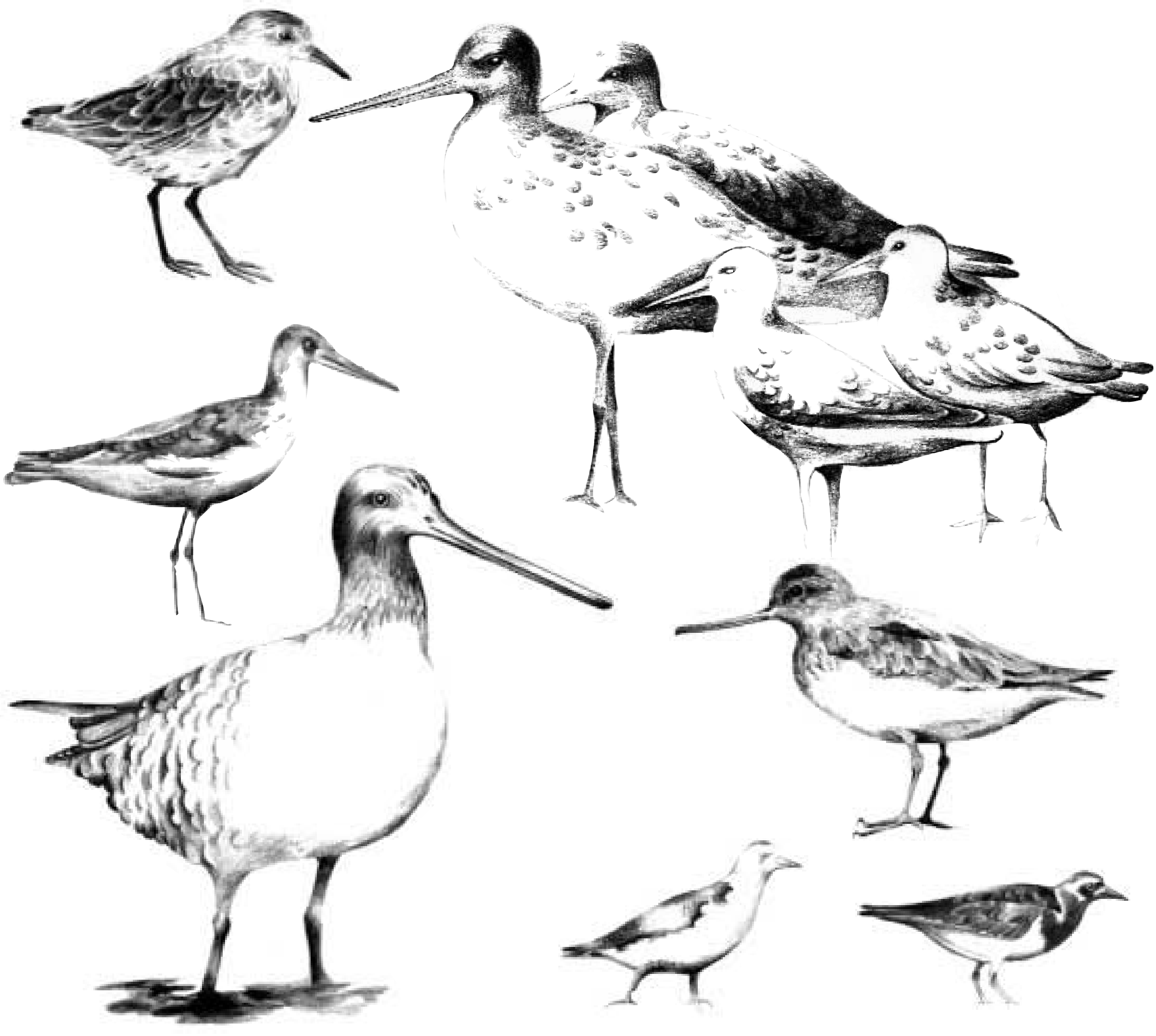
Feathers, Flyways and Fast Food



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Teacher Release to Industry Program TRIP

Feathers, Flyways and Fast Food

Notes about Shorebirds provided to Australian Schools by Environment Australia

The Wetlands Section, Environment Australia, provides these notes to encourage students to learn about birds, especially migratory shorebirds. The notes are for teachers and students and include some questions, some suggested teaching strategies for using the material and links to websites which may be of interest.

Use of these notes will be more meaningful if teachers and students can refer to the illustrations in a handbook of Australian birds.

Initially the notes were prepared for Australian schools located near wetlands listed in the East Asian—Australasian Shorebird Site Network. These schools are invited to share information about migratory shorebirds by participating in an education project organised by the Yatsu Higata Nature Observation Center, Narashino, Japan.

There is also considerable interest in establishing correspondence between Australian and Japanese schools with a shared interest in shorebirds and terns. It is hoped that fruitful exchanges of information will increase over the next few years and will include other countries in the Flyway.

February 2002

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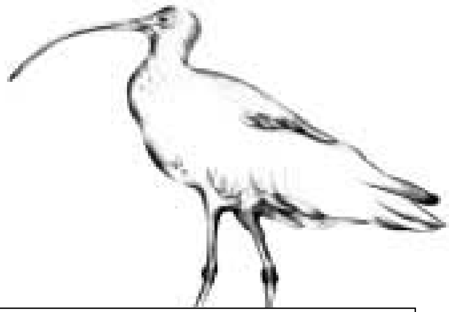


Biologists group living creatures using a system based on similarities and differences between them. The classification system includes a "family tree" showing how creatures are related to each other, and telling the story of evolution.

Birds belong to the animal kingdom.

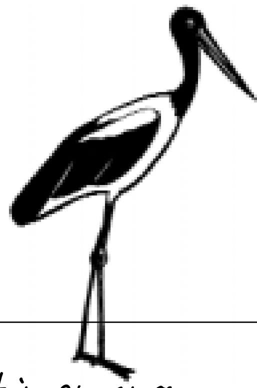
Within the animal kingdom they are grouped under Phylum Chordata in the Class Aves—the birds.

Within the Class Aves, birds are classified into smaller groups known as **orders** and **families**. Each bird has a scientific name: a genus and a species. Worldwide, it has been agreed that the genus is always written first and begins with an upper case letter. The species is written entirely in lower case letters. Both the genus and species are written in *italic* font.

As examples, a shorebird, the Red-necked Stint, a tern, the Little Tern, and a human are classified and named in the table below:

	Red-necked Stint	**Little Tern**	**Human**
Kingdom	Animal	Animal	Animal
Phylum	Chordata	Chordata	Chordata
Class	Aves	Aves	Mammalia
Order	Charidriiformes	Charidriiformes	Primate
Family	Scolopacidae	Sternidae	Hominidae
Genus & species	*Calidris ruficollis*	*Sterna albifrons*	*Homo sapiens*
Common name	Red-necked Stint	Little Tern	Human

How are birds classified?



Special features of birds

1. Birds have feathers
2. Birds have bills (beaks)
3. Birds have no teeth
4. Birds are endothermic ("warm blooded"– use energy obtained from their food to maintain a constant body temperature)
5. Birds produce large eggs, with a rich food supply for the developing embryo
6. Birds have highly developed senses, communication systems and some have elaborate navigation systems
7. Birds have elaborate behaviour patterns associated with reproduction.

Where do birds fit in among the vertebrates (animals with backbones)?

Keys like the one here are used to help people decide what type of animal (or plant) they have found. Keys are not perfect—sometimes you can think of some exceptions!

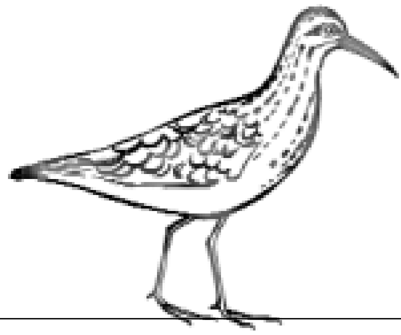
Key to the vertebrates

1a	Has scales on its skin, has gills, lays eggs in water, has no legs	fish
1b	The animal is not as in 1a	**go to 2**
2a	Has no scales on skin, adults have legs, lay eggs in water	amphibian
2b	Not as in 2a	**go to 3**
3a	Has scales on its skin, lays eggs on land, eggs have a leathery shell	reptile
3b	Not as in 3a	**go to 4**
4a	Has feathers, lays eggs with hard shells	bird
4b	Has fur (or bristles), females feed young on milk	mammal

Some unusual examples:

- What bird(s) have very unusual feathers that look more like fur?
- What mammals have very little, or no fur?
- What mammals lay eggs?

How are birds classified?



What are shorebirds?

Shorebirds, sometimes called waders, feed in shallow water or on wet sandy or muddy flats on coastal and inland wetlands. They are a group of families of birds that belong to the order Charadriiformes. Shorebirds include plovers, sandpipers, stints, curlew, knot, snipe, godwits and oystercatchers.

Terns are often included under the heading shorebirds. They are not waders but seabirds that feed by diving for fish. However, like shorebirds, they often rest in flocks (roost) on beaches and the shores of lakes.

Many species of shorebirds and terns are long-distance migrants. Most of the migratory shorebirds breed in the Arctic and sub-Arctic regions, during the northern summer. They journey to the temperate regions of the southern hemisphere for the southern summer.

Did birds evolve from dinosaurs?

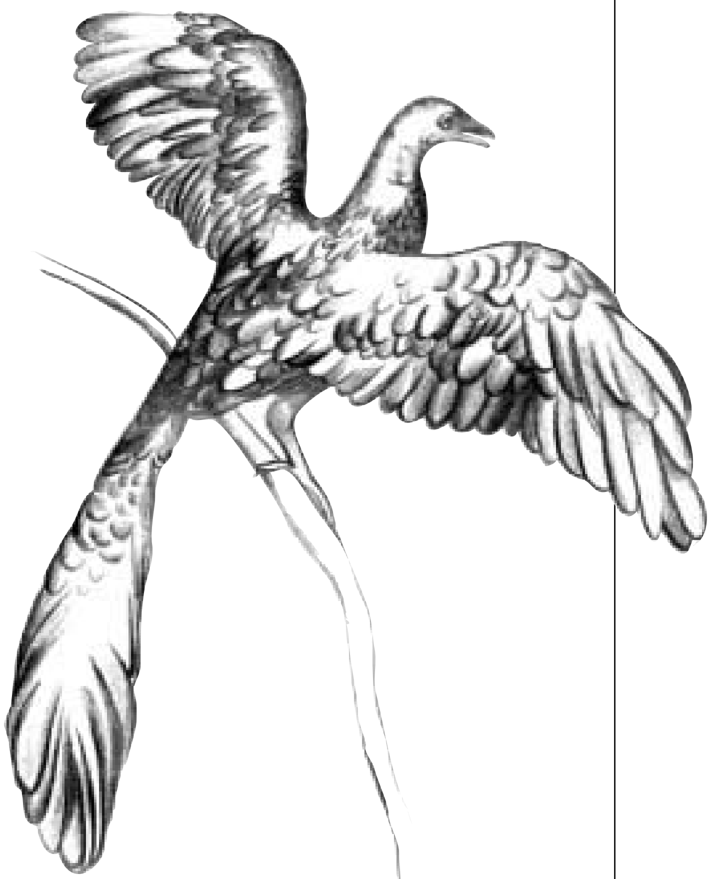
Biologists believe that birds evolved from dinosaurs. The earliest evidence of bird-like creatures is found in 150 million year-old fossils. *Archaeopteryx* was a crow-sized animal with teeth and a tail like a reptile, and feathers like a bird.

Birds have evolved along a great variety of pathways, becoming adapted to a wide range of habitats, diets and ways of life. For example, a variety of bill sizes and shapes adapt different birds to eating certain of types of food. Birds' legs and feet vary, suiting birds to perching, walking, running, climbing or swimming. The various wing shapes found among birds are suited to different styles of flight.

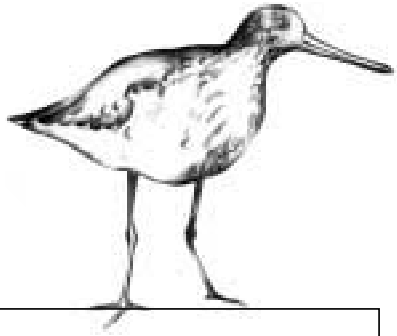
Gene technology is being used to compare the genetic make-up of groups of birds and to sort out their evolutionary relationships. Sometimes evidence from DNA brings into question the existing views about the relationships of groups of birds to each other. Some of the similarities in appearance are because the birds are adapted to similar surroundings and a similar way of life, and not because they are closely related. For example, many shorebirds have bands of colour across their chest, but may or may not be closely related.

> How could these bands of colour across the chest help the birds survive?
> (Hint, read about "Colours, patterns and camouflage" in the secion "The feather coat")

Fig. 1 *Archaeopteryx* an ancient ancestor of modern birds



The feather coat



How feathers help birds survive

- Insulation—helps keep an even body temperature (not too hot and not too cold)
- Feathers are very important for flight
- The colours are useful for camouflage and sometimes for communication
- In various situations, feathers also repel water and assist in swimming, hearing, protection and cleanliness.

Feathers

A typical feather from the main body or wing consists of a central shaft with a vane on either side. The vanes are made up of barbs that are held together with tiny hooks. As the bird preens, these tiny hooks grip the barbs, keeping the feathers in good condition.

Find a feather and look at it with a magnifying glass or microscope.

Flight feathers

The main flight feathers of the wings are large and stiff. The outer ten flight feathers on each wing are called primaries. They are attached to the section of the forelimb of the bird that is the equivalent, in bone structure, of the human hand. The inner flight feathers of the wing, the secondaries, are attached to the ulna bone of the forelimb of the bird, the equivalent of the human forearm. There are usually 12 flight feathers in the tail, attached to a **tail bone**. Amongst these main flight feathers are many overlapping smaller feathers, called **coverts**.

Down feathers

These tiny feathers are soft and fluffy. They provide a thick cover under the larger, stiffer main body feathers and on the front of the bird.

Fig. 2a A down feather

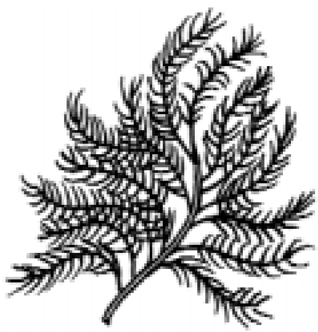


Fig. 2b Contour feathers

The feather coat

Fig. 2c A main flight feather

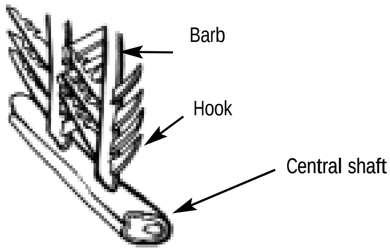
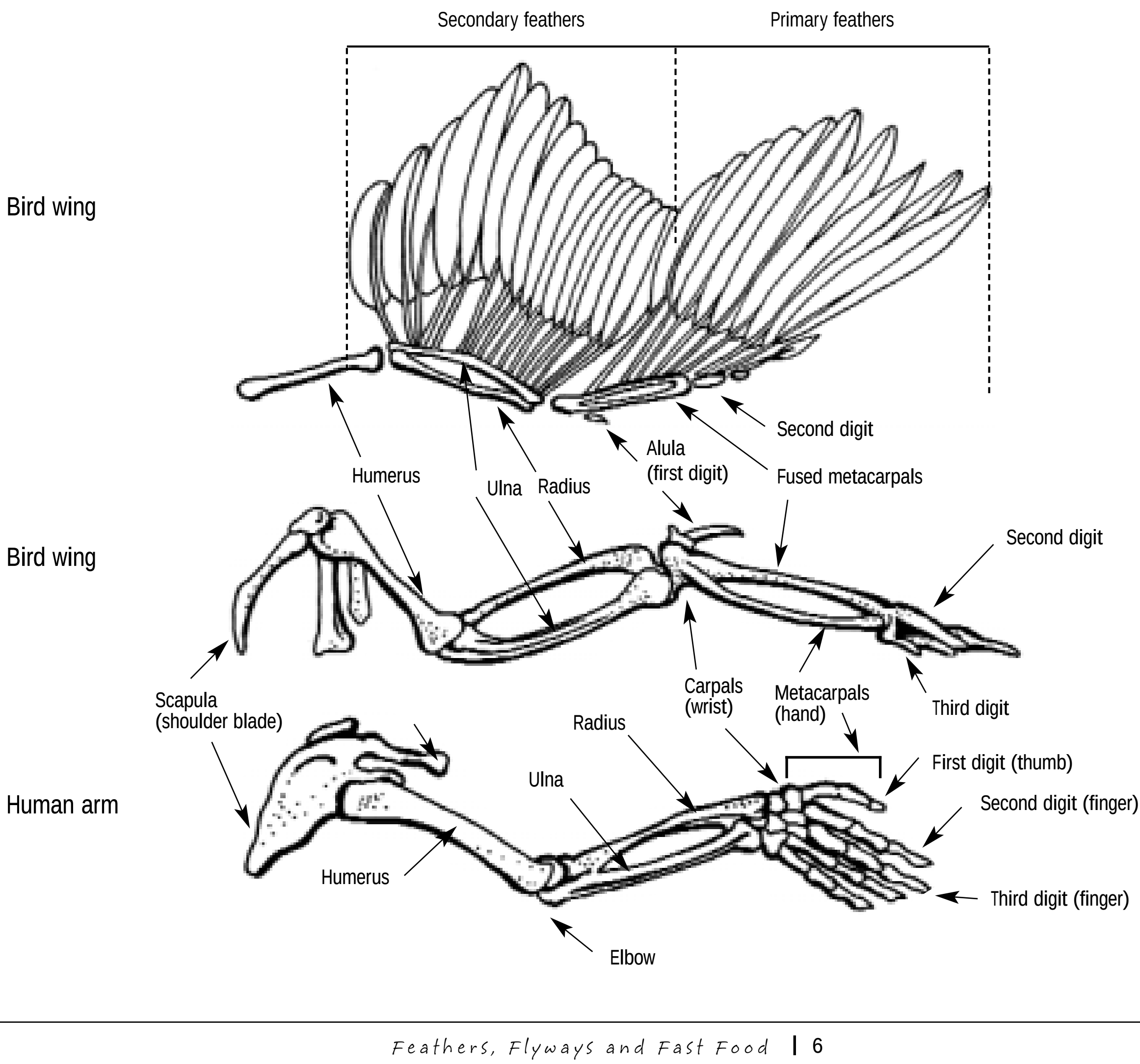
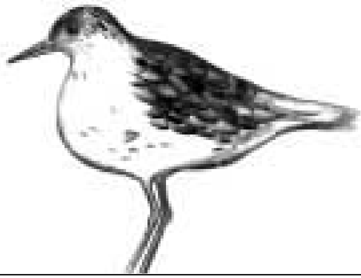


Fig. 3 Comparison of bird wing with the human arm



The feather coat



Feather care and replacement

Birds **preen** their feathers frequently, arranging them and drawing them through their bills. They groom their head and neck feathers by scratching them with their feet. A rich oil of waxes, fats and water from the preening gland on the rump of the bird is wiped over the feathers. This keeps them flexible and waterproof, protecting them from bacteria and fungi.

Feathers fade and wear over time and are replaced regularly. **Moulting** occurs as new feathers grow and push the old ones out. Primary feathers are usually replaced yearly, while secondary feathers are likely to be replaced twice a year.

In most birds, primary wing feathers are replaced in sequence, one at a time. Only small gaps are present at any one time, so the bird is always able to fly. Ducks and swans are an exception to this; they are unable to fly during the moult of their wing feathers.

Feather colour

Feather colour is due to coloured pigments, called biochromes, or to special features of the surface of the feathers which create their effect by scattering and reflecting light.

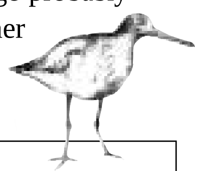
Colours, patterns and camouflage

The patterns and colour of birds assist their survival in some way. Sometimes the patterning on the bird, and its eggs and chicks, blends in with the surrounding landscape. For example, the nest of many shorebirds is nothing more than a shallow depression, like a saucer, in the sand or gravel. The eggs and the newly hatched chicks are pale buff, speckled with brown. They are very difficult to see against the background of sand and pebbles.

The parent bird has irregular bands of colours such as brown, grey, black and white across its head, neck, breast and back. These bands of contrasting colours break up the outline of the bird very effectively, and blend with the horizontal lines of the shoreline and the horizon. The bird is not easily detected against the background.

Many shorebirds have a dark upper surface and are pale underneath. This also disguises by disrupting the outline of the bird. The white undersides of shorebirds reflect the colour of the sand or mud. Shorebirds with long legs cannot rely on this reflected colour and they are usually darker underneath.

Shorebirds are usually well camouflaged, but the colours and patterns of their plumage probably also assist in recognition of each other and of a suitable mate.



Obtain an illustrated handbook of birds:

- Look at coloured pictures of some of the Plovers found on our beaches.

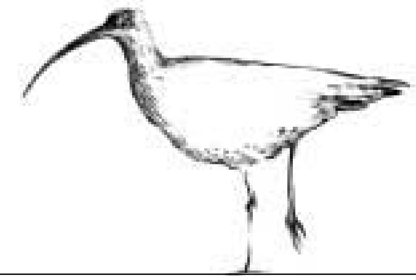
  Can you see the bands of colour that make it hard to see the bird when on the beach?

  What colours are they?

- Look at coloured pictures of some of the sandpipers and stints. They are mainly, grey-brown and white when visiting Australia. They moult into breeding plumage, a more reddish-brown colour, before reaching the tundra regions during the Arctic summer.

  Make an educated guess, by looking at the colours of the breeding plumage, to work out what colours provide good camouflage in the vegetation of the tundra?

Flight



The skeleton

The skeleton of a typical bird is lightweight and strong—well suited to flight. The bones of birds are not solid; they contain air and are supported internally by struts. The bill, too, is light and strong. Bones form a strong and rigid frame for the chest cavity so it will not collapse during flight. The strong flight muscles are attached to the large keel of the breast bone (sternum). Birds, such as emus and penguins, that do not fly, have heavier bones.

The wing contains bones equivalent to those in the forelimbs of other vertebrates and to the human arm. In birds, the sizes and shapes of the bones and the structure of the joints are suited to flight and to folding the wing neatly against the body while resting. The bones that are equivalent to the human hand and finger are joined and shaped in a way that gives strength to the outer wing.

If you have chicken wings to eat, have a look at the bones.

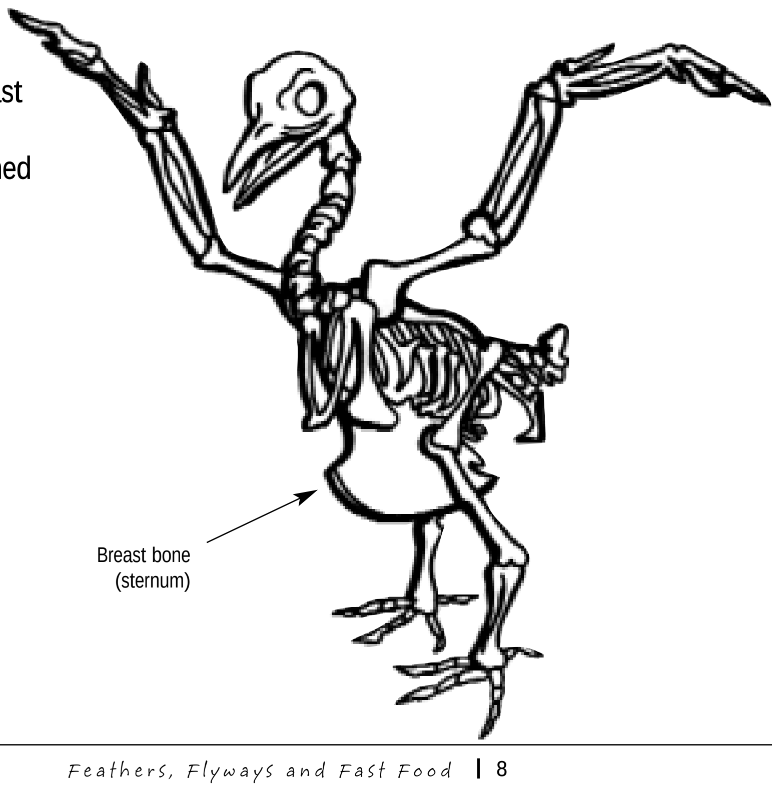
Flight muscles

Birds have two pairs of main flight muscles connecting the wing bones to the bones of the chest. One pair of muscles lifts the wings and the other group, the stronger group, pulls the wings down. It is the downstroke that propels the bird forward; the upstroke then lifts the wing into position for the next downstroke.

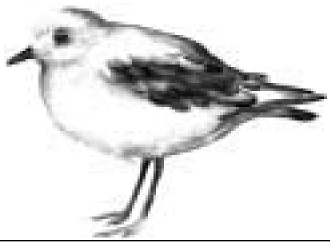
The muscles contain a mixture of red and white muscle fibres. The red muscle fibres, which use oxygen, provide endurance, enabling the bird to fly long distances. The white fibres, which obtain energy without using oxygen, are capable of a few rapid, powerful movements, but tire quickly. The bird relies on these white fibres to provide the explosive power for take off and fast turns.

Birds of different species, adapted to different ways of life, vary in the mix of red and white fibres. They vary in their ability to endure long flights and in their ability to move rapidly over short distances.

Fig.4 Skeleton of a bird showing large breast bone, where wing muscles are attached



Flight



Compare a robin, or other bushbird, with a shorebird.

- Which one would be best at making quick turns?
- Name another bird that would be good at making quick manoeuvres?
- Which would be best at enduring long flights?
- Name another bird that would be good at enduring long flights.

Power for flight

Like boomerangs and the wings of aeroplanes, the wings of birds are aerofoils. They are shaped in a way that provides lift when air flows over them. If the wing is tilted too strongly, the effect of the aerofoil is lost and the bird slows and stops—this is used in landing.

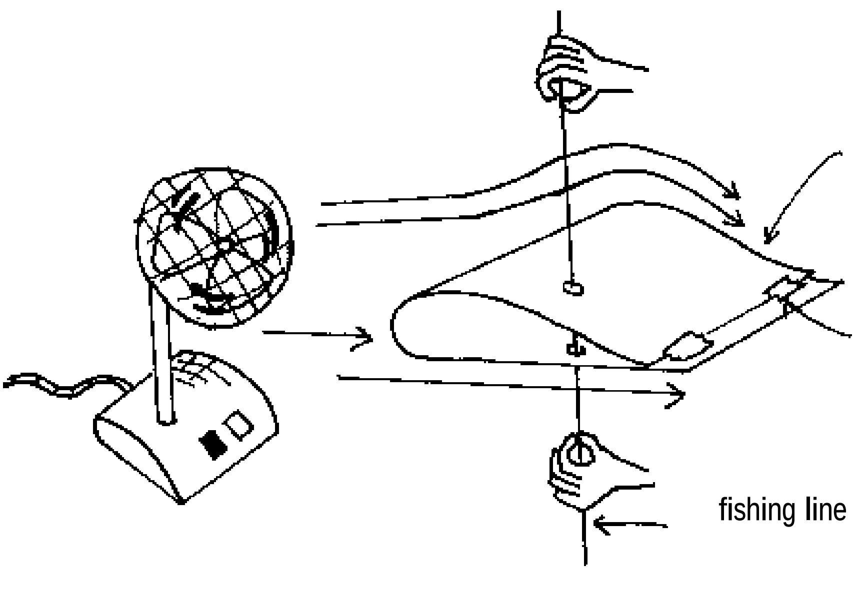
The upward force (lift) of an aerofoil is created by the rounded shape of the upper surface, and the flatter shape of the lower surface. The upper surface has a larger area than the lower surface.

Air that passes over the top of the wing spreads out more than the air that passes across the flatter underneath surface. Because of this, the air on the top of the aerofoil has a lower pressure than the air underneath it. Overall, this creates an upward lift that supports the weight of the bird.

The lift is provided only when an airstream is moving over the wing. For this reason, birds usually take off by facing into the wind, or by running or jumping so that air moves over their wings and creates lift.

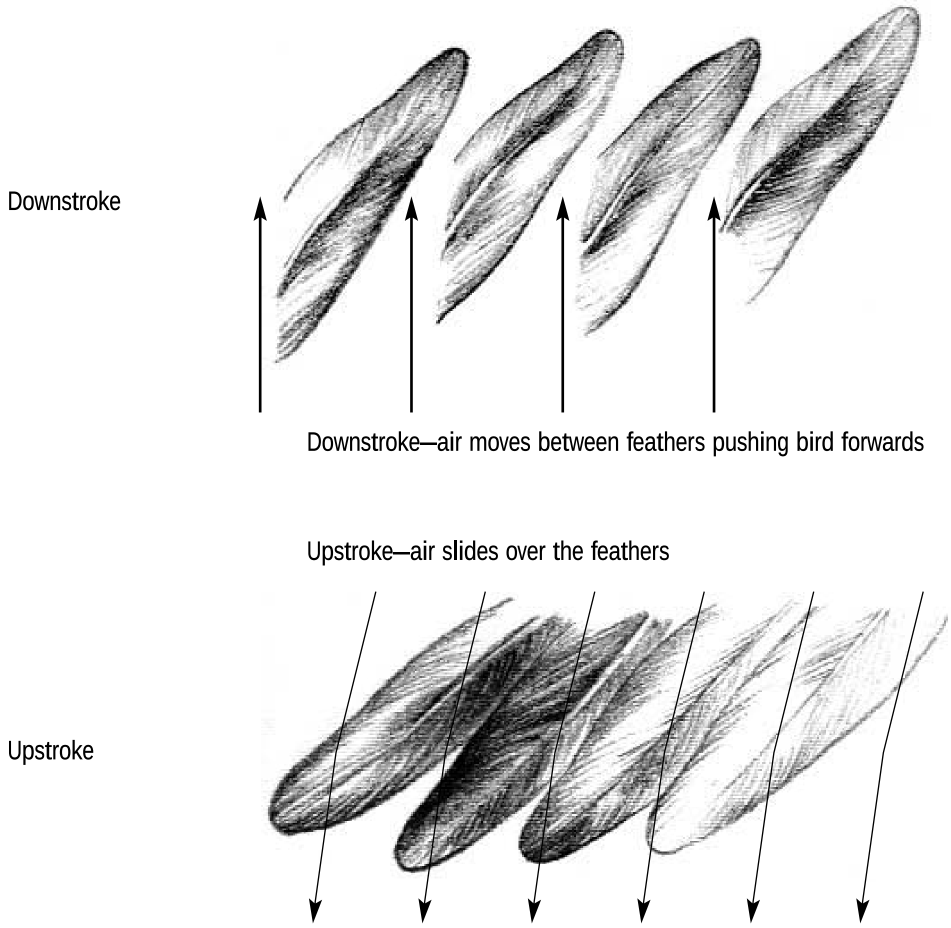
To demonstrate that the shape of the wing provides lift fold a sheet of paper as shown in Fig.5 and tape it in place. Make sure that the underneath surface is flat and the top surface is curved. Without damaging the curved shape of the "wing", punch two holes and thread a length of fishing line through the paper as shown. Face this model wing into a gentle airstream from a fan, or create an airstream by walking as you hold the model.

Fig.5 The wing as an aerofoil



Flight

Fig.6 On the downstroke the feathers at the tips of the wings act like propellers



Once they are in the air, birds move forwards by flapping their wings. The stroke down and towards the back pushes them through the air. The feathers on the outer half of the wing (the primaries) move vertically through the air on the downstroke. They have the effect of little propellers, pushing the bird forward. The effect of the airstream over the upper and lower wing surfaces holds the bird up.

Most birds fly at 30 to 60 kilometres per hour. Birds use more power when flying very slowly or very rapidly than they do at medium speeds.

Birds manoeuvre through the air, using about fifty different muscles to control the positioning of each wing and its feathers. Friction between the birds' feathers and the air results in drag which has to be overcome by the birds' efforts. When flying in flocks, birds avoid flying in the turbulent airstream directly behind another bird. They sometimes fly in a V formation. Birds have difficulty flying if the wind is very strong.

Flight

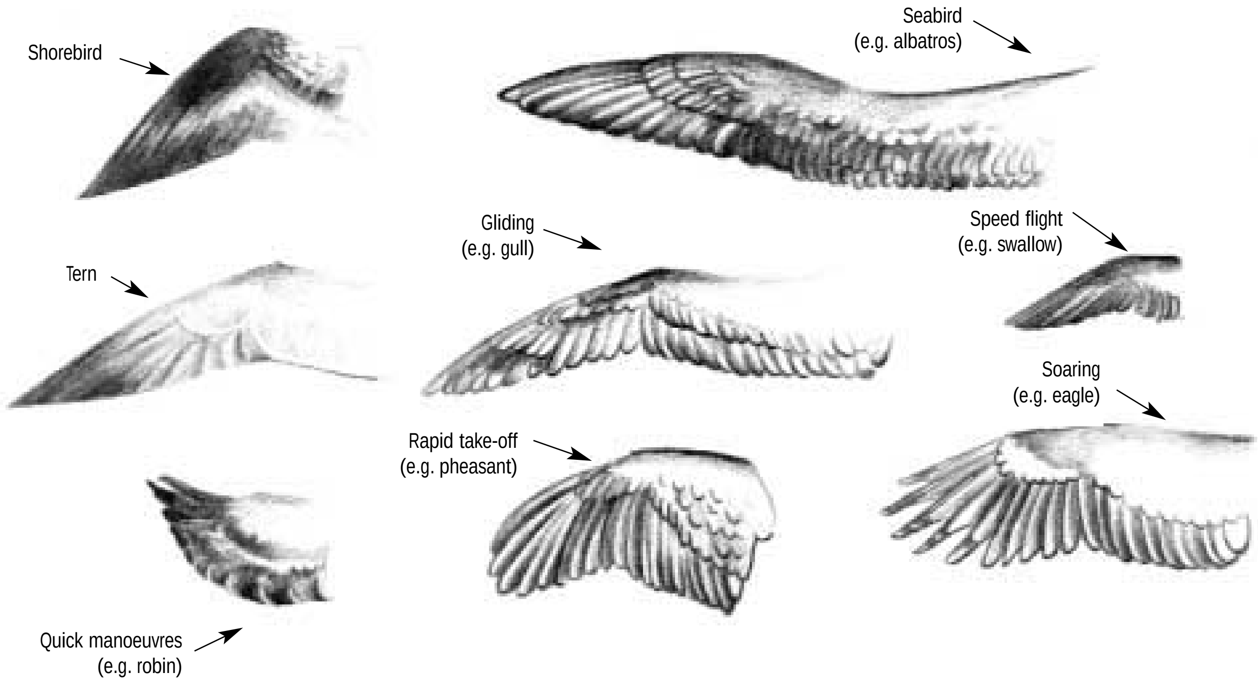
Wing shapes and sizes

Birds differ in **wing loading**. Wing loading is the weight of the bird compared with the area of its wings. Birds that are heavy, compared to the area of their wings, have difficulty in taking off and have to run to become airborne.

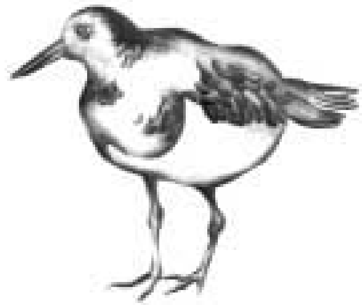
Long narrow wings provide more lift and less drag than short broad ones. Long narrow wings are suited to gliding and high speed flight. Shorebirds and terns have fairly long pointed wings. Long narrow wings are an advantage to birds that migrate over long distances. Birds that live in dense vegetation usually fly in short bursts and have shorter, rounded wings that allow the bird to manoeuvre within confined spaces.

> Name three birds that are heavy compared with their wing size and three that are light compared with their wing size.
>
> (Hint: the heavy ones would have big bodies and make good food for humans.)

Fig.7 Wing shapes are adapted to the bird's way of life



> Look at the illustrations of wing shapes.
>
> - Compare the shape of the shorebird's wing with the others. What sort of flight is typical of shorebirds? Is the wing suited to these types of flight?
> - Compare the shape of the shorebird's wing with the others. What sort of flight is typical of robins? Is the wing suited to these types of flight?



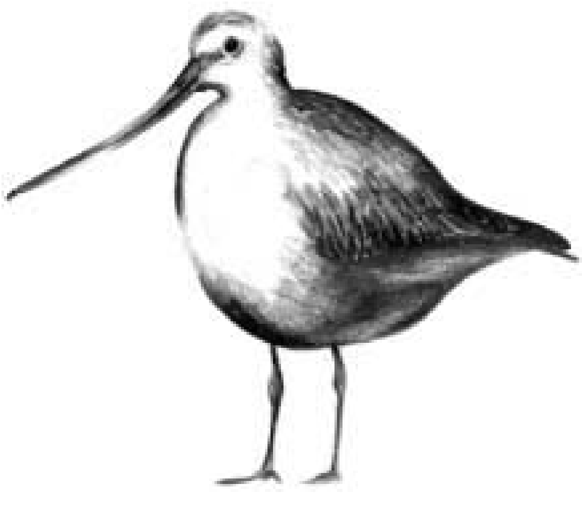
Keeping warm

Whatever the weather, birds keep their body temperature steady at about 40º C. The warm body temperature allows messages to be carried rapidly in the nerves, giving birds a quick reaction time. It also allows strong, rapid movement of muscles, enabling birds to be fast, active creatures at all times of day, in all seasons, and in extremes of climate. The constant, warm body temperature also makes endurance in flight possible; some birds can fly for hours, days, or even weeks without becoming exhausted.

How do birds create warmth?

From their food birds obtain substances such as sugars and fats that contain stored energy. Chemical processes in birds' body tissues release this energy, providing heat energy and energy for growth and movement.

Birds can gain or lose heat to their surroundings. Dark plumage absorbs more heat than pale plumage. The wind has a dramatic cooling effect.



There are a number of ways birds can adjust their body temperature if they are too hot or too cold by:

- changing feather positions. When cold, a bird can fluff its feathers, creating more air pockets and increasing the insulation. When hot, raising feathers allows heat to escape from the body, cooling the bird.
- adjusting the amount of blood that flows into blood vessels near the surface of their skin. More blood near the surface of the skin has a cooling effect as heat passes into the surroundings.

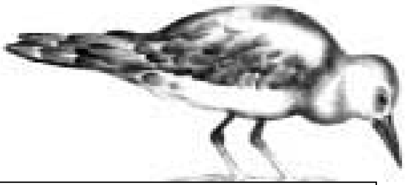
A bird that is too hot can lose heat by:

- panting—rapid breathing with bill open increases the evaporation rate of water from the mouth and throat. The process of evaporation uses heat. In this way heat is removed from the mouth and throat tissues, cooling the bird.
- birds do not have sweat glands, but may lose some water from their skin by evaporation, providing a cooling effect.
- birds can behave in ways that keep them cool. For example, they can live in a burrow, or they may be nocturnal, resting during the day and becoming active at dusk or during the night.

A bird that is too cold can warm up by:

- shivering which produces additional heat. The movement of shivering muscles requires energy, increasing respiration which generates heat.
- birds can behave in ways that keep them warm. For example, they can roost in holes, cluster together, or take shelter from the wind among vegetation. Nests provide insulation that helps keep the eggs warm.

Keeping warm



Temperature control

Some birds, such as petrels, herons, penguins and gulls that live in cold places, have a special system which cuts down on heat lost from their feet. Blood vessels carrying blood down each leg pass very close to the blood vessels carrying the blood back up the leg. In cold conditions, heat is transferred from the warmer blood moving down the leg to the cooler blood moving up the leg.

In addition to this, some birds can reduce the amount of blood that passes through their feet. This also cuts down on heat lost when the bird's feet are touching cold surfaces. Penguins do this when standing on snow.

Some people use doonas that contain feathers and down—usually from ducks.

- Why do the makers recommend that you shake the doona and "fluff" up the feathers when it is first removed from its bag?

Energy is needed to keep warm

Keeping warm uses up a lot of energy. Birds get energy from their food. When comparing birds with reptiles (snakes and lizards), we find that birds use 20 or 30 times more energy than reptiles of similar size. Reptiles do not maintain a constant body temperature and rely on absorbing heat from their environment to help warm their bodies. They do not need as much food as birds.

When comparing birds with mammals, we find that flight usually needs a lot less energy than running. For example, a 20 gram bird, in flight, uses less than one percent of the energy it takes a 20 gram mouse to run the same distance.

Feeding

Birds use a lot of energy and need to eat a lot and feed frequently to refuel themselves. When moulting, preparing for migration, or their eggs are developing, they need even more food. The bodies, legs and bills of different types of birds are suited to a variety of ways of getting food. They may sit, walk, hop, fly or dive in search of food. The size, shape and strength of a bird's bill suits it to a specialised type of feeding. Bills are designed to tear meat, spear fish, crack hard seeds, catch insects, gather water weeds, reach the nectar in flowers, probe into mud for tiny shellfish, or filter tiny creatures from mud. Many birds are able to gather food in more than one way, when necessary.

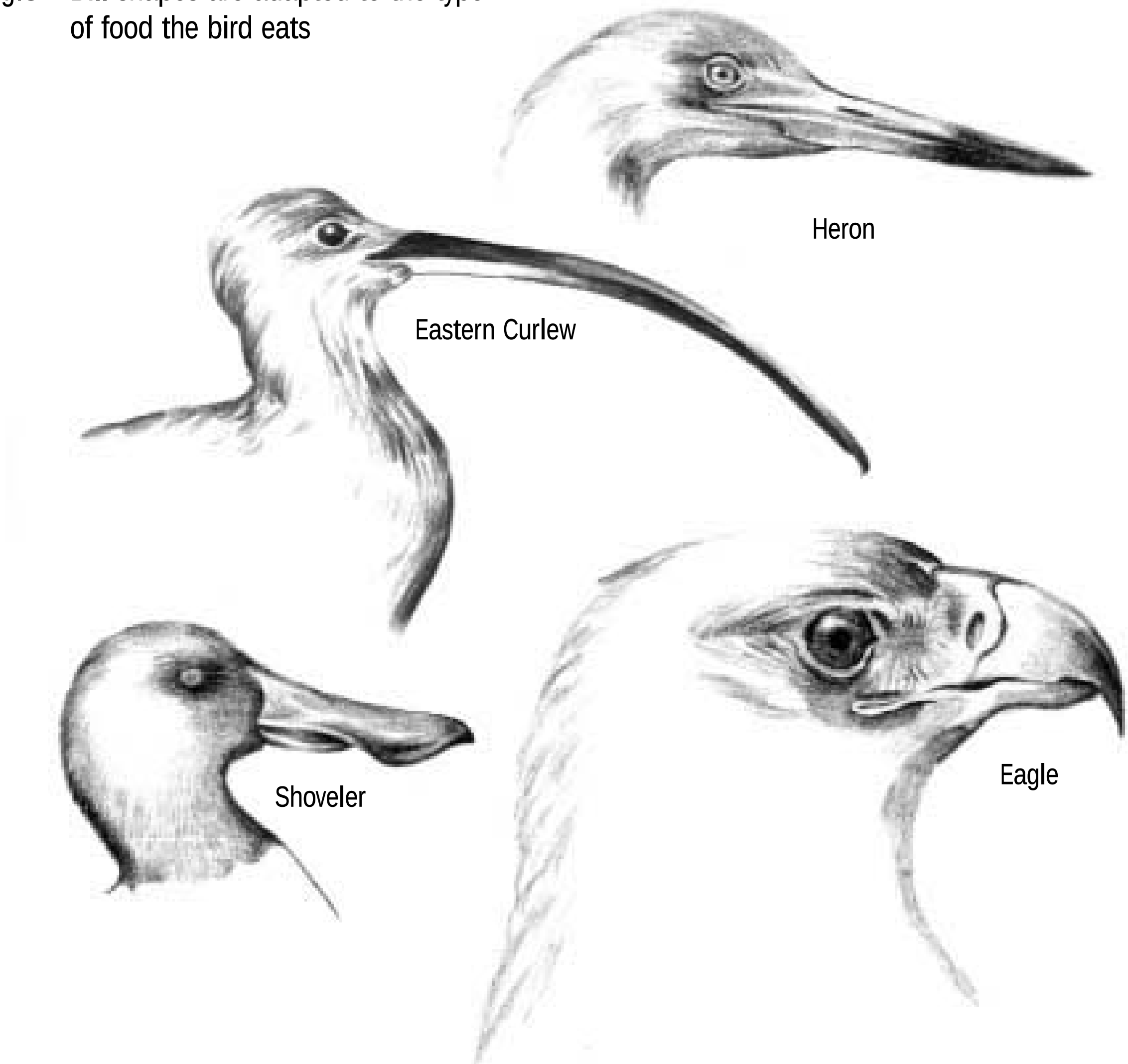
Look at the bill shapes shown in the illustration.

- Draw the bill shapes and write answers beside each one:

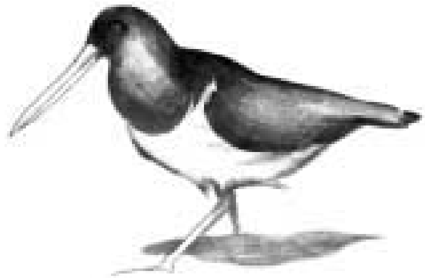
(i) What type of food do you think the bird eats?

(ii) Give a reason for your answer.

Fig.8 Bill shapes are adapted to the type of food the bird eats



Feeding



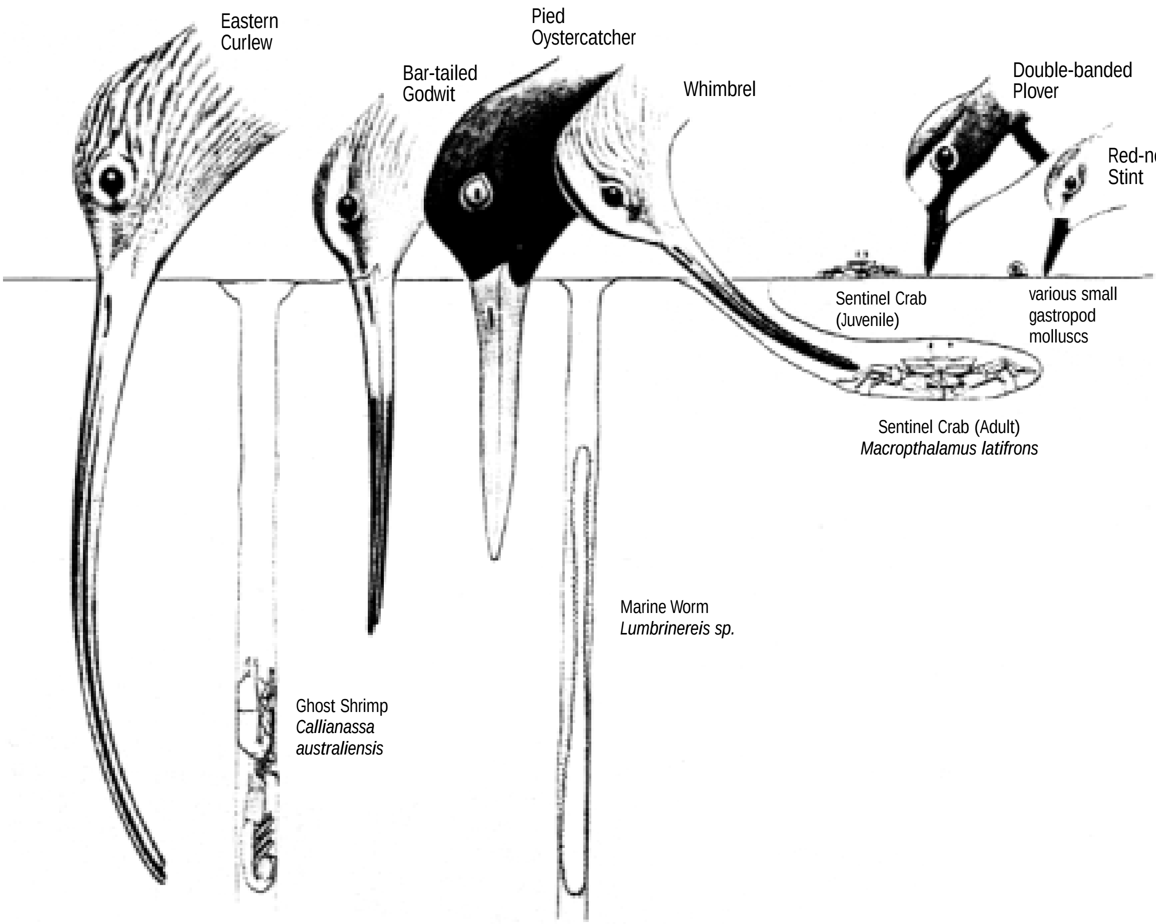
Birds usually swallow their food whole. Fish-eating birds often have hooks on their bill or tongue that help swallow slippery fish, headfirst. Most birds can store and soften food in their expandable oesophagus and crop before it is passed into the stomach. In the first of the two sections of the stomach, digestive juices begin dissolving the food. In the second section of the stomach, the muscular gizzard, food is ground to a pulp. Moisture and digested food passes through the walls of the intestines into the bird's blood. Parts of the food that cannot be digested are ejected from the mouth as pellets or pass out of the body through the cloaca.

- Why do fish-eating birds always swallow the fish head first?
- Suggest an advantage of having a large, expandable oesophagus and crop that stores food while it waits its turn to enter the stomach to be digested.

Look at the bills of the shorebirds shown in this illustration.

- Do they all eat the same food?
- What stops them from competing with each other for food?

Fig.9 Bill lengths and food of shorebirds



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Feeding

Shorebirds feed by walking on wet sand or mud, or wading in shallow water pecking small worms, insects, fish, and a variety of molluscs and crustaceans. Expansive intertidal flats provide good feeding areas for most shorebirds at the wintering grounds. Some shorebirds, like plovers, rely on their extra good eyesight to find their prey. Others, like sandpipers and curlew that probe in the sand or mud for their food, use their sensitive bills to feel for prey.

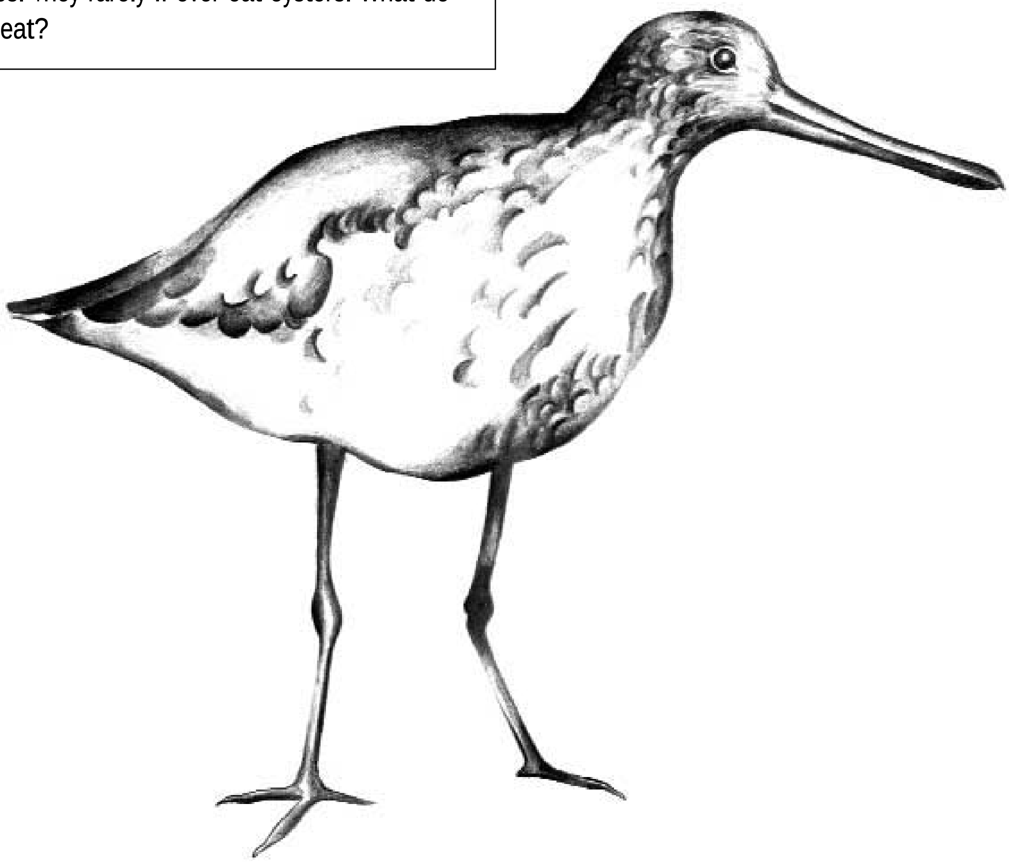
- Which of the shorebirds can feed best in dull light, plovers or curlew? Why?
- Terns dive for fish. Would good eyesight, or a sensitive bill be more useful?
- Turnstones are waders that winter on rocky seashores. Make a guess at what food they eat. (Hint: their name.)
- Some types of oystercatchers also feed on rocky shores. They rarely if ever eat oysters. What do they eat?

Feeding alone and in flocks—which is best?

When food supplies are stable birds may defend territories and feed within these areas. When food is hard to find, and birds must be on the move, they often find safety in flocks. When a member of a flock sees a predator, it calls to warn the flock. Isolated individuals in exposed places are easy targets for predators. The flock can confuse an attacking predator.

Shorebirds, when resting (roosting) at high tide, usually form flocks. Their predators include foxes and birds such as eagles, hawks and falcons.

- What advantages does a bird have if it is in a flock?

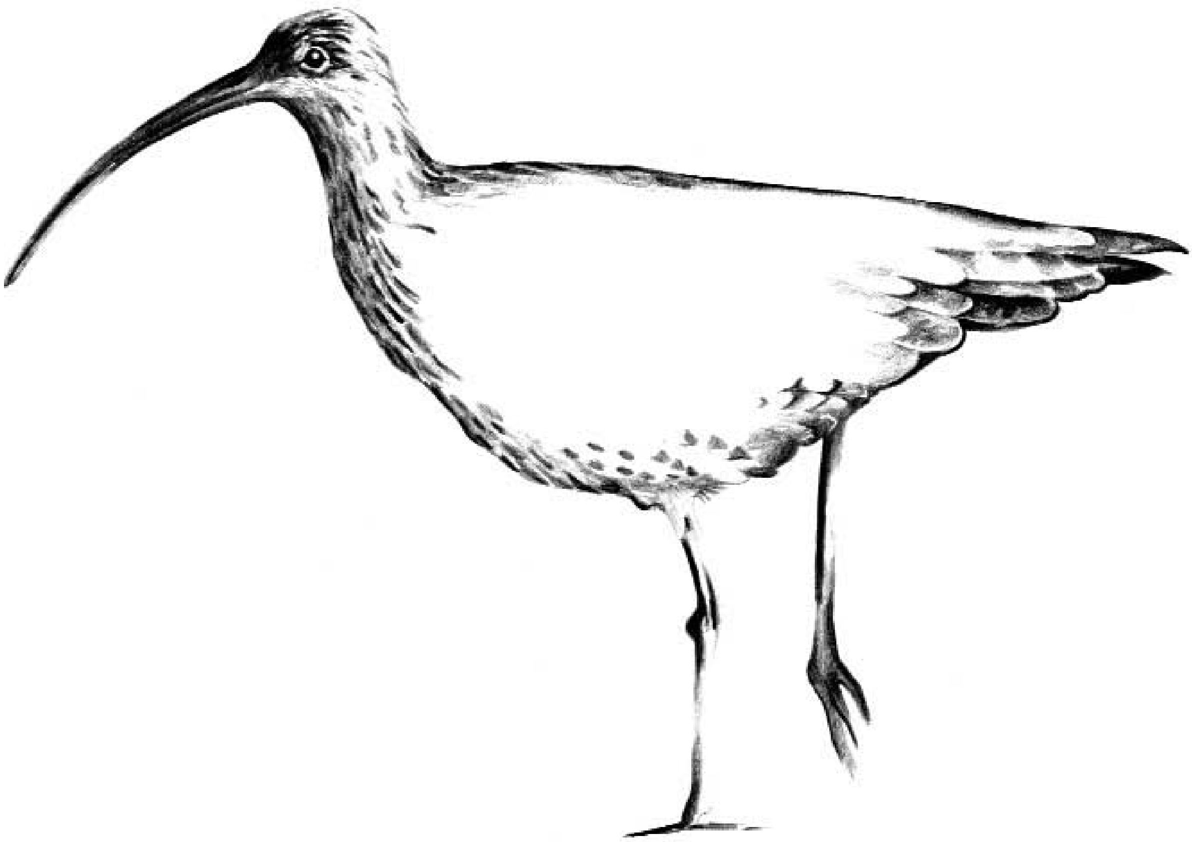


Birds need water

Birds obtain water in three ways: gaining it from their food, drinking water and from some of the chemical processes that take place in their bodies.

Birds economise on water by removing wastes from their bodies in semi-solid form. For example, wastes containing nitrogen are removed in a paste containing uric acid. By contrast, mammals use over 20 times as much water to remove the same amount of nitrogen-containing waste in the form of urine.

Birds which inhabit salt water and eat seafood have a problem as they take in food and water that is about 3% salt while their body fluids contain only about 1% salt. They must get rid of salt somehow and their kidneys are unable to do it. Many of them have salt glands within their nasal passages. Salt glands remove salt from the bird in a 5% salt solution. Drops of the solution run down the bill and drip off.

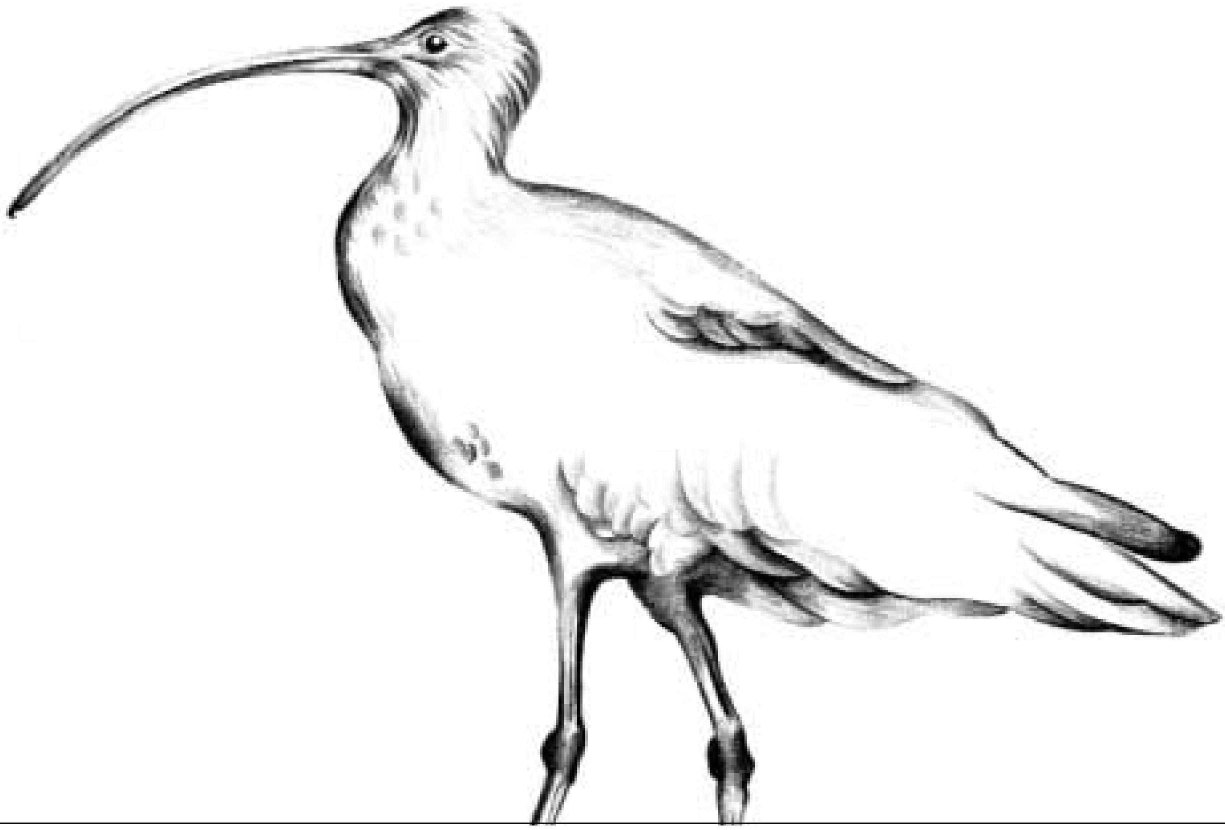


Heart and blood circulation

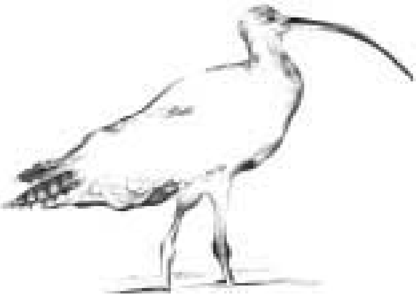
Birds have very efficient, 'high performance' hearts. The heart of a bird is similar to that of a mammal. Blood returning from the head and body to the heart is pumped to the lungs. In the lungs it picks up a new supply of oxygen. Blood returning from the lungs, is pumped throughout the body. The blood carries food and oxygen to all parts of the body and removes waste products including carbon dioxide.

Find a reference book that shows the path taken by blood as it flows around the body and to the lungs (humans and birds are similar).

- Which chamber of the heart pumps blood to the lungs?
- Which chamber pumps blood to the head and body?



Birds have very efficient lungs



Air is breathed in and carried through the lungs in millions of very tiny, fine tubes which are inter-woven with tiny blood capillaries. Here oxygen diffuses from the air into the bird's blood. The blood carries the oxygen to all parts of the body. At the same time, carbon dioxide diffuses from the bird's body tissues into the blood; then from the blood into the air and is breathed out.

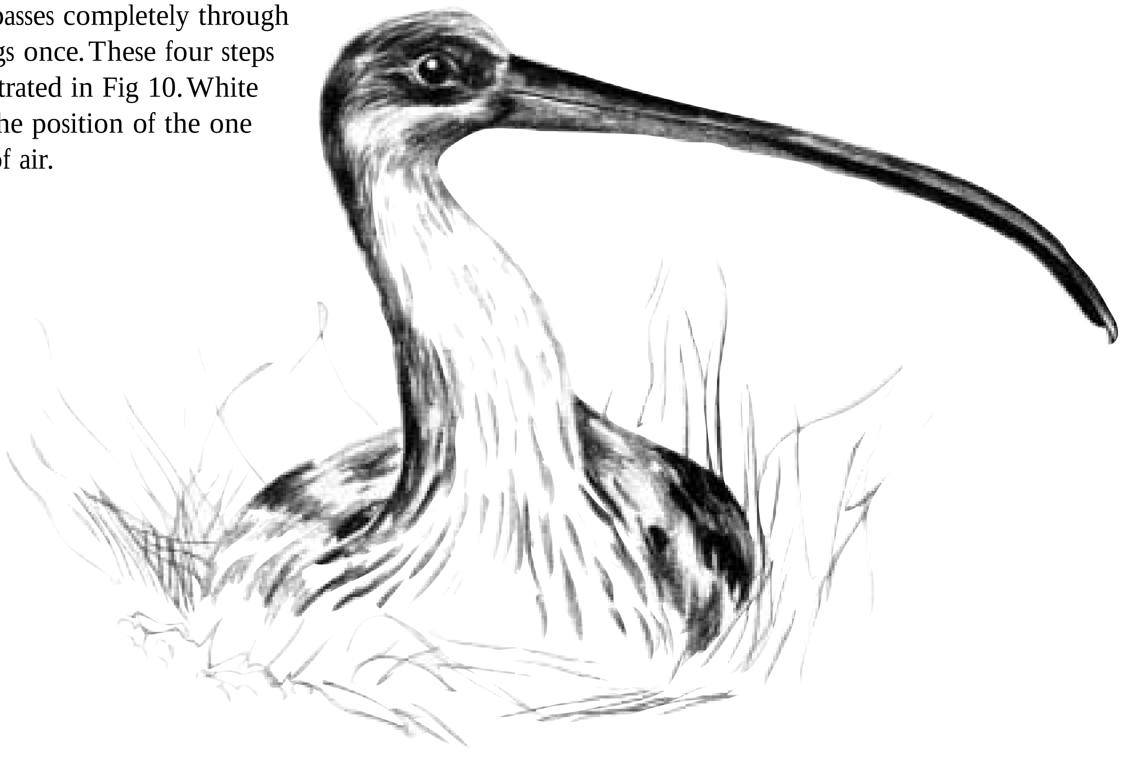
Air-flow through the lungs of birds is very efficient—more efficient than that of mammals. This assists birds to get enough oxygen, even when flying at high altitudes.

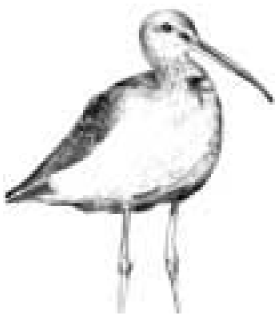
In addition to lungs, birds have a number of airsacs that are connected to their lungs. Most birds have 9 air sacs, while shorebirds have 12.

Air moves through the bird in two stages. The bird needs to breathe in and out twice for one intake of air to pass through its body. Air is breathed in and passes along tubes into air sacs in the bird's abdomen. As the bird breathes out, this air moves into the lungs. As the bird breathes in again, this air passes into a second set of air sacs. When the bird breathes out again, it passes out to the atmosphere. All air passes completely through the lungs once. These four steps are illustrated in Fig 10. White shows the position of the one intake of air.

Our lungs are not as efficient as birds' lungs.

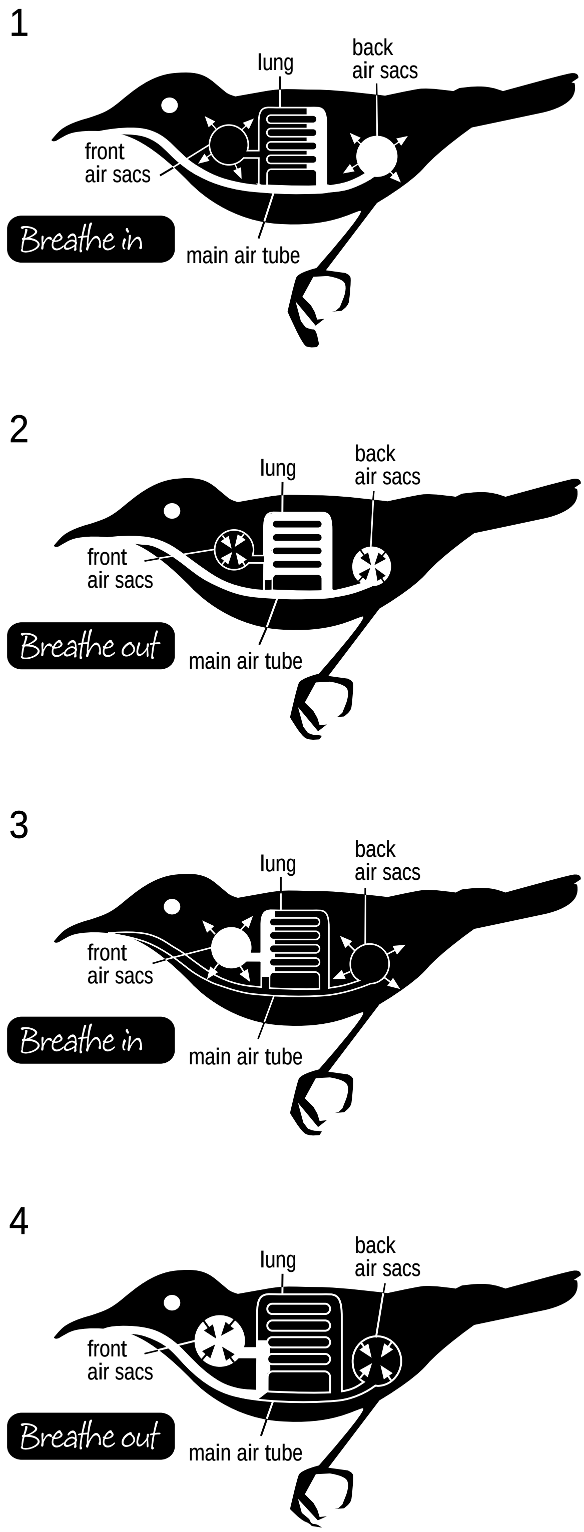
- Find out and explain how we move air over the surface of our lungs.

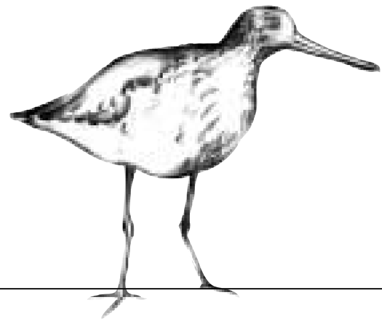




Birds have very efficient lungs

Fig.10 How a bird breathes





Five senses, or more?

Considering the size of their body, birds have large brains. The parts of the brain that deal with messages from the eyes and from the parts of the ear and body that detect balance are especially large. These two senses are very important for birds.

Birds have good eyesight

Excellent vision is very important to the survival of birds. The eyeballs of birds are relatively large. Birds can focus very sharply on the whole visual field at the same time, detect movement and, for most birds, detect colour vividly. Birds have very little ability to move their eye-balls and make up for this by moving their whole head.

Birds with eyes close together, like owls, can judge close distances very accurately, using the three-dimensional vision resulting from overlap of the images received by the two eyes. In most birds, the eyes are so widely apart, and towards the sides of the head, that there is not much overlap of the images received from the two eyes. This results in vision over a wide field, but their sight is largely two-dimensional. Many of these birds have other ways of estimating distances. Some cock their heads while viewing prey, judging distances by viewing it from different angles.

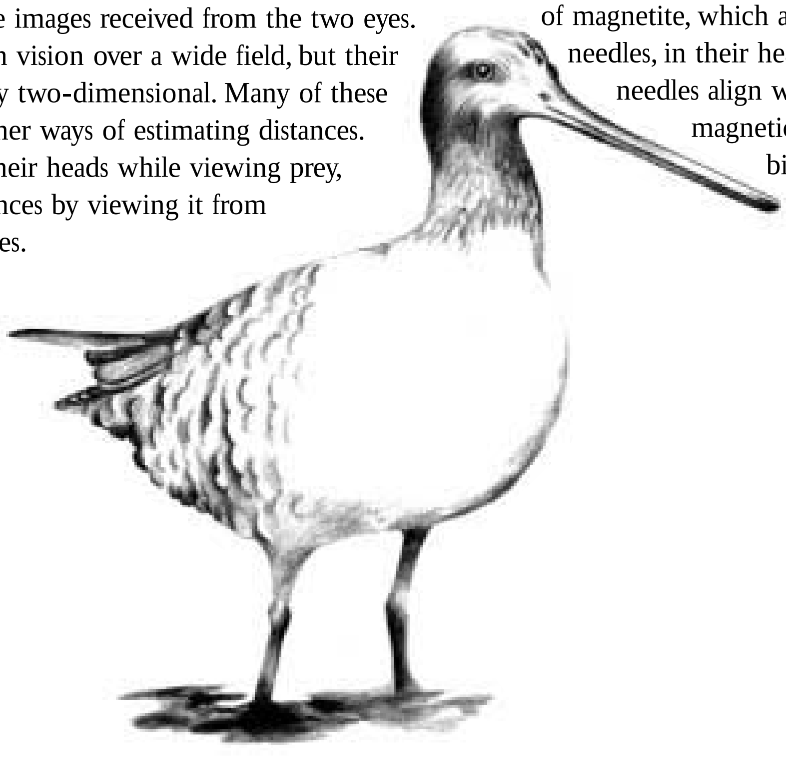
Birds have a third eyelid. It is clear and has its own lubricating gland. It passes over the eye like the windscreen wiper of a car. It provides good protection from wind during flight.

Balance, hearing, taste, smell and touch

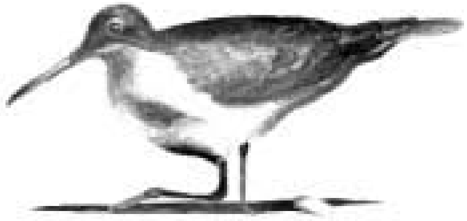
Birds have an excellent sense of balance and fairly good hearing. They also have good senses of taste, smell and touch.

How do migrating birds find their way?

This is not fully understood. The birds have an inbuilt compass. It has been shown that some species of birds can observe the direction of the sun's rays and use these as a compass. Others use patterns of stars to orient themselves towards the north or south. Some birds have tiny crystals of magnetite, which act as tiny compass needles, in their heads. These compass needles align with the earth's magnetic field and help the birds set the directions of their flights.



Five senses, or more?



The bird's internal clock, indicating the time of day, is also needed so that the bird can account for changes in the position of the sun and stars over the 24-hour period. Other methods used include detecting wave patterns and the use of other senses such as sound and smell. It is likely that some birds use combinations of these methods.

When migrating south to their wintering grounds, shorebirds usually return to the same site each year. They use familiar landmarks to help them recognise their chosen site.

Timing of breeding and migration

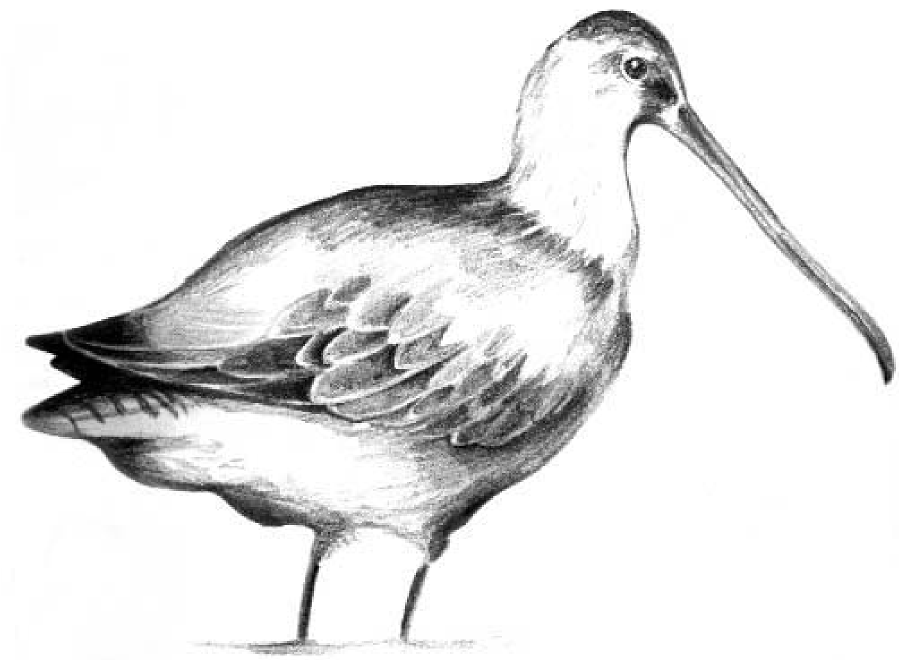
Birds have an inbuilt "body clock" which tells them when it is time to migrate. Hormones circulate in the birds' bodies in response to changes in the number of daylight hours each day. The hormones trigger breeding.

Air pressure

Some birds seem to have an inbuilt barometer. This allows them to detect changes in air pressure.

Communication

Birds communicate to each other by the sounds they make, by displays including postures and dances and by feather colours and patterns. They are capable of remembering and recognising each other by their voices. They can recognise familiar places. Migratory birds communicate by calling to each other as they fly.



Reproduction and development

Eggs

After mating, fertile eggs are produced. Egg production uses a lot of energy and females must be well fed if they are to produce eggs. There are some types of bird, like domestic chickens, that can lay an egg nearly every day. Most birds only lay a few eggs per year, during the breeding season. Shorebirds lay a clutch of no more than four eggs once a year. The eggs contain all the food and water needed for the tiny chick to grow.

Eggs vary in shape from almost round to oval "pointed" shapes. Many shorebirds, gulls and terns lay their eggs in very shallow, saucer-like depressions in the dry sand. Their pointed eggs do not roll away easily. The deeper nests made by other birds hold eggs safely, and their eggs are more oval or round in shape.

In some birds it is important that the eggs are well camouflaged. This is true for many shorebirds and terns that cannot guard their eggs all the time. The splashes of colour on the shells blend with the surroundings, making it unlikely that predators will see the eggs.

- Use plasticine, clay or playdough to make eggs of the two different shapes illustrated here. Try rolling them.

Chicks

Chicks hatch by using the special "egg tooth" on their bill to chip a big hole in the shell of their egg. The movements of their body then usually shatter the egg.

The chicks of some types of bird are naked and helpless when they hatch. They have a huge appetite and depend on their parents to bring food, and provide a clean, warm nest.

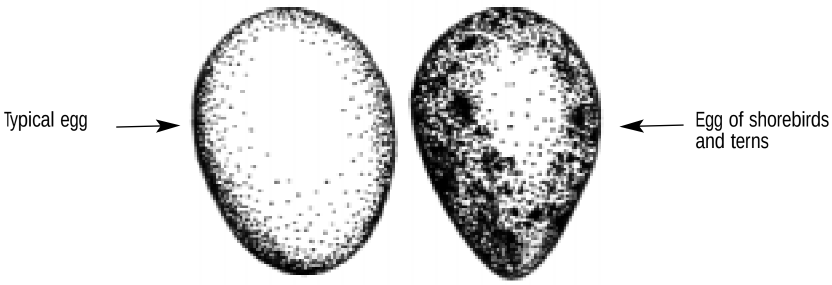
Shorebirds hatch with a thick coat of down and can run about. In most species, chicks can feed themselves shortly after hatching. They are camouflaged well and their parents keep an eye on them, protecting them from predators. In the species that do rely on their parents for food, it is often the male that cares for the chicks.

The newly hatched chicks of gulls and terns also have a thick covering of down, but they take a little longer to become mobile. Their parents bring fish for them until they are old enough to fly and hunt for fish themselves. Their parents protect them from predators.

Length of life

Small species of birds can live up to about 5 years. Larger species can live to the age of 20 to 40 years or more. Most individual birds die before they reach these ages. Small shorebirds can live for nearly 20 years and larger ones probably live longer than this.

Fig.11 Eggs of shorebirds and terns are more pointed than the typical bird's egg



Long distance migration of shorebirds

Many shorebirds migrate, making long-distance journeys, spanning the globe in a north-south direction. Most of the long-distance migrating birds breed in the Arctic regions, during the Arctic summer. Some 2 million of these birds—many weighing as little as 30 grams—make a yearly trip of 25,000 kilometres to Australia and back. During a 20 year lifetime, a long-distance migrating shorebird would travel over 400,000 km.

These migrations are tuned to the seasons and are a response to the fact that when it is winter in the northern hemisphere it is summer in the southern hemisphere.

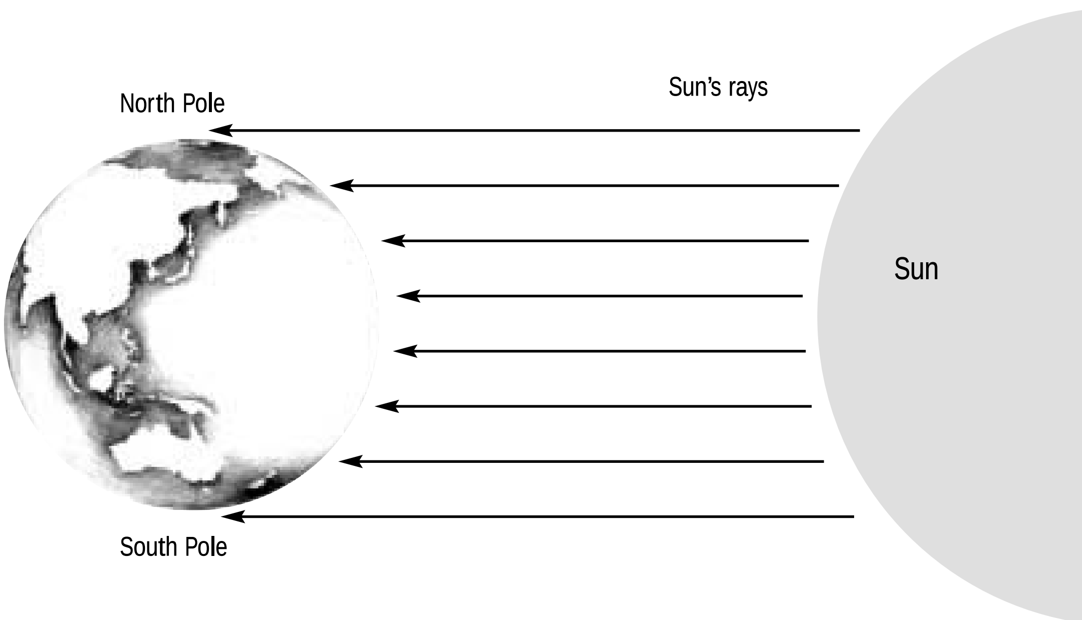
They arrive in Australia in August or September and leave in March or April, to return to their breeding grounds in the tundra areas of Siberia and, for some, Alaska, to breed in June and July.

While in Australia, they live along quiet stretches of the coast or inland waters, spreading out over the wet sand or mud. They feed on small worms and a variety of molluscs and crustaceans. On the coast, as the tide comes in and covers the feeding areas, the birds move onto the remaining patches of dry sand, roosting there in flocks until the tide recedes.

Why is it so cold near the North and South Poles?

Because of the spherical shape of the earth, the sun's rays strike the earth's surface more directly at the equator and at much lower angles nearer to the poles. This has the effect of spreading the sun's rays out over a larger area near the poles. In addition, near the poles, the sun's rays have to pass through more atmosphere before striking the ground. As a result, the climate is generally a lot colder near the poles than near the equator.

Fig.12 Why it is colder near the poles than near the equator



Long distance migration of shorebirds

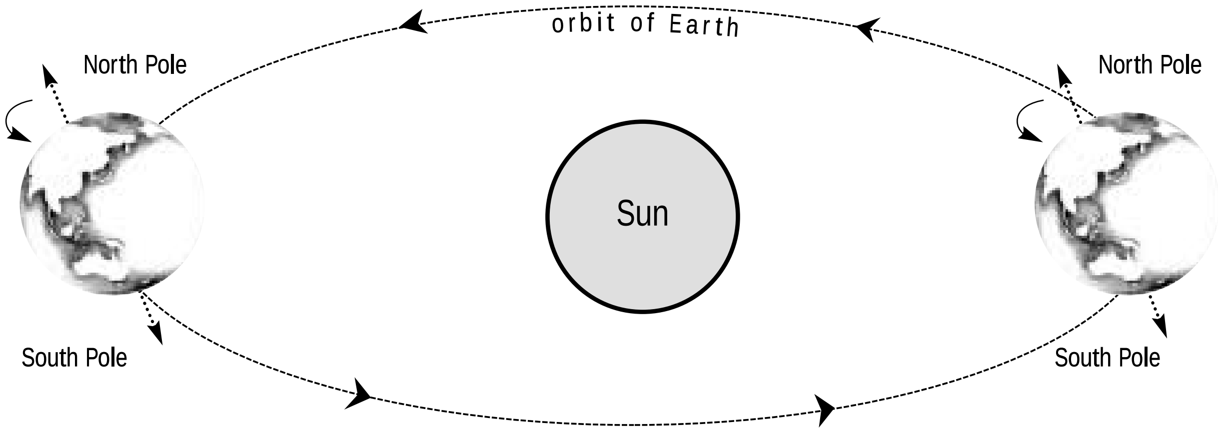
What causes the seasons?

As well as spinning on its own axis, the earth revolves on a yearly path around the sun. Because the earth's axis is tilted, the sun's rays strike parts of the earth at different angles at different times of year. During the northern summer, countries near the North Pole are tilted a little more directly into the sun's rays. This creates summer in the northern hemisphere. At the same time, countries nearer the South Pole are tilted so that the sun's rays strike at a very low angle. This creates winter in the southern hemisphere.

During summer in the Arctic regions, daylight hours are long, almost 24 hours, and temperatures are warm enough to melt the snow. As the Arctic regions are gradually tilted further away from the sun, summer passes. Meanwhile, the southern hemisphere is tilted further into the sun and experiences, spring, summer and autumn.

This seasonal effect is not nearly so great near the equator as it is towards the North and South Poles. Nearer to the poles, the change in the angles of the sun's rays during the year is greater, and the influence on the weather and on the number of hours of daylight each day is greater.

Fig.13 The seasons—why do we have summer, autumn, winter and spring?



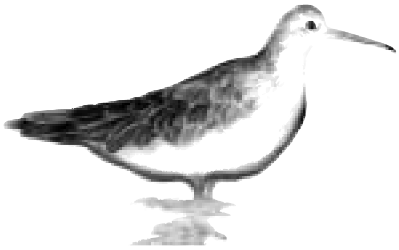
Earth (December)

Earth's position in summer in the southern hemisphere and winter in the northern hemisphere

Earth (June)

Earth's position in summer in the northern hemisphere and winter in the southern hemisphere

Long distance migration of shorebirds



Flyways

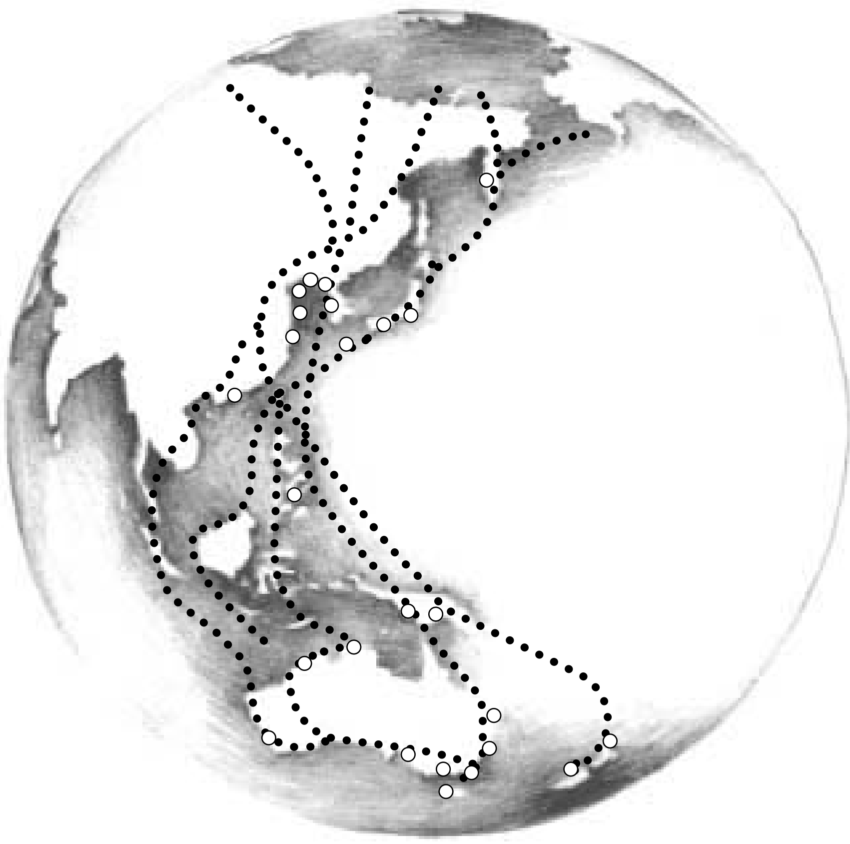
Each year over 2 million migratory shorebirds travel between their breeding grounds and their wintering grounds in Australia and New Zealand. They make the journey, stopping at a few places on the way for two or three weeks to build up their reserves of fat for the next stage of their journey. The places where they pause to feed are called **stopovers** or **staging sites**.

The routes they travel are called **flyways**. On a map of the world, a few main flyways can be drawn. Australia is in the East Asian—Australasian Flyway. This flyway extends from the Arctic Circle through eastern and south-eastern Asia to Australia and New Zealand. Flyways provide chains of wetlands, usually coastal mudflats, which provide abundant food. These well stocked "snack bars" along the journey are essential to the survival of the birds. The birds cannot afford delays or food shortages if they are to migrate and breed successfully. These wetlands are very important.

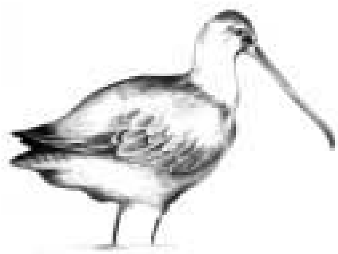
These web pages on the ABC site show pictures and tell the story of migration:
Wader Birds off to Siberia"
http://www.abc.net.au/science/scribblygum/March2000/default.htm

- The care of the wetlands along the flyways, and the future existence of the birds that depend on them, requires international cooperation. Why?

Fig.14 A map of the East Asian–Australasian Flyway



Long distance migration of shorebirds



Long-distance migrants—why do they migrate?

Birds need a year-round food supply as well as suitable nesting sites. It is believed that this may explain why many shorebirds migrate.

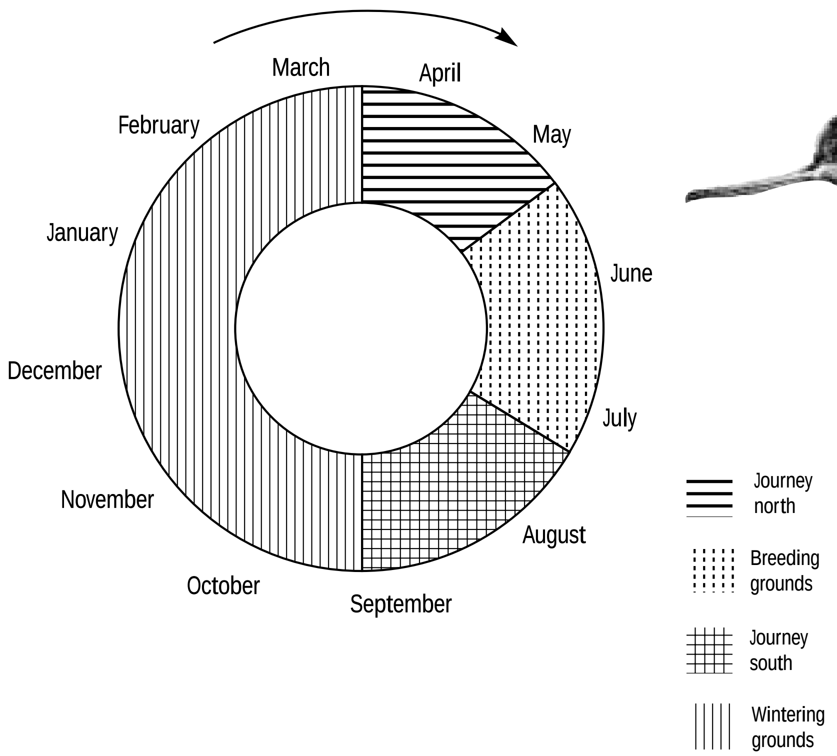
The short summer in the Arctic tundra provides abundant nesting sites and a rich supply of food. The low vegetation of ground-hugging shrubs, mosses and lichens is dotted with pools of water and the area swarms with insects. These provide plenty of food for the newly hatched chicks of shorebirds.

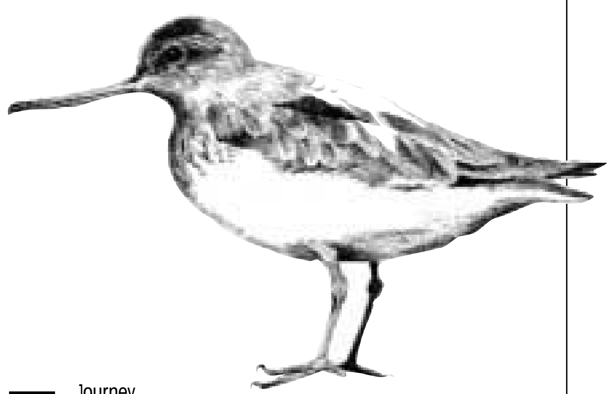
The birds spread over millions of square kilometres, each pair defending their own territory. Eggs are laid and chicks grow rapidly, feeding on nutritious "insect soup". This convenient supply of fast food, ideal for raising chicks, is not available in other parts of the world. On the other hand, the birds could not survive the freezing weather of the Arctic tundra regions during the northern autumn, winter or spring.

The Arctic tundra supports an incredible quantity of life with its dense populations of lemmings, Arctic wolves, hares, owls, ptarmigan and other birds. Some of these feed on the eggs and chicks of shorebirds. It is believed that in years when the lemming population is low, shorebirds are more likely to fall prey to wolves and owls.

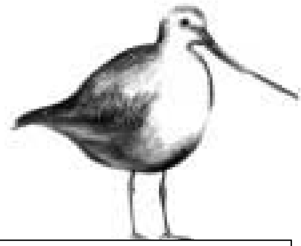
The adult birds spend no more than eight weeks in the tundra, flying south again, leaving their chicks to follow a little later. They travel, in stages, over several weeks, to more temperate regions in the southern hemisphere where they spend spring, summer and early autumn on coastal or inland wetlands. These sites are known as the **wintering grounds** because the birds are avoiding winter in the country where they hatched. Here they feed on small creatures found in the tidal sand- or mud-flats or shallow fresh water. Food includes shellfish, worms and insects.

Fig.15 How birds spend their year





Long distance migration of shorebirds



Young birds, juveniles, do not return home to the Arctic the following winter, and do not breed; they remain in southern hemisphere in the wintering grounds for at least one Arctic summer, sometimes more.

In summary, the adult birds spend approximately two months in their Arctic breeding grounds in the northern hemisphere, five or six months in their wintering grounds in the southern hemisphere and about two months on each journey.

What kind of trip do they take?

Long-distance migration involves flights of 4000 km and more—sometimes up to 8000 km—non-stop. Flocks of these shorebirds fly by day and night, over land and sea at altitudes of around 3000 to 8000 metres. They can adjust their altitude to avoid strong winds and take advantage of tail winds. They fly at speeds of approximately 30 to 60 kph.

Timing of migration

Birds have an inbuilt body clock which tells them when it is time to migrate. It is sensitive to hormones that are made in the bird, in response to changes in the number of daylight hours each day as the seasons change.

The exact time of leaving may depend on the weather. Migratory shorebirds are sensitive to the weather patterns. Large flocks leave for long flights when weather and winds are in their favour. Some birds seem to have an inbuilt barometer. This allows them to detect changes in air pressure. They can detect an approaching storm, set off on their journeys during extensive high-pressure systems, and choose the best altitudes for long flights.

Preparing for the journey

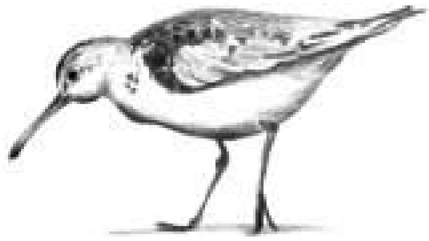
Before it is time to fatten up for migrations, birds complete their moult, replacing the important flight feathers. Moulting is gradual—the bird is able to fly at all stages.

Over two or three weeks in late summer the shorebirds put on weight, storing a layer of fat under their skin and developing larger flight muscles. The fat will be used as fuel during the journey. Birds gain about one third or more of their usual body weight. Some almost double their weight. Some organs in the birds' bodies, not essential for flight, may shrink, reducing unnecessary weight.

Refuelling during the journey

Birds use their stored fat as fuel and also need to stop a few times during their long journey. They renew their fat layer by feeding for two or three weeks. The birds rely on stopover sites to provide plentiful food—"fast food" which is vital for their journey. In some conditions, such as bad weather or poor food supply, birds turn back, returning to their wintering grounds. The birds that reach the breeding grounds must be well fed and in good condition so that they can breed successfully. If humans destroy or damage these feeding grounds, the stopovers, the birds will have no future.

How shorebird migration is studied



Information is collected and recorded by people doing research into the lives and habits of the birds and is useful when decisions are being made about protecting the birds.

Birdcounts: These are carried out by people on foot and from light aircraft and boats. This is done largely by interested volunteers who record the numbers, species and locations of the birds they see.

Banding and flagging: Birds are trapped by catching chicks before they are able to fly or by netting adult birds. The leg of each bird is fitted with a metal band and sometimes a coloured plastic flag. The metal bands are numbered and records are kept to indicate when and where each bird was banded. Details about the bird's age, stage of moult, weight and various body measurements are also noted. The birds are then released.

The colour of the flags can be seen by using binoculars. The colour indicates the region of the flyway where the bird was flagged.

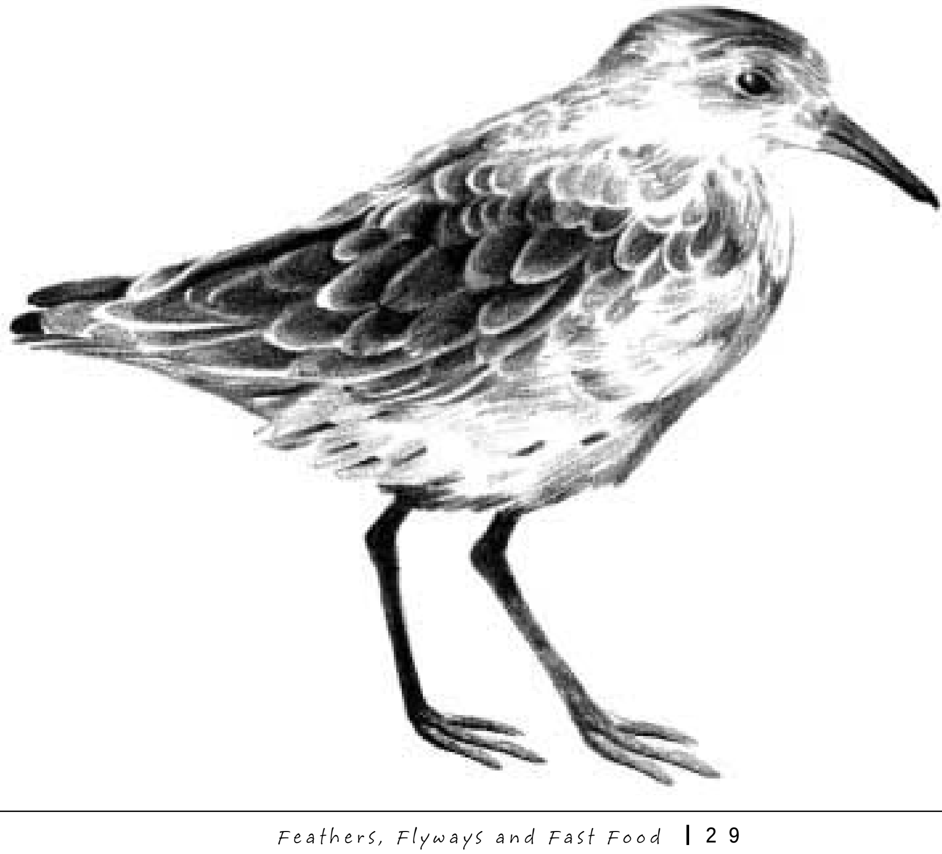
The numbers on the bands of birds trapped a second time, and those on birds found dead, also provide useful information about the movements of the birds.

Reports from different countries of sightings of flags on birds are providing the most information at the moment.

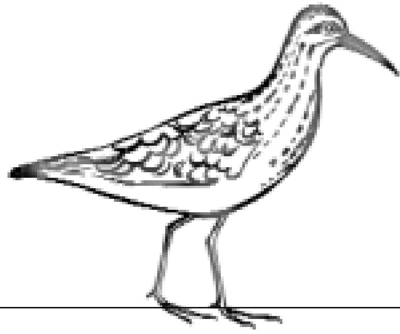
In Australia, bands are issued by the Australian Bird and Bat Banding Scheme. People finding dead birds with bands on them can report the band number to the Australian Bird and Bat Banding Scheme by telephone: **(02) 6274 2407**, e-mail: **abbbs@ea.gov.au** or post: **GPO Box 8, Canberra, ACT, 2601 Australia.**

Gene technology: This is used to study relationships between different species and between groups within species.

Satellite tracking: This method is only just beginning to be used for shorebirds. Most shorebirds are too light to carry transmitters.



Threats to shorebirds



The East Asian—Australasian Flyway contains 45% of the world's population of humans.

Loss of habitat or food supply: Sometimes we drain wetlands for industrial or housing development or pollute the wetlands, killing the food supply. If an area is heavily used by people, birds may be disturbed so often that they cannot live there at all. Humans sometimes remove birds' food to use as bait, or for their own food.

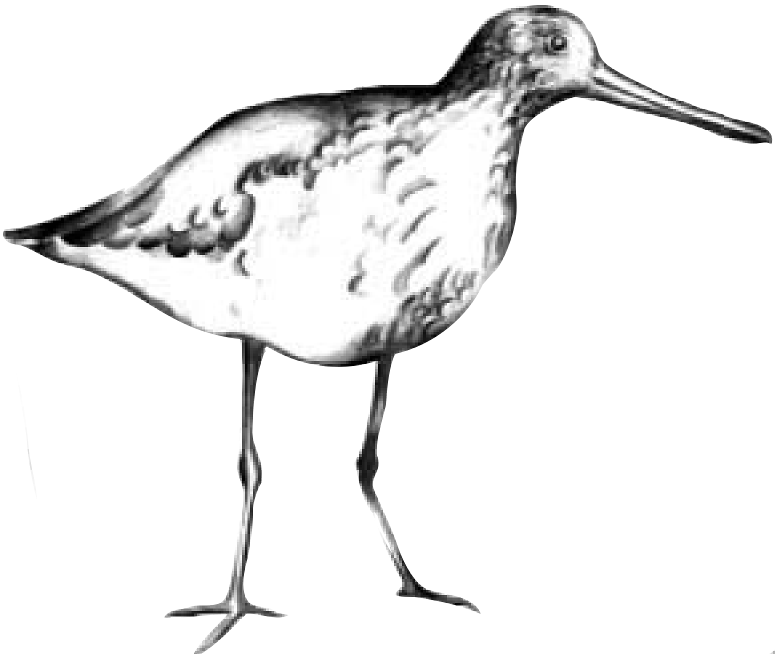
Hunting: In some parts of the flyway shorebirds are hunted for food.

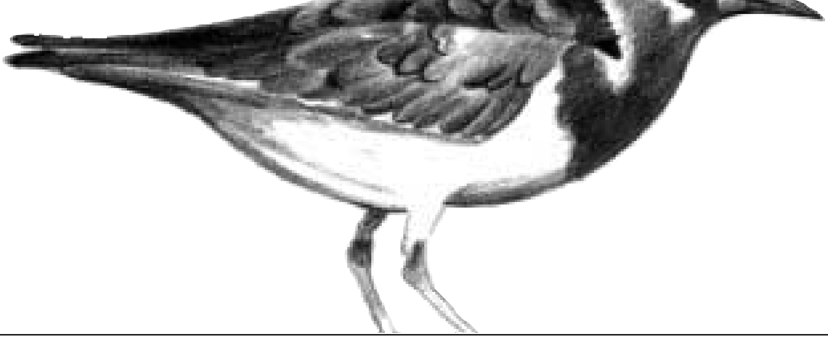
Pollution of habitat: Disposal of toxic substances and accidental spills of oil and other chemicals can, directly or indirectly, kill birds.

Disturbance: People sometimes use, for recreation, the beaches, lakes and mudflats that the birds need for survival. Disturbance: from people, animals such as dogs/foxes/horses, light aircraft, boats or jetskis make the birds fly to other parts of the shore, or even to other sites.This results in loss of feeding or resting time for the birds. Disturbances could affect the birds' ability to fatten up and get back to their breeding grounds fit enough to breed successfully.

Predators: Shorebirds and terns are hunted by birds such as eagles, hawks and falcons and by mammals such as Arctic wolves, foxes and cats.

Bad weather: Cyclones and bushfires can kill birds. Strong winds can blow birds way off their path; leading to death from exhaustion.





Actions being taken to protect shorebirds and their habitat

It is important that all countries in the flyway take responsibility for protecting shorebird breeding and wintering grounds and stopover sites. Australia is involved in several (formal and informal) international agreements aimed at protecting migratory shorebirds and their habitats. These include the Japan-Australia Migratory Bird Agreement (JAMBA), the China-Australia Migratory Bird Agreement (CAMBA), the Convention on the Conservation of Migratory Species of Wild Animals (the Bonn Convention), the Convention on Wetlands of International Importance (the Ramsar Convention) and the Asia-Pacific Migratory Waterbird Conservation Strategy.

Find out more about these agreements:

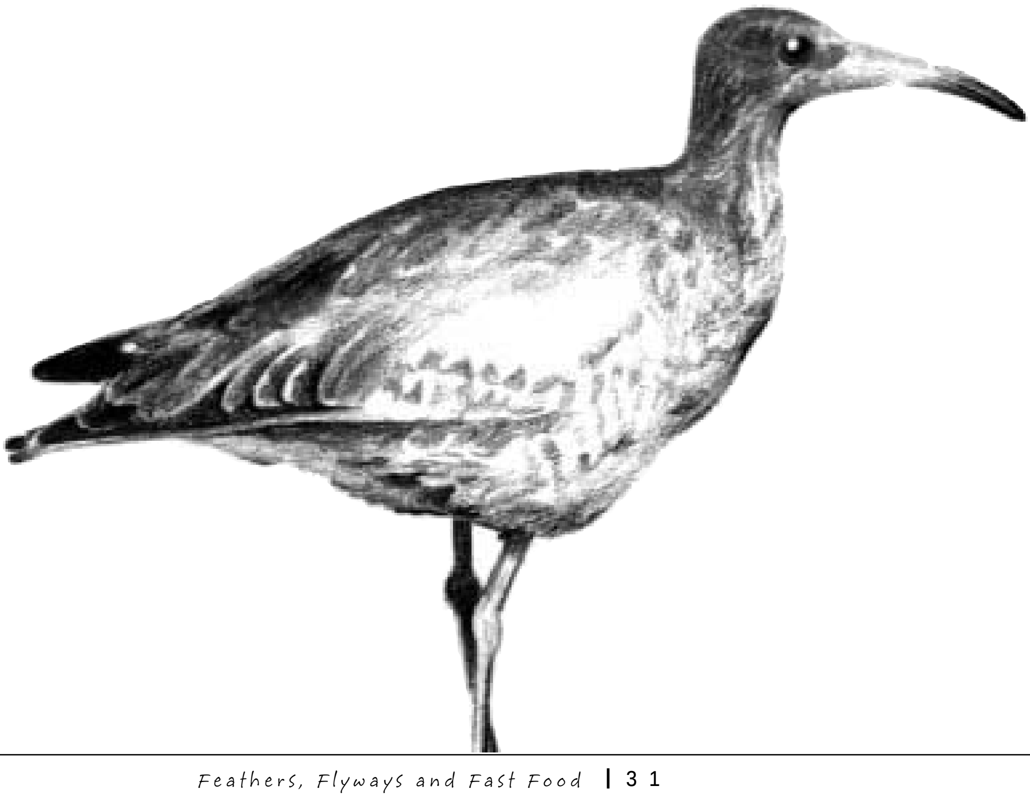
Ramsar Convention, CAMBA, JAMBA and the Asia-Pacific Migratory Waterbird Conservation Strategy at the Environment Australia website: http://www.ea.gov.au/water/wetlands/index.html

Find out where the important wetlands are, in Australia, and whether you live near any of them:

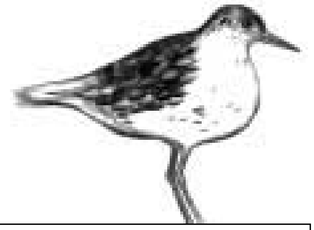
Directory of Important Australian Wetlands http://www.ea.gov.au/water/wetlands/index.html

The Commonwealth of Australia has laws and policies to protect important wetlands and species that are under threat. For example, the Federal Government administers the *Environment Protection and Biodiversity Conservation Act*, which protects important sites for migratory shorebirds from damage that could result from unconsidered development.

Find out more about this Act at: http://www.ea.gov.au/epbc



Actions being taken to protect shorebirds and their habitat



Asia-Pacific Migratory Waterbird Strategy and the Shorebird Action Plan

Conservation of migratory waterbirds and their habitats (largely wetlands) in the Asia-Pacific region has been promoted through the Asia-Pacific Migratory Waterbird Conservation Strategy. The strategy is an international cooperative initiative, with core support from the governments of Australia and Japan and is coordinated by Wetlands International.

Implementation of the strategy has been largely dependent on the capacity of governments, conventions, non-government organisations (NGOs), technical experts, local communities and others and their ability to work cooperatively to implement actions to achieve the conservation of migratory waterbirds and their habitats.

Based on the successes of the strategy during the first five years, a second strategy: 2001-2005 and three action plans for species-groups (ducks, swans, geese, cranes and shorebirds) have been developed; the main mechanism for implementing these action plans is through species site networks. The action plans provide an international framework further to promote the conservation of migratory waterbirds and their wetland habitats in the Asia-Pacific into the 21st century.

The East Asian—Australasian Shorebird Site Network

The East Asian—Australasian Shorebird Site Network comprises wetlands that are very important sites for migratory shorebirds in the flyway. The managers of the sites in the network highlight the importance of wetland areas for shorebirds and promote activities to conserve these areas.

The sites include breeding grounds, stopover sites where birds call in to feed during their migrations, and wintering grounds in the southern hemisphere, where birds find the food and space to live during the warmer months in the south.

Countries can nominate suitable sites to be added to the network.

A map indicating the sites in the East Asian—Australasian Shorebird Site Network may be viewed on the Environment Australia website: http://www.ea.gov.au/water/wetlands/mwp/infosrn1.htm

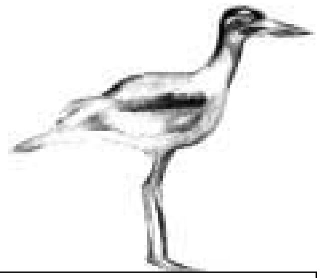
The East Asian—Australasian Shorebird Site Network—Education Project

The Yatsu Higata Nature Observation Center is located in Japan, in Narashino City on Tokyo Bay. The center is beside one of the sites in the Network. The staff of the center have begun a project to link schools that are located near sites throughout the East Asian—Australasian Shorebird Site Network. Schools are encouraged to share observations and information about their sites.

Australian schools located near the sites are encouraged to contact the Yatsu Higata Nature Observation Center.

The website:
http://www.city.narashino.chiba.jp/~yatsu-tf

Suggestions for teachers



Learning activities

- **Questions and activities**—these are included with the above notes.
- **Read to the class parts** of *Jonathon Livingston Seagull.*
- **Make contact** with students at a school somewhere else in the flyway.
- **Take an excursion to view birds** (seek help from a government agency or a local group with an interest in birds or natural history).
- **Watch a video about birds**—e.g. *Life of Birds*, by Attenborough, ABC.
- **Make a light aerofoil** and try it out in front of a fan.
- **Experiment with tins of warm water**—measure temperature changes over time while the tins are wrapped in black paper, white paper, thick insulating material.
- **View the vanes** of a feather with a microscope.
- **Investigate the technology** and use of the boomerang.
- **Investigate early attempts** of humans to fly and modern flight
- **Read sections of the previous notes and summarise the main points using concept maps:** For example, use the words: shorebirds, migration, breeding grounds, wintering grounds, stopovers, flyway, food, moult, hatch, navigation.
- **Make posters or Power Point presentations.** For example, groups of students specialise in an aspect of the information provided above. Power Point presentations should be restricted to 6 or 8 slides, planned on paper first.
- **Jigsaw method.** Students could be assigned to 4 or 5 expert groups to gather information about an aspect of the information provided above and gather additional pictures and information. They then return to their home groups of 4 or 5 students to share what they have learned and contribute to some kind of group presentation.
- **Write questions**—students can be provided with two or three paragraphs of text (from these notes) printed in the middle of an A3 sheet. They can be asked to write questions around the text. They then indicate the answer to their questions with an arrow and underline within the text provided. If all students have the same text they can then ask and answer each others' questions. (This can be modified by the teacher writing the questions and the students underlining the answers and indicating them with an arrow from the question to the answer.)
- **Students can be provided with a diagram** and asked to annotate it with information and explanations.
- **Students find a suitable map** and draw in the flyway, with suggested stopovers, for a particular bird.
- **Students could write the diary** of a particular bird—making monthly entries over a year.
- **Students could "migrate with a bird"**, recording their experiences.
- **Make model birds, or a bird mobile** (either realistic or an imagined birds)—from scrap bits and pieces, from vegetables and plants, or using clay, paper maché etc. Write an explanation about the bird's way of life—what it eats, how it gets its food etc.
- **Students write a story for a young child.** The main character is a particular shorebird that tells its story The story should incorporate some facts about the bird's life and journey. The story could be illustrated, making a little booklet or screen presentation.

Suggestions for teachers

- **After studying the topic revise by:**

  Place 6 sheets of butchers paper at stations around the room. Each sheet has a topic on it (see below). Divide students into 6 groups. Give each group a different coloured texta. Start with one group at each station. Allow about 3 minutes for the groups to write 1 or 2 answers to the question at their first station. Rotate the groups. Repeat this, until all groups have visited each station. Share the results.

Suggested interest areas:

Facts about birds feathers

How birds keep their body temperature steady at about 40˚C.

The journey made by migratory shorebirds

Shorebirds breeding ground—where? What is it like?

Eggs and chicks

Birds and their senses—what can they detect?

Inside a bird's body—lungs, heart, digestive system

What do shorebirds need to survive?

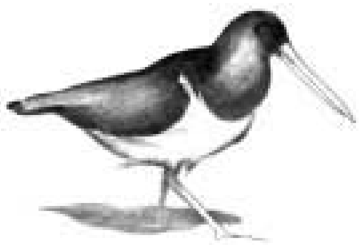
What dangers do shorebirds face?

Students can be asked to prepare a very brief summary of information on an A3 sheet:

Example of A3 worksheet:

Where the bird lives at various times of the year	Picture of a shorebird	What is there about the shape of the bill, or wings that suits the bird to its way of life
What the bird eats and how it feeds at various times of the year	Scientific and common name of the bird	What does the bird do that protects it from predators
Aspects of the bird that camouflage it in the different places is lives	List of books, notes and websites used for reference	Something interesting about the lungs, heart, digestion or senses of the bird

Suggestions for teachers



Where do birds and international migratory shorebirds fit into the curriculum?

The subject matter fits into the science curriculum and the environmental education aspects of SOSE or integrated studies. Skills in English, mathematics, technology and the arts can be involved when gathering and communicating information. In some cases, it may be possible to communicate with a school overseas, involving and encouraging students in developing skills in LOTE.

The information provided may also be suitable for year 11 biology students. For example, the principles of structure and function and adaptations to the environment are illustrated.

The Science Area of Study

Middle primary school

Shorebirds, migration, what they need to survive (especially food, water and suitable space to feed and roost). Senses of the birds—e.g. tactile and visual feeders. Navigation. Effects of humans.

Upper primary school

Food chains—shorebirds, migration, what the birds eat (including what the prey eat and what eats the birds).

Foraging for food—different bill lengths—different food.

Competition for food—other shorebirds—bill length.

Lungs, heart and blood circulation, excretion of birds—compare with humans, mention water budget.

Camouflage Strong skeletal structure of chest and strong flight muscles.

Lower secondary school

Classification of living things—5 kingdoms.

Classification of vertebrates—use of dichotomous keys.

Characteristics of birds.

Classification of birds—what is a species?

Food chains and food webs—lemmings, wolves, owls and shorebirds.

Communication between birds, flocking (mixed), pairing.

Changes in ecosystems—seasonal migration.

Middle secondary school

Flow chart explaining wing movements in flight and effect of airofoil.

Flow chart explaining process of breathing in birds—compare with humans.

Evolution: Diagrams and points of comparison—forelimbs of birds and various mammals.

Adaptations to the environment—structure, camouflage, migratory behaviour, feeding behaviour.

Nerves and hormones—cycles—daily and yearly.

Sense organs—eye, ear, navigation skills.

DNA testing—identification of races—are they separate and identification of destinations of birds.

Concept maps (shorebirds, migration, flyway, stopover sites, wintering grounds, breeding grounds, weight (fat), moult, breeding plumage).

References

Any field guide to birds of Australia, or parts of Australia, would be helpful.

Caras, Roger. (1985). *The Endless Migrations*. New York: Truman Talley Books.

Elphick, J. (Ed.). (1995). *The atlas of bird migration*. R.D. Press: Australia

Gill, Frank. (1990). *Ornithology*. W.H.Freeman and Company: USA

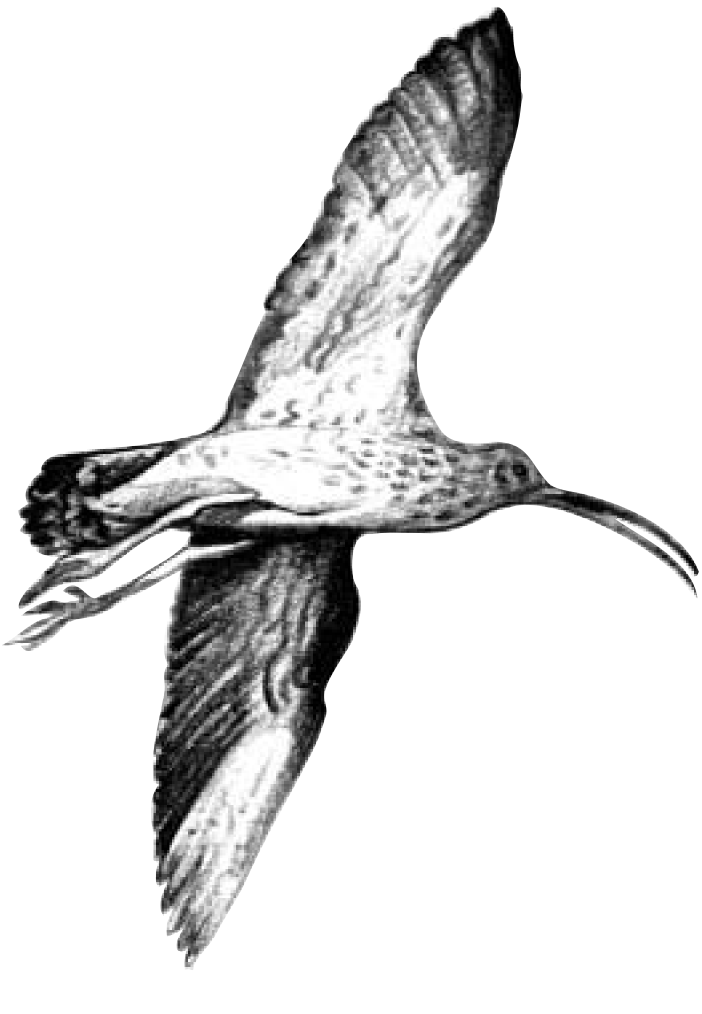
Howes, J. and Bakewell, D. (1989). *Shorebird studies manual*. Asian Wetland Bureau: Kuala Lumpur

Lane, B.A. (1987). *Shorebirds in Australia*. Nelson: Australia

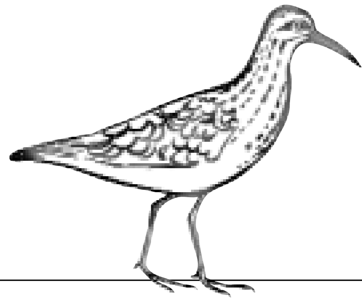
Pizzey, G. and Knight, F. (1997). *Field guide to the birds of Australia*. Angus & Robertson: Australia

Pringle, J.D. (1987). *The Shorebirds of Australia*. Angus & Robertson: Australia

Simpson, K and Day, N. (1993). *Field guide to the birds of Australia*. 4th ed. Viking O'Neil: Australia



Internet Sites



Site	Address
Environment Australia (Commonwealth Wetlands Policy, Directory of wetland sites, shorebirds, migratory birds, threatened species, International agreements, map of flyway, links, EPBC Act, education)	www.ea.gov.au www.ea.gov.au/water/wetlands/index.html
Ramsar Bureau (International site—wetlands)	www.ramsar.org
Birds Australia	www.birdsaustralia.com.au
Australasian Wader Studies Group	www.tasweb.com.au/awsg/home.htm
Victorian Wader Study Group	www.home,vicnet.net.au/~vwsg/contact.html
Wader Birds off to Siberia Scribbly Gum—ABC website	www.abc.net.au/science/scribblygum/March2000/default.htm
"Bird Count" Quantum—ABC TV, 29/6/2000	www.abc.net.au/quantum/stories/s142411.htm
Australian Birds ABC website	www.abc.net.au/birds/
Australian Bird and Bat Banding Scheme	www.ea.gov.au/biodiversity/science/abbbs/index.html
NSW Parks and Wildlife Service (Select "Threatened Species Profiles"—includes details of Broad-billed Sandpiper, Great Knot, Little Tern, Sanderling, Sooty Tern, Terek Sandpiper, White Tern)	www.npws.nsw.gov.au/wildlife
Birding Aus (Provides links to other sites)	www.shc.melb.catholic.edu.au/home/birding/index.html
Tasmanian Government Information about the Little Tern	http://www.dpiwe.tas.gov.au/inter.nsf/WebPages/BHAN-54GUJ7?open
Western Australia—photos which may be used with acknowledgment.	members.iinet.net.au/~foconnor/
School websites—Australian schools with an interest in the coast	www.abc.net.au/oceans/beach
Yatsu Higata Nature Observation Center, Japan	www.city.narashino.chiba.jp/~yatsu-tf

Internet Sites

Site	Address
USA Fish and Wildlife Service Migratory Birds	birds.fws.gov
Migratory Shorebirds and links to other relevant sites	migratorybirds.fws.gov
Shorebirds Sister Schools Program (Administered from Alaska—some Alaskan birds migrate to Australia)	http://sssp.fws.gov Email: sssp@fws.gov
Attenborough—Life of Birds (Includes lesson plans, questions, to accompany ABC video *Life of Birds*)	www.pbs.org/lifeofbirds/
Birds	www.ucmp.berkeley.edu/diapsids/birds/birdintro.html
Arctic search for Red Knot (July 2000—photos and account of the expedition.	www.state.nj.us/dep/fgw/ensp/arctic2k.htm
Arctic Birds (Includes description of conditions on the breeding areas of the Arctic and breeding success)	soil.msu.ru/~soloviev/arctic
Curriculum material (prepared in North America)	www.ducks.ca/edu/resource.html
Manomet site (Map of North and South America showing that flyway network)	www.manomet.org/
USA Department of Defence: Partners in Flight (Has links to several organisations with an interest in birds)	www.dodpif.org
Wetlands International Asia-Pacific Migratory Waterbird Conservation Strategy Quick Reference Information. (e.g. Dragonflies, Farmers' Feathered Friends, Wetland Destruction (threats), Wetlands habitats—Malaysia, Mangroves)	www.wetlands.org
New Zealand migratory waders	www.natureandco.co.nz/land_and_wildlife/wildlife/seashore-birds.htm
About Bird Migration and wetlands	north.audubon.org/facts.html
Smithsonian Migratory Bird Centre How Things Fly—Science	natzoo.si.edu/smbc/ educate.si.edu/resources/lessons/siyc/flight/start.html)