

WADER MIGRATION SYSTEMS IN EAST ASIA AND AUSTRALASIA

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The East Asian/Australasian Flyway extends from breeding grounds in East Siberia, China and Alaska, south to wintering areas in South-east Asia and Australasia. There are 77 migratory wader species in this flyway of which 75 migrate from northern breeding grounds to southern wintering grounds. The first site counts were made in the 1940's in New Zealand. Major co-ordinated counts started in the 1970's and 1980's in Japan, Australia and South-east Asia. The main techniques used in the region are aerial, boat and ground surveys, regular counts and marking. Other techniques include observations by radar, and of breeding and feeding ecology. Southwards migration is from late June to November. Northwards migration is from late February to late May. Migration strategies include arc-routing, overflying, and trans-Pacific flights. The main non-breeding grounds for *Tringa* sandpipers are in South-east Asia, and for *Calidris* sandpipers are in Australia. Non-breeding habitats in the tropics are mangrove/mudflat areas and partly flooded rice fields. In the temperate zone, coastal lagoons and large bays are used. Northward and southward migration routes of many species appear to differ, but insufficient data are yet available to plot precise routes. Major gaps include the location of the breeding and non-breeding areas of some species, and the migration routes between. The most important work to be carried out in the next decade will be to continue to locate major sites, to make detailed studies on endangered species, ringing, and to continue regular counts to monitor population levels.

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INTRODUCTION

The East Asia/Australasian Wader Flyway has until recently been relatively little studied. The flyway extends from breeding grounds in East Siberia, China and Alaska, south to wintering areas in South-east Asia, Australasia and New Zealand. The human population density is low in the breeding grounds and the migration terminus. However, in the migration zone, population density is high and rapid habitat destruction and hunting for food threaten many flyway populations.

It is a considerable task to survey the region, as there are many technical, logistic and political problems to be overcome before surveys can be conducted. There are 36 countries along the flyway, with many different political ideologies. There are seven major language groups and hundreds of languages spoken by the people of the region. Access to sites in the Soviet Union, China and Australia are extremely difficult due to the lack of roads and great distances involved. The Philippines and Indonesia comprise respectively of 7 000 and 13 000 separate islands, each with potential wader habitat. In the Pacific there are innumerable islands, each providing a small area of habitat for migrating waders. Expertise in ornithological studies is primarily restricted to the few developed nations within the region. The tasks of accurately mapping the migration routes of waders along the flyway is very difficult.

There are 103 species of wader in the Asia/Australasian Region, of which 77 are

migratory. All migratory species, except two, fly from northern breeding grounds to southern non-breeding sites. The exceptions are Double-banded Plover *Charadrius bicinctus* which migrates from New Zealand to Australia, and the Australian Pratincole *Stiltia isabellae* which moves north from Australia to Indonesia. Several other Australian breeding species are nomadic within their country, rather than migratory.

HISTORY OF FLYWAY STUDIES

The first scientific work on waders in the flyway involved collecting expeditions between the 1850s and 1930s. In Siberia, important collections were made by Middendorf, Pallas, Radde, Maak, Schrenk, and the Vega Expedition. In South-east Asia, Bartels and Aagard collected extensively, and in Australia early work was carried out by Seebohm. These studies laid the taxonomic and distributional basis for future research. Collecting studies continued in China and Philippines until recently.

The first regular site counts in the flyway were made in New Zealand, at the Waikanae Estuary (Wodzicki 1946). Subsequently, counts were undertaken at many other coastal sites, the most extensive being those at Manukau Harbour and the Firth of Thames, where wader counts began in 1951 (Veitch 1978) and, since 1959, have continued each southern summer and winter. All these counts were undertaken by members of the Ornithological Society of New Zealand (OSNZ), an amateur organisation.

Also in the 1950s, Gladkov in the Soviet Union began faunistic studies that included work on waders, such as their breeding biology, and a study of the differences between Red-necked Stint *Calidris ruficollis* and Little Stint *Calidris minuta*.

The 1960s was the era of the Migratory Animal Pathological Survey (MAPS), which covered most countries in the flyway except Australia, New Zealand, USSR and China. MAPS involved a large scale bird ringing, and 65 000 waders were ringed (McClure 1974). Most waders were ringed in the Philippines (18 638), Japan (1 624) and India (41 730) (McClure and Leelavit 1972). Fifty overseas recoveries resulted. Although not enough to demonstrate all migration routes, these gave a good indication for some species. The cyclical route of the Turnstone *Arenaria interpres* in the Pacific was demonstrated at this stage. Ringing recoveries of Turnstones during MAPS indicated that the western Pacific population, breeding in east Siberia, follows a circular route. Birds migrate to the Pribolof Islands and Aleutian Islands, then southwards to the islands of the south-west Pacific. During northwards migration, Turnstones move westwards to the islands off New Guinea, then north to Japan and back to the nesting area (McClure 1974). The MAPS programme finished officially in 1972, but three countries (India, Japan and Malaysia), continued the ringing.

The 1960s saw the first regular wader counts in Asia. Jeram in West Malaysia was counted intermittently 1963/64 (Medway and Nisbet 1965) and Jurong, Singapore, was counted regularly in 1960/61 (Medway and Wells 1964, 1976). In the Taymyr Peninsula in West Siberia, Krechmar began studies on breeding birds including much work on waders. Portenko undertook similar studies in Siberia in the 1950's and 1960's (Portenko 1957, 1959, 1968).

In Australia in the late 1960s and early 1970s, regular, systematic counts of entire estuaries were made in Hobart, Tasmania (Thomas 1970a), Westernport Bay, Victoria (Loyn 1978), and Botany Bay, New South Wales. These counts were undertaken in response to the threat of industrial and urban development in these areas.

The first detailed feeding ecology studies in the flyway were made by Kistchinski in Siberia during the 1970s. In 1973 a national wader studies programme was started in Japan, by the Wild Bird Society of Japan (Research Division WBSJ 1986). In 1974, a new direction of bird migration studies was initiated in the USSR. Migration Study Teams were formed under Gavrillov at Alma Ata in Khazakstan, Yurlov in Novosibirsk in West Siberia, and Tolchin and Melnikov in the Baikal region of Southern Siberia.

These studies involved large scale ringing, together with some counting and some single species studies. Results were published in an annual book on the Birds of Asia. Most studies ended in 1985, but those in Alma Ata and Novosibirsk are continuing. Large-scale ringing and migration studies have now been started by Savchenko in Tuva and Southern Krasnoyarsk Region. In 1972, an institute was established at Magadan in East Siberia to study the biology of extreme tundra conditions. Wader studies included general study by Kandratiev, and studies of wader energetics and tundra productivity by Khlebosolov. Also in the 1970s Lobkov studied waders in Kamochatka and Nechaev studied Nordmann's Greenshank *Tringa guttifer* on Sakhalin Island. Working out of Vladivostok,

Glustchenko produced reports on waterbirds at Hanka Lake, on the border with China. One of the few contributions in the USSR by an amateur ornithologist was a paper, on wader migration at a site near Vladivostok in the 1970s.

Wader ringing elsewhere increased in the 1970s. In Malaysia, a team from the University of Malaya and the Department of Wildlife and National Parks ringed about 8 000 waders (Wells 1984). During the 1970s and early 1980s the Bombay Natural History Society ringed about 100 000 waders at Bharatpur and Point Calimere in India. Japan continued ringing at a rate of about 1 000 birds per year (Ozaki 1982). In Australia, the first banding programmes aimed specifically at waders commenced in the early 1970s (Purchase 1981) in New South Wales (Hunter Estuary), Western Australia (Swan Estuary in Perth) and South Australia (Kangaroo Island). Waders were caught using mist-nets, and also by cannon-nets in the Hunter Estuary. Until then, nearly two-thirds of the waders banded had been Australian-breeding species. Since 1975, wader ringing has been carried out in Victoria where cannon-nets were introduced in 1978 and the Victorian Wader Study Group was formed. Later, cannon-netting was introduced to Tasmania and the Tasmania Shorebird Study Group formed; and to Western Australia where the Western Australian Wader Study Group commenced operations. These groups, together with individuals using mist-nets in Darwin (Northern Territory) and Kalgoorlie (Western Australia) and expeditions to North-western Australia (using cannon-nets and mist-nets), now ring about 10 000 waders each year.

In December 1979, the first simultaneous count of more than one wetland system was organised by the Victorian Wader Study Group (Dann 1980). Over 90 volunteer observers were involved and in excess of 80 000 shorebirds were counted. For the first time, the comparative importance of sites could be determined on a statewide basis. In February 1981, the first simultaneous National Wader Count was held. In August 1981, the first expedition to, and aerial surveys of, the northern coast were organised and regular wader counts started at many more sites. The Royal Australian Ornithologists Union (RAOU) Wader Studies Programme had commenced. The techniques used during the programme, which ran from 1981 to 1985, are outlined in the methods section.

The RAOU study was co-ordinated by a full-time organiser and a part-time scientific assistant. This small office staff co-ordinated a team of over 700 volunteer bird-watchers throughout most of Australia who did all of the data collection.

Since the 1970s, two government departments in New Zealand, the Wildlife Service and Ecology Division, have completed intensive surveys of coastal sites, usually in response to the threat of industrial, urban or agricultural development. In such surveys there has been close co-operation between the government departments and OSNZ.

In January 1983, OSNZ organised a pilot operation to determine the feasibility of undertaking national wader counts. This operation proved successful and full national wader counts were initiated in November 1983. Since then, three summer and three winter counts have been completed. Some 200-250 observers were involved with each count during which about 85% of the coastline was covered. These counts enabled, for the first time, the comparative importance of sites to be

determined on a nationwide basis, and reliable estimates of wader populations to be made.

Most wader banding has involved species breeding in New Zealand, particularly South Island Pied Oystercatcher *Haematopus longirostris*, Black Stilt *Himantopus novaezelandiae*, New Zealand Dotterel *Charadrius obscurus*, Double-banded Plover *Charadrius bicinctus* and Wrybilled Plover *Anarhynchus frontalis*. In the early 1980s attempts were made to catch migratory waders and this resulted in 58 Bar-tailed Godwits *Limosa lapponica*, 892 Red Knots *Calidris canutus*, 9 Ruddy Turnstones and 4 Curlew Sandpipers *Calidris ferruginea* being banded before the project was abandoned.

In 1983, The East Asia/Pacific Shorebird Study Programme (INTERWADER) was begun to discover more about wader distribution in South-east Asia. INTERWADER conducted surveys of West Malaysia in 1983, then Thailand, West Malaysia, Singapore, Sabah and the Philippines in 1984. In 1984 a network of contacts was also established from Japan, USSR and China to Australia to enable flyway migration studies to commence. Migration monitoring projects with regular counts and colour-marking were initiated in 1985. In 1985 and 1986 INTERWADER expanded its survey programme to Indonesia, Brunei, Vietnam and China. INTERWADER started detailed feeding ecology studies in 1984 and in 1985 began examining the ecology of the mangrove/mudflat ecosystem. Training workshops and programmes have been organised and INTERWADER is now developing education material on wader conservation to increase interest in wader studies in Asia.

In the Philippines in 1985, Simplicia Alonzo - Pasicolan initiated a wader study programme in Luzon and in 1986, Perla Magsalay in Cebu and Nina Ingle in Mindanao began similar studies. In Thailand, Nukul Ruttanadakul and Surapol Ardeungnurn set up a regular counting and hunting evaluation project in Pattani, South Thailand. Shorebird hunting was also studied by Milton and Marhadi in Indonesia in 1985/86. In Vietnam, teams from Hanoi University under Professor Vo Quy and Le Lien Duc looked at coastal waders. In 1984, the Chinese set up a bird ringing scheme and in 1985 had their first wader recovery from Japan - a Mongolian Plover *Charadrius mongolus*. A team at East China Normal University, including Wang Tian Hou, started banding in 1985 and counting in 1986 in the Yangtse River Delta.

METHODS

A very wide range of methods have been used to study waders on the flyway. The methods fall into 3 categories: surveys, marking and ecological research.

Surveys

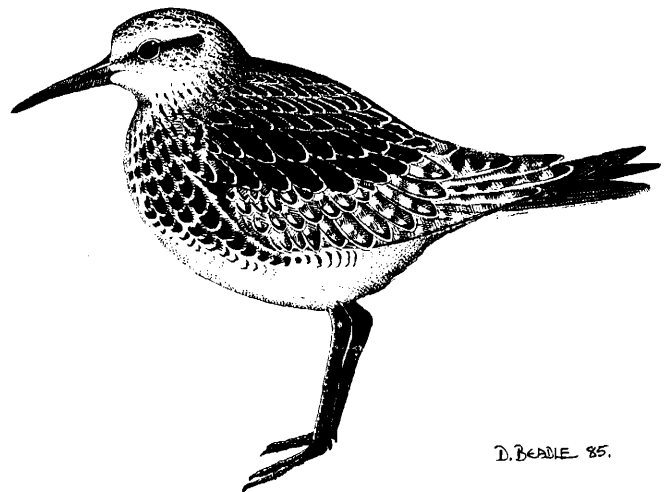
Aerial surveys: Aerial surveys, using light aircraft flying at low altitude and low speed, enable the numbers of shorebirds to be estimated on long, inaccessible stretches of coast. However, species identification is often difficult, although larger or more boldly marked species, such as oystercatchers *Haematopus* spp., Eastern Curlew *Numenius madagascariensis*, Whimbrel *Numenius phaeopus*, Redshank *Tringa totanus*, stilts and avocets, Beach Thick-knee *Esacus magnirostris* and Black-tailed Godwit *Limosa limosa*, can be sometimes identified. Owing to this limitation, aerial surveys in Australia are used to locate

concentrations of waders, which are usually later surveyed by ground-based observers.

Accurate counting of shorebirds from the air is difficult. Studies have shown that inexperienced observers underestimate shorebird numbers more than experienced observers, and that the underestimate is greater for larger numbers of birds (Prater 1979; Garnett and Carruthers 1982). In Australia, these problems were confirmed during simultaneous aerial and ground counts on the Broome-Port Hedland expeditions. Consequently only counts done by experienced counters (who achieved counts within 10% of ground count results) were accepted. Ground counts were not always necessary if observers were experienced.

Aerial surveys for waders have also been used in USSR (by Lokhov in Kamchatka for Oystercatchers) and in South-east Asia (by INTERWADER for mangrove-lined coasts). Waders feeding on mudflats backed by mangroves are extremely difficult to count, since the forest restricts access from the land and soft mud and shallow seas restrict access for the seaward side. Aerial surveys are therefore important in determining numbers present. Aerial surveys of waders in South-east Asia mangroves are normally conducted just before or after high water on a neap tide. At high water on spring tides the waders often roost inside the mangrove forest and thus cannot be counted from the air. Timing is very important, because the strip of mud adjacent to the mangroves has to be wide enough for the birds to have left their roosts in the mangrove, but not so wide that the birds are widely dispersed. Aerial surveys in the tropics are also hampered by unpredictable weather. Aerial wader surveys have so far been successfully used by INTERWADER in Malaysia, Thailand, Brunei, Sabah and Sarawak.

Boat surveys. In many parts of tropical Asia, wader habitat is accessible only from the sea. It may be on offshore islands or be mainland mudflats backed by a 10 kilometre-wide mangrove forest. Boat surveys for waders were first used extensively in South-east Asia in 1984 by INTERWADER in Sabah (Beadle and Whittaker 1985) and in south-east Sumatra (Silvius et al. 1986b) and Sarawak (Edwards et al. 1985). Boats act as an observation platform and enable shore landings for counts of high tide roosts and habitat evaluation. Boats have been used also to provide access to habitat in many parts of Australia since 1981.



Great Knot

Radar. Radar was used to study bird migration in the early 1970s when a study involving filming of radar screens and complicated analysis was carried out in Hong Kong by Myers and Apps (1973). However, the full details of the study have not yet been published. In 1975, David Melville devised a simple chart on which air traffic controllers recorded the direction and number of bird movements. This study produced valuable results (Melville 1980). From 1981-84, radar was used to study migration through Hangzhou Bay in East China (Mao Ying 1985). In 1984 T. and J. Williams correlated nightly radar observations with daily counts of the beaches on Guam to ascertain which species were passing through. In 1985 and 1986 radar observations were made of migrating waders in north-west Australia (Lane and Jessop 1985b).

National counts. National counts are organised by the RAOU/AWSG in Australia (1981-85), the OSNZ in New Zealand (1983 onwards), the Wild Bird Society of Japan (WBSJ) in Japan (1973 onwards), and the Hong Kong Bird Watching Society (HKBWS) in Hong Kong. Their purpose is determine the number of waders occurring simultaneously in as many wetlands as possible. These counts are carried out by co-ordinated networks of amateurs. In the case of Hong Kong, counts are made only in the mid-winter. In Australia and New Zealand, two counts are held during both winter (June-July) and summer (November in New Zealand, February in Australia). In Japan counts are held during peak migration (April and September). Counts are normally held over a two-week period when tides are suitable. In New Zealand about 85% of the coastline is surveyed (Figure 2). Previous studies have shown that relatively few waders occur in areas not counted.

In some parts of Australia, all sites were counted each year. However in areas with few observers, it was not possible to obtain complete coverage in each year of the study. Here different areas were counted every year. Over the five-year study almost all areas were counted at least once. National Counts have provided a picture of the total importance of a particular country to wintering or migrating waders; and of the key sites and the distribution of waders in each country.

Survey expeditions: Wader survey expeditions are organised primarily to remote areas. Such expeditions have been organised in the Soviet Union, China and Australia. Expedition teams in the Soviet Union are relatively small (5-10 people). Those in Australia are larger (20-40), while those in China may number over 100 scientists. However, the Chinese expeditions are usually multi-disciplinary rather than studying just waders.

In Australia, expeditions since 1981 have gathered much new data on the status and distribution of waders on the remote north coast. To date, 12 such expeditions have been completed. These usually combine one or two light aircraft for aerial surveys with a fleet of 3-5 four-wheel drive vehicles and boats. Local radar stations are manned to examine movements of waders. These are correlated with ground and aerial censuses, and with local and continental weather patterns. Other work includes extensive banding and colour-marking, and feeding observations. Such expeditions have, for example, demonstrated that north-west Australia is an important arrival area for migrants, many of which refuel for a direct flight to south-east Australia. Before 1981, the population of the Great Knot *Calidris tenuirostris* was thought to be about 10 000

birds. Surveys during the expeditions have now shown the Great Knot to be the second most common wader in Australia, numbering at least 250 000 birds.

Regular counts. Regular counts of areas of wader habitat are being carried out at in Australia (co-ordinated by the AWSG), and in East Asia (co-ordinated by INTERWADER). The Australian counts are conducted at monthly intervals, or more frequently, at over 60 locations. In Asia counts are conducted at monthly intervals only during migration. At a few sites, such as Pattani (Thailand), Seria (Brunei) and Jurong (Singapore), counts have been carried out on a weekly basis. These counts give information on the timing and location of migration.

Marking. To catch birds for marking, a wide variety of trapping methods are used in the flyway. Walk-in traps are used in the Soviet Union, and in the past in Australia. Mist-nets are used in the Soviet Union, Japan, Australia and South-east Asia, clap-nets in China, rocket-nets in Japan, cannon-nets in Australia and New Zealand, and snares in Thailand. At Point Calimere in India, gongs, torches and throw-nets are used.

Once trapped, the birds are marked in a variety of ways. Ringing schemes using metal rings are operated by the following countries: Malaysia (2 schemes), China, USSR, Japan, Australia, India and New Zealand. Colour-flags have been used by Gavrilov in Alma Ata on Little Stints *Calidris minuta*, Curlew Sandpipers and Dunlins *Calidris alpina*. Colour rings have been used by Tomkovich in E. Siberia on Spoon-billed Sandpipers *Eurynorhynchus pygmaeus* and in New Zealand and Australia on Double-banded Plovers. Neck Collars have been used on Red-necked Phalaropes *Phalaropus lobatus* and Wood Sandpipers *Tringa glareola* by Gavrilov. Temporary wing-tags made from cotton have been used in Japan.

Colour-dying is a technique which has been of great value in Australia in discovering the north-west/south-east migration route. A variety of dyes have been tried but the two main colours used are Picric acid and Astrazon Blue. Birds dyed with Picric have flown from Australia to Hong Kong, and between sites in Australia. An Astrazon-marked bird from Singapore was recorded in N.W. Australia in 1983.

Early bird-ringing operations, such as MAPS, were more concerned with migration routes between general areas than with gathering detailed morphometric information on the birds. Ringing operations since the 1960s have tended to involve a major component of morphometric and moult data collection. Bird-in-the-hand studies are most developed in Australia (e.g. Barter 1984, 1985).

Ecology

Several breeding ecology studies have been carried out in the Soviet Union. Most have involved mainly observation of nests and descriptions of behaviour. Recently, breeding ecology studies involving mapping of nests, colour-marking of individuals, observation on voice, display, dispersion and feeding have been made. Breeding ecology studies have also been made in Japan, on resident species in Australia, and on most resident breeders in New Zealand.

Early feeding ecology studies in the region

were principally confined to listing stomach contents of specimens. Such studies are obviously biased towards identifying prey species with resistant hard parts such as insects and bivalves. Some papers have made erroneous conclusions about the regular occurrence of small stones and bone fragments in the gizzard - for example Spoon-billed Sandpipers have been claimed to feed on lemmings because bone fragments were present in the gut.

More detailed studies have been made in Siberia in the 1970s on Pectoral Sandpipers *Calidris melanotos* and Phalaropes (Kistchinskii 1973, Kistchinskii and Chernov 1973). From 1981-86 the East China Normal University at Shanghai studied the gut contents of specimens. Direct observations of feeding behaviour, combined with benthic sampling were pioneered in South-east Asia in 1984 by Swennen and Marteiijn (1985) working Malaysia and Thailand. In the same year similar studies were carried out in the Nakdong Delta (Piersma 1985). INTERWADER has continued these studies, and has gathered data from Brunei and Sarawak. In Australia very few feeding ecology studies have been made, other than a study of the feeding of Red-necked Stints and other waders in the Swan Estuary, Western Australia, in 1983/4 (Dann unpubl.). In 1985 the research programme of the North-west Australia expeditions included the collection of gut contents from banding casualties.

Energetic studies, relating waders to the energy flow through the ecosystem, have been carried out since 1972 in north-east Siberia by the Institute of Biological Problems of the North, at Magadan.

Analysis

Recent publications by Barter (1985, 1986) have analysed Curlew Sandpiper and Great Knot morphometric data. However, there have been rather few other detailed analyses of such data for waders in East Asia and Australasia.

BREEDING AREAS

Most migratory shorebirds in the flyway come from breeding grounds in the eastern USSR, Mongolia, northern and western China, Japan and Alaska, an area covering 40 degrees of latitude and a number of distinct vegetation zones and climatic regions. They breed in areas ranging from the Gobi Desert (e.g. Greater Sandplovers *Charadrius leschenaulti* and Oriental Plovers *C. veredus*), grasslands (e.g. Eastern Curlew), Taiga forest (e.g. Wood Sandpiper) and tundra regions (e.g. many of the small *Calidris* sandpipers). The breeding season begins in late April in the south, and late May or early June in the north.

SOUTHWARD MIGRATION

Failed breeders, and also sexes not involved in incubation (males in the Sharp-tailed Sandpiper and Curlew Sandpiper, and probably females in the Least Sandpiper), begin to leave the breeding grounds from June onwards and the first birds arrive in South-east Asia from mid July, still in partial breeding plumage. Numbers build up slowly during August and major arrivals have been recorded in late August/early September in Malaysia (Parish and Wells 1984). Red-necked Stints, from Northern Siberian breeding grounds, arrive in Japan from early July, with peak numbers occurring in late August; all have moved on by early October

(McClure 1965). This species start arriving in West Malaysia in mid-September with largest numbers being recorded in mid-January (McClure 1965).

Adults leaving the breeding grounds in Siberia appear to migrate on a broad front across Central Asia, whereas the juveniles, which follow 4-6 weeks later, probably head straight to the coast and follow it southwards. This pattern has been documented for Sharp-tailed Sandpipers *Calidris acuminata* (Tomkovich 1982). Some juvenile Sharp-tailed Sandpipers follow a curious route from east Siberian breeding grounds to the East Asian coast via Alaska, where they stop briefly in August and September.

When waders reach the Chinese coast they appear to follow one of two routes - a Chinese Coast Route to Indochina and the "Ryu-Kyu-Philippine Flyway" to Indonesia (McClure 1958).

Different species use different migration routes. Data collected and collated by INTERWADER from 1983-86 indicate several possible routes in East Asia. Some use a dog-legged route over South-east Asia (arc-routing), some overfly Asia, and others migrate across the Pacific Ocean. Red-necked Stints and Curlew Sandpipers initially head south-west from their central and east Siberian breeding grounds, then fly southwards over South-east Asia and then south-east over Australia to reach south-eastern Australian non-breeding grounds (Parish and Wells 1984b). This route is 2-3000 km longer than the great circle route, but enables the birds to refuel regularly along the migration. These small calidrids have much shorter flight ranges (2-4000 km) compared to larger species (e.g. Lesser Golden Plovers *Pluvialis dominica*) which seem able to fly 4-7000 km non-stop.

Long-distance migrants like Lesser Golden Plovers and Wandering Tattlers *Heteroscelus incanus* use the trans-Pacific route. These species breed in eastern Siberia and Alaska and migrate across the Pacific using small islands as staging-posts. These islands do not have the extensive mudflats suitable for feeding calidrid sandpipers, but seem to provide sufficient food for plovers and other sandy shore feeders.

The Little Curlew overflies much of Asia. It migrates south in large flocks across Eastern Mongolia in August, refuels in China and overflies South-east Asia (where there are only a handful of records each year) and makes a landfall in Irian Jaya where large numbers were recorded in October 1984 (Bishop 1984). The major arrival point is north Australia where vast numbers have been recorded from November onwards (e.g. 250 000+ at Fogg Dam, Northern Territories, Crawford 1971). Such a strategy may also be used by species such as Great Knot which is only recorded in South-east Asia in groups up to 100-200 but over 240 000 occur in northern Australia. The Latham's Snipe *Gallinago hardwickii* may fly non-stop from Japan to Australia (Naarding 1985).

Major sites identified so far, that are used by migrant waders in central and southern Asia are shown in Figure 1.

In northern Australia, large numbers of adult shorebirds of many species arrive in the third week of August. Small parties of adults also arrive in the south at this time, but larger numbers do not arrive until the last week in August and the first week in September. From

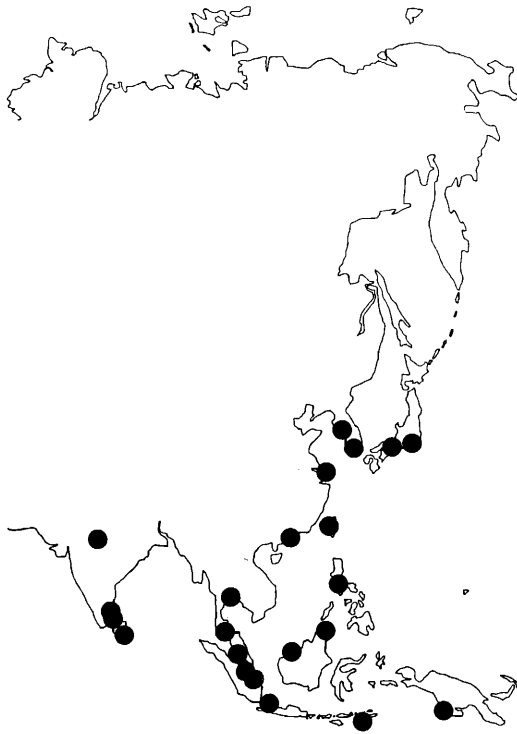


Figure 1. Currently known key sites (those used by over 20 000 birds) for migrant waders in central and southern Asia.

then until late November, numbers increase in the south. From December to mid-February, numbers of migratory shorebirds are stable in most parts of Australia, suggesting that little movement occurs in this period. There is some variation between species in the timing of arrival. Newly-arrived flocks of Eastern Curlews can be seen on the east coast as early as late July but Oriental Pratincoles *Glareola maldivarum* do not reach northern Australia in large numbers until December, with the onset of the wet season. Most species are migrating southwards in largest numbers between September and mid-November. Juvenile shorebirds first arrive in the south in late September and early

October. In some species, (e.g. Sharp-tailed Sandpiper) males migrate ahead of females (Lane and Minton, in prep.).

The distribution of species in Australia, together with the results of regular counts, suggest that there are two principal migration routes into Australia, one entering via the north-west coast and the other via the east coast. Table 1 shows which species enter Australia via each route. Thomas (1970b) hypothesised that there might be 2 routes represent a migratory divide around the high mountains of New Guinea. However, some species, e.g. Lesser Golden Plover and Little Curlew, do migrate across these mountains (Heron 1978). Those species that use the western route come from breeding grounds in central and mid-eastern Siberia and use South-east Asia as a refuelling area. Those that use the eastern route probably come from far eastern Siberian and Alaskan breeding grounds and migrate across the Pacific Ocean (e.g. Bar-tailed Godwit and Ruddy Turnstone) may come from two or more breeding populations or may be species migrating on a broad front.

The two routes terminate in south-eastern Australia. Here, for example, the non-breeding ranges of Grey Plover *Pluvialis squatarola* and Lesser Golden Plover overlap by about 800 km, but they occur on separate marine embayments, often as little as 15 km apart.

From September to November, shorebirds occur individually or in small flocks along most of the south and east coasts and in inland wetlands, often in apparently unsuitable habitats. These are probably birds newly arrived from north-east Australia. By late November, most shorebirds have moved to the larger estuaries and coastal bays where they stay until northward migration starts in mid-February. These observations indicate that many shorebirds migrate from the north coast, directly across the western and central deserts, to the south coast. The trans-continental migrants are mostly species which use the western route into Australia (see Table 1). This long flight over the deserts is comparable to the migration of birds, including waders, across the Sahara Desert (see Piersma et al. this volume, Summers et al. this volume).

Table 1. Routes used by different wader species reaching Australia on southward migration. Main wintering destinations of each species are shown where known.

NORTH-WESTERN ROUTE	NORTH-EASTERN ROUTE	BOTH ROUTES
+ Grey Plover	+ Lesser Golden Plover	* Large Sandplover
* Oriental Plover	* Mongolian Plover	+ Ruddy Turnstone
* Little Curlew	+ Eastern Curlew	* Whimbrel
+ Greenshank	+ Latham's Snipe	Common Sandpiper
+ Marsh Sandpiper	* Wandering Tattler	Grey-tailed Tattler
* Wood Sandpiper		* Terek Sandpiper
* Black-tailed Godwit		+ Bar-tailed Godwit
+ Red Knot		
* Great Knot		
+ Sharp-tailed Sandpiper		
+ Red-necked Stint		
+ Curlew Sandpiper		
+ Sanderling		
* Broad-billed Sandpiper		
* Asian Dowitcher		
* Oriental Pratincole		

+ = move to southern Australia
 * = move to other parts of northern Australia

The availability of the inland wetlands used during southward migration follows an annual pattern. Most shorebirds arrive on the north coast at the end of the dry season, when non-coastal wetlands are minimal. In the south, inland wetlands fill in winter and spring, just as the shorebirds are arriving. The pattern of inland wetland availability is reversed during northward migration in March and April.

As well as trans-continental migration, there is considerable movement of shorebirds southwards down the east coast of Australia between August and November. Most of these species do not appear on inland wetlands at this time (e.g. Mongolian Plover, Grey-tailed Tattler *Heteroscelus brevipes*, Terek Sandpiper *Tringa terek* and Bar-tailed Godwit).

In New Zealand, the first migratory shorebirds to return are Curlew Sandpipers, small numbers arriving during the third week of August. These are followed by Red-necked Stints and then the majority of the Bar-tailed Godwits and Red Knots in mid-September. The influx of Bar-tailed Godwits occurs over a similar time period at many localities, suggesting that most birds return directly to traditional wintering sites (Heather and Braithwaite 1985). After the initial influx the number of godwits at various sites remains relatively stable until spring. Numbers of Curlew Sandpipers and Red-necked Stints at favoured sites also tend to reach a plateau in early October and remain at that level until spring. Lesser Golden Plovers, Sharp-tailed Sandpipers and Pectoral Sandpipers differ, with birds apparently moving south through the country until December when numbers appear to stabilise at Invercargill, the southernmost site.

NON-BREEDING GROUNDS

In East Asia the main non-breeding grounds are in South East Asia and the Indian subcontinent. There is insufficient mid-winter data to yet identify the wintering distribution of many species. However, studies have indicated that 4000+ Asian Dowitchers winter in Sumatra, and that Nordmann's Greenshanks winter along the shores of the Malacca Straits. Small numbers of species such as Kentish Plovers *Charadrius alexandrinus* and Dunlins are found in southern Japan, with large numbers along the China Coast. Other species such as Spotted Redshanks *Tringa erythropus* winter no further south than Northern Thailand. South-east Asia is the main wintering ground of the Redshank, Wood Sandpiper, Long-toed Stint *Calidris subminuta*, and the *atrifrons* race of Mongolian Plover. Other wintering species such as Curlew Sandpiper, Red-necked Stint and Black-tailed Godwit are shared with Australia. The main habitats used are the coastal mangrove/mudflat ecosystem and partly flooded ricefields.

In Australia (Figure 2 and Table 2), about 80% of the almost 2 million non-breeding shorebirds occur in three main regions:

- the north-west coast, between Broome and Port Hedland;
- the north-east coast of Arnhem Land and the Gulf of Carpentaria;
- and the south-eastern coast and Lake between Eyre Peninsula and Corner Inlet.

Most species are not spread uniformly, probably due to migration patterns rather than just the availability of habitat. There are species which occur in the north-west and the south but not in the north-east (e.g. many of those that arrive via the western route). Other species

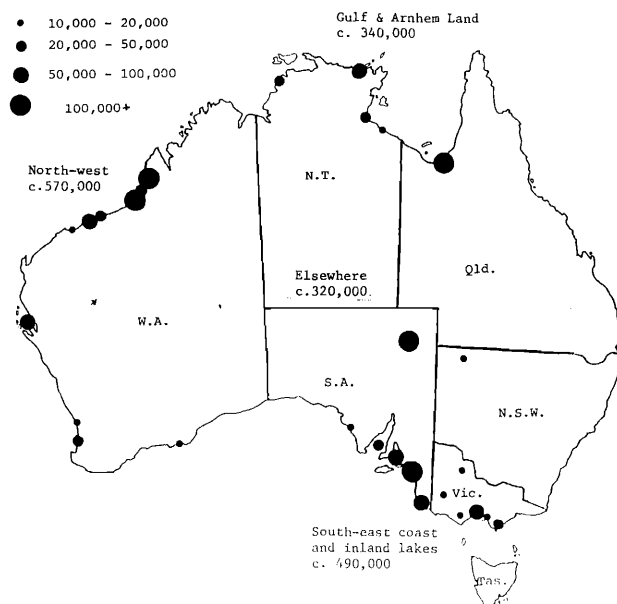


Figure 2. Map showing wintering areas for waders in Australia. Only sites with >10 000 waders are shown. Areas are listed in Table 2.

occur mainly in the north (e.g. Great Knot) and others occur on the east coast. Detailed information on the distribution of each species in Australia are given by Lane (in press).

The muddy intertidal shores which are preferred by shorebirds in Australia occur in both tropical and temperate areas. In tropical areas, mudflats form on the open coast as the sea is normally calm. Furthermore, much sediment is delivered to the coast from a hinterland subject to the higher rates of weathering prevalent in tropical regions. In southern Australia, mudflats form only in the calm water behind sandy barriers thrown up across basins or river mouths by the rougher seas. In most parts of Australia, higher numbers of shorebirds occur where the tidal range is greater. The main areas in northern Australia that hold shorebirds have the highest tidal range. In Australia, coastal shorebird habitat differs from the predominantly arid land. The habitat is therefore subject to marine rather than estuarine conditions.

The preferred habitat of migratory shorebirds in New Zealand is intertidal mudflats in harbours and estuaries, mainly those with shell or sandbanks to use as high tide roosts (Veitch 1977). The major sites are in the north (Parengarenga to Tauranga), Farewell Spit and Invercargill (Figure 3). Smaller areas of suitable habitat occur throughout the country, although the west coast of the South Island has few such sites.

About 136 000 migratory shorebirds spend the northern winter in New Zealand. Bar-tailed Godwits and Red Knots comprise over 95% of this total with about 80 000 and 50 000 respectively. Ruddy Turnstones and Lesser Golden Plovers with about 5 000 and 500 respectively comprise the bulk of the less abundant species. Regular but less abundant migrants include Red-necked Stint, Curlew Sandpiper, Sharp-tailed Sandpiper, Pectoral Sandpiper, Greenshank *Tringa nebularia*, Eastern Curlew and Whimbrel.

Habitat availability is the main factor

Table 2. Maximum counts at zones in Australia that held more than 10 000 shorebirds at some time between 1981 and 1985. A = aerial count, G = ground count.

ZONE	MAXIMUM COUNT	
Eighty Mile Beach, WA*	337 500	A
SE corner, Gulf of Carpentaria, Qld	250 000	A
The Coorong, SA	236 000	G
Roebuck Bay, WA	170 900	G
*Lake Eyre, SA	123 400	A
NE Arnhem Land, NT	79 000	A
Port Hedland Saltworks, WA	66 800	G
Port Phillip Bay, Vic	64 100	G
St Vincent Gulf, SA	64 000	G
*SE coast and lakes, SA	63 100	G
Shark Bay, WA	50 000	A
Corner Inlet, Vic	46 200	G
Spencer Gulf, WA	37 000	G+A
Cape Kerquadrin-Port Hedland, WA	30 000	A
LaGrange Bay, WA	23 800	A
Peel Inlet, WA	23 300	G
SW corner, Gulf of Carpentaria, NT	21 900	A
Darwin region, NT	20 900	G+A
W coast, Eyre Peninsula, SA	19 900	G
Moreton Bay, Qld	18 200	G
Western District Lakes, Vic	17 600	G
Horsham region lakes, Vic	16 700	G
*Far NW region, NSW	16 700	G
Kangaroo Island, SA	13 900	G
Hervey Bay-Great Sandy Strait, Qld	13 600	G
Kerang-Sawn Hill region, Vic	13 400	G
S coast, Gulf of Carpentaria, NT	12 700	A
Swan coastal plain, WA	12 500	G
*Esperance region, WA	11 900	G
Westernport Bay, Vic	11 200	G
Pilbara coast, WA	11 100	G

* = predominantly non-migratory species; mostly Banded Stilt *Cladorhynchus leucocephalus* and Red-necked Avocet *Recurvirostra novaehollandiae*

* WA = Western Australia; Qld = Queensland; SA = South Australia; NT = Northern Territories; Vic = Victoria; NSW = New South Wales.

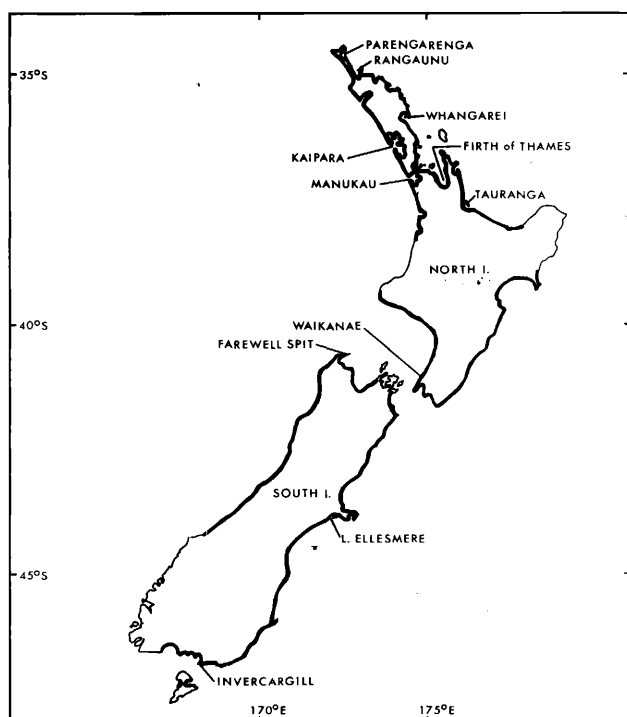


Figure 3. New Zealand, showing localities mentioned in the text. Bold lines indicate the area covered during each national water count.

governing the distribution of migratory shorebirds. The largest concentrations of Bar-tailed Godwits and Red Knots are found at Kaipara Harbour (10 981 and 4 770 respectively in November 1985), Manukau Harbour (10 700 and 16 750), Firth of Thames (7 150 and 4 450), and Farewell Spit (11 100 and 11 350). All these sites are characterised by large expanses of intertidal mud and sand. Ruddy Turnstones prefer shelly or stony and foreshores and rockpools, as well as intertidal flats. However, the largest variety of shorebirds occurs on the large, brackish water coastal lakes (e.g. Lake Ellesmere) which support most of the Red-necked Stints, Curlew Sandpipers, Sharp-tailed Sandpipers and Pectoral Sandpipers that visit in New Zealand.

NORTHWARD MIGRATION

In southern Australia, large numbers of migratory shorebirds depart in mid to late March and early April. In New Zealand, Bar-tailed Godwits move from southern sites after late February (Hawkins 1980) and pass through northern areas in March. However most godwits appear to migrate directly from many sites in the second half of March. Some species (e.g. Sharp-tailed Sandpiper, Latham's Snipe), depart from southern Australia as early as mid-February. Most species depart from northern Australia between late March and late April. Some (e.g. Little Curlew, Grey-tailed Tattler and Red Knot) remain until the first week in May (Lane and Jessop 1985a). In New Zealand, Red-necked Stints and Curlew Sandpipers are the

last to depart - usually in the last week of April.

Details of the routes taken during northward migration are lacking. Many species which migrate southwards down the east coast return that way. Those that cross the continent during southward migration do not appear to touch down in as large numbers on the north-west coast as they do during southward migration. Furthermore, there are few inland records of shorebirds at this time. Regular counts suggest that many of these species depart directly from their non-breeding grounds in both northern and southern Australia into south-east Asia (Lane and Jessop 1985a, 1985b, Starks and Lane in press). This is also supported by banding studies which show that many species accumulate sufficient fat before departure to fly non-stop across the north coast into parts of Asia (Minton and Lane 1984). The regular count data suggest that northward and westward movement (up to 1 000 km) of these species occurs along the east and south coast before departure from Australia.

The first northward movements of waders in South-east Asia is in late February when Mongolian Plovers and Greater Sandpipers start to move north (INTERWADER in prep.). These species nest at temperate latitudes and are on their breeding grounds by April. Redshanks, Greenshanks and Wood Sandpipers move north in March. Calidrid sandpipers pass through in April and early May. By the first week of May, only non-breeding birds remain. In Hong Kong peak migration is in April, and in N.China and Japan it is in late May. Waders arrive breeding grounds from April (southern breeders) to early June (northern breeders).

The routes used on southward and northward migration vary considerably. Ruddy Turnstones, for example, have a loop migration with the southward leg from the Pribilofs and Alaska taking them across the Pacific towards Australia and the northward route taking them via Japan (McClure 1974). Red-necked Stints migrate south through Japan and Brunei but not north through these countries. Little Ringed Plovers *Charadrius dubius* and Dunlins migrate north, but not south, through Japan. Ringing recoveries and regular monitoring at sites throughout the region will help to build up the picture of migration flyways but much work is needed before routes can be mapped accurately.

GAPS

The East Asia/Australian Flyway is probably the least studied of the major flyways, with major distribution studies commencing only after 1980. In many parts of the flyway there is little information on the distribution, population, and ecology of waders. Important wader habitats have been located in Australia, New Zealand, Malaysia, Thailand, Hong Kong, Taiwan, Japan, and in parts of the USSR and Indonesia. Elsewhere, information is of poor quality or relates to only a small part of the country.

The size and inaccessibility of the breeding areas in the USSR mean that the breeding and distribution of some species is still poorly known. For example, only 4 nests of the Great Knot have been found, and very little is known about the breeding of the Long-toed Stint (Myers et al. 1982). The feeding ecology of most species, population sizes and migration routes of most species are also poorly known in the USSR.

Even the approximate migration routes of many species outside the USSR are still very poorly defined. The non-breeding grounds of different breeding populations are still not fully known. Concentrations (if they exist) of species such as Nordmann's Greenshank and Spoon-billed Sandpiper have not yet been properly located. The differences between northward and southward migration routes have been mapped for only one or two species. The reasons for the changes in site attractiveness between years, and the extent of local movements in the non-breeding areas have been little examined. Differences in migration routes and non-breeding areas between different ages and sexes have yet to be studied for most species.

FUTURE RESEARCH

In the USSR, the priority will need to be given to further study of the rare species, and the location of important breeding and migratory stop over sites. Studies on migration, breeding biology and feeding ecology will still continue. In China, migration studies and the location of key sites will be important objectives together with feeding ecology and socio-economic studies. In South-east Asia, INTERWADER will continue to co-ordinate studies on site location and conservation. It is hoped to identify all major sites in the next 5-10 years. Training programmes will be increased to ensure long-term continuation of projects. New ringing schemes in the Philippines, Taiwan, Indonesia and Thailand are under active planning and would lead to wider international co-operation.

In Australia, very limited resources, and the difficulty and cost of undertaking research in the vast remote areas of northern Australia, preclude quick answers to many of the remaining questions about shorebird distribution and migration. In 1985, the Australasian Wader Studies Group redefined its research objectives in the light of the lack of money to undertake large scale studies and the need for information which will help in the battle to conserve Australia's shorebirds effectively. It decided upon two projects: a population monitoring project, with annual counts at many sites to assess population levels; and a regular count project, to assess seasonal patterns. These are co-ordinated by volunteers from the group's membership and the administrative costs are met from an increased subscription.

The population monitoring project arose out of the need to continue monitoring the population levels of waders. Five year's data had been generated by the RAOU Wader Studies Programme and it was thought that some form of continuity was desirable. More importantly, the findings of INTERWADER in Asia on the extent of habitat destruction and hunting necessitated monitoring to identify species in trouble and to produce recommendations on hunting limits. The project involves two parts: counting and banding.

Twice-yearly counts are being continued at a selection of disturbed and undisturbed sites on the Australian coast. The range of sites should enable local, human-induced, changes in numbers to be separated from overall trends, the latter being caused by factors affecting the birds in Asia. The data will also help to identify factors in Australia which have detrimental effects on shorebirds.

Banding studies will monitor annual changes in the proportion of young birds at a number of

sites. These sites hold relatively discrete populations of shorebirds of a number of species. Between-year retraps will enable mortality rates to be calculated and the age structure of the populations to be examined. Whether mortality (e.g. that due to hunting) is exceeding recruitment can be determined from these data. Appropriate hunting limits can then be recommended for Asian species.

The regular wader counts continue on from those of the RAOU Wader Studies Programme and aim to fill out our knowledge of the phenology and routes of arctic and boreal shorebird migration to and within Australia. They will also monitor the movements of resident species in response to the frequent droughts and floods that affect most of Australia. Discrete sites such as small sewage farms, lakes, or coastal inlets have been chosen for these counts.

Most future research on shorebirds in New Zealand probably will be based upon continued voluntary efforts by OSNZ members. Government agencies have limited resources and are likely to be concerned with the conservation of wetlands threatened by developments. Therefore their research will involve short-term intensive studies of all habitats at particular sites.

New Zealand national wader counts will continue in summer and winter, at least until the analysis of current information is completed. A further project, also co-ordinated by volunteers, is likely to be the more intensive monitoring of populations at important sites. The aims of this would be to monitor populations and determine more precisely the movements of birds within New Zealand.

There are few experienced banders in New Zealand and unfortunately it is unlikely that anything but a small-scale effort will be put into banding and morphometric studies of migrant waders.

CONCLUSIONS

Information on the status, distribution, migration and ecology of waders on the East Asia/Australasian Flyway has increased dramatically in the last 15 years. Programmes have been initiated in the Soviet Union, China, Japan, South-east Asia, New Zealand and Australia. Many important sites have been located and some have been protected. There are still many threats to the flyway populations, but concentrated efforts over the next 15 years may be able to reduce the effect some of these threats.

ACKNOWLEDGEMENTS

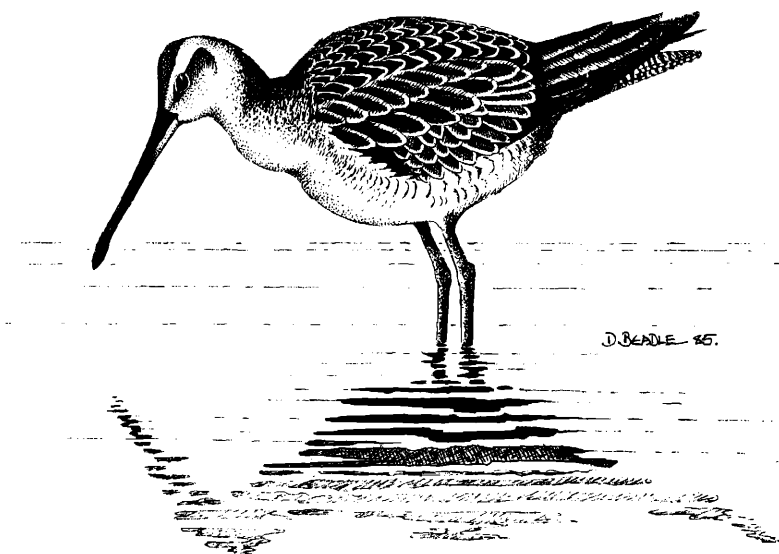
INTERWADER'S programme in Asia has been funded primarily by World Wildlife Fund (WWF) - Malaysia, International Council for Bird Protection (ICBP), IUCN/WWF, ICBP Japan, ICBP Australia, Wild Bird Society of Japan, Australian National Parks and Wildlife Service, WWF-US and United Nations Environment Programme (UNEP). Government and non-government agencies in all countries involved have provided invaluable assistance for survey projects and implementation of recommendations.

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Asian Dowitcher