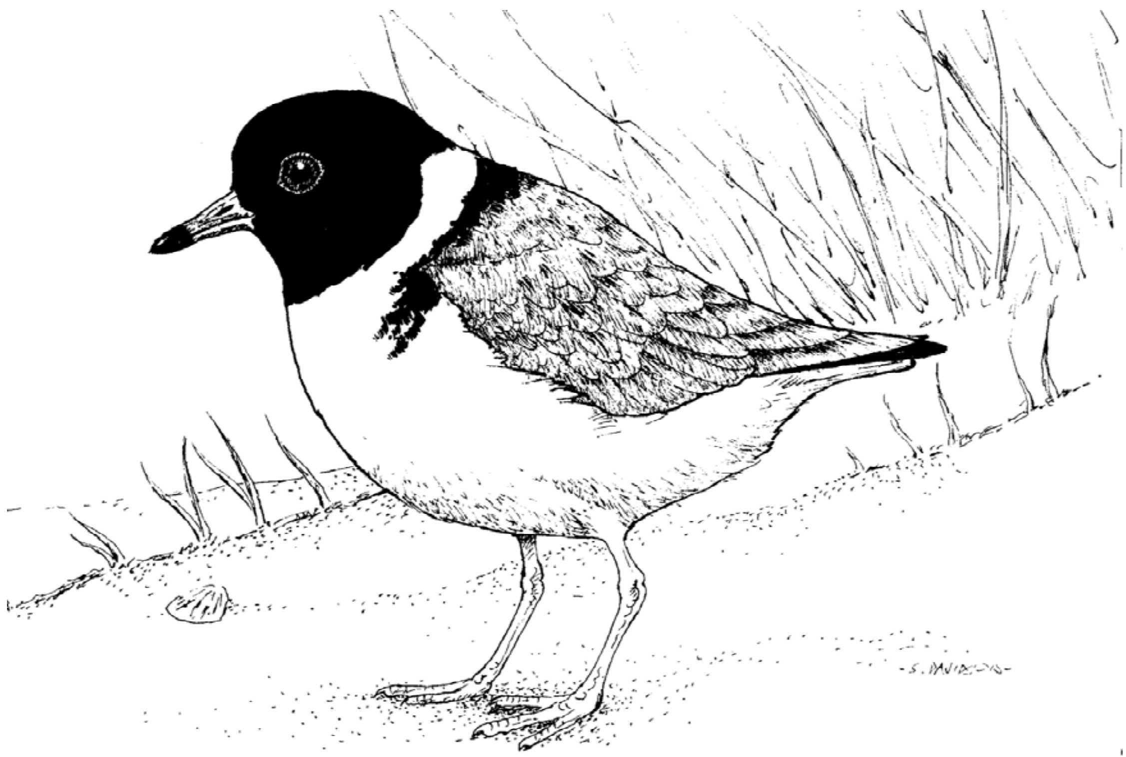
The
Stilt



The Bulletin of the East Asian-Australasian Flyway



Australasian
Wader
Studies
Group

A special interest group of Birds Australia

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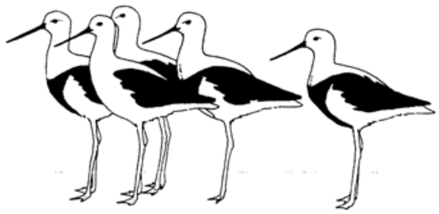
April 1998



The Stilt

ISSN 0726-1888

OBJECTIVES OF THE AUSTRALASIAN WADERS STUDIES GROUP (AWSG) OF BIRDS AUSTRALIA, A DIVISION OF THE ROYAL AUSTRALASIAN ORNITHOLOGISTS UNION (RAOU):

1. To develop or assist with plans for wader research in Australasia in conjunction with other interested bodies.
2. To co-ordinate and encourage counting, banding, foraging studies and other scientific programmes involving amateur and professional skills.
3. To encourage and assist with the publication of results.
4. To maintain effective communication between wader enthusiasts within Australasia and with similar groups overseas.
5. To formulate and promote policies for the conservation and management of waders and their habitat.

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Ken Harris, David Henderson, Laurie Living, Clive Minton, Brenda Murlis and Doug Watkins.

MEMBERSHIP OF THE AUSTRALASIAN WADER STUDIES GROUP

Membership of the AWSG is open to anyone interested in the conservation and research of waders (shorebirds) in the East Asian-Australasian Flyway. Members receive the twice yearly bulletin *The Stilt*, and the quarterly newsletter *The Tattler*. Please direct all membership enquiries to the Membership Manager at Birds Australia (RAOU) National Office, 415 Riversdale Rd, East Hawthorn, 3122. Vic., AUSTRALIA. Ph: 03-9882 2622, fax: 03-9882 2677. Email: Membership@RAOU.COM.AU

Cover Illustration: Stephen Davidson

EDITORIAL

This volume marks the start of my "apprenticeship" as editor of *The Stilt*. Following Mike Weston's decision to resign, I approached the executive committee to express my interest in becoming editor of *The Stilt*. I am a professional fisheries scientist by training but my personal interests lie with birds, especially waders and seabirds. I have been a member of Queensland Wader Study Group since it was formed in 1992 and have enjoyed participating in counts and banding activities as an amateur. In my new position as editor of *The Stilt*, I hope to contribute further by bringing aspects of my professional training to the job. I do not have any prior experience as an editor but hope to use my extensive experience as an author and journal referee to continue Mike Weston and the editorial team's excellent work to improving the standard of production and content of *The Stilt*.

The AWSG executive committee has recently developed a draft editorial policy on *The Stilt*. They wish to maintain and encourage the publication of amateur studies of waders and terns. The aim of *The Stilt* is to rapidly publish material on waders and terns from throughout the East Asian-Australasian Flyway. Papers and reports are welcome from both professional and amateur scientists even if the results are preliminary. We material published in *The Stilt* can be re-published elsewhere in a scientific journal (but probably with minor alterations).

I see some difficulties with this policy that may lead to potential conflicts for me in my role as editor. *The Stilt* has become an important source of relevant and useful scientific data that are being increasingly cited by other authors in the scientific literature. Many of the articles in *The Stilt* are of high scientific standard and could be published in scientific journals instead of *The Stilt.* Very few of the articles in *The Stilt* have been subsequently published elsewhere in a scientific journal. This means that much important information only appears in *The Stilt*, forcing other authors to cite these articles when discussing their own findings. For this reason, I feel that it remains important for me to try and maintain or improve the scientific standard of articles published in *The Stilt*. I will continue to consult referees for advice on major manuscripts and apply scientific editing as well as editing for style and format. This may mean that articles are not published in the next issue after they have been submitted.

The Stilt publishes articles from throughout the East Asian-Australasian Flyway but we receive most of our material from Australian authors. I hope to continue the efforts to reduce this bias and especially encourage amateurs and professionals from other Flyway countries to write articles for *The Stilt*. Only in this way can *The Stilt* fulfill its role as the bulletin of the entire Flyway and stimulate and encourage interest in waders in all countries.

Finally, I hope readers will appreciate my inexperience in the job and give me constructive feedback on the format and content of *The Stilt*. The bulletin belongs to us all and it is only by becoming involved that we can make a difference.

David Milton, *Editor*

CHAIR'S REPORT FOR 1997

I can report that 1997 was another year of solid progress. Major events were the holding of a meeting to develop an AWSG strategy, the completion of a comprehensive review of the AWSG's Population Monitoring Project, continuing support of training activities at Chinese Shorebird Reserve Network sites and publication of the Proceedings of the 1996 Brisbane Conference on Shorebird Conservation in the Asia-Pacific Region.

Although a review of the AWSG's achievements during the last ten years uncovers much that we can be proud of, it is important to continually question what we are doing - and the way in which we are doing it. So, in mid-November we had a meeting at Birds Australia involving the Committee and a representative from Environment Australia. It was a very productive session with lots of good ideas and constructive comments on existing and potential new activities. Major outcomes will be revised AWSG objectives, a thoroughgoing review of the Population Monitoring Project (more on that below), development of a Migration Studies Project, organising one overseas expedition each year, strengthening of the conservation role of AWSG and agreement to hold biennial technical conferences, the first hopefully in conjunction with the 2000 Southern Hemisphere Ornithological Conference to be held somewhere on the east coast of Australia. The task of bringing this all to fruition will be that of the new 1998/2000 Committee to take office in mid -1998.

The review of the Population Monitoring Project confirms what we had thought for some time - that there is an urgent need to improve the Project's statistical design, particularly in relation to count accuracy, and site habitat and bird usage information. Long term projects require strict attention to control of data quality and the counting process, otherwise later analysis and interpretation of the data in a statistically meaningful way is difficult. There is also a need to expand the programme to include additional species and populations. All of this is a very challenging task, especially for a volunteer-run organisation. We are hopeful that the significant interest that Environment Australia has indicated in wildlife monitoring will encourage them to assist us in redesigning the Project. Having said all that, we are confident that we can get useful and important information from the existing 18-year data set. During the review all of this was put on a single database, which also includes that from the Regular Counts Project which ran from 1981-90 .

Dale Tonkinson and I returned to China in April to continue the wader training activities started in 1996. This time we spent another two weeks at Chongming Dao, in the mouth of the Yangtze River near Shanghai, and then moved on for a further fortnight to the Huang He (Yellow River) Nature Reserve some 800 km further north. Our broad objectives were to train local nature reserve staff in wader ecology, study methods and habitat management. Much of the training activity involved collecting count, resource utilisation and habitat data, and the analyses of this are being progressively published - some in *Stilt*. The most exciting outcomes in 1997 were the very large numbers of waders seen at Huang He, with an estimated minimum of 500,000 waders using the delta region on northward migration, and the discovery of the first major northward staging area for the Little Curlew.

Phil Straw has done an excellent job of producing the Proceedings of the Brisbane Conference on *Shorebird Conservation in the Asia-Pacific Region* held in March 1996, just before the Ramsar Conference. The collected papers provide very useful information and background on flyway issues. We are discussing with the International Wader Study Group the possibility of using the document as the basis for a volume on the East Asian-Australasian Flyway to be published in the International Wader Studies Series.

Each year, I comment on the improvements in the quality and coverage of *Stilt* and *Tattler*. This year is no exception. Michael Weston has lifted *Stilt* to new heights and Phil Straw has made *Tattler* into a very "newsy" and readable bulletin. Unfortunately, Mike's heavy PhD research commitments have forced him to resign but we have been very fortunate to obtain the services of David Milton, who is also a QWSG member. It's good to see the jobs being spread around the country and helping to make the AWSG truly Australian. David starts his editorial role with this issue. His introduction to the job is being made much easier by the presence of Andrew Dunn, the Production Editor. Many thanks to Michael Weston for a job very well done!

Our Conservation Officer, Sandra Harding, has done a great job of promoting the conservation of waders around the Flyway. She is currently starting to gear up for the next Ramsar Conference, which is to be held in Cost Rica in 1999. She played an important role as an NGO representative at the Brisbane Conference and it is essential that we continue to monitor the performance of the Australian States and Territories and press them to live up to their obligations to conserve waders and their habitats.

The Queensland and Victorian Wader Study Groups have been very active during the year, with pride of place going to the successful Eastern Curlew satellite tracking project which the QWSG is carrying out in conjunction with the Wild Bird Society of Japan. The advances in satellite transmitter technology are remarkable, as evidenced by the fact that one of the birds was tracked to the breeding grounds and then back almost to Moreton Bay (where the transmitter was fitted) before the transmitter ceased functioning. We wish the QWSG similar successes during the continuation of the project in 1998. The Tasmanians made a major contribution to our knowledge of waders in Australia by carrying out a comprehensive count of the exciting "new" wader area in north-western Tasmania.

Looking ahead to 1998, the next, and longest ever, AWSG North-west Australia Expedition takes place from August to October. Apart from the usual banding activities, it is planned to carry out a complete count of Eighty Mile Beach in October. The previous estimate of the wader population of this region was mainly done using aerial surveying, with limited ground-truthing. It will be very interesting to see how the numbers come out this time around. Again, Clive Minton is mine host.

It is good to see that the QWSG has obtained funding from the National Heritage Trust for three years of wader studies in the south-east corner of the Gulf of Carpentaria. This area is among the top three regions for waders in Australia, but little has been done to assess its importance during the later part of the non-breeding season and during northward migration due to access difficulties in the wet season. The funding will enable helicopters and planes to be used to get to important roosting and feeding areas which are unreachable by land-based vehicles.

I have mentioned a number of Committee Members in this report, but the other members all make important contributions to the successes of the Group and I would like to thank them all for their assistance during 1997.

This is my last report to you, as I am retiring as Chairman after 12 not-so-long years! When I look back over the events of that period there is much that has been done well - improvements to *Stilt*, commencement of *Tattler*, our various research projects, expeditions both in Australia and overseas, the Brisbane Shorebird Conservation Conference, and so on... I have found being your Chairman a very rewarding experience and am thankful for having had the opportunity to make whatever contribution to wader studies and conservation that I could. But there are many challenges ahead and it's time for new ideas and people.

Mark Barter

TREASURER'S REPORT FOR 1997

This is the second year that Birds Australia have been handling our membership and financial records and this arrangement is now running satisfactorily. The end-of-year balance is somewhat over inflated because a specific grant of $3300 for the purchase of two-way radios was received from the Feilman Foundation in 1997, but the radios were not purchased until 1998. These radios will be primarily located at the Broome Bird Observatory but will be available for use elsewhere on AWSG projects if required.

Jeff Campbell, Secretary/Treasurer

Australian Wader Study Group
Consolidated Accounts
Statement of Receipts and Payments
1 January 1997 - 31 December 1997

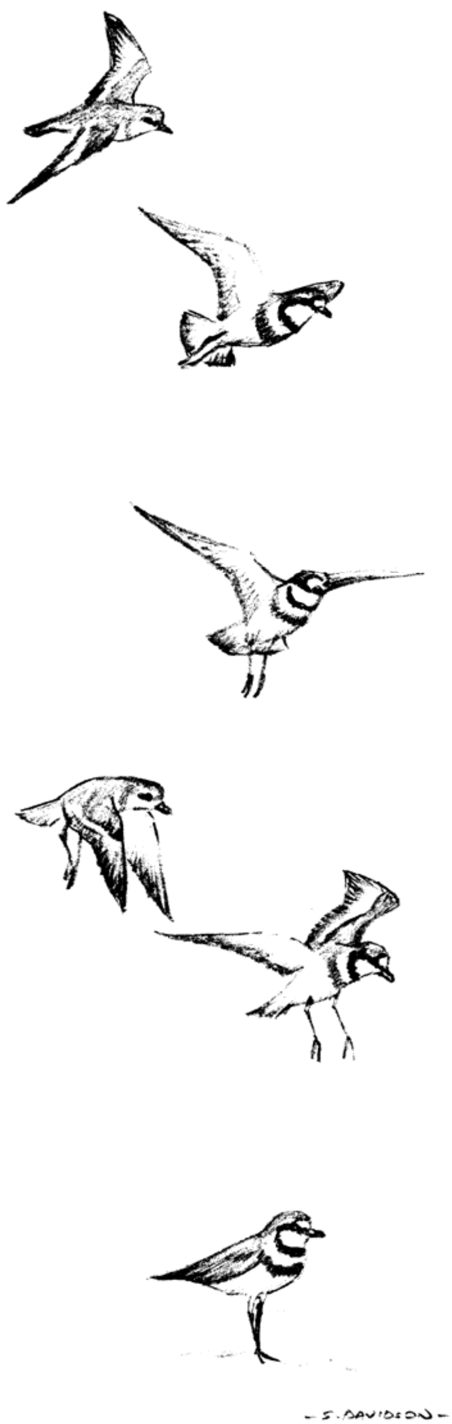
RECEIPTS	$	PAYMENTS	$
Balance b/f	14151.60	Stationary & Printing	6483.87
Subscriptions	4473.00	Photocopying	4051.75
W.I. Subscriptions	3000.00	Insurance	310.00
Sales	30.00	Travel & Accomodation	481.00
Specific Donations	13660.00	Field Expenses	92.90
		Telephone & Fax	111.51
		Strategy Meeting Costs	106.70
		Administration Fee	1000.00
		Balance c/f	22676.87
	35314.60		**35314.60**

AWSG COMMITTEE FOR 1998-2000

The new AWSG Committee to take office from 1 June 1998 is:

Chairperson	Jim Wilson
Vice-Chair	Peter Driscoll
Secretary/Treasurer	Jeff Campbell
Research Coordinator	Ros Jessop
Editor	David Milton
Assistant Editor	Phil Straw
Conservation Officer	Sandra Harding
Liaison Officer	Hugo Phillipps
Committee Members	Mark Barter
	Ken Harris
	Laurie Living
	Clive Minton
	Brenda Murlis
	Doug Watkins

As no more than one nomination was received for each position, an election was not necessary. May I take this opportunity to thank outgoing office bearers for their efforts. In particular, I thank Mark Barter, who has served as Chair of the AWSG since 1985, and has played a pivotal role in developing the group since that time. We are pleased to be able to retain his services as a committee member.



Jeff Campbell, Secretary/Treasurer

AWSG WADER EXPEDITION TO NW AUSTRALIA

Clive Minton, 165 Dalgetty Road, Beaumaris Victoria 3193 AUSTRALIA

The next special wader study expedition to NW Australia will take place, as previously announced, from 1st August to 31st October 1998.

The expedition is already "fully booked" with an average team of 26 people scheduled to be in the field throughout the 13 week period. Altogether there will be 105 participants, half from Australia (all states except Tasmania are represented) and half from overseas (10 countries).

The fieldwork programme will include regular banding at Broome and 80 Mile Beach, a week long visit to Port Hedland Saltworks, the first ever complete ground count of waders on 80 Mile Beach (200 km long and with an estimated half million waders), the first aerial survey of waders on the Broome to Port Hedland coastline since 1985, and the deployment of radio transmitters attached to birds in order to find out where the waders on Roebuck Bay roost on night-time high tides (currently a mystery). The expedition will also, for the first time, spend three days on Bush Point-at the south end of Roebuck Bay and, with 100,000 waders, the largest single high tide wader roost in the East Asian-Australian Flyway.

Clive Minton

CAN PRE-MIGRATORY WEIGHT GAIN RATES BE USED TO PREDICT DEPARTURE WEIGHTS OF INDIVIDUAL WADERS FROM NORTH-WESTERN AUSTRALIA?

Mark Barter[1] and Clive Minton[2]

[1] 21 Chivalry Avenue, Glen Waverley, VIC 3150, AUSTRALIA
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ABSTRACT
Analysis of individual and mean weight change data for eight wader species, caught in large numbers before departure on northward migration from north-western Australia, confirms previously published results that such data is of little use in predicting the departure weights of individual birds. Identifying about-to-depart birds, in some way, is likely to be a more productive approach. It is recommended that further work be done to determine whether segregation within a species occurs in roosting flocks, to elicit why many individuals in some species have markedly different mass gain strategies from year to year, and to establish the cause and nature of extended weight loss following capture.

INTRODUCTION

The departure weight of an individual wader is a key piece of data for both the foraging ecologist, who is interested in understanding how a wader attains this critical mass, and the biologist studying migration energetics, who wishes to know more about how a wader budgets fuel resources for a long flight.

Methods used to estimate departure weights have involved techniques such as manipulation of flight range equations to solve for departure weight, extrapolation of weight gain rates (obtained from a series of catches or retrapped individuals) to the departure date, or identifying about-to-depart weighed birds. These methods, and their limitations, have been discussed by Zwarts *et al.* (1990), Ens *et al.* (1990a), Barter (1996) and Rogers *et al.* (1996).

Major problems that have been identified with the use of weight gain extrapolation methods include:

1. Significant underestimation of individual weight gain rates when regressing mean catch weights over time;
2. Inability to determine departure dates accurately due to asynchronous migration;
3. Post-release weight loss affecting the ability to estimate individual weight gains for same-season recaptures.

A potential solution to the weight loss effect is to estimate weight gains for individuals captured in different departure seasons. Success depends on individual birds having recovered from the effect by the time they are recaptured in a later year and also having similar mass gain strategies in the different capture years.

Whilst the limitations listed above have generally made it difficult to use weight gain methods to predict departure weight, it seems worthwhile checking whether similar problems apply in north-western Australia, from which a large banding data set for the pre-migration period is available for many species and populations of waders. The majority of birds commence their northward migration from this region, although band controls and leg-flag sightings show that individuals of some species, eg. Red-necked Stint and Curlew Sandpiper, use it as a staging area on northward migration. Thus, complications associated with an influx of light birds affecting mean catch weights are limited.

The seven-week 1996 AWSG Wader Study Expedition to north-western Australia was a particularly fruitful one with a total of 8,135 waders being captured from early March onwards. The good adult samples obtained at frequent intervals during this expedition allowed an investigation of the mean catch weight gain technique to be conducted for a number of species, whilst the large pre-departure data set obtained over the 1985-96 period enabled the same- and different- season retrap methods to be evaluated using samples of reasonable size.

METHODS

Almost all birds were caught at three widely separated study sites (see Figure 1), mainly using cannon nets but also with mist nets at Port Hedland.

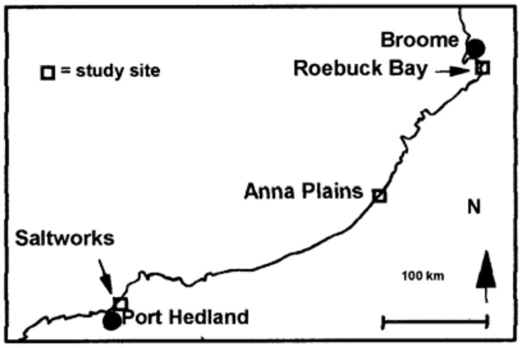


Figure 1. Locations of main catching sites in north-western Australia - Roebuck Bay, Anna Plains and Port Hedland Saltworks.

Following capture, the netted birds were quickly covered with shade cloth, extracted, and placed in shaded, covered keeping cages. Processing was always completed within four hours, and often three. Speedy extraction and processing under shady conditions is particularly important for bird welfare during the March-April period because of the high shade temperatures, which are nearly always in the 34 - 37^{0}C range, but occasionally reach 40^{0}C (Minton 1997).

Weights were measured using Pesola balances (accuracy of $\pm$ 0.3%). Rogers *et al.* (1996) have pointed out that the weights used for analysis should ideally be those existing at the time of capture. Appropriate corrections can be made to measured weights if the hold times and the temperature-dependent weight loss rate during holding are known (Castro *et al.* 1991). Weight loss rates are likely to be significant in north-western Australia as Castro *et al.* (1991) found that the rate for shorebirds approached 8% of capture weight.h^{-1} between 33^{0}C and 38^{0}C, although an experiment conducted on five adult Greater Sand Plovers on 5 April 1996 (35^{0}C) gave a weight loss of 1.5%.h^{-1} (Minton 1997). Capture weight is also dependent on the length of time since feeding ceased and on feeding effectiveness, which can be affected by weather and tidal conditions. No information is available on the magnitude of these latter factors in north-western Australia. Rogers *et al.* (1996) noted that the effect of uncorrected weights will be to underestimate catch mean and individual weights, and to increase variance.

Weighing errors can arise from measurement, recording and data entry mistakes. Incorrect balance calibration and windy weighing conditions are also potential sources of error. Potential weight variations caused by birds of varying degrees of wetness (from a wet catch) are unlikely to be serious as birds soon dry out when left in keeping cages for a short period , even in the cooler climate of Victoria, south-eastern Australia (pers. obs.).

The species selected for analysis were those for which a sufficient number of adult samples were caught during March and April 1996 to enable the appropriate mass gain period to be identified. On this basis eight species were selected: Red-necked Stint *Calidris ruficollis*, Curlew Sandpiper *C. ferruginea*, Terek Sandpiper *Xenus cinereus*, Greater Sand Plover *Charadrius leschenaultii*, Grey-tailed Tattler *Heteroscelus brevipes*, Red Knot *C. canutus*, Great Knot *C. tenuirostris* and Bar-tailed Godwit *Limosa lapponica*.

All birds were aged according to Rogers (1989). Only those aged as 2+ (second-year birds, or older) or 3+ (third-year birds, or older) were used in this analysis. In 1996, the only species for which birds were aged as 3+ were Red Knot (95 birds [=19% of 2+ plus 3+]) and Bar-tailed Godwit (661 birds [=60%]). In the mean catch weight analysis, based on the 1996 data, 2+ and 3+ Red Knot were lumped together whilst only 3+ Bar-tailed Godwit were considered.

Some species return to the breeding grounds for the first time towards the end of their second year, eg. Red-necked Stint and Curlew Sandpiper. Mature birds of such species (ie. age 2+) can be readily identified. However, other species, eg. Red Knot, Great Knot and Bar-tailed Godwit, take longer to mature and many do not return to the breeding grounds for the first time until they are near the end of their third year, or even older (ie. age 3+) (AWSG, VWSG unpub. data). Immature birds of this latter group often gain some degree of breeding plumage and are difficult to separate from breeding birds, even in the hand (Minton 1997). As the departure period approaches, more confident separation is possible on the basis of increased weight and amount of breeding plumage.

Bar-tailed Godwit were sexed using the total-head length criteria: male $\leq$ 92 mm, female $\geq$ 100 mm (Barter1989).

Table 1. Mean non-breeding weights of adults (2+ or older) based on birds caught during the October-January period.

SPECIES	Sample size	Mean weight	Standard deviation
Red-necked Stint	664	28.4	2.633
Curlew Sandpiper	722	54.8	3.931
Terek Sandpiper	169	69.4	5.828
Greater Sand Plover	627	74.2	4.627
Grey-tailed Tattler	172	97.8	7.585
Red Knot	224	109.2	8.305
Great Knot	725	141.5	12.810
Bar-tailed Godwit (male)	363	257.3	24.142
Bar-tailed Godwit (female)	200	302.8	24.726

Mean non-breeding weights were calculated from birds caught during the October to January period, when weights can be expected to have stabilised following arrival in August and September and not to have started increasing in preparation for migration. The results are given in Table 1.

The mean post capture weights of each species and adults of all species combined were estimated using a modified von Bertalanffy equation of the form:

$$W = A(1 - e^{Kt}) + Bt$$

where W = change in weight (in g) of reptraps of Curlew Sandpiper and Greater Sand Plover during the non-breeding season and percentage change in non-breeding weight (%) for all retraps combined, t = capture interval (days) and A, B and K are the estimated parameters. This equation has the advantage of fitting the observed reduction in bird weights after capture and estimates the linear rate of increase in the weight of birds as they recover from handling using an equation that has a physiological basis.

Statistical analyses were carried out using Systat 5.0 (Wilkinson 1990).

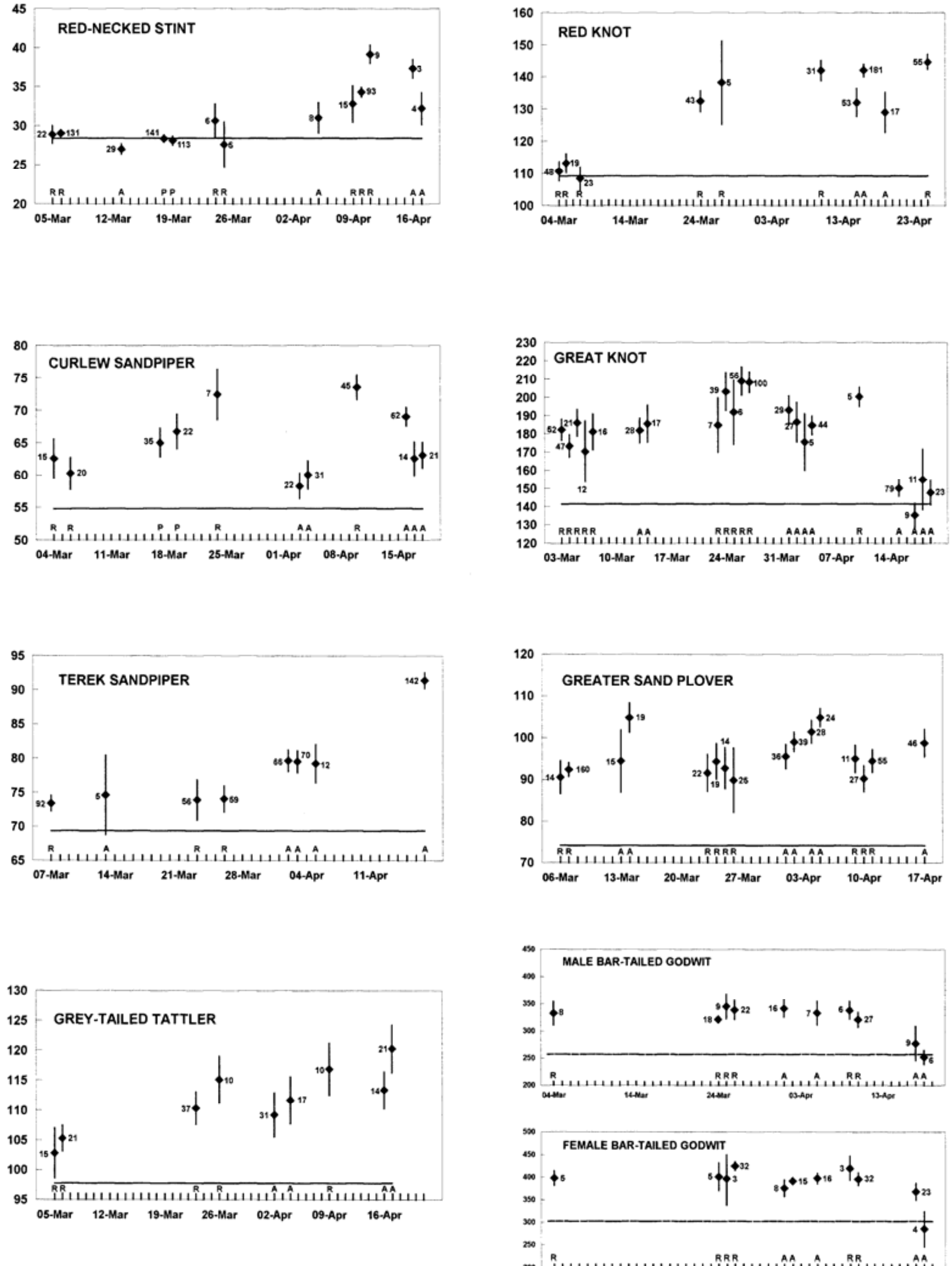
RESULTS

Mean catch masses

The 1996 mean catch weight data for the eight selected species is shown in Figure 2. Problems in using the data to predict weight gain rates and departure masses are readily apparent:

1. There is often considerable weight variability between catches made close in time. Possible explanations are:
   (1) Weight gain between catches, which is unlikely to be substantial over periods of a day or two.
   (2) Departure of heavier birds on migration and/or an influx of lighter migrants, both of which will lead to a fall in mean population weight.
   (3) Non-representative sampling. Rogers *et al.* (1996) have suggested that “bunching” may occur in roosting flocks, eg. congregations of heavier or lighter birds, either of which may be selectively caught by a cannon net catching only part of a flock.
   (4) Ageing problems, leading to the accidental inclusion of lighter immature birds in adult samples.
   (5) Differences in mass gain strategies at the three sites (Roebuck Bay, Anna Plains and Port Hedland saltworks). However, examination of the results does not indicate any general tendency for birds at one site to be heavier, or lighter, than at another.

Departure of heavier birds, bunching in flocks and ageing difficulties seem to be the most likely explanations of mean catch weight variability over short time periods.



Figures 2. Mean catch weights ± se of eight species of wader in north-western Australia during March-April 1996. Sample sizes are shown next to each observation. Horizontal line represent the mean non-breeding weight of each species. Catching locations are shown above dates: R = Roebuck Bay, A = Anna Plains, P = Port Hedland.

2. The presence of heavy, apparently ready-to-go, birds throughout much of the catching period indicates that departures may be asynchronous. This suggestion is consistent with visual observations of departing birds which show that the main migration periods are spread over one to three weeks, depending on the species (AWSG unpub. data).

Five species (Curlew Sandpiper, Great Knot, Greater Sand Plover, Bar-tailed Godwit and Grey-tailed Tattler) were already well above their mean non-breeding weight when the catching programme commenced in early March, showing that they had commenced pre-migratory weight gain. This is not an unexpected situation, especially for the first four species which depart in late March and the first half of April, but is rather surprising for the Grey-tailed Tattler, which leaves in late April. Weight gain rates of waders preparing for migration from their non-breeding site are generally of the order of 1-1.2 $\%.d^{-1}$ (Zwarts *et al.* 1990). Thus, Great Knot, having an mean non-breeding weight of 141.5 g (Table 1) and needing to put on about 100 g before departure, would require about 70 days to achieve this weight gain. Similarly, it can be calculated that Curlew Sandpipers may need about 80 days to reach migration weight. Thus, both species can be expected to have put on substantial pre-migratory weight by early March.

Early weight gain may be advantageous. Butler *et al.* (1997) have suggested that birds may maintain their energy reserves at a high level during the pre-migratory period in order to take advantage of unpredictable, but favourable migration conditions such as a strong following wind.

Three species (Red-necked Stint, Terek Sandpiper and Red Knot) had mean weights in early March which were similar to, or a little above, their non-breeding level. These species generally depart in late April (AWSG unpub. data). Both Red-necked Stint and Terek Sandpiper appear to commence pre-migratory fattening towards the end of March. The situation with Red Knots is unclear due to lack of mid-March data. However, asynchronous departures, and the possible influx of lighter migrants from southern Australia (evidence from banding controls for Red-necked Stint, Tulp & de Goeij 1994 for Red Knot), makes use of the mean catch weight gain rate approach for all three species problematical.

The effective use of mean catch weight extrapolation to the departure date as a means of estimating departure weights of individual birds appears to be precluded for a variety of reasons. The most important of these identified in this study are asynchronous departures and mean catch weight variability. Rogers *et al.* (1996) concluded similarly for Red-necked Stint in Victoria, where they said "the mean weight in each catch varies too much for reasons we cannot adequately explain".

Same-year retraps

Data for individual birds are shown in Figure 3. All available March-April data for adults have been used for Curlew Sandpiper, Greater Sand Plover, Grey-tailed Tattler, Red Knot, Great Knot and Bar-tailed Godwit, as these species have commenced gaining weight before, or at the beginning (ie. Red Knot), of this period. In the case of Red-necked Stint and Terek Sandpiper, data used are limited to the apparent mass gain periods of 1-18 April and 25 March-17 April, respectively (see Figure 2). Checks were made to ensure that no identifiable immature birds were included in the analysis (on the basis of weights similar to non-breeding levels close to the main departure period).

It is evident that the majority of recaptured birds lose weight in the days following capture. Overall, 102 out of 154 individuals recaptured within 10 days (ie. 66%) are below their initial weight and 44 out of 92 (48%) are still similarly affected in the 11-20 day period (see Table 2). However, it should be noted that some birds may have departed following capture, which could cause the proportion of birds suffering weight loss to be overestimated if those leaving were less affected than those which remained.

The fact that more than twice as many birds have lost weight as gained it during the first ten days cannot be explained by weight errors, such as incorrect measurement, recording and data entry, all of which should be randomly distributed. Other confusing factors such as wet birds and varying amounts of weight loss since capture for the different individual capture events could also be expected to behave randomly.

Empirical trend lines, which summarise the general pattern, have been fitted to the weight change data for Curlew Sandpiper, Greater Sand Plover (the two species with greatest recapture rate) and combined adult Red Knots and Bar-tailed Godwits (Figure 4). The best fits for each species were: Curlew Sandpiper (weight change (in g) $W = -24.04(1 - e^{-0.14t}) + 1.35t$; $P < 0.001$), Greater Sand Plover ($W = -16.21(1 - e^{-0.14t}) + 0.92t$; $P < 0.001$) and all reptraps (% non-breeding weight $W = -11.84(1 - e^{-0.34t}) + 0.84t$; $P < 0.001$) . On average, birds lose about 5% of their initial capture weight, reaching a minimum at 4-5 days following capture, and return to their

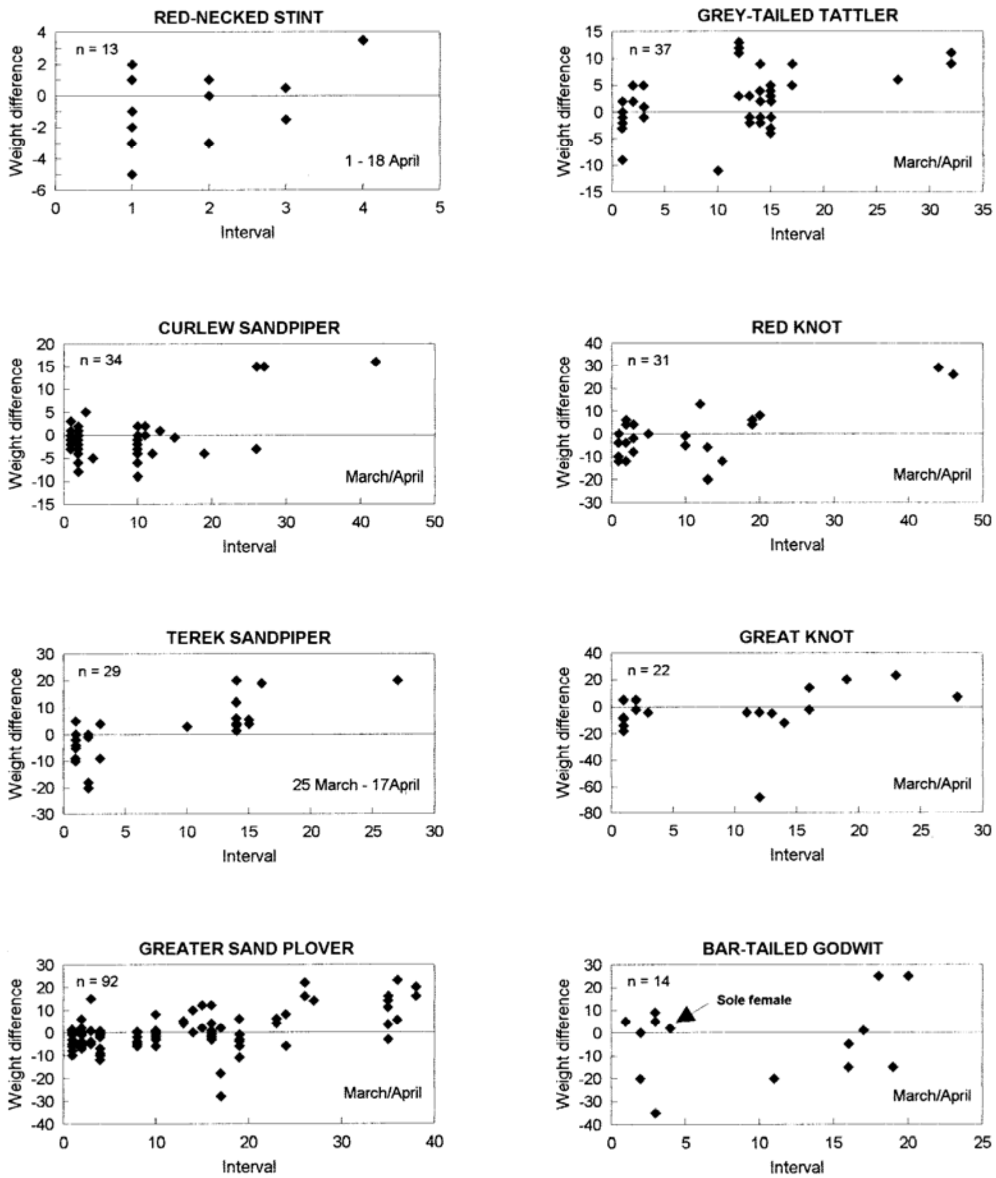


Figure 3. Weight changes (in g) of individuals caught twice in the same March-April season (Interval in days). n = sample size.

initial weight after about 15 days. Departure of relatively less affected birds would cause both mean weight losses and the recovery time to be overestimated. Weight gain rates of Greater Sand Plover and all retraps combined, approach 0.92g (1.24%) and 0.84%.d^{-1} respectively, following the return to initial capture weight. These values are broadly consistent with estimated weight gain rates for waders commencing migration from Australia, South Africa and the Banc d'Arguin (Zwarts *et al.* 1990) and for Red-necked Stint leaving south-east Australia (Rogers *et al.* 1996).

Weight losses in the three to eight day period following capture have been reported elsewhere (van Broderode *et al.* 1982, van Dijk *et al.* 1986, Mascher 1966, Morrison 1984, Page and Middleton 1972, Thompson 1974 in Ens *et al.* 1990a) and Ens

Table 2. Numbers of same March-April season recaptures which are above, same or below initial capture weights during three different periods following capture.

	0 - 10 days			11 - 20 days			21 - 44 days			
SPECIES	above	same	below	above	same	below	above	same	below	TOTAL
Red-necked Stint	2	0	4	1	0	6	0	0	0	13
Curlew Sandpiper	7	3	24	2	1	3	3	0	1	44
Terek Sandpiper	3	3	13	9	0	0	1	0	0	29
Greater Sand Plover	13	5	34	11	2	11	14	0	2	92
Grey-tailed Tattler	5	2	7	15	0	8	0	0	0	37
Red Knot	2	0	9	2	0	6	2	0	0	21
Great Knot	2	0	9	2	0	6	1	0	2	22
Bar-tailed Godwit - male	3	1	2	3	0	4	0	0	0	13
Bar-tailed Godwit - female	1	0	0	0	0	0	0	0	0	1
TOTALS	**38**	**14**	**102**	**45**	**3**	**44**	**21**	**0**	**5**	**272**

et al. (1990a) found that Mauritanian Ruddy Turnstones *Arenaria interpres* caught within 10-20 days on average decreased in weight, that the subsequent weight gain rate was less than that of the population as a whole and that it took birds 25 days to recover from the apparent traumatic effects of catching. Rogers *et al.* (1996) also found that Red-necked Stint in Victoria seemed to lose weight following capture.

Whilst weight gain rates appear to return to normal levels in time, this is not certain (eg. as for Mauritanian Ruddy Turnstones, see above), and it seems inherently unsatisfactory to predict departure weights based on results obtained from birds suffering adverse capture-effects. The delayed resumption of weight gain could adversely affect breeding success if it results in late arrival on the

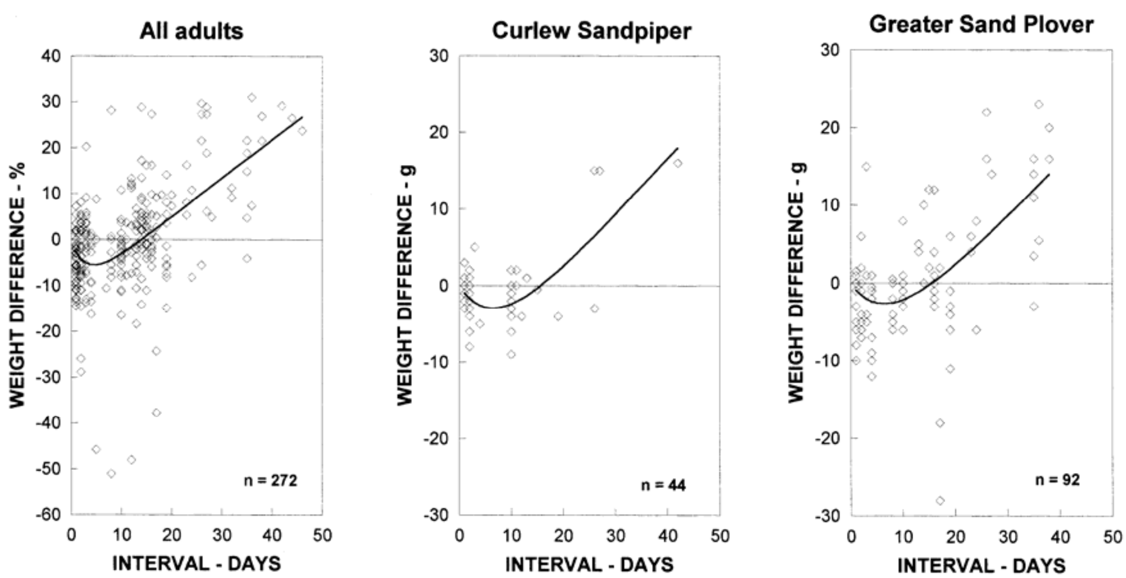


Figure 4. Same-season weight changes (in g) of recaptured Curlew Sandpiper, Greater Sand Plover and "All adults". The equation for the estimated mean changes in weight is given in the methods.

breeding grounds.

Both Ens *et al.* (1990a) and Rogers *et al.* (1996) suggest that for these reasons the analysis of data from different-season retraps may be more rewarding.

Different-year retraps

Data for individual birds are shown in Figure 5. The data selection criteria used for same-season retraps were also employed for this group. Below-weight Red-necked Stint caught in mid-April 1985 were not included in the analysis because they may have been passage birds whose annual weights could have been substantially affected by factors such as differences in migration timing and weather conditions en-route. This resulted in the Red-necked Stint sample size being reduced to only five birds and it was decided to eliminate the species from further consideration.

Ens *et al.* (1990a) chose to discard data for individuals caught at intervals of less than one week separation between years due to the potentially disturbing effects of differences in gut contents and migratory timing. Rogers *et al.* (1996) did likewise for Victorian Red-necked Stint data. Inspection of the data in Figure 5 does not indicate any greater variability in the 14-day interval around zero than at longer intervals, and it was decided to retain all the selected data for analysis.

Retraps for four species show a clear tendency to gain weight with time (ie. Curlew Sandpiper, Terek Sandpiper, Grey-tailed Tattler and Red Knot) and regressions of weight gain vs. time are statistically significant (Curlew Sandpiper: 0.23 $g.d^{-1}$; $r^2=0.20$; $p<0.001$), Terek Sandpiper (1.27 $g.d^{-1}$; $r^2=0.52$; $p<0.001$), Grey-tailed Tattler (0.86 $g.d^{-1}$; $r^2=0.67$; $p<0.001$) and Red Knot (0.57 $g.d^{-1}$; $r^2=0.55$; $p<0.001$). If it is assumed that these species increase their weight by 70% prior to migration, the calculated mean weight gain periods are Curlew Sandpiper - 167 days , Terek Sandpiper - 38 days, Grey-tailed Tattler - 80 days and Red Knot - 134 days. These times seem considerably more realistic for Terek Sandpiper and Grey-tailed Tattler than Curlew Sandpiper and Red Knot.

The remaining three species (Greater Sand Plover, Great Knot and Bar-tailed Godwit) do not exhibit a significant weight gain vs. time relationship (Greater Sand Plover: -0.04 $g.d^{-1}$; $r^2=0.0005$; $p>0.05$), Great Knot (0.21 $g.d^{-1}$; $r^2=0.027$; $p>0.05$) and Bar-tailed Godwit (male:-0.35 $g.d^{-1}$; $r^2=0.037$; $p>0.05$; female:-0.27 $g.d^{-1}$; $r^2=0.030$; $p>0.05$). So, why is there no apparent weight gain with time for these species ?

Inspection of the retrap data in Figure 5 shows that substantial numbers of Greater Sand Plover, Great Knot and Bar-tailed Godwit are following very different mass gain strategies in the different capture years. The proportions doing so are much lower in the case of the other four species.

Thus, the use of weight gain rates, based on different-year retraps, is precluded for Greater Sand Plover, Great Knot and Bar-tailed Godwit due to the number of individuals with differing annual mass gain strategies. The problem of asynchronous departures effectively eliminates the use of weight gain rates to predict departure weights for the other four species, even though the estimates may be accurate.

DISCUSSION

The results confirm many of the limitations noted previously with the use of weight gain extrapolation techniques to determine departure masses of individuals. There seems little to be gained from using these techniques on the north-western Australian data set. So, where to next?

The second option mentioned is to use manipulated flight range equations to calculate departure weight. Barter (1996) reviewed the technique and concluded that the difficulties and assumptions involved cast serious doubt on its applicability. Ens *et al.* (1990b) noted that these imprecisions lead to multiplicative, not additive errors. Thus, this method also does not seem to offer an informative path forward, although an improved understanding of migration physiology may open the way in the future.

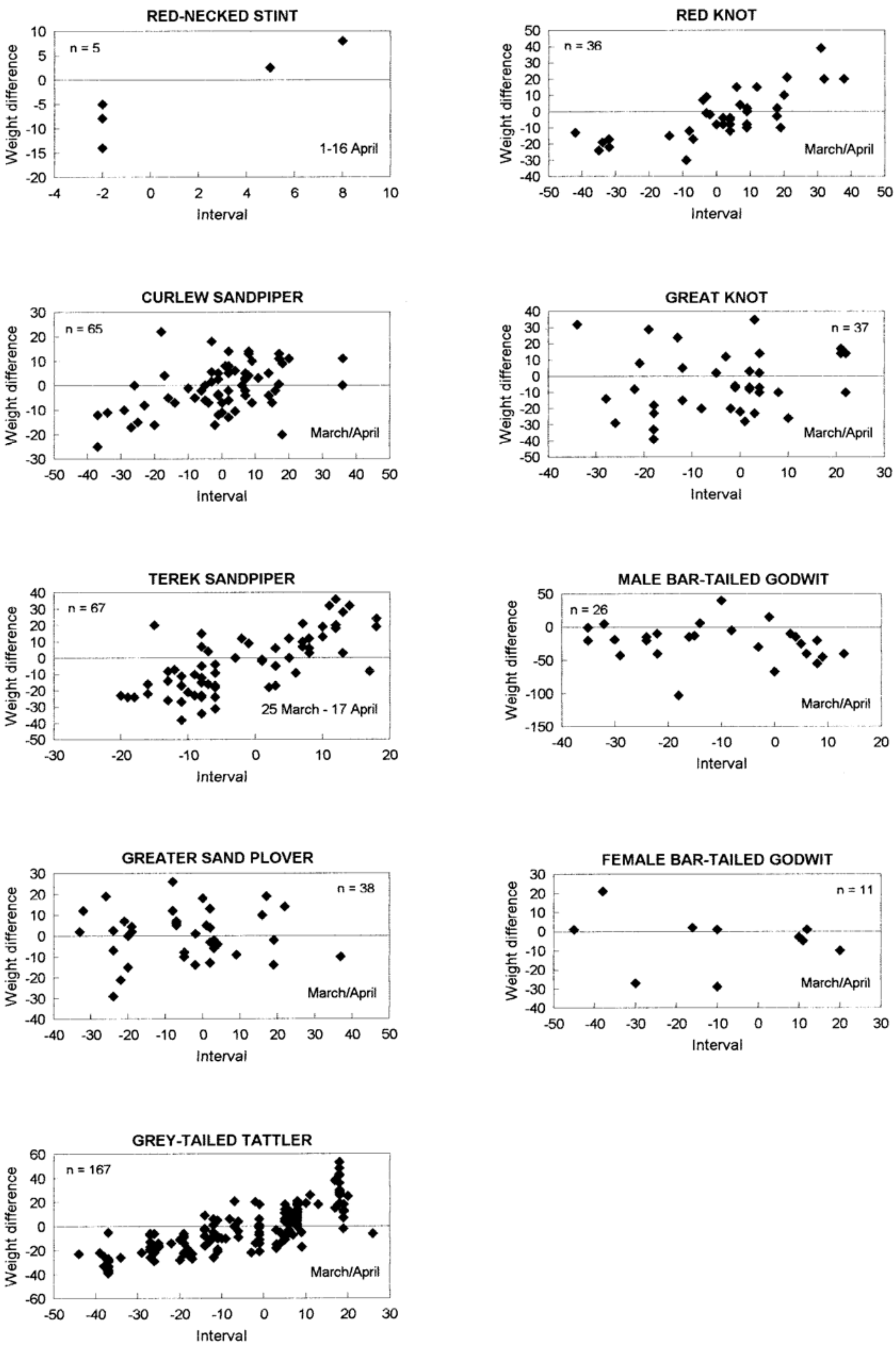


Figure 5. Weight changes (in g) for individuals recaptured once, or more, in different years during the March-April period (Interval in days). n = sample size.

The third option of identifying about-to-depart individuals seems to provide the best opportunity of estimating departure weight. Use of the 1996 weight data set, with its complementary biometrics and body moult data providing essential information on structural size and "migration preparedness', is currently limited by the lack of data to correct for weight loss following capture. Hopefully, the missing data can be obtained from future catches, under similar temperature conditions to those in occurring in March/April 1996, so that the technique can be satisfactorily investigated.

This analysis has raised some interesting matters and questions that ought to be followed up:

1. It would be useful to determine if bunching occurs in roosting flocks, as its potential effect on the utility of cannon netting data could be significant, eg. estimation of age structure, sex ratios and survival rate. As a start, it is suggested that an investigation be commenced in Victoria where catching is carried out frequently throughout the year and there is a good supply of experienced people.

2. Why should individuals of some species exhibit a greater tendency to have different annual mass gain strategies than those of others? This is an intriguing question with important implications for our understanding of migration strategies.

3. The cause and nature of weight loss in the days following capture should be established. Hopefully, measures can be identified to minimise the capture effect. Information on the behaviour of released birds (vs. that of non-captured birds) could be instructive.

For those species in which breeding is delayed, an attempt should be made to establish ageing criteria that enable intending breeders and non-breeding birds to be identified early in the mass gain period. The ability to do this would have removed some of the variability in mean catch weights; it is also an essential prerequisite to the study of mass gain strategies.

Weight loss whilst roosting is probably an important contributor to scatter in the data. The capture log should record the time of high tide and the times over which build up of the roost commenced and finished. In conjunction with this, the time of processing should be recorded without fail, perhaps for every fifth bird, on the field sheets. As mentioned previously, it is important that more weight loss rates during captivity be obtained, preferably for a range of species at different holding temperatures.

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Our very grateful thanks are due to those hundreds of members of AWSG North-western Australia Expeditions who, over the years, have travelled from afar and worked very hard, often in uncomfortably hot and humid conditions, to collect the data used for this paper.

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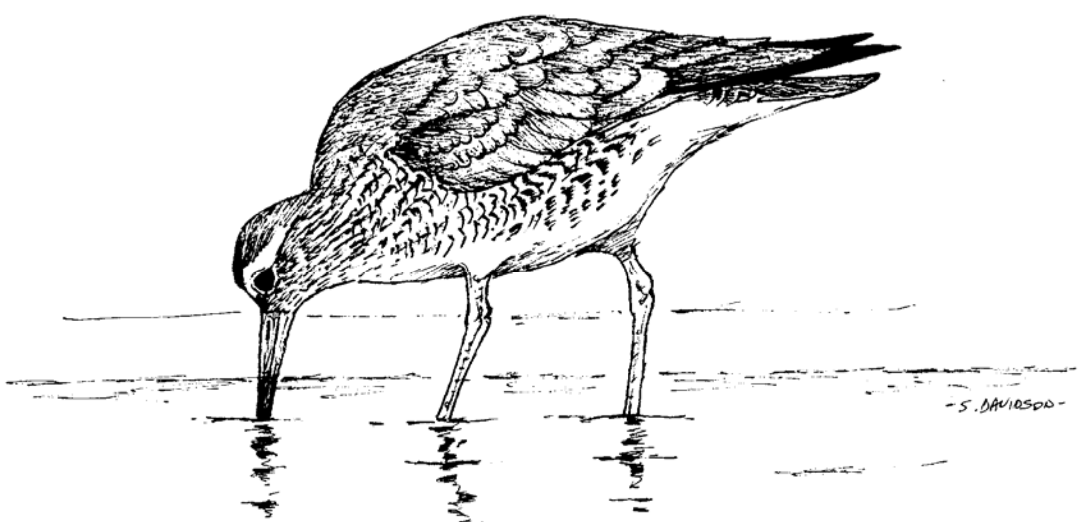

IDENTIFICATION OF POTENTIALLY IMPORTANT STAGING AREAS FOR 'LONG JUMP' MIGRANT WADERS IN THE EAST ASIAN-AUSTRALASIAN FLYWAY DURING NORTHWARD MIGRATION.

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ABSTRACT
We document the current information on the route of Great Knots, Red Knots and Bar-tailed Godwits as they migrate northwards from their non-breeding areas in Australia to the breeding grounds in Russia and Alaska. We especially focus on migration through the Yellow Sea region northeast of China and use data on departure and arrival times, population sizes, counts, leg flag sightings and band recoveries of each species in the Yellow Sea, Japan and Sea of Okhotsk to show that there is a period of three to four weeks during migration (in April – May) when these species are missing. We demonstrate that these species are probably feeding on the extensive mudflats in the northern Yellow Sea during this time and suggest that these areas are the final staging areas before the birds reach the breeding grounds.

INTRODUCTION

Migratory waders are dependent on the availability of suitable wetlands for the successful completion of their annual movements between breeding and non-breeding areas. These wetlands are under worldwide threat and nowhere is this more evident than in the East Asian - Australasian Flyway (Melville 1997). The "Summary Statement" of the March 1996 Conference on Shorebird Conservation in the Asia-Pacific Region, reflecting the views of 145 participants from 16 countries, expressed "particular concern at the destruction of critically important staging sites in China, Korea and Japan" (Anon 1997).

The waders most likelt to be affected by habitat loss are those which fly long distances between staging sites (ie. "long jumpers"). Such species typically collect in large numbers at a few sites (Cramp & Simmons 1983), the loss of which may seriously affect their ability to migrate successfully and, therefore, to breed and maintain a viable population.

Within the East Asian-Australasian Flyway, knowledge of the important staging sites used by 'long jump' waders is limited. Even when key sites are known, the way in which they are used (eg. arrival and departure times, turnover rate, energy needs to reach the next site) is generally sketchy or non-existent.

Incomplete knowledge of the important sites 'long jump' waders use, and how they use them, makes planning for their conservation difficult. Effective conservation action can only be based on accurate scientific data which are in short supply for much of the East Asian-Australasian Flyway. However, possible migration strategies and potential key staging sites can be identified by a desk top study and this information can be used to plan field studies to collect essential data.

There is considerable evidence that Great Knot *Calidris tenuirostris*, Red Knot *C. canutus* and Bar-tailed Godwit *Limosa lapponica* adopt a 'long jump' strategy, They fly nonstop from non-breeding areas in north-western Australia (Barter & Wang 1990, Tulp *et al.* 1994, Barter 1996) to the southern Yellow Sea coastal areas of east China and South Korea and to the Yellow River delta in the north-west Yellow Sea, where they congregate in large numbers (Long *et al.* 1988, Wang & Tang 1990, Wang *et al.* 1992, Barter *et al.* 1997a, Wang 1997, Barter *et al.* in prep.[a,b], Lee in prep.). Little is known about their movements within the Yellow Sea region or their onwards migration strategy to the breeding grounds. Tomkovich (1997) suggests that Great Knot migrate across the Russian Far East during a few days in the last third of May (Figure 1).

Possible strategies for the three species on northward migration through the Yellow Sea (Figure 2) were studied by drawing together information on:

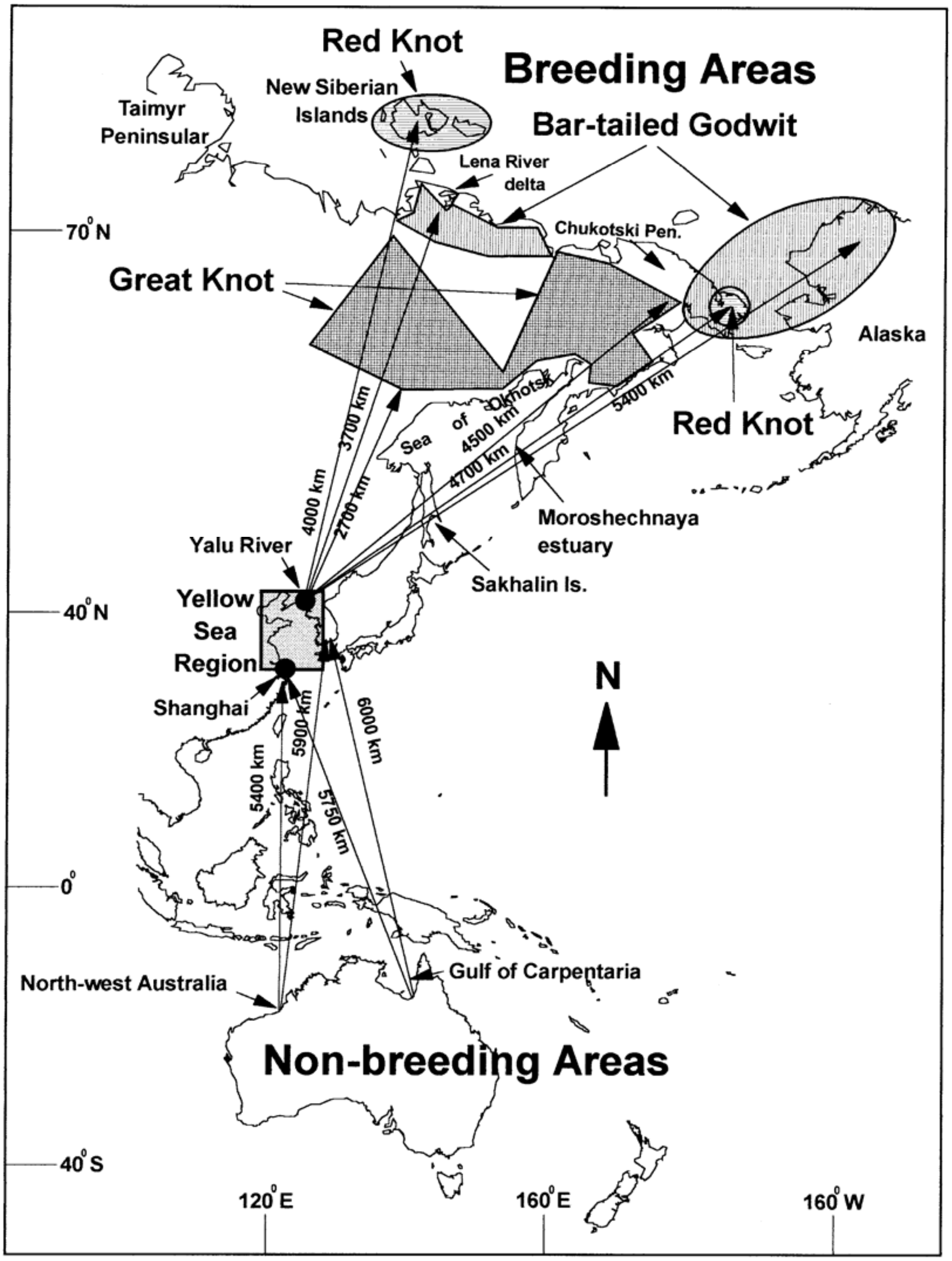

Figure 1. Map of the East Asian-Australasian Flyway showing breeding and non-breeding areas, the Yellow Sea region, great circle flight distances and locations referred to in the text.

- population sizes.
- timing of departures from north-western Australia.
- timing of visual observations in the Yellow Sea region, Japan and the Sea of Okhotsk, Russia.
- band recoveries and flag sightings in the Yellow Sea region and Japan;
- timing of arrival on the breeding grounds.

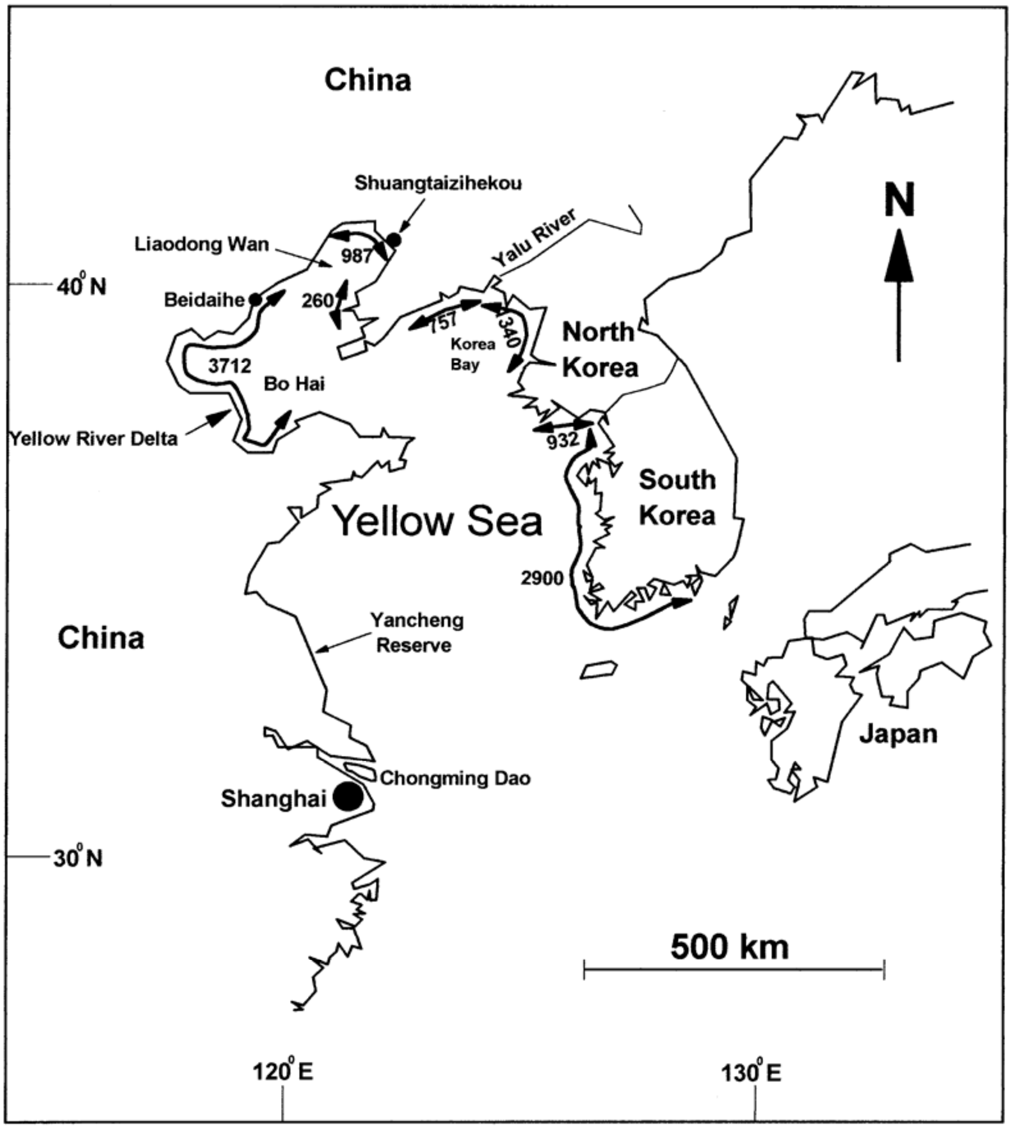

Figure 2. Map of the Yellow Sea region showing the areas of intertidal mudflat (in km2) and locations referred to in the text.

- intertidal areas potentially available for foraging waders in the Yellow Sea region.
- northern winter and early spring climate in the northern Yellow Sea and the Sea of Okhotsk.

METHODS

Population sizes

An approximate estimate of the number of Great Knots, Red Knots and Bar-tailed Godwits migrating to the breeding grounds has been obtained by using the flyway population estimates of each species in Watkins (1993) and assuming that the proportion of breeding birds is 80%. This figure was derived by comparing non-breeding and breeeding season counts of each species in Australia and New Zealand. We found that theoretically anywhere between 10 and 50% of waders could be staying in Australia and New Zealand during the breeding season, depending on which data, assumptions and models were used. Although much more work needs to be done on the population dynamics of waders in Australia, we have assumed that the proportion overwintering is 20%. It has also been assumed that all individuals migrate through the Yellow Sea. Whilst we know from flag sightings and observations that some pass through Japan, these represent only a very small proportion of the population of each species (Mundkur 1993, Japan Wetland Action Network unpub. data).

Timing of departure

Most departure information available from Australia are data obtained from the north-west of the country (Lane & Jessop 1985, Tulp *et al*. 1994 and Barter 1996). Much of the data collected by Broome Bird Observatory and the Australasian Wader Studies Group (AWSG) have yet to be published.

Visual observations

Count data are relatively sketchy for China and the Sea of Okhotsk, especially at migration times. There are no count data available for North Korea. The situation in South Korea is improving quickly and the results of some regular counts at several west coast sites have been published. Counts were made at many sites in Japan in the period late April to early May in 1973-1975, 1981-1984 (Mundkur 1993) and 1996-1997 (Tobai 1997).

Band recoveries and flag sightings

Band recovery data and the more recent flag sightings have been obtained from the Australian Bird and Bat Banding Schemes (ABBBS). Earlier flag sightings were obtained from Stilt (Jessop & Minton 1995, Driscoll 1995, Minton & Jessop 1995, 1996, 1997, Minton 1995), the Victorian Wader Study Group Bulletin (Minton 1993, Minton 1997) and Queensland Wader, the newsletter of the Queensland Wader Study Group (Taylor 1995/1996, 1996a, 1996b, 1996/1997).

Arrival dates on breeding grounds

We have used arrival times on the Taimyr peninsula for Red Knots (Tomkovich & Soloviev 1996). Although the populations involved are different to those spending the non-breeding season in Australia, the Taimyr is in the same climatic region as, and at a similar latitude to, the breeding areas of Australian Red Knots and, therefore, arrival times are probably similar. Arrival times for Great Knots and Bar-tailed Godwits on the breeding grounds used by Australian birds are available from the literature (Tomkovich 1996, Higgins & Davies 1996).

Intertidal areas

Maps of the Yellow Sea region were studied at the National Library of Australia, Canberra, which holds very good and detailed 1:50,000 maps of North Korea published by the U.S.A. Defence Mapping Agency Topographic Centre, Washington D.C. Most of the maps were produced in 1976, a few in 1977 and two in 1986. The library only has 1:250,000 maps of the northern Chinese coastline. They were published by the U.S. Army Map Service, Washington D.C., mostly in 1954, but two in 1956. Not surprisingly, the Chinese maps are not as detailed as those for North Korea . The China maps show the extent of the mudflats without details of the tidal channels; the Korea maps show tidal channels and offshore mudbanks in detail, including the depths at which the flats are uncovered. The areas of intertidal mudflats were measured using an electronic planimeter.

Climate

The northern parts of the Yellow Sea and, especially the Sea of Okhotsk, are cold during winter and it is necessary to check whether the intertidal flats are covered with ice during the northward migration season, thus making food unavailable to waders. Weather data published by the Meteorological Office in London and the U.S.Navy have been used. Although the data we have been able to find are mostly 40 years old or more, it probably still reflects today’s situation.

RESULTS

Population sizes

Watkins (1993) estimated that there are 319,000 Great Knots in the flyway, almost all migrating to Australia, 255,000 Red Knots, of which 153,000 migrate to Australia and 87,700 to New Zealand, and 330,000 Bar-tailed Godwits, of which 165,000 migrate to Australia and 102,000 to New Zealand. Applying the notional 80% breeding proportion to the individual total populations indicates that approximately 255,000 Great Knots, 205,000 Red Knots and 265,000 Bar-tailed Godwits migrate northwards and equals a total of 725,000 birds of the three species.

Timing of departures from north-western Australia

GREAT KNOT

The main departures occur at the end of March and during the first days of April (Lane & Jessop 1985, Tulp *et al*. 1994, Barter 1996).

Red Knot
Some birds leave at the beginning of April, followed by a second wave in mid-April (AWSG unpub. data).

BAR-TAILED GODWIT

The main departures occur in the first half of April (Lane & Jessop 1985, Tulp *et al*. 1994, Barter 1996).

Visual observations in the Koreas and China

South Korea
Long *et al.* (1988) counted a maximum of 167,771 waders during a survey of the south and west coasts of South Korea between 10 April and 6 June. These included maximums of 35,588 Great Knots, 666 Red Knots and 15,720 Bar-tailed Godwits. They stated that, when turnover was taken into account, these numbers "are undoubtedly a considerable underestimate of the real number staging in coastal Korea". Long *et al*. (1988) suggested that peak passage for Great Knot and Red Knot was probably in late April, and for Bar-tailed Godwit in the last week of April and first week in May. Some Great Knot and Bar-tailed Godwit were present in late May.

NORTH KOREA

Mundkur (1993) mentions all the main intertidal areas, except the Yalu River estuary (Figure 2), as possibly important wetlands. There was no information on migrating waders. We have been unable to find any published information for the country (but see Chong (1994) for limited data on four important coastal wetland areas).

Chinese coast of Korea Bay
No information on waders is available. However, the presence of more than 30 species of economically important shellfish with a total available resource of 110,000 tonnes in the Yalu River estuary (Xiao *et al*. 1996) indicates that the area is very productive and could be important for waders.

COAST OF LIAODONG WAN

Brazil (1992) made some observations on the shores of the Shuangtaizihekou National Nature Reserve between 20 April and 28 July 1991. The area of intertidal flat surveyed, which was near to or in the Reserve, was a very small proportion of the total along the Liaodong Wan coast (see Figure 2), and most of his bird counts were done in the Reserve away from the flats. Brazil's observations, therefore, only indicate the potential of this coast to support significant numbers of waders on northward migration. The first Great Knots were seen on 3 May (66) and birds were found on a number of occasions in May, June and July including 98 on 6 July and 1,140 on 24 July. The first Red Knots were seen on 17 May, 225 were recorded on 22 May, 6-10 on 29 May and 25+ on 15 June. No Bar-tailed Godwits were recorded. We have not found any additional published information on the waders of Liaodong Wan.

North coast of Bo Hai
At Beidaihe, Hebei Province, 1,500 Great Knots were recorded on 15 May 1992 and it was also stated that ''great numbers pass through on northward migration''. Red Knots pass though in mid-May and Bar-tailed Godwits in late April to early (Mundkur 1993).

Yellow River Delta
Counts at the Yellow River Delta between 10 April and 2 May 1992 gave a maximum of 72,000 waders (31,000 unidentified), including 3,645 Great Knots, 118 Red Knots and 2,578 Bar-tailed Godwits (Wang *et al*. 1992). Counts made between 18 April and 1 May 1997 recorded a total of 130,122 waders, including 11,957 Great Knots, 371 Red Knots and 10,678 Bar-tailed Godwits (Barter *et al.* in prep. [a]). It is estimated that 800,000 to 1,000,000 waterbirds, the majority of which are waders, stop and refuel in the Delta in their migratory passage periods (Wang 1994)**.** An independent assessment by Barter *et al.* (in prep. [a]) came to the conclusion that the delta "probably supports in excess of 1 million waders annually", half of these being on northward migration.

Yancheng Reserve, Jiangsu Province
On northward migration up to 3,271 Great Knots, 3,169 Red Knots and 562 Bar-tailed Godwits were

recorded in 1990 of which 2,061 Great Knots, 2,513 Red Knots and 556 Bar-tailed Godwits were present in the period 15 to 20 May. (Wang & Liu 1994).

Shanghai region (Chongming Dao)
Counts from 13 to 14 April 1990 were 382 Great Knots and 93 Bar-tailed Godwits; on 2 May 1990, 20 Great Knots, 80 Red Knots and 4 Bar-tailed Godwits; from 25 to 31 March 1996, 5,761 Great Knots, 4 Red Knots and 309 Bar-tailed Godwits; on 15 April 1996, 1,262 Great Knots, 12 Red Knots and 93 Bar-tailed Godwits; from 9-10 April 1997, 2,333 Great Knots, 29 Red Knots and 290 Bar-tailed Godwits; on 15 April 1997, 1,810 Great Knots and 567 Bar-tailed Godwits. (Wang *et al*. 1992, Barter *et al*. 1997a, Barter *et al.* in prep. [b]). Barter *et al*. (1997b) suggest that the three species spend little time at Chongming Dao, although the suspected high turnover rate implies that the counts are significant underestimates of the total numbers using the area during northward migration.

Visual observations in Japan

There were a maximum of 3,522 Great Knots, 69 Red Knots and 3,306 Bar-tailed Godwits in Japan on northward migration in the years 1973 to 1975 and 1981 to 1984 (Mundkur 1993). Counts at 223 sites in 1997 gave totals of 487 Great Knot, 12 Red Knot and 2809 Bar-tailed Godwit out of 116,117 waders counted (Tobai Sadayosi pers. comm.).

Visual observations in the Sea of Okhotsk

At Lunskiy Bay, Sakhalin Island, the northward migration of waders is largely during the third ten day period of May with 26% being Dunlin *Calidris alpina* and 51% Red-necked Stint *Calidris ruficollis*. Only one Great Knot, no Red Knot and no Bar-tailed Godwit were recorded (Zykov 1997). Tomkovich (1997) states that in the Russian Far East "the similarity of the main passage dates for Great Knots is striking and implies that the main migration across the whole region is occurring over a few days in the last third of May, almost without staging". He lists observations of birds on northward migration. The most important site in the Russian Far East is the Moroshechnaya River estuary, west Kamchatka Peninsula (Figure 1) where 12,000 to 15,000 Great Knots have been recorded from 21-29 May and the total number of passage birds was estimated to be 35,000-40,000. Tomkovich suggests that the estuary is being used as an "emergency site". Gerasimov & Gerasimov (1997) estimated a total of 300,000 waders, including 40,000 Great Knots, 3,000 Red Knots and 1,000 Bar-tailed Godwits, could be using this site in the second half of May.

Band recoveries and flag sightings

Figure 3 shows the dates of band recovery/flag sightings, in 5-day intervals, of Australian-marked Great Knot, Red Knot and Bar-tailed Godwit in the Shanghai region of China, South Korea and Japan. Other than one flagged Bar-tailed Godwit, there have been no band recoveries or flag sightings of these species north of the Shanghai region on the east China coast, on the north China coast or in North Korea.

Great Knot
In the Shanghai region, most of the recoveries/sightings (n=55) were in April with peak numbers occurring from 6-10 April. Two were at the end of March; only three were in May, with two from 1-5 May and one from 11-15 May. In South Korea, five were from 21-25 April and three were at the end of May. In Japan, there were four from 6-15 May.

Red Knot
In the Shanghai region, recoveries/sightings were made between 6 April and 5 May (10), except for a late bird on 21 May. This was a second-year bird which may have migrated late or may not have been travelling all the way to the breeding grounds. In South Korea, two occurred in the period 16-20 April. In Japan there was one during 11-15 April.

Bar-tailed Godwit
In the Shanghai region nearly all recoveries/sightings occurred in April (19); there was only one in May (1-5 May). In the Yellow River Delta there was one on 1 May (pers. obs.). In South Korea, most were between 6-10 April to 11-15 May (37); one was at the end of May. In Japan, most were from 1-6 April to 11-15 May (28), with two being in the second half of May.

Arrival dates on breeding grounds

Great Knots arrive from 22 May (Tomkovich 1996). A leg-flag sighting and two banding recoveries indicate that the breeding grounds of north-west Australian Red Knots are on the New Siberian Islands, as suggested by Tomkovich (1995), whilst it is likely that those from eastern Australia and New Zealand breed on the Chukotski Peninsular (Barter 1992). Red Knots arrive on the Taimyr breeding grounds from 7-10 June in average or early springs, and in late springs from 13-14 June or even on 21 June (Tomkovich & Soloviev 1996). Red Knots breeding on the New Siberian Islands are not likely to arrive earlier than those on the Taimyr. Bar-tailed Godwits from western Australia (race *menzbieri*) breed in central Siberia, while those in eastern Australia (race *baueri*) breed on the Chukotski Peninsular and Alaska (Barter 1989, Higgins and Davies 1996) .Bar-tailed Godwits do not arrive on the far east Russian and Alaskan breeding grounds until late May or early June (Higgins & Davies 1996).

Intertidal areas

Areas of intertidal mudflats measured from maps are shown in Table 1 and Figure 2. The calculated areas are subject to unquantifiable error. The tidal range on the Korean west coast is one of the highest in the world, ranging from 4.6 m to 9.1 m on spring tides. In contrast, on the west coasts of Bo Hai the tides range from 1.8 m to 4.1 m (British Admiralty Sea Charts No. 1258. 1983. Korea - West Coast and No. 1250. 1980. China - Bo Hai). It is not clear if the flats shown on the maps represent what is uncovered at spring tides or mean low water. Also, considerable reclamation has obviously taken place in North Korea, with the construction of numerous small barrages across the bays, sea walls enclosing salt marshes, saltpans or fishponds on the mudflats, etc. It is not known what additional reclamation has taken place since 1977. More limited reclamation had taken place in China up to 1954, but it may have increased considerably since then.

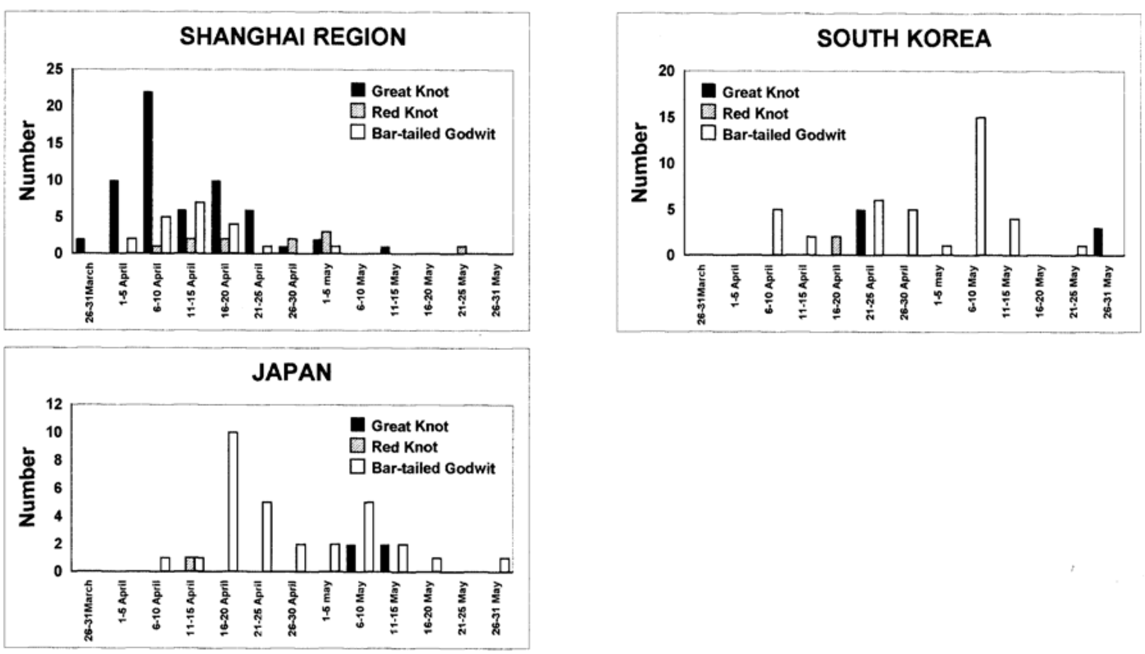

Figure 3. Numbers of band recoveries and leg-flag sightings in the Shanghai Region, South Korea and Japan in five-day periods during March, April and May.

Table 1. Area of significant intertidal mudflat in the Yellow Sea based on Yu (1994).

Mudflat	Area (km^2)
South Korea	2900
North Korea	2272
China - Korea Bay	757
China- Liaodong Wan	1247
China - Bo Hai	3712
Total northern Yellow Sea	10888

Wang *et al*. (1991) estimated the Yellow River Delta had 1,500 km^2 of intertidal flats. Our estimate of 2,745 km^2 includes intertidal areas to the north and south of the delta (Figure 2).

An evaluation of South Korea's tidal flats in 1979 estimated that they covered 3,000 kms^2 (Yu 1994). From 1981 to 1989, 10,427 ha were reclaimed. Thus, by 1989 there were about 2,900 km^2 of intertidal flats remaining. We have used this figure, and have not measured South Korea intertidal areas from the maps.

We have not been able to do any ground truthing of the maps or measure areas from satellite imagery. The maps, however, do indicate that there are huge potential feeding areas available for waders in the northern Yellow Sea, in addition to those already known on the east China and South Korea coasts.

To put these intertidal areas in perspective we compared them with important staging and non-breeding areas on the East Atlantic flyway (Table 2). The west and south coasts of the Korean peninsular and the China coast of Korea Bay have 5,929 km^2 of intertidal area which, when treated as one complex, rates as the largest intertidal area in the world. If it is assumed that the wader carrying capacity is similar to that of the Wadden Sea,ie. 500 birds/km^2, the region could hold 3,000,000 waders. The west coast of the Bo Hai, which includes the Yellow River Delta, has 3,712 km^2 of intertidal flats and these could hold 1,850,000 waders and the shores of Liaodong Wan have 1,247 km^2 of intertidal flats, which could carry 600,000 waders. Thus, the Yellow Sea coastline from the Yellow River Delta to South Korea could have a total carrying capacity of around 5,500,000 waders during the migration period.

Table 2. The areas of intertidal mudflat along the east Atlantic flyway that are important to waders.

Intertidal mudflats	**Area (km^2)**	**Number of waders**	**Density no.m^{-2}**	**Reference**
West Iceland	343	285854	833	1
Waddensee (Holland, Germany, Denmark)	4000	2000000	500	2
Wash	298	203826	684	3
Morecambe Bay	337	168275	499	3
Solway	277	84708	306	3
Banc D'Arguin	540	2247500	4160	4
Guinea-Bissau	1570	979490	625	5

References: 1. Gudmundsson & Gardarsson (1992), 2. Smit & Wolf (1981), 3. Davidson *et al.* (1991), Cranswick *et al.* (1995), 4. Zwarts *et al.* (1990), 5. Zwarts (1988).

Climate

The mean air temperatures on the north coast of the Yellow Sea are about -4°C to -7°C in December to February, but then increase to 0°C in March, 7°C in April and 13°C in May (U.S. Navy 1958). The sea surface temperatures are about 4°C in December, 0°C in January and February, 2°C in March, 4°C in April and 10°C in May. (Meteorological Office 1947). The town of Yingkow on the north coast of Liaodong Wang has maximum average air temperatures of -4°C in January and minimum of -12°C, but in April the averages are 14°C and 3°C and in May 22°C and 11°C (Meteorological Office 1966)

These temperatures are not exceptionally low when compared to those occurring in northern European wader staging areas. In the German Wadden Sea, the average air temperature in January is 0.2°C, in March 2°C, in April 5.9°C and in May 10.5°C (Prokosch 1988). The staging areas for Knots in northern Norway are mostly ice covered in winter and ice can still be present in early May. Davidson & Evans (1986) recorded air temperatures of 2-4°C in the first half of May 1995, and mud temperatures were below 5°C in early May, increasing to 8-10°C at the end of May.

The temperatures indicate that intertidal areas of the Yellow Sea are available to feeding waders in April and May. This is also confirmed by the presence of large numbers of waders in the Yellow River Delta in late April and observations on the north coast of Liaodong Wan in May.

Sites lying further north, in the Sea of Okhotsk, which are used by many waders on southwards migration (Gerasimov & Gerasimov 1997, Tomkovich 1997, Zykov 1997) must be very inhospitable in May. For example the average air temperature on the west coast of the Kamchatka Peninsular in mid May is 2.4°C, whilst the average sea surface tempearature is l.7°C (NOAA 1997) .

SYNTHESIS

Great Knot

Departure timing from north-western Australia fits well with recoveries in the Shanghai region in early April (Figure 3), assuming a non-stop flight. Band recoveries and flag sightings indicate that the main passage through Shanghai is in April. Large numbers have been seen in the Yellow River Delta in the second half of April, although their status there in May is unknown as no field work has been carried out during this month. Some (2,061) however have been recorded in Yancheng area, south of the Yellow River, in the second half of May. The main passage in South Korea is stated to be in late April with some birds staying until the end of May. Recoveries/sightings in Japan indicate that passage occurs in the first half of May. They do not reach the breeding grounds until the last third of May.

The band recoveries/flag sightings and visual observations suggest that large numbers of Great Knots are "missing" for about the first three weeks of May.

Red Knot

The later departure of Red Knots from north-western Australia compared to Great Knots ties in with the two week later migration schedule indicated by band recoveries in the Shanghai district (Figure 3). No large flocks of Red Knots have been found in the Shanghai District of China, or the Yellow River Delta, although 2,513 have been seen on the Yancheng reserve in the period 15 to 20 May. South Korea (maximum 666) and Japan (maximum 69) seem to be off the main migration route. The band recoveries/flag sightings and visual observations imply that most Red Knots pass through the southern Yellow Sea in the last three weeks of April and the first week of May, and most may overfly this region.

As birds do not arrive on the breeding grounds until early June (Tomkovich & Soloviev 1996) and have left Shanghai by early May, they appear to be "missing" throughout most of May.

Bar-tailed Godwit

Departure dates from north-western Australia fit in well with recoveries in the Shanghai region in the first half of April, assuming a nonstop flight. Band recoveries/flag sightings and visual observations indicate that the main passage of Bar-tailed Godwits through Shanghai is mid-April, and through South Korea and Japan it is during the second half of April and the first ten days of May, although some birds are present in the latter two regions until the end of May. Large numbers have been seen in the Yellow River Delta in the second half of April and 556 were seen on the Yancheng reserve in the period 15-20 May. As Bar-tailed Godwits do not arrive on the breeding grounds until late May or early June many seem to be ‘’missing’’ for about three weeks in May.

DISCUSSION

The Yellow Sea is strategically placed on the migration route between non-breeding areas in Australia and breeding areas in Russia (Figure 1). Great Knots, Red Knots and Bar-tailed Godwits probably fly non-stop from north-western Australia to the Shanghai district of China (Barter & Wang 1990). It seems likely that Shanghai is mainly used by less fit birds or as emergency staging sites if winds are unfavourable (Barter *et al.* 1997c). Banding and count data from the Shanghai area (Barter *et al.* 1997a, 1997b) indicate that the favoured strategy for Great Knots, Red Knots and Bar-tailed Godwits on leaving northern Australia is to fly non-stop to the south or west coasts of the Korean peninsular, to the Yancheng reserve, to the Yellow River delta or, possibly, to other sites in the northern Yellow Sea, as yet unidentified.

Whilst counts show that the west coast of South Korea holds large numbers of Great Knots and Bar-tailed Godwits in April, the timing of the peak concentrations, supported by band recovery/flag sighting information, implies that many birds go “missing” for some weeks during their northward migration. Major staging sites for Red Knots have not yet been identified. The only large numbers recorded were on the Yancheng Reserve and at the Moroshechnaya estuary.

It seems unlikely that the “missing” birds are located on intertidal areas further north on the migration routes to the breeding grounds. The Sea of Okhotsk, which holds large numbers of waders on southward migration (Gerasimov & Gerasimov 1997, Tomkovich 1997, Zykov 1997) is only used on northward migration in late May, and then probably only for a very short period. Temperatures earlier in May indicate that the mudflats would still be ice covered and, thus, unsuitable feeding habitat. Further south on the Russian coast feeding habitat is limited due to the rocky nature of the Primorye coast.

We suggest that the “missing” Great Knots, Red Knots and Bar-tailed Godwits, move on to the extensive intertidal mudflats located around Korea Bay, Liaodong Wan and Bohai in areas which have not yet been investigated in May. We also suggest that these areas are the final staging sites before the breeding grounds. Some birds may reach these areas from Australia in one flight.

The northern Yellow Sea is within a single flight of the breeding grounds. For example, from the Yalu River estuary region of Korea Bay the most distant part of the Great Knot breeding area is 4,550 km away, whilst the nearest is 2,700 km. The distance to the emergency staging site on the Moroshechnaya River estuary from the most northern sites in the Yellow Sea is about 3,100 kms. The breeding areas for Red Knot on the New Siberian Islands lie at a distance of 4,000 kms, whilst those of the Bar-tailed Godwit on the Lena River Delta are 3,700 kms away, but those in west Alaska are 5,400 kms distant.

If there are very large numbers of Great Knots, Red Knots and Bar-tailed Godwits in the northern Yellow Sea, the lack of recoveries of marked birds at first seems surprising. However, most recoveries in China are by hunters, as there is little banding activity and only very few people are looking for flags. We have little information on the the extent of hunting north of Shanghai. Hunting in the Yellow River Delta is limited to salt ponds (Wang *et al*. 1991) and does not occur on the intertidal flats (pers. obs.). It seems likely that low hunting activity, compared to the Shanghai area, may explain the lack of recoveries.

Other examples of final northward migration wader staging areas are the Wadden Sea for birds flying to Siberia, north Norway for Red Knots and west Iceland for Red Knots and other species bound for Greenland and Canada, and Delaware Bay for birds headed for the Canadian arctic. Interestingly, as with the northern part of the Yellow Sea, these sites still lie far (up to 4,500 kms) from the breeding grounds.

The quality of the final staging site is of key importance in enabling waders to store enough fat and protein to reach the breeding grounds in good condition to ensure successful breeding, especially if the flight is long. The coasts of the northern Yellow Sea are, therefore, probably amongst the most important in the whole East Asian - Australasian Flyway. Up to 725,000 Great Knots, Red Knots and Bar-tailed Godwits could be staging there. Other wader species could also be using these coasts, implying that more than a million birds in total could be present. Although the importance of the Yellow River Delta has been already been established, the possible huge size of wader migration through the northern coasts of the Yellow Sea is undocumented.

The fact that we still do not have direct evidence of exactly where the final key staging sites used on northward migration lie is probably the most important issue for investigation in the East Asian - Australasian Flyway. The suggestion in this paper that they are located in the northern part of the Yellow Sea needs to be followed up by ground truthing as a matter of urgency, especially as this area may well be one of the most threatened in the whole flyway.

We invite comments, contributions and discussion about this paper, particularly from colleagues in China, the Koreas and Russia. There may be additional information, either unpublished or in Chinese, Korean or Russian publications which are not generally available to non-speakers. This information may substantiate the theory that there are undocumented, hemispherically important intertidal areas for waders in the northern Yellow Sea.

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MIGRATORY MOVEMENTS OF CURLEW SANDPIPERS *CALIDRIS FERRUGINEA* THAT SPEND THE NON-BREEDING SEASON IN AUSTRALIA

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ABSTRACT

Banding and leg-flag records of Curlew Sandpipers in the East Asian-Australasian Flyway show that birds from non-breeding areas in both southeastern Australia and northwestern Australia appear to follow similar northward migration routes through Asia to their breeding grounds in northern Siberia. A single flight from the north coast of Australia takes birds to their first major stop over region on the Asian coasts between Thailand and Taiwan during late March and April. By May, most birds have moved to the northern half of the Chinese coastline – from the latitude of Taiwan northwards. The main Curlew Sandpiper migration routes do not pass through either mainland Japan or Korea. Curlew Sandpipers leaving northern China in the second half of May take an inland route across Siberia to the breeding grounds. Most Curlew Sandpipers from Australia breed in the Yakutia part of the northern Siberian coastal region, between 133° and 154°E. However, some breed much further westward on the Taimyr Peninsula (recoveries at 98° and 111°E). There is a significant overlap with the breeding range of Curlew Sandpipers that migrate southwestwards to spend the non-breeding season in western and southern Africa, or southwards to India. During the return passage to Australia in August and September, many fewer recoveries and leg-flag sightings occur. The Chinese coast appears to be a much less important stopover location during southward migration. Some birds follow a more westerly loop migration. Most still appear to overfly the south-east Asian islands during either migration. Curlew Sandpipers from Australia do not migrate back to the breeding grounds for the first time until they are two years old.

INTRODUCTION

Sufficient data has now been accumulated to enable an initial analysis of the migration routes of some wader species that breed in the northern hemisphere and spend the non-breeding season in Australia. The first major analysis was a comprehensive examination of all inter-country movements of Red-necked Stints (*Calidris ruficollis)* banded in the East Asian-Australasian Flyway (Minton 1996).

This paper considers the long distance movements of Curlew Sandpipers (*Calidris ferruginea)* into and out of Australia. It will form part of a comprehensive presentation from Australia at the Curlew Sandpiper Workshop being held by the International Wader Study Group at Cape Town, South Africa in August 1998. In due course, recoveries of Curlew Sandpipers banded by other countries in the flyway, and recovered outside Australia will also be included to produce a flyway-wide analysis.

METHODS AND RESULTS

The Australian Bird and Bat Banding Scheme provided a comprehensive list of all overseas recoveries of Curlew Sandpipers banded in Australia and all overseas – banded birds subsequently reported within Australia. This data was supplemented by records of colour leg-flagged Curlew Sandpipers marked by the Victorian Wader Study Group in Victoria, southeastern Australia, and by the Australasian Wader Study Group and Broome Bird Observatory in northwestern Australia. These sightings are reported via a variety of methods and the complete data base is currently maintained by the VWSG and AWSG themselves. I also include two Curlew Sandpipers that were colour-banded in Siberia by the Tundra Ecology–94 expedition and subsequently seen in Australia.

Banding

It is estimated that approximately 31,000 Curlew Sandpipers have been banded in Australia up to December 1997 (Table 1). In addition, about 5,000 recaptures of banded birds have occurred, mostly at the original banding site. The majority of birds were caught in cannon nets with probably only about 5% being mist-netted.

Of the 36,000 total handlings, 86% were from only three areas – Victoria (23,017), northwestern Australia (6,182) and Tasmania (1,779).

Leg-flagging

Colour leg flagging of waders in Victoria (orange) commenced in 1990 and in northwestern Australia (yellow) in 1992. The total number of Curlew Sandpipers leg-flagged in each of these areas up to the end of December 1997 were –

Table 1. The number of Curlew Sandpipers banded in Australia up to December 1997. Sources were Baker *et al.* (1997), A. Fletcher (pers. comm. - Tasmania) and VWSG/AWSG records.

Banding sites	Newly banded	Retrapped	Total
Victoria	19,250	3,767	23,017
northwestern Australia	5,787	395	6,182
Tasmania	1,319	460	1,779
TOTAL AUSTRALIA (est.)	c.31,000	c.5,000	c.36,000

Victoria	5,361 birds
N.W. Australia	2,090 birds

An overseas sighting of a leg-flagged bird enables it to be ascribed to a region of origin, but not of course to any particular marking date.

Recoveries

Sixty Australian-banded Curlew Sandpipers have been recovered overseas up to the end of February 1998. In addition, 15 overseas-banded Curlew Sandpipers have been recovered in Australia (all recaptured alive by Australian banders). Their origins/destinations within Australia are shown in Table 2. Most of these recoveries have occurred since 1980 but a few took place in the late 1970s.

The 60 overseas recoveries were reported from 8 different countries, with almost half coming from China (Table 3) and a further 20% from Hong Kong. Russia featured strongly also – surprising considering the remote areas which birds inhabit there – with 10 of the recoveries (17%). In contrast, a third of the 15 overseas-banded birds recaptured in Australia were caught in Taiwan and a further third came from Hong Kong. These figures reflecting the higher level of wader banding in those countries compared with most others in the flyway.

Flag Sightings

There have been 86 overseas sightings of Curlew Sandpipers leg-flagged (orange) in Victoria and 46 of birds leg-flagged (yellow) in northwestern Australia. In addition, two Curlew Sandpipers colour-banded on the breeding grounds in Russia have subsequently been seen in Australia. The flag sightings (Table 4) are dominated by reports from Hong Kong (122 out of 132 reports). This is partly a reflection of the intensity of wader observations at the Mai Po Marshes Reserve and the high quality of the field observers there. It contrasts with the pattern of Red-necked Stint recoveries (Minton 1996), when a much lower proportion of sightings came from Hong Kong (43 out of 98).

Recovery and flag-sighting rates

The current overseas recovery rate of Curlew Sandpipers banded in Australia (60 recoveries from 31,000 birds banded) is around 0.2% (one overseas recovery for every 500 birds banded). This will increase slightly in the future as further recoveries occur from birds currently still alive and carrying bands.

Table 2. Origin of Australia-banded Curlew Sandpipers that were recaptured overseas or where overseas-banded birds were recaptured.

Site	Banded	Recaptured
Victoria	37	7
N.W. Australia	14	6
Tasmania	4	-
New South Wales	4	1
Queensland	1	1
TOTAL	60	15

Table 3. Overseas movements of Curlew Sandpipers that spent their non-breeding season in Australia. Source data are from the Australian Bird & Bat Banding Scheme, as at 28 February, 1998 (E.B. Dettman, pers. comm.)

Country of recovery or origin	Overseas recoveries of Australian banded birds	Origins of birds banded overseas and recaptured in Australia
China	27	-
Hong Kong	12	5
Russia	10	2
Vietnam	3	1
Indonesia	3	-
Taiwan	2	5
Thailand	2	1
India	1	-
Singapore	-	1
TOTAL	60	15

This rate is approximately three times the overseas recovery rate of Red-necked Stints (Minton 1996), but still less than a third that of the similar sized Dunlin (*Calidris alpina*) banded on The Wash in eastern England (Evans 1995). However, it is higher than the overseas recovery rate for Curlew Sandpipers banded in southern Africa (33 out of 24,851 – 0.13%) (L. Underhill pers. comm.)

As in almost all species of waders, the overseas reporting rate of leg flags of Curlew Sandpipers is much higher than the reporting rate of metal bands (the recovery rate). For northwestern Australian birds the rate is 2.2% (46 reports from 2,090 birds flagged), and for Victorian birds it is 1.6% (86 reports from 5,361 birds flagged). These rates will continue to rise as many flagged birds are still alive. But in making comparisons of flagging and recovery rates, it needs to be remembered that some flag sightings may be multiple reports of the same bird (resting for a period on migration) whereas recovery reports are unique. Thus the flag sighting rates, at 11 times the national recovery rate of birds colour marked in northwestern Australia and 8 times that of birds marked in Victoria, will be an overestimate of the real situation in terms of individual birds actually located.

Table 4. Overseas sightings of Curlew Sandpipers leg-flagged in Australia.

Country of sighting	Flagged in Victoria	Flagged in N.W. Australia
Hong Kong	79	43
Taiwan	4	1
China	1	1
Russia	1	-
East Malaysia (Sabah)	1	-
Japan	-	1
TOTAL	86	46

ANALYSIS OF RECOVERIES AND FLAG SIGHTINGS

The overseas locations where Curlew Sandpipers banded in Australia have been recovered are shown in Figure 1. Those banded in northwestern Australia are differentiated from those banded in south eastern Australia (Victoria, Tasmania and New South Wales). Figure 2 shows the origins of Curlew Sandpipers banded overseas and subsequently recovered in Australia – again differentiated by region. The sighting locations and origins of leg- flagged birds reported overseas are shown in Figure 3.

Migration Routes and Destinations

The most obvious feature of the recovery pattern is the large concentration of bird sightings in the China/Hong Kong/Taiwan area – especially on northward migration. Overall 51 out of the 75 recoveries and controls relate to this area and 129 of the 132 flag sightings. In contrast, and unlike the Red-necked Stint, there are no recoveries and only one flag sighting in Japan or Korea (on a Japanese island halfway between Korea and southern Japan). This tallies with count data from those countries which shows relatively few Curlew Sandpipers in either migration season. Therefore, Curlew Sandpipers appear to have a more westward migration route than Red-necked Stints and one which involves fewer staging sites during northward migration.

This is not unexpected given that the main Curlew Sandpiper breeding range in Siberia does not extend as far east as that of the Red-necked Stint (Lappo 1996). However, there is a wide spread of recoveries on the arctic breeding grounds – from 98°E in the northwestern Taimyr to 154°E in northeast Yakutia, similar to Red-necked Stint.

Overseas Recoveries of Australian Banded Curlew Sandpipers (to Feb. 1998)

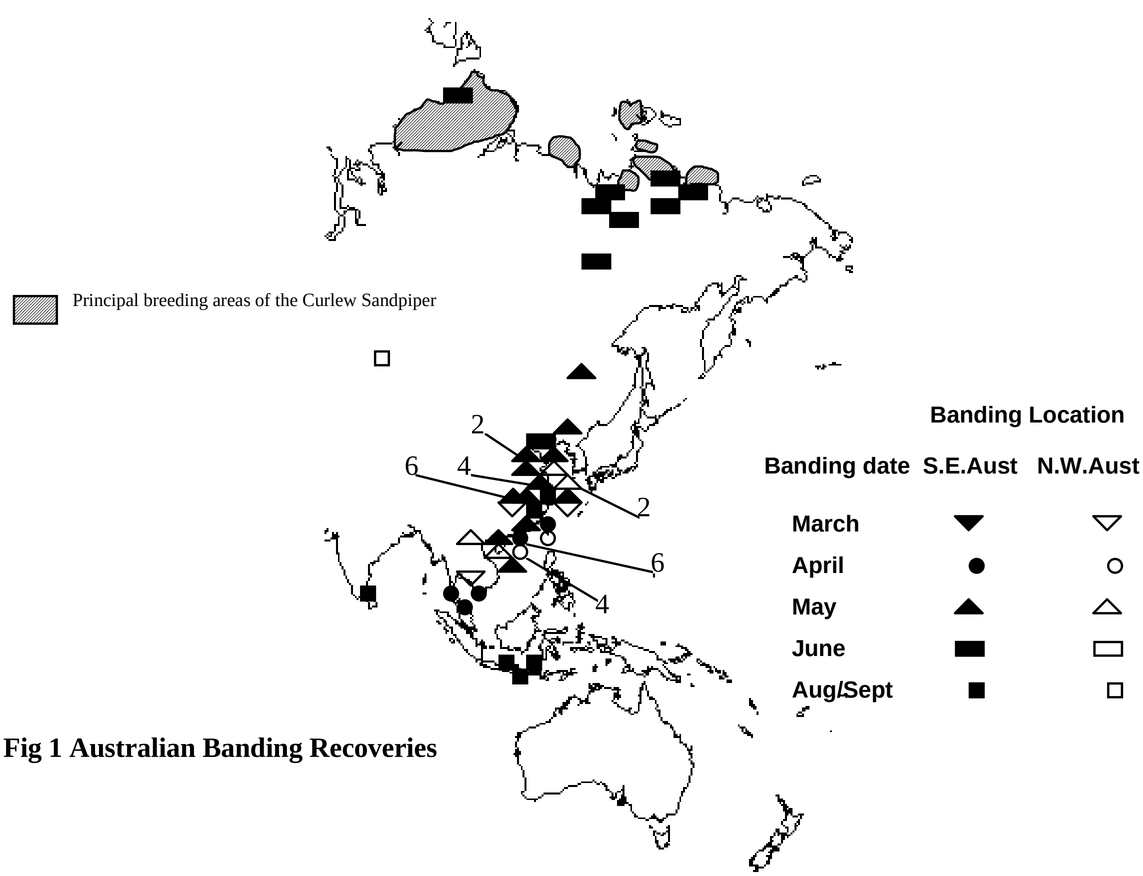


Fig 1 Australian Banding Recoveries

However, it appears that the majority of Australian birds head for the eastern end of the breeding range (7 recoveries there compared with only one in the Taimyr). The three records of colour-banded birds are also biased 2:1 in favour of the Yahutia breeding grounds.

The bird recovered at 76°N 98°E in the Taimyr was 13,100 km from its banding site at Werribee Sewage Farm, near Melbourne, in southeastern Australia. The bird was caught by Pavel Tomkovich, one of the leading arctic wader specialists, who was undertaking a detailed study of waders in the region in the 1991 summer. He saw this banded male bird and set up a stuffed Curlew Sandpiper decoy in the catching area of a spring-operated net in its territory. Curlew Sandpipers are renowned for their aggressiveness on the breeding grounds and it was not long before the urge to attack the stuffed intruder led to the live capture of the banded bird. This is the longest movement so far reported of any wader on the East Asian-Australasian Flyway.

There is insufficient evidence to indicate whether there is any difference in the breeding areas of Curlew Sandpipers from northwestern or southeastern Australia, as postulated for the Red-necked Stint (Minton 1996). All 8 recoveries on the breeding grounds, and one in south eastern Siberia on northward migration, relate to birds banded in southeastern Australia. Of the three colour marked birds from Russia, one that was originally banded in northwestern Yakutia was reported from northwestern Australia. However, its sighting date (1 May) on the Ashmore Reef (500 km north of Broome) does not preclude a bird on passage which had spent the non-breeding season elsewhere. Thus, there are, as yet, no breeding area recoveries or sightings of Curlew Sandpipers that migrated

Origins of Overseas-banded Curlew Sandpipers recovered in Australia (to Feb. 1998)

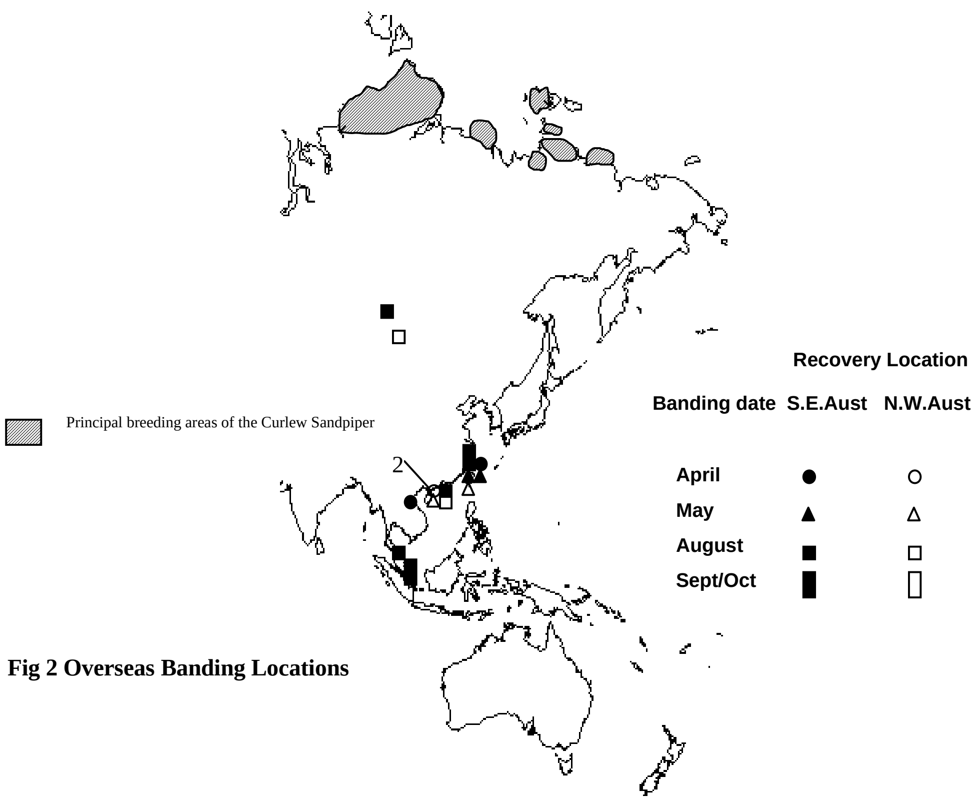


Fig 2 Overseas Banding Locations

from northwestern Australia.

The distance between the Yakutia breeding grounds and the southeastern Australian non-breeding areas of the Curlew Sandpiper is between 11,500 and 12,500 km. Birds from SE Australia travelling to the Taimyr breeding areas are moving around 13,000 km. Such birds are therefore typically undertaking round-trip migratory journeys of a minimum of 23-26,000 km annually. The distance travelled will be longer than this if non-Great Circle routes are flown and current evidence indicates that this is probably the case.

A surprising feature of the breeding season recovery range is that this shows a significant overlap with the breeding range of Curlew Sandpipers that spend the non-breeding season in South Africa and India (Underhill 1995, P.S. Tomkovich pers. comm.) or northwest and west Africa (Wilson *et al.*. 1980). In most widespread wader species, the sub-populations tend to have discreet breeding and non-breeding areas (even if there is considerable overlap and mixing during migration).

It is now possible to significantly add to the data in Underhill (1995) when comparing the breeding ranges of Curlew Sandpipers in the East Asian-Australasian Flyway with those from other flyways (Table 5 & Fig. 4). Underhill quoted four Australian-banded birds recovered on or close to the breeding grounds. There are now 11 movements of Curlew Sandpipers between Australia and Siberia for which the breeding area can be identified. (see Figure 4).

I divided the core breeding range into three partially distinct regions in Table 5 (although in practice

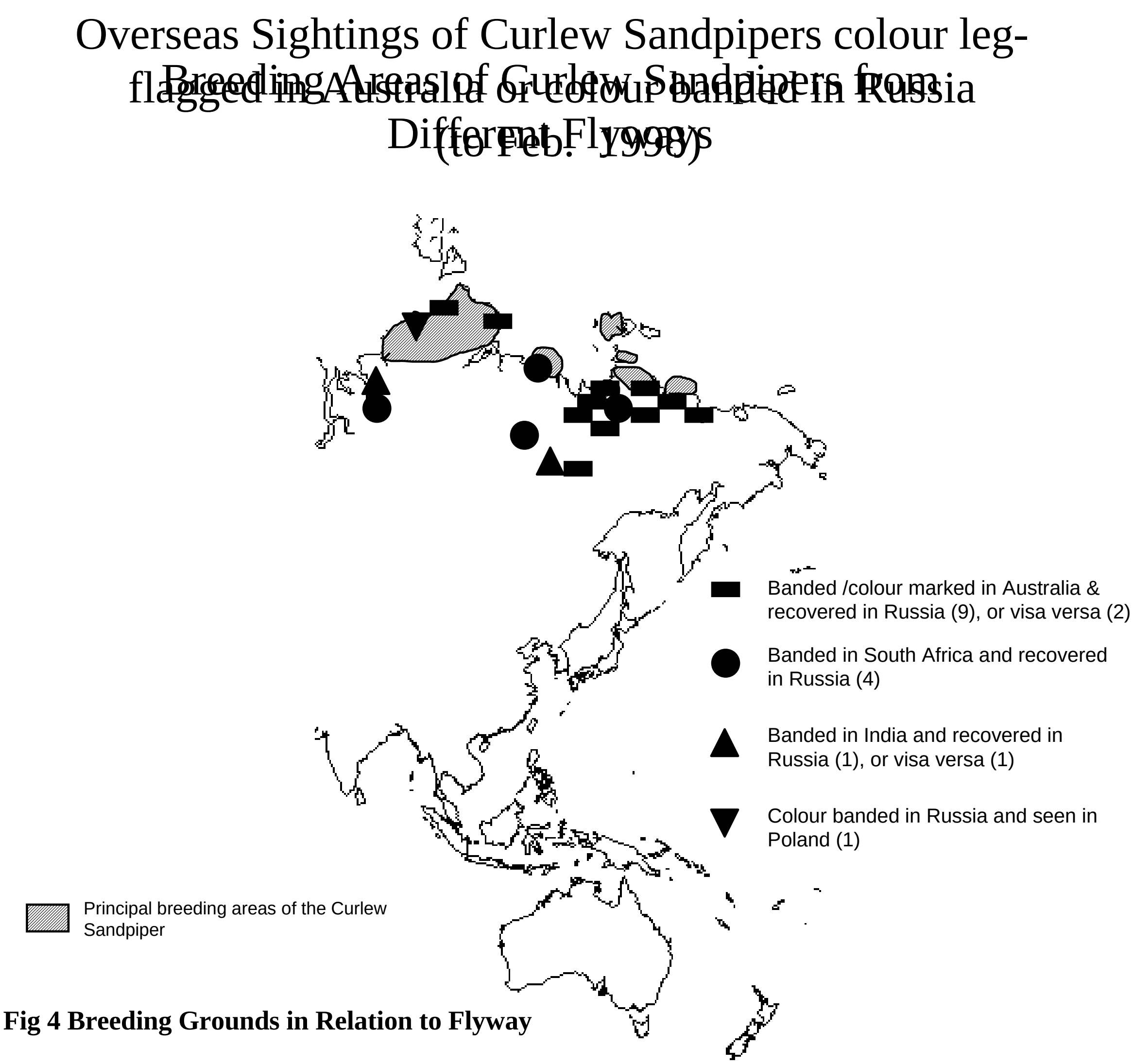


Fig 4 Breeding Grounds in Relation to Flyway

breeding ranges may vary from year to year (Lappo 1996)). Three of the four designated flyways have recoveries from both the western (Taimyr) end of the breeding range and to the eastern (Yakutia) end. Therefore, the data suggests that there is an overlap in breeding areas of populations of Curlew Sandpipers migrating through the different flyways. Data are too few to accurately quantify the overlap but there is clearly a tendency for East Asian-Australasian Flyway birds to breed in the Yakutia region (9 out of 11 records) and for most South African birds to breed further west (only 1 out of 4 records were in the Yakutia region).

These analysis was based on records from Siberian sites north of 62° N. In fact, all but three were actually in identified breeding areas between 67° and 76° N. The three exceptions (from Australia and India at 62°N and South Africa at 63°N) were all close enough to the breeding grounds for the ultimate destination area to be identified.

Omitted from this analysis (but included in Underhill 1995) are recoveries during migratory stopover in the southern part of Siberia and in Kazakhstan. The number of such recoveries is now significant with four relating to Australia (three in the 51° – 55°N, 90° – 95°E area, as already mentioned) and 19 relating to India (18 in the 42° – 49°N, 62° – 81°E area; the other at 55°N 78° E). Although these are all at longitudes corresponding to the Taimyr breeding area it would be unwise to attribute them to any particular breeding region because of the tendency of Curlew Sandpipers to make a westward loop during southward migration. In fact the position of the recoveries of some Indian birds are west of all the main Curlew Sandpiper breeding areas as well as being west of the Indian non-breeding site destinations. These results suggest that most of these birds are also taking a westward route during southward migration. This is true even if they had all originated in the Taimyr, which is unlikely given the 1:1 split of recoveries of Indian birds in the Taimyr and Yakutia breeding grounds. Such a westward loop would conveniently take the birds around the western end of the Himalayan mountain ranges.

Table 5. Longitudes (in °E) of recovery or banding locations of Curlew Sandpipers on the breeding grounds of birds banded on the different flyways. Sources were Australian Bird & Bat Banding Scheme (E.B. Dettman, pers. comm.), the Russian Bird Ringing office (per P.S. Tomkovich, pers. comm.) and Underhill (1995).

Flyway/Country	Region/Longitude of recovery or banding in Siberia (°E)		
	Taimyr (80 - 115°E)	Lena delta (120 - 130°E)	Yakutia (130 - 160°E)
East Asian-Australasian Flyway			
Banded in Australia	98	-	133, 134 (2), 135 146, 147, 154
Leg-flagged in Australia	111	-	-
Colour banded in Russia and recovered in Australia	-	-	140,149
Central Asian (Indian) Flyway			
Banded in India	-	-	133
Banded in Russia and later recovered in India	80	-	-
South Africa-Middle East Flyway			
Banded in South Africa	86	12,127	135
West European-North & West African Flyway			
Banded in Russia and recovered in Poland	98	-	-

As Underhill (1995) pointed out, there is no evidence of any Curlew Sandpiper changing its flyway even though there is an overlap in breeding ranges. The Australian bird recovered in southern India could possibly be an example, but it equally could just be an extreme example of the westward loop return migration. With a recovery date of 29 August in southern India the latter is probably the more likely explanation. One wonders whether this bird came around the west, the east or over the top of the Himalayas. A potential disadvantage of the westward loop migration of Curlew Sandpipers enroute back to Australia is that it appears to increase the amount of high ground to be traversed (the east end of the Himalayas Ranges) compared with the more direct route to Australia (as used in northward migration).

The number of reports of birds on southward migration is markedly less than on northward migration (Table 6) as in the Red-necked Stint (Minton 1996). It is not clear why there is such a marked dichotomy but it must relate to some difference in migration route and/or strategy between the migrations. Curlew Sandpipers may not need to depend on feeding grounds on the Chinese and Hong Kong coasts during their southward migration.

Another interesting (and possibly related) feature of the recoveries during southward migration is that four (out of 14) occur well to the west of the direct route (and the Great Circle route) between Australia and even the western part of the northern Siberian breeding grounds (Figs. 1 & 2). Three were in central Russia (two banded there – as juveniles – and one adult recovered there) at 90 - 95°E and 51 - 55°N, and one bird was recaptured near the southern tip of India at 80°E (and 10°N).

This suggests that some Curlew Sandpipers may return from the breeding grounds on a markedly different route to their northward migration and that some juveniles may utilise this route on their first journey to Australia. Such a loop migration is well established for Curlew Sandpipers spending the non-breeding season in West Africa (Stanley & Minton 1972, Wilson *et al.* 1980). Many utilise the coasts of Western Europe on southward migration but take a more direct route across the Eastern Mediterranean and Black Sea on northward migration.

As in the Red-necked Stint, there are very few records of Curlew Sandpipers in the south- east Asian islands of Indonesia, Borneo, Papua New Guinea or Philippines during northward or southward migration. There have been no reports of northwestern Australian banded birds from these areas and only four of southeastern Australian birds – a flag sighting in Sabah on northward migration and three recoveries in Java on southward migration. Therefore, it appears likely that most Curlew Sandpipers accomplish the journey between the northern Australian coastline and the Asian continental land mass in a single flight. This involves a minimum of 3500 km and, more typically a 4000 to 4500 km non-stop flight. At an assumed average flight speed of 70 km/hr, this would take 2 to 2-2/3 days.

One other recovery deserves mention – a "double journey" recovery of a Curlew Sandpiper moving between SE Australia and Hong Kong. Originally banded as an adult at Queenscliff, Victoria, on 3 January 1987, it was recaptured on migration at Mai Po marshes in Hong Kong on 26 April 1987. It was then caught again back at Queenscliff on 15 January 1989. Given the low live overseas recovery rates of waders banded in Australia the chances of a local "retrap" having been also captured overseas in the intervening period are very small.

The principal migration routes and stopover regions, derived from this analysis of banding recoveries and colour leg flag sightings, are depicted in Figures 5 & 6. The northern migration (Fig. 5) has a fairly firm foundation of data. However, similar data are lacking on the breeding ground destination of Curlew Sandpipers from northwestern Australia. The southward migration picture (Fig. 6) is more tentative because of a shortage of data, especially on the extent of any westward flight after leaving the breeding grounds.

Timing

An examination of the dates of recoveries and flag sightings (Figures 1-3) throws light on the timing of the migration through the flyway and the regions most likely used as major stopover locations.

The first overseas reports of birds on northward migration occurred in the last week of March. All three recoveries were of birds from northwestern Australia – one in Vietnam and the other two in China (one as far north as Shanghai). In contrast, only Curlew Sandpipers flagged in southeastern Australia have been seen in Hong Kong in March (8 birds – the earliest being 23 March). Victorian Wader Study Group data suggests that Curlew Sandpipers start to leave Victoria around 10 March which would allow only about a 10-day fattening period at a stopover site on the northern Australian coast before the earliest birds travelled on to Hong Kong.

Table 6. Relative reporting rates of Curlew Sandpipers on northward and southward migration.

Source	Northward	Southward
Overseas recoveries	44	7
Overseas flag sightings	127	4
Banded overseas and recorded in Australia	8	7

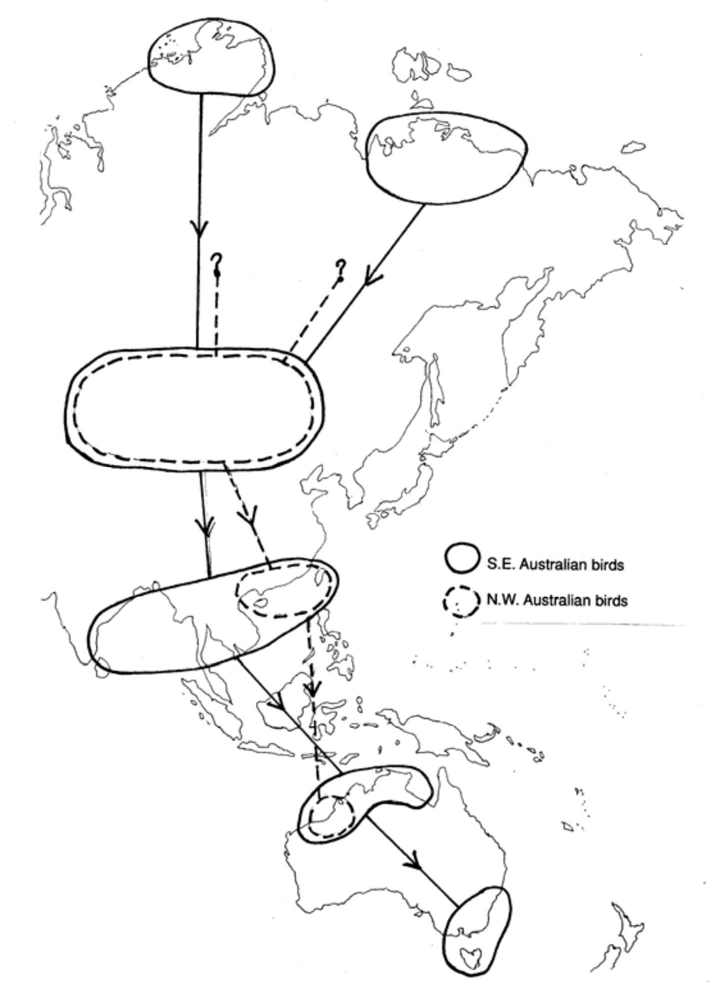
Amazingly, there are no recoveries of Curlew Sandpipers from mainland China in April. Instead, recoveries in April occurred in Hong Kong (10), Taiwan (2), Thailand (1) and Vietnam (1). Also birds banded in Hong Kong (2) and Taiwan (1) in April were later recaptured in Australia. Additionally, there was a huge concentration of leg flag sightings in Hong Kong in April (54 from southeastern Australia and 35 from northwestern Australia).

The overall pattern suggests that Curlew Sandpipers leaving the northern Australia coast in the last week of March and during April are making a prolonged stopover during this period in the area of Thailand/Vietnam/Hong Kong/Taiwan – and presumably also in southern mainland China even though there are no recoveries or flag sightings from there.

By May, most recoveries come from mainland China – from the latitude of Taiwan northwards right up almost to the Korean border. These recoveries occur in three principal areas – Shanghai and the coastline southwards until adjacent with Taiwan, the base of the Shandong Peninsula, and the northwest shores of the Sea of China (Fig. 1). Recoveries were spread throughout the first three weeks of May with only one (out of 14 for which recovery dates were available) being after 21 May. There was also one late record in northern China on 15 June. In addition, three birds banded in Taiwan between 2 and 20 May were subsequently recaptured in Australia.

Relatively few leg-flag sightings come from Hong Kong in May. The median overall date for flag sightings in Hong Kong is 21 April for birds from southeastern Australia and 23 April for birds from northwestern Australia. Although these dates are similar, the migration of southeastern Australian

Figure 6 Tentative migration routes and stopover regions for Curlew Sandpipers on southward migration.



Curlew Sandpipers through Hong Kong is spread over a much wider period (23 March to 24 May) compared with the narrow time span of birds from northwestern Australia (8 April to 12 May). Presumably, this is partly a function of the fact that most birds from northwestern Australia are reaching Hong Kong after a single flight whereas those from southeastern Australia have increased variability following a two-stage migration. This pattern suggests that birds which make their initial Asian stopover between Thailand and Taiwan during April use the area between Taiwan and the northernmost coast of China is the next major stopover region in May.

On 25 May, there is a recovery in inland southeast Siberia (51°N 133E°) of a bird that was presumably still on migration. This, and the lack of any recoveries or flag sightings on the Asian or Siberian coast north of China, suggests that inland staging sites are used from northern China onwards if needed during the final 3-4000 km journey to the breeding grounds. Recoveries on the breeding grounds in Russia have mainly been in June (range 1-27 June) with the flag sighting in the Taimyr being on 2 July.

There is little information on the timing of southward migration. There have been two recoveries and a leg-flag sighting in China, and another in southwestern Siberia, in mid August. The recovery in southern India occurred on 29 August. Two leg-flagged birds were sighted in Taiwan on 12 September. Of the three recoveries in Indonesia, one occurred on an unspecified date in August and the others were on 12 and 21 September. All these dates are consistent with adult birds leaving their breeding grounds in July, with most migrating back to Australia in August and September. Newly returned adults are usually seen after about 15 August in northwestern Australia. The main arrivals of adults in southeastern Australia occurs in early September.

There is even less information on the migration dates of juveniles on their first journey to Australia. One which subsequently came to Australia was banded in southern Thailand (7°N) as early as 28 August – the same period at which two others were still at 51-53°N in southwest Siberia. A bird, presumed to be a juvenile, which later turned up in southeastern Australia was banded in Singapore on 9 October. A bird colour-banded in its natal area in northeastern Siberia had already reached northern Tasmania by 30 October, less than three months after banding. Again, these records are consistent with sightings and catches which show that a few juvenile Curlew Sandpipers arrive in Australia in September but that the main arrivals occur later during October.

Age of first northward migration

There are no overseas recoveries of Curlew Sandpipers banded in Australia that are less than two years old. This tallies with other catching and count data that suggest that one year old Curlew Sandpipers do not return to their breeding grounds at the end of their first year, but mainly remain in their non-breeding areas. However, there is one record which indicates that one-year old birds may occasionally undertake a significant northward movement. A Curlew Sandpiper, which was aged as a second year bird when banded in Hong Kong in late August, subsequently turned up in northwestern Australia. Given the strong evidence that most adult and juvenile Curlew Sandpipers have a strong tendency to return to the same location for each non-breeding season (VWSG and AWSG unpublished data), it is probable that this bird had been to northwestern Australia in its first year. There is increasing evidence that some immature birds have a tendency to move a little northwards at the end of their first year (whilst remaining within the Australian continent) but this appears to be an extreme example of such a movement.

Counting and banding evidence indicates that all two-year old Curlew Sandpipers leave Australia on northward migration. It would thus appear likely that most breed for the first time at this age.

CONCLUSIONS AND RECOMMENDATIONS

The 209 overseas recoveries and flag sightings which have accumulated so far on Curlew Sandpipers from Australia have enabled an outline of the migration routes and breeding areas to be drawn up. Considerable additional data is needed before the situation can be resolved further. In particular, the breeding areas of northwestern Australian Curlew Sandpipers remain unidentified. Also, the southward migration routes are still poorly defined, especially the extent of the apparent westward loop migration undertaken by some birds. Many more Curlew Sandpipers need to be banded and flagged throughout the flyway for the migration routes and strategies to be fully delineated.

ACKNOWLEDGMENTS

I am extremely grateful to the many hundreds of people who have spent time labouring in the field throughout Australia, often in unpleasantly inclement weather conditions, to catch and band the 31,000 Curlew Sandpipers on which this recovery analysis is based. Thanks are also due to the people, throughout the flyway who have found and reported banded birds and who have observed and notified details of coloured leg-flags. Mention should especially be made of Geoff Carey and Paul Leader and their team of dedicated "flag observers" in Hong Kong.

I thank the Australian Bird and Bat Banding Scheme for administrative support, including the supply of the Curlew Sandpiper recoveries file printout. Alan Fletcher is thanked for providing Tasmanian banding and retrap totals. Professor Les Underhill kindly provided band recovery rate information from southern Africa. David Melville helped by confirming the ageing of Curlew Sandpipers banded in Hong Kong as well as being responsible for banding and recovering a significant number of birds.

I am also extremely grateful to Renate Lipovas for typing this paper (honours for reading my writing!), Ken Gosbell for putting some of the maps on to the computer with the aid of software loaned by Mark Barter and my wife, Pat, for drawing figures 5 and 6.

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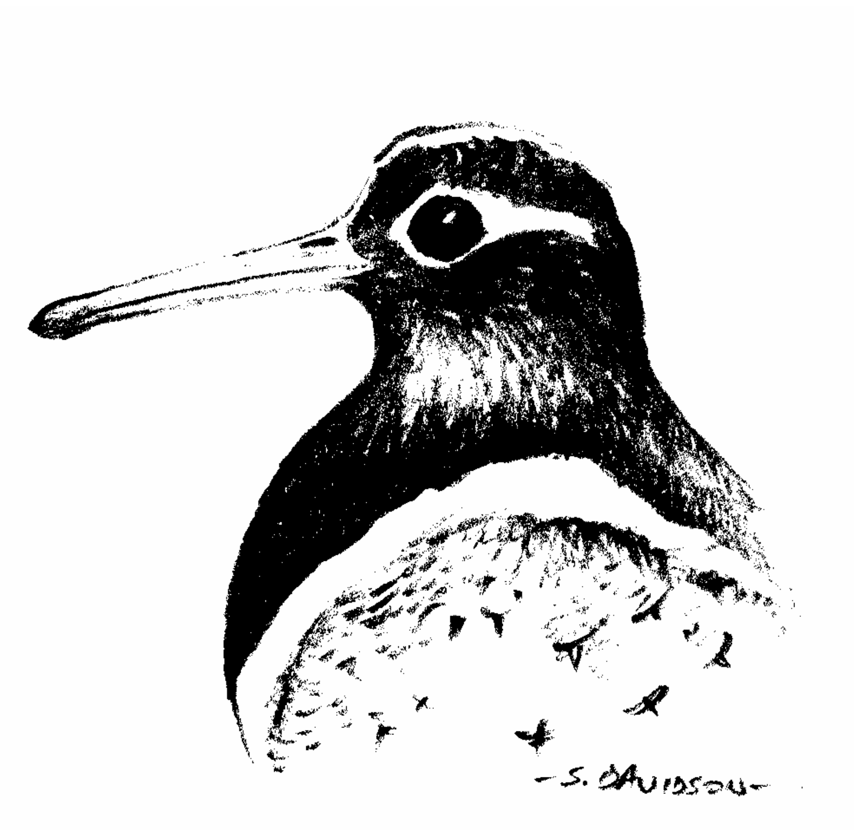
-S. DAVIDSON-

A SIGHTING OF A LEG-FLAGGED GREY-TAILED TATTLER *HETEROSCELUS BREVIPES* ON GUAM, MARIANA ISLANDS

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The Mariana Islands in western Micronesia lie near the eastern limit of the East Asian-Australasian Flyway. Significant numbers of shorebirds are believed to overfly the region during southward migration (Williams & Williams 1988, Williams & Mao 1990). Surveys during the past 20 years have revealed that nearly all species visiting the Marianas occur in relatively small numbers (Jenkins 1981, Maben 1980, 1981, Williams & Grout 1985, Stinson et al. 1997). However, to date, almost no information has been gathered on the migration routes of birds using this segment of the flyway.

This note documents a sighting of a color-marked Grey-tailed Tattler (*Heteroscelus brevipes*) on Guam, the southernmost of the Mariana Islands, on 21 December 1996. The bird had a bright blue leg flag on its left tibia and a metal band on its right tibia, and was seen at a sewage treatment pond in Merizo village (13°16'N, 144°40'E) at the southern end of the island. It was identified as one of about 1600 Grey-tailed Tattlers marked by Japanese researchers since 1992 at Furen Lake (43°16'N, 145°27'E) near Nemuro City in eastern Hokkaido, Japan (Y. Shigeta, pers. comm.).

The only previous sightings of color-marked birds in the Marianas were of single wing-tagged Lesser Sand Plovers (*Charadrius mongolus*) observed at Togcha Beach, Guam during the northern autumns of 1991 and 1992 (Stinson *et al.* 1997). Both sightings may have represented the same individual. The bird or birds were also tagged in the vicinity of Nemuro City, Hokkaido (at Shunkunitai). Despite this small sample size, these records suggest that many of the shorebirds seen in the Marianas during southward migration pass through Japan.

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WYNDHAM - AN IMPORTANT AREA FOR SHARP-TAILED SANDPIPER IN THE NORTH WEST OF AUSTRALIA ?

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On the 10 May1996 a visit was made to an area of mudflats and shallow freshwater near Wyndham in the west Kimberley division of Western Australia. The aim was to investigate the possibility of migratory waders using the area as a stopover point on their northward journey. The area was located when a bed of reeds was spotted from the main road into the town. This particular area forms part of the King River floodplain separated from the Parry River floodplain by a range of low hills.

The position of this wetland was 15 kilometres south of Wyndham and was reached from the main road by a track that led to Moochalabra dam. The extensive mudflat was dissected by a causeway. On the northern side it was shallow with a few creeks and, using the plant species as indicators, either fresh or slightly brackish in nature. The dominant species included grasses and *Phragmites* reeds as well as several species of rush. The creeks were piped under the causeway flowing moderately strongly in a southerly direction, but they quickly disappeared into the mudflats, either by percolation or evaporation. The southern mudflats were dissected by embankments making the area easily scanned from all angles. The southerly area did not appear to be regularly inundated by high tides but, because of the vegetation, mostly saltbush, on the edges and *Sarcicornia* species on the exposed areas, it appeared that during very high tides this area was indeed flooded by saltwater. To illustrate this point, in a few areas there were deposits of salt in crystalline form indicating that there had been saltwater pools that had evaporated slowly during the heat of the day.

On the fresher water waterfowl dominated. Counts of 12,000 Grey Teal *Anas gracilis*, 400 Pink-eared Duck *Malacorhyncus membranaceus* 30 Pacific Black Duck *Anas superciliosa* and 4 Hardhead *Aythya australis* were made. Amongst some grassy tussocks there were 3000 Black-winged Stilt *Himantopus himantopus*, 300 Common Greenshank *Tringa nebularia* and 400 Marsh Sandpiper *Tringa stagnatalis* all of which seemed to be feeding. Large counts of other species were 1000 Glossy Ibis *Plegadis falcinellus*, 150 Little Egrets *Egretta garzetta* and 100 Intermediate Egrets *Egretta intermedia*.

On the southern mudflats 300 Gull-billed Terns *Sterna nilotica* were seen from the beginning of the causeway. There was also a large flock of small to medium size waders in the distance but these were too far off to be identified. It was decided to track these birds down and we drove 4 kilometres to the other side of the mud to get a better view. The waders in question were roosting and were very co-operative in staying long enough for them to be identified as Sharp-tailed Sandpipers *Calidris acuminata*. Independent counts of the flock came to 3500 individuals. Almost all of the birds appeared to be in 75 - 100 % breeding plumage. These observations were confirmed later in the day, as when we returned to the main causeway, the Sharp-tailed Sandpipers and were feeding by the pipes that ran under it. Other migratory waders using the area, Common Greenshanks and Marsh Sandpipers were also in breeding plumage, perhaps indicating that these species were staging on northward migration.

Two species of non-migratory waders were also present in some numbers: Red-capped Plover *Charadrius ruficapillus*, which appeared to have recently finished breeding in the area as there was a high percentage of juvenile birds present, and 300 Red-kneed Dotterel *Erythrogonys cinctus.*

The numbers of Sharp-tailed Sandpipers in the East Asian-Australasian Flyway is estimated to be 166,000 (Watkins 1993) so the 3500 birds present on this area were of international significance (one percent being 1660). The size of this flock can be considered as unusual in the "Top End" (Ray Chatto pers comm.). The population of Red-kneed Dotterel, which is found only in Australia and New Guinea, is difficult to determine as numbers vary in response to rainfall. However the 300 present here indicates that this area is internationally important for this non-migratory species (one percent of the population is 260, Watkins 1993). This aggregation is also considered unusual by workers in the area (Ray Chatto pers.com.)

Two other species of migratory wader occurred in numbers of national importance. These were Common Greenshank (300), nationally important numbers are 200 (Watkins 1993), and Marsh Sandpiper (400), nationally important numbers are 90 (Watkins 1993). The 3000 Black-winged Stilt (non-migratory) are also of national significance (one percent of the Australian population is 2660, Watkins 1993). The large counts of Grey Teal, Glossy Ibis and Egret species also show that this area is also very important for these species.

Blakers *et al.* (1984) state that most Sharp-tailed Sandpipers move out of Australia during the breeding season, however scattered records exist from southern Australia and from the Darwin area throughout the year. They also state that birds begin moving out of Australia in mid February with most gone by late March and a few remain until early May. However there are increasing numbers of records for mid to late May from the "Top End". Records of over a hundred birds after early May are "hundreds" at Lake Frome in mid- May 1918, when it was flooded and 200 seen at Parry Lagoons, near Wyndham in mid-July 1989 (Higgins & Davies 1996). Observations of birds forming into moderate sized flocks in the Darwin area in mid-May have also been made (Ray Chatto pers. com). In addition 1500 (3-5 May 1986) and 540 (7 to 9 May 1988) were observed by Jaensch at Parry Lagoons (Jaensch & Vervest 1990). These records together with our observations of birds in breeding plumage, in early May indicates that some Sharp-tailed Sandpipers do not depart from Australia until early May and birds may spend the non-breeding season in northern Australia. The birds observed at Wyndham may not have been adults as one year old Sharp-tailed Sandpipers attain breeding plumage even although they may not return to the northern hemisphere breeding grounds (Higgins & Davies 1996).

Most adult Common Greenshank and Marsh Sandpipers are thought to leave Australia by early April (Higgins & Davies 1996). The presence of these species at this site in May indicates that it may be an extremely important over-wintering area for sub-adults of these species and an important staging area for adults on their way to the breeding grounds.

The reasons why this area was being utilised by waders at this time are obscure. Similar habitat is common in the north of Australia, particularly in the Joseph Bonaparte Gulf area (Ray Chatto pers. com). Inundation only occurs with spring high tides and is more extensive if high tides coincide with heavy rains or strong winds. However aerial surveys have shown low overall numbers of waders over huge areas of saline flats, with or without water. It could be that this area represents a wader “hot spot” (Ray Chatto pers com.).

The area with its diverse habitat was supporting both mud foragers, such as Sharp-tailed Sandpipers and, shallow freshwater feeders such as Marsh Sandpipers and Common Greenshank. One possible explanation may be the occurrence of late cyclones in April making conditions at this time of year much wetter than usual. Parry Lagoons an area of international importance for migratory waders is located about 20 km away (Jaensch 1989). A visit to this location, on the same day, found the lagoons were overflowing probably making the habitat unsuitable for waders as none were observed. Sharp-tailed Sandpipers are most particular on the depth of water in which they will feed and seem to prefer short surrounding vegetation (pers obs.).

The area near Wyndham needs to be monitored closely at other times of the year and if possible under different types of ‘wet season’ conditions so that an overall picture can be built up of its importance. In the future, it would be an advantage for a series of wetlands be registered under the Ramsar Convention as the conditions in the tropics vary enormously in the unpredictable ‘wet season’. Ultimately a chain of wetland refuges could be built up and protected to the positive benefit of both migratory and resident bird species.

Table 1. Count of bird species on a wetland 15 km from Wyndham.

Species	Number
Pacific Black Duck	30
Grey Teal	12,000
Pink-eared Duck	400
Hardhead	4
Little Black Cormorant	1
Australian Pelican	8
Little Egret	150
Pied Heron	2
Great Egret	10
Intermediate Egret	100
Glossy Ibis	1000
Australian White Ibis	1
Marsh Sandpiper	400
Common Greenshank	300
Red-necked Stint	12
Sharp-tailed Sandpiper	3500
Black-winged Stilt	3000
Black-fronted Dotterel	5
Red-capped Plover	50
Red-kneed Dotterel	300
Masked Lapwing	23
Gull-billed Tern	300
Little Tern	50
White-winged Black Tern	2

ACKNOWLEDGEMENTS

We would like to thank Ray Chatto for information on numbers of waders he has observed in the “Top End” and Ray Chatto, Roger Jaensch and Doug Watkins for useful comments on earlier drafts of this manuscript.

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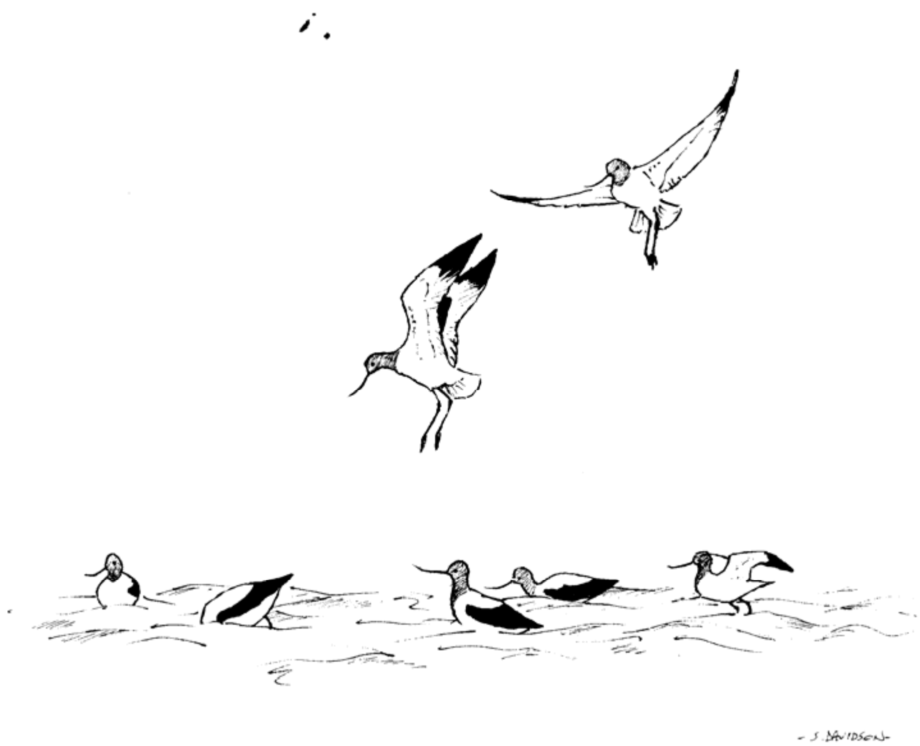

MORETON BAY - CONSERVATION AND MANAGEMENT OF A WETLAND.

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INTRODUCTION

Moreton Bay is listed in "A Directory of Important Wetlands in Australia" (Australian Nature Conservation Agency, 1996). It is located in south-east Queensland, east of Brisbane.

The following description of Moreton Bay is from the account of Moreton Bay compiled by Blackman and Craven (1995).

"Moreton Bay forms a basin enclosing one of the largest estuarine bays in Australia bounded by one of the largest sand dune islands in the world. It is 80 km long, 35 km wide in the north and 5 km wide in the south. It is situated in an area transitional between tropical and temperate zones and a number of marine fish and invertebrate species and associations reach the southern limit of their ranges in Moreton Bay."

A total of 23 000 ha of tidal flats with substrates of mud, sand or coral are exposed at low tide. More than 43 species of waders including 30 covered by international treaties use the bay. It holds internationally significant numbers of wintering Pacific Golden Plover *Pluvialis fulva*, Lesser Sand Plover *Charadrius mongolus*, Grey-tailed Tattler *Heteroscelus brevipes*, Eastern Curlew *Numenius madagascariensis*, Bar-tailed Godwit *Limosa lapponica* and Curlew Sandpiper *Calidris ferruginea* (Watkins 1993).

There are a number of threats to the integrity of Moreton Bay. These include encroachment and flow on impacts from contiguous urban and industrial development, shipping and port activities, impact of sewage and industrial discharge on water quality, alienation of public land for development, reclamation and soil dumping, mining and eutrophication of waters (Blackman and Craven 1995).

PROTECTION OF MORETON BAY

Ramsar Listing

The intertidal and sub-tidal areas of Moreton Bay together with the wetlands of the various islands of the bay and ocean shore of Moreton Island, North Stradbroke Island, South Stradbroke Island and Bribie Island were proposed for nomination and listing as a Ramsar site under the "Convention on Wetlands of International Importance, Especially as Waterfowl Habitat" and were declared a Ramsar site in 1994.

Queensland Marine Parks Legislation

The Queensland *Marine Parks Act 1982* provides for the creation and management of marine parks in Queensland waters. While some restrictions are placed on uses and activities in relation to declared marine parks, they do not have the same degree of protection as do terrestrial protected areas under the *Nature Conservation Act 1992* (Anon, 1997).

Planning

The Moreton Bay Marine Park was declared on 18 February 1993 at the same time as the Queensland Government adopted the Moreton Bay Strategic Plan. The Moreton Bay Strategic Plan is the policy guideline to the management of different areas in the bay.

The boundaries of the Marine Park follow the line of highest astronomical tide (HAT) and freehold land is excluded.

The draft Zoning Plan for Moreton Bay Marine Park was originally released in December 1993 and the *Marine Parks (Moreton Bay) Zoning Plan 1997* came into force in December 1997.

Marine Parks (Moreton Bay) Zoning Plan 1997

The Marine Park is divided into five zones and certain activities, including entry, require application for permission. One of the criteria for deciding to grant an application is "the effect of the proposed entry or use on shorebirds, particularly international migratory bird species, and their habitat and the need to protect shorebirds and their habitat".

Activities that need an application include:

- commercial aquarium collecting;
- collecting marine plants or declared animals;
- discharging waste;
- commercial fishing competitions;
- hovercraft;
- oyster ground and mariculture operations;
- manipulative research;
- tourist programs;
- traditional hunting;
- commercial whale watching programs;
- flying an aircraft below 500 feet;
- building structures such as jetties, buoys or pile moorings;
- dredging and disposing of dredge material;
- extraction and mining activities; and
- works.

Furthermore Section 66 sets out the following requirements:

- that a public authority must consult with the chief executive about any proposal or action that may affect the value of the marine park to shorebirds;
- a person must not take a dog into the marine park unless the dog is controlled in a way that prevents the dog from causing undue disturbance to shorebirds; and
- a person must not cause undue disturbance to shorebirds or their habitat, navigate a boat, hovercraft or personal water craft (jet ski), or drive a vehicle, through a group of feeding or roosting shorebirds or land or take off in an aircraft through a group of feeding or roosting shorebirds.

CONCLUSION

The conservation and management of shorebirds and wetland habitats of Moreton Bay should improve with this comprehensive planning for the marine area. The policy espoused by this document recognizes the environmental values that warranted listing of Moreton Bay as a Ramsar site.

Marine park management has yet to reach its full potential, particularly recognizing the range of other legislation that also applies to the conduct of activities and works in a marine area. It is hoped that this document can promote conservation values to the degree necessary.

There is still the need for further planning to take account of the shorebird roost sites that are above HAT or on freehold land. Clearly the intent provided by this zoning plan could be adopted by land oriented planning agencies that also manage shorebird habitat.

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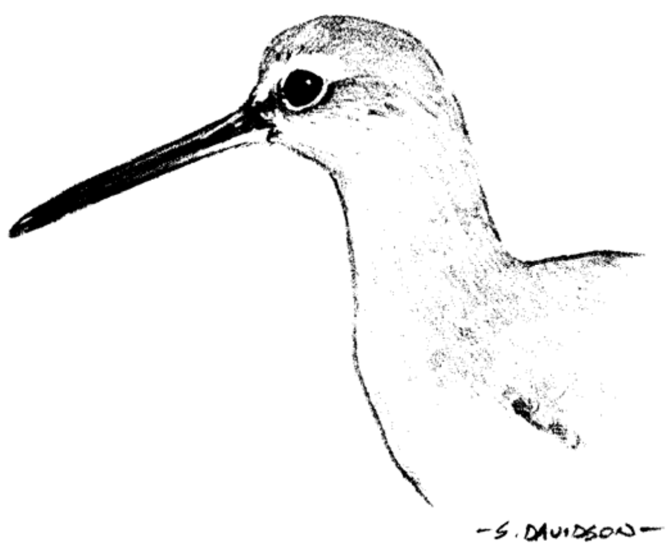

REPORT ON THE BIRDS AUSTRALIA/AWSG PRELIMINARY LATHAM'S SNIPE EXPEDITION TO JAPAN: RESULTS AND RECOMMENDATIONS

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This report is an edited version of a report submitted to Environment Australia in 1995. David Geering, who accompanied me on the expedition and remained counting Snipe after I departed, has published a brief report in *Tattler*.

Background

In 1993 Birds Australia (then the RAOU) and the AWSG made a proposal to the Migratory Species Unit of Australian Nature Conservation Agency (now Environment Australia) to re-estimate the breeding population of Latham's Snipe *Gallinago hardwickii*. The original initiative to make another estimate of the breeding population came from a recommendation made by Naarding (1986). Unfortunately, this new proposal soon became obsolete, as new literature came to our attention and as other relevant literature was published (e.g. Nechaev 1994). It became apparent that a visit to Japan would be necessary to clarify methodological, logistic and other issues relating to the Birds Australia/AWSG proposal. From 19 May to 29 May, 1995, I visited Japan on behalf of the AWSG in order to develop a new proposal designed to determine the breeding population of Latham's Snipe. This long overdue report serves to inform AWSG members of the progress with the Latham's Snipe Project.

Is Another Population Estimate Really Necessary?

Besides the fact that Naarding (1986) recommended another population estimate, there is a good biological reason to determine the population size. Dr Y. Fujimaki suspects that the Snipe population in Hokkaido may have decreased as have other ground-nesting birds which have suffered a decrease in population size. The probable mechanism for this decrease is increased predation, from an increased fox population, which has benefited from an increase in artificial food supply in the form of afterbirth from livestock. Of course, habitat modification might also be affecting the population of Snipe.

Activities in Japan

My visit to Japan included four main meetings with representatives from a range of organizations including the Hokkaido Government, the Wild Bird Society of Japan, the Japan Environment Agency, Obihiro University's Department of Wildlife Ecology, and the Kushiro City Council (Division of International Cooperation). In addition, three days of field work was undertaken during which David Geering and I visited all types of Latham's Snipe breeding habitat. I was also able to observe Snipe in display.

Literature

It should be noted that the most detailed and up to date literature review of Latham's Snipe (at least in English) in the breeding quarters is provided by Driscoll (1993). Japanese researchers provided recent literature but unfortunately these papers are mostly in Japanese with only English summaries. All recent Australian literature was distributed to relevant Japanese ornithologists.

Publicity

A number of Japanese newspapers (including at least one national newspaper) covered the visit to Kushiro. These newspapers ran an article explaining the purpose of the Snipe visit. They also published photographs of me in a suit, a fact that disturbs me greatly!

We also came across a number of stickers and cloth badges that featured Snipe. These initiatives, apparently mostly by the Wild Bird Society of Japan, served to increase public awareness of Snipe. Overall, there seemed to be a high awareness of Snipe and the conservation issues relating to them. Snipe are, after all, an obvious component of the avifauna in northern Japan.

Field Observations

Very poor weather (wind driven rain and low temperatures) was encountered on two of our three field days. Nevertheless, Snipe were observed perching and in aerial display, including diving, in the worst of the rain and the wind. Wisely, Hans Naarding did not count on windy days in order to standardize the detection of displaying Snipe which is often based on call or noise produced during the display ("winnowing").

Many Snipe were detected while perching (about 50% were detected while perching, and about 50% in aerial display). They were seen perching on trees, on traffic signs, on power and telephone poles, on fence posts, on a lighting tower at a sports stadium and on a tin shed in a farm. On one occasion a Snipe struggled for about a minute to perch on a small sapling, it flapped its wings vigorously as it tried to balance on a small branch. Snipe sometimes called from their perch; sometimes this was clearly associated with alarm at our presence, but on other occasions they appeared to be making display calls that were an obvious feature of the aerial display. When Snipe flew from their perch, they either began aerial display, or flew to an area on the ground and quickly disappeared in the dense ground cover.

It was also interesting that one favoured feeding site of Snipe are piles of rotting hay on farms. These piles were obviously rich in invertebrate food items (Y. Fujimaki pers. comm.). Snipe were also seen using highly disturbed habitats, such as perches immediately beside major roads.

Methodological and Logistical Problems and Some Solutions

Transects
While on the field we quickly learned that it was not possible to detect all Snipe in an area by driving slowly with the windows lowered. Regular stops, with the engine turned off, proved much better and many more Snipe were detected. The best possible way of conducting transects might be by bicycle (WBSJ pers. comm.). This would allow a counter to cover more distance than by foot, and would still allow the detection of all (most?) Snipe. Counting by bicycle would also prevent many problems associated with parking vehicles on narrow, and sometimes busy roads. Of course, the best transect count method needs to be determined using a quantitative approach.

Perches
The distribution of suitable perches along a transect would have an influence on the detectability of perching Snipe. For example, along a road with power lines, there are many perches where Snipe are highly detectable, but along an embankment with open forest and perhaps a fenceline, perching Snipe are far less detectable. This potential problem is of concern because of the high proportion of birds that I detected perching (Naarding's stationary display). Perching behaviour might vary diurnally and seasonally, and so the influence of the distribution of perches along a transect might also vary diurnally and seasonally. This could possibly be examined by classifying and quantifying the perches along each transect, and by examining the proportion of time that Snipe perch within a day, and across a season. Perhaps other habitat attributes, such as feeding sites, ought to be quantified on transects as well.

Study Site
The Kushiro and Tokachi districts of Hokkaido must be included in any population estimate of Latham's Snipe. There are also many other areas of Hokkaido that should be covered. More local studies from Honshu (e.g. Endo & Hirano 1986) were brought to my attention, and it was considered that the sum total of the breeding population on Honshu is probably significant (WBSJ pers. comm.).

Dr Fujimaki was particularly interested in a questionnaire survey of the distribution of Snipe in Hokkaido. Such an activity would be extremely useful to the population estimate.

Timing
Dr Fujimaki recommends that any survey should occur from late April to early June.

Recent Research in Australia

Banding has been conducted in Victoria for the few years up to 1995 (see Weston 1995), and significant catches have been made by the VWSG since then. There have also been captures in New South Wales (D.J. Geering pers. comm.). Leg-flags have been fitted in both states, in the hope Japanese researchers will sight the birds on the breeding grounds (Weston 1994; D.J. Geering pers. comm.). Surprisingly, one Victorian leg-flagged bird was resighted in Australia away from its banding site (D. Rogers pers. comm.). The banding activities were mentioned to all relevant Japanese authorities and appropriate literature was provided.

One consulting agency is studying the nocturnal distribution of Snipe in the Geelong area, Victoria, as part of an impact assessment. There could be other research being conducted, and we would be happy to hear about it.

Both the New South Wales and Victorian banders have independently developed plans to radio-track Snipe. It is considered important to encourage research on Snipe in Australia, particularly as an exchange visit of Japanese scientists to Australia is possible.

Problems with a population estimate based on a survey of Hokkaido only.

A survey of Hokkaido only would have the following problems:

Other parts of the breeding range would not be covered. Snipe might occur in different densities or even different habitats in different parts of the range. Consequently it would be impossible to produce a good estimate of the total population (though Naarding produced an estimate, and we could produce a similarly-derived estimate as well).

Difficulty in interpretation. Any decrease in density (using Naardings baseline) could represent a displacement of the population rather than an actual decrease in population size. Any increase in density could represent an influx from other parts of the range rather than an actual increase in population size. No change in density could be the net result of migration rather than represent a stable population.

Benefits of a Hokkaido only survey

There are some good reasons to re-survey Japanese Snipe in Hokkaido (beside the possible fox-related decline). They are:

An application of new methodology to survey Snipe in breeding habitat to order to get a better population estimate of the single most important breeding area.

Setting an improved baseline with explicit documentation to allow a re-count in later years.

Perfecting methods that could be used in other parts of the range.

To maintain the scientific contacts, and community and institutional support generated by Naarding and the May 1995 visit.

To encourage Japanese research on Snipe.

ACKNOWLEDGMENTS

The visit was supported financially by the Environment Australia Migratory Species Unit. The Japanese were a wonderful help. Particular thanks to Dr Fujimaki (Obihiro University), Mr Akasaka (Director of the Nature Protection Division, Hokkaido Government), Mr Okuda (Japanese Environment Agency), Mr Tsukamoto and Dr Kanai (Wild Bird Society of Japan) and of course, all staff of the Department of International Cooperation Section of the Kushiro City Council.

D.J. Geering and family were great company, and David has written a draft report of his surveys conducted after my departure. Hans Naarding, Danny Rogers, Mark Barter and David Baker-Gabb provided useful discussions and comments during the preparation of the funding proposal. Thanks also to David Rounsevell for locating the original survey maps. I apologize for the lateness of this report.

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THE MANUFACTURE OF LEG FLAGS IN THE LIGHT OF EXPERIENCE.

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The following article is an update of the article - Leg-flagging in Australia - Why and How? by Mark Barter and Megan Rush that appeared in Stilt 20. Diagrams are modifications of those appearing in that article. Since publication of the Barter and Rush article in 1992, the techniques employed by the Victorian Wader Study Group have been modified to cope with the demand for large numbers of high quality leg flags, needed by the VWSG and the Australasian Wader Studies Group.

Material

The material used for leg-flag manufacture is 0.5 mm thick unplasticized PVC sheet made by Imperial Chemical Industries in the UK under the trade name of "Darvic". Darvic has been used before for the manufacture of both colour bands and flags. The dyes are colour-fast and serious fading does not occur.

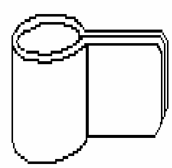
Darvic can be purchased from:
AC Hughes
1 High Street
Hampton Hill
Middlesex. TW12 1NA
UK

Tel: (0181) 979 1366
Fax: (0181) 979 5872

The plastic is manufactured by ICI in 6ft x 4ft (1.83m x 1.22m) sheets and AC Hughes will cut sheets up into 24 x 1ft x lft (30cm x 30cm) squares upon request. The smaller size is more easily transportable and very convenient to handle. The need to purchase Darvic should be planned for well in advance as it can take over 8 weeks to obtain it from AC Hughes.

Manufacture of Leg-flags

Flags are made slightly larger in diameter (D) and the same height (h) as the equivalent Australian metal band (Table 1). This is to take account of the slightly larger size of the tibia in most shorebird species. In some species, which are size dimorphic, the larger sex may require a larger size leg-flag than the band. For example, some female Bar-tail Godwits require a size 8 flag. This may also be true for different sub-species so try the flag on before you "glue" it and keep a list of appropriate sizes for each species with the flags.



The basic design, illustrated left, shows that the flag portion has sides which can be glued to ensure that the leg-flag remains secure on the bird's leg.

The first stage in the manufacturing process is to cut the plastic squares into strips with a width which is equal to the height of the flag to be made (Table 1). This can be easily done on a sharp, office paper, guillotine. The wide strip which is inevitably left over at the end (unless you want to slice the tips of your fingers off) can be utilised by slicing off the

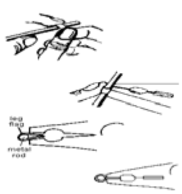
Table 1. Measurements for leg-flags currently used on Australian shorebirds.

Band size	Internal diameter of flag (D) - mm	Width of plastic strip (h) - mm	Length of flag blank - mm
03	3.0	5.0	27
04	3.5	5.0	30
05	4.5	7.0	32
06	5.0	7.0	35
07	6.5	8.0	43
08	7.5	8.0	43
09	9.0	10.0	45
10	9.0	10.0	45

appropriate widths at right angles to the original cutting direction. The yield will be virtually 100% if the width of the remaining strip is equal to the flag blank length required. Pre planning will achieve this.

Flag blanks are made from the strips by cutting to the desired length. The required blank length can be calculated by allowing for the circular part of the flag and for a flag length of approximately twice the flag diameter or use Table 1. Following trimming, the resulting flag length will be about 1.5 times the internal diameter of the band.

To make the flags you will need a metal rod such as a knitting needle or drill bit (a plastic rod can be used if metal is unavailable), of the relevant size (D) (Table 1), a shallow dish in which to heat water, several pairs of thick-nosed pliers and some dishes of cold water. It is important that the pan be clean and free from oil and grease that could coat the internal surfaces of the flag and interfere with the "gluing" action. The pan should be thoroughly cleaned with hot water and detergent (more than once if necessary).



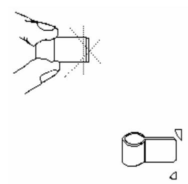
Flags are formed by bending the blank around the rod using the thumb and index finger as shown here in the top diagram. The pliers are used to grip the plastic against the rod to form a circle taking care not to squeeze the plastic against the rod as this will tear the plastic, see diagram 2.

The rod and blank are then held in the hot water for 10 seconds. The flag and pliers are then plunged into a bowl of cold water to set the flag into the new shape. The flag is gently slid off the end of the rod and left for a few minutes in the container of water. The cold water should be renewed at regular intervals as it heats up due to the pliers being plunged into it. The flags will not set properly if they are plunged into warm water!

It is very important to get the correct squeezing action so both the surfaces of the flag sides are firmly in contact with each other in the finished flag. If the sides are separated to any extent, the "springiness" of the flag tends to work against the "glue" when the flag is being attached to the bird's leg and satisfactory "gluing" takes longer. The possibility of subsequent separation of the flag sides, and consequent flag loss is also greater. It is also important to make sure that the ends of the flags are square or the resultant flag will be twisted and therefore unusable.

Badly formed leg flags can be re-used by putting them in the hot water which will cause them to return to the unformed flat state.

Slightly mis-formed flags can be renovated by replacing them on the metal rod, gripping to the correct shape with the pliers and re-immersing for a short time in hot water. The flag can then be removed as before, and dropped into cold water.



The formed flags are trimmed with a sharp pair of nail clippers or scissors to make both sides of the flag of equal length and to remove any sharp corners - see diagram opposite.

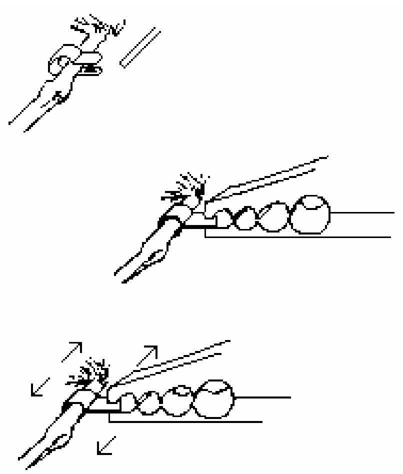
Old 35 mm plastic film containers hold a convenient quantity of flags - don't forget to label both the lid and the base with the flag size.

The trimmed flags are then air-dried, and thoroughly cleaned by agitating in a suitable solvent. Priming fluid for PVC pipes and fittings used by plumbers is suitable (Methyl ethyl Ketone, 53%, (V/V)). Flags should be cleaned for 20 seconds, air-dried again, clipped (see below) and kept in labelled containers. It is best to wash the bands outside away from any sources of ignition as Methyl ethyl Ketone is highly flammable. Do not leave the flags is the solvent too long or the legs will stick together making the flag useless.

Only clear Methyl ethyl Ketone should be used as the dye in the type used by some plumbers will colour the flags. This is especially important when flags are washed in red dyed fluid as the colours of the flags will change beyond recognition.

Leg-Flag Attachment

The most suitable method for "gluing" the flags has been found to be the solvent cement used by plumbers to glue PVC pipes and fittings (UPVC Solvent Cement, produced by Marley Extrusions Ltd, Lenham, Maidstone, Kent, UK, phone Maidstone 0622 858888 or fax 0622 858725). The solvent cement contains Methyl ethyl Ketone as a solvent and partially dissolves the plastic and upon setting, forms an adherent bond. Super Glue is unsuitable as it does not work by solvent action and is not an effective adhesive for the hard, shiny Darvic surface especially in the marine environment. Additionally, Super Glue is more hazardous to use because of its propensity to glue "anything" to "anything", including fingers to flags and birds and bird's legs to flags.



The most successful technique for attaching the flag is to, firstly, open the flag portion just sufficiently to push over the bird's leg and then to place a drop of solvent between the flag sides using a screwdriver, whilst they are still separated by the leg (see top figure above). The flag is then pushed completely on to the leg and it should snap shut due to the inherent spring in the plastic. The flag sides are then clamped lightly with a pair of pliers for at least 20 seconds until the solvent has had time to dissolve some of the plastic and then evaporated sufficiently to hold the two sides together (see middle figure above). The exact drying time will depend on the air temperature. It is important to only use just enough solvent to cover the joint surface when the sides are clamped by the pliers. Excess solvent will be squeezed out and may cause the flag to adhere to the feathers on the bird's leg. It is good practice to continuously move the flag relative to the leg whilst the flag is clamped by the pliers (see lower figure above). The solvent evaporates rapidly and a flag that is moving freely on the leg after 20 seconds will remain free thereafter. Slide the pliers gently from the flag, as opening them may cause the flag to spring open if they are contaminated with solvent.

Birds can then be released after checking that flags are properly glued and moving freely on the leg (see lower figure above).

It is very important not to open the flag sides too much during application to the bird's leg or the flag will become permanently distorted and it will be difficult to get a satisfactory bond between the two sides of the flag.

Removal of Leg-flags

Sometimes retrapped birds have been found that have worn or faded flags. Flags are easily replaced by gently cutting the "legs" of the flag near the birds leg and this will enable the flag to be removed.

ACKNOWLEDGMENTS.

Special thanks go to Doris Graham of the Victorian Wader Study Group for organising leg-flag making "parties" where members of the VWSG spend many hours over hot pans in sometimes trying circumstance to produce the many thousands of flags used in Victoria and the north-west of Australia.

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REGULATIONS CONCERNING CANNON NETS

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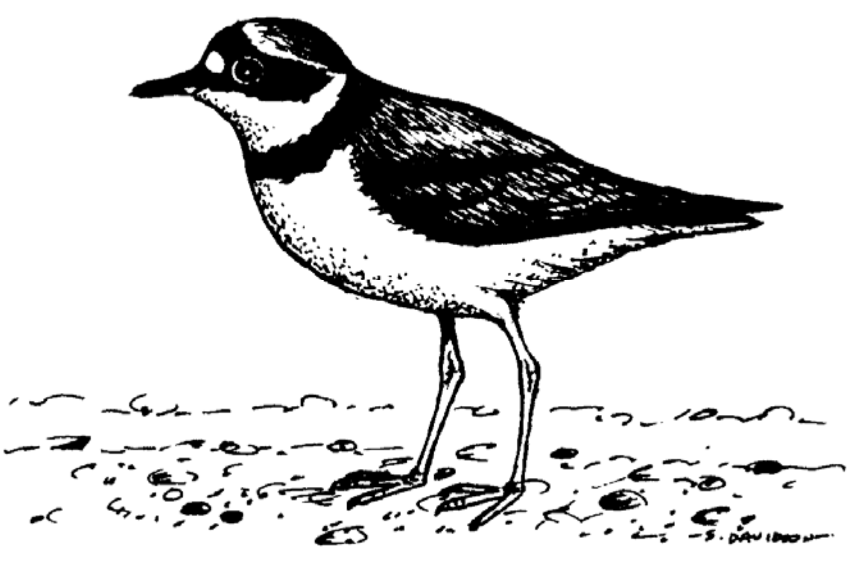
Soon after the new Firearms Legislation was introduced in Victoria in early 1997, the Victorian Wader Study Group was advised that cannon netting equipment fell within the new definition of 'firearms'.

The process of obtaining a special licence to operate the equipment was initiated and resulted in the Group and one (initially) of its members being granted licences (at a total cost of $130 per year!).

In February 1998, an amendment to the legislation in Victoria was made to specifically exclude "a device which is designed for and used to throw a net to catch animals (commonly known as a cannon net)" on the basis that the new Firearms Act had not been set up to cover such equipment. No licence is therefore now needed.

This is a welcome and sensible clarification of what has, for a long time, been a 'grey area'. At one stage in the past the equipment was officially classed as a pistol!

The above situation relates to Victoria, but will be of interest to all cannon netters. The Firearms Legislation in each state varies somewhat and it is probable/possible that in some states cannon nets would not be construed to be covered by the Act. I was also informally told that some other, unspecified, states had recently amended their legislation to eliminate the unintended inclusion of cannon nets.



WADER THESES 2

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This is a list of theses relating to shorebirds, supplementary to that published in Stilt 28: 15-21. Many thanks to all the people who responded to the first list with additional information. Further additions and corrections, as well as translations of titles from languages other than English, would be welcomed by the compiler.

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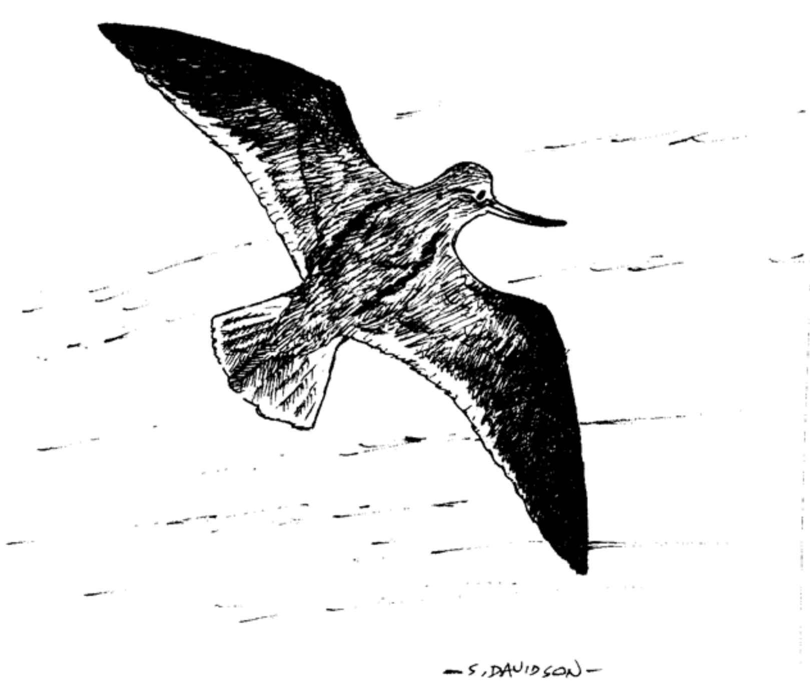

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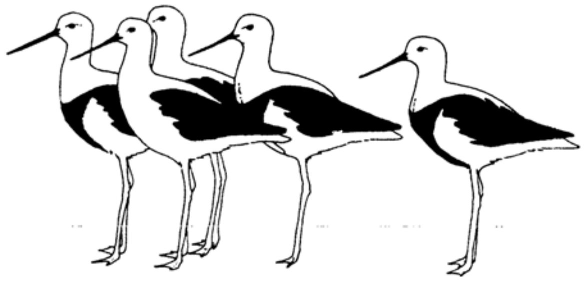

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