The Flight of Birds.

By F. E. Parsons.

There are three different modes of flight. Some birds only make use of one of these methods, some use two methods, and others use the three methods.

1. Gliding.—This is the simplest form, and is no doubt the most primitive. It is the method used by flying animals which have a vane of skin which they stretch out by extending the legs and arms (Flying Phalanger, *Petaurus*). This method can only be used when the bird has either already attained a high velocity or commenced flight from some elevated point, as this method always results in either loss of velocity or loss of altitude, and in this particular differs from the third method of flight mentioned later. A very good example of gliding flight that is sustained or made possible by loss of velocity is the flight of the Crested Pigeon (*Ocyphaps lophotes*). This bird, by rapid beats of the wings, attains a good speed, then it glides along on the same plane with outstretched wings, and gradually loses its velocity, and when the speed gets too low for gliding it reverts to the flapping of the wings to gain speed, then glides on again. A good example of gliding flight made possible by loss of altitude is in the flight of a Falcon, which flies lazily at an altitude, then, sighting an intended victim, it dives straight down, gaining much momentum; if it misses its aim it converts this velocity gained by loss of altitude into a long gliding flight, or converts the momentum back to altitude by merely keeping the wings rigid. We have all noticed a Magpie (*Gymnorhina*) on the ground when a high wind is blowing. If it wishes to alter its position in the direction of the wind it first faces the wind, then outstretches its wings. The wind lifts it off the ground; the bird then turns with the wind and with motionless wings glides to the required place, turns into the wind, which checks the velocity, and the bird lands. Although in this instance the bird started with neither velocity nor elevation, yet it belongs to this type of flight, because the inertia, as in the case of *Ocyphaps lophotes*, is supplied by the force of the wind.

2. The second method of flight is by flapping of the wings. All birds use this type of flight, even the gliding and soaring birds use it at times. It requires very little to be said about it. Photographs, exposing a film about every one-fiftieth of a second, have been taken of flying birds. These showed that the downward sweep of the wing was slower than the upward motion; that the motion of the wings resembled an over-arm

swimmer, the wings being further forward for the downstroke than for the upstroke, and the wings more extended for the downstroke and contracted for the upstroke; and it also showed that the bird slightly rose on the downstroke and fell on the upstroke. This is just what may be expected, only one would think that a sharp upstroke would have the effect of the bird dropping quickly. There are two reasons to explain this. Firstly, the wide vane of the feather being the underneath vane, when the downstroke occurs this wide vane is forced against the shaft of the next feather, and is so made airtight; but on the upstroke there is no support for the wide vane, consequently it bends, and a lot of air slips through, thereby lowering the resistance. The other reason why the flight is not more undulating will be explained later.

3. The third method of flight is soaring. This is the most wonderful method, and comparatively few families of birds can make use of it. This flight differs from gliding in the fact that the bird does not necessarily lose either altitude or velocity, but, on the contrary, it appears to be able to, at will, gain either or both of these, and many species of soaring birds are able to maintain this flight for hours at a time. It does not seem to be properly known just what is the scientific reason for this wonderful method of flight, but there are, no doubt, several contributing factors—

(a) At times the soaring bird makes use of the principle described in gliding by gaining velocity at the expense of altitude, or *vice versa*, or by converting the force of the wind into velocity, which in turn is converted into altitude. If the bird always did its soaring in the direction of the wind, then the foregoing would account for sustained soaring flight; but it as often as not does its soaring against the wind, so we must look for some other reasons. When the soaring is done against the wind I do not think the bird could maintain such a long-sustained soaring flight as when the main direction is with the wind. When the main direction is with the wind, of course, altitude or velocity could be gained; then the bird could turn and soar against the wind at the expense of altitude and velocity, but this will become almost used up, and the bird could then turn with the wind and once more gain velocity and altitude.

(b) Those soaring birds are apparently gifted with an extra sense, which enables them to locate currents of air and pockets of rarefied air, which they are able to use and convert into velocity or altitude. (You will notice that all soaring flight resolves itself into using all available phenomena and converting it to either velocity or altitude; for instance, it would be very detrimental to soaring if a bird came from a high altitude to a low one and steadied itself down by using its wings to prevent increase of velocity, because this would be a dead loss—the bird must if it loses altitude convert it into velocity.)

(c) The peculiar construction of the wing must play a great part. We notice that soaring birds have very long wings with little width. The proportion of length to width in the case of the Wandering Albatross (*Diomedea exulans*) is about 6 to 1. The Wedge-tailed Eagle (*Uroaetus audax*) is about 3 to 1. Birds that do not soar, but which glide, have the difference between length and width not nearly so exaggerated; whilst birds which only make use of the flapping of wings for flight have a very much rounder wing; the rounder the wing the quicker the bird has to beat its wings, although this latter must vary inversely with the wing area per unit of weight, e.g. a Grebe (*Podiceps*), with 3.5 square inches of wing per ounce of weight, must beat its wings much quicker than an Australian Goshawk (*Astur fasciatus*), which has 11½ square inches per ounce, or very much quicker than a Brown Flycatcher (*Microeca fascinans*), which has 55 square inches per ounce. The three main factors in flight are (1) ratio between wing area and weight of bird; (2) strength of the wing muscles; and (3) shape of the wing. It is interesting to note that the construction of a bird is such as to give the maximum of stability, i.e. the wings are attached to the body from the highest part so that when the bird is in flight all the weight is below the wings—the light organs, such as the lungs, are situated along the backbone, and the heavy organs, as the stomach, are low down; also the heavy wing-muscles are attached to the breastbone so as to keep the centre of gravity as low as possible below the point of suspension. We note also that the point of suspension by the wings is a little forward of the centre of gravity; if a bird is held by the outstretched wings the forward end of the bird always turns upwards. The smooth contour given to the body by the thatching of the feathers offers the minimum of resistance to the air. Without the contour feathers the body would offer considerable resistance. One could not say a plucked bird exhibited a streamline body. It is really very ugly, and if it were not for the pleasing streamline appearance of the feathered bird it would be shunned as much as a lizard or a frog. Can anyone tell me if the point of suspension by the wings is any further forward of the centre of gravity in slow-flying birds than in the fast-flying birds, i.e. if they are held out on the outstretched wings, will the fast-flying birds hang more horizontally than the slow-flying ones? Although I have never made any examination in this way, yet I think this will be the case. The point of suspension is placed ahead of the centre of gravity so as to give a turning moment, and tends to elevate the bird, and the faster the bird flies the greater becomes the upward lifting force, so that in fast flyers it is not required that the point of suspension should be so far forward of the centre of gravity.

It might be interesting to explain a few facts with respect to flat surfaces falling in the air. When a flat surface falls vertically the resistance to the air is greatest at the centre of the surface, and diminishes towards the edges. The air slipping past the edges reduces the resistance around the edges. But when the plane moves forward as well as downwards the point of greatest upward pressure moves forward, because less air can escape past the forward edge and more air escapes past the hinder edge. The greater the velocity forward, the further forward the centre of greatest upward pressure moves. This explains why a flat piece of paper when falling swings to and fro. It commences to fall vertically with the centre of upward pressure opposite the centre of gravity, then it gets a slight forward motion which moves the point of upward pressure ahead of the centre of gravity that tilts the forward edge upwards; the paper then swings upwards until stopped by gravity; it then slips down backwards, which moves the centre of upward pressure towards the other end, that turns this edge upwards, and so on.

I think this will explain why fast-flying birds have narrow and long wings, because the maximum lifting force is near the front edge, and if the bird flies very fast there cannot be much lifting force on the back portion of the wing. As mentioned previously, the faster the bird flies the further forward the centre of upward pressure gets from the centre of gravity, and so has a greater tendency to tilt the bird up; and this explains why when a bird flies very fast it stretches its head well forward to keep the centre of gravity as far forward as possible to counteract the advanced position of the lifting force. When looking at the primary flight feathers one notices that the vane on the front half of the feather is very much narrower than the other half, and at first sight the reason for this is not too clear, but the principle just explained supplies the reason. When the wing is outstretched the secondary feathers are at right angles to the front of the wing, and therefore, when the bird accelerates, the centre of upward pressure moves along the shaft of the feather, and consequently these feathers have balanced vanes; but in the case of the primaries the nearer the feather gets to the tip of the wing the closer it gets to being in the same direction as the wing or at right angles to the body, and so when the bird accelerates the centre of upward pressure moves across the feather, and if the stiff shaft were not close to the front edge the vane would bend upwards and so retard flight. The first primary being about square with the wing and the last one almost parallel with the wing, we would expect the vanes on the first primary to be equal and then the front vane gradually getting smaller in comparison until it is very narrow on the last primary, and that is exactly what the position is.

A gliding bird as it increases its velocity has a greater tendency to rise, because the upward pressure moves further forward. This the bird has to counteract, which it does in different ways. The long-necked do this by stretching out the neck when flying fast and bringing up the head into the body when flying slowly. Short-necked birds have to resort to other methods. This is generally done by retarding the wings, thus moving the centre of upward pressure further back. Fast-gliding birds have the wings bent, but slow-skimming birds have the wings well extended for the same reason. Another method of bringing the upward centre of pressure further back is by spreading the tail. The tail, thus increasing the surface to resist the upward thrust, naturally has the effect of bringing the centre of upward thrust further back; but it is evident that the tail is not used very much in this way, because fast-flying birds like the Albatrosses have very short tails; so have the Ducks, Pelicans, and very many others. If a Silver Gull (*Larus novae-hollandiae*) flying along the seashore is carefully watched, one will note that when wishing to dive quickly after some titbit, it spreads the tail and stretches out the head. Both these actions have the effect of upending the bird; it also retards the wings very much to bring the point of suspension as far behind the centre of gravity as possible, then with quick wing-beats the bird is up-ended.

In mentioning the flapping flight of a bird I said there were two reasons why the flight was not very undulating—the first was because on the upstroke the wide vane of the feather bends and lets the air through; and the second is that when the downstroke is made the wings are forward, so that the point of suspension is ahead of the centre of gravity, thus tending to

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counteract the effect of gravity pulling the bird down; then for the upstroke the wing is further back, bringing the point of suspension behind the centre of gravity, and as the pressure is on the top of the wings the tendency is again to turn the bird upwards, and in this way a fairly even elevation is kept. The Crested Pigeon was mentioned as an example of gliding flight. One must have noticed how this bird glides along, keeping the same elevation all the time. To do this the bird must gradually move the wings further forward as it loses velocity, because, as previously explained, the centre of upward thrust moves back as the velocity decreases.

A bird to turn sideways in flight does it, in the case of long-necked birds, by putting the head on one side; or it can be done by twisting the tail, one side being up and the other down; or the most usual method is by creating a turning moment by contracting one wing: this places the forward driving power on one side of the centre of gravity, and so must turn the bird.

Moult.—In speaking of the flight of birds it is not out of place to mention the different methods of moulting the flight feathers. Birds which do not rely on their wings to secure their food will moult all their flight feathers at once, e.g. Ducks, Swans, Geese, etc., get on to some quiet backwaters where there is plenty of food and cover to hide in, and will moult all their flight feathers and are not able to fly at all, but they can secure their food by swimming. But if a honeyeating bird lost its flight feathers it would have to starve. Birds which must have their wings to secure their food will moult their flight feathers in pairs and one after another. When skinning a bird I have often noticed that perhaps the fourth primary in each wing is a new fully-grown feather and the seventh on each wing is a feather about half-grown, and the third secondary on each wing is just peeping from the skin. The moult in one wing agrees with the moult in the other, so as not to upset the equilibrium. Another interesting point about some birds' moult is that they moult the flight feathers twice during their first year of existence, getting two different sets of flight feathers. Birds that do this are those which fly in the chicken stage, like the Moorhens. Their first flight feathers are only long enough for the bird when half the weight of a fully-grown bird. Then, when it approaches its full size, the small wings are not large enough for the extra weight, and it moults these small flight feathers and grows larger ones. This must be the case, because half-grown birds do not have flight feathers as long as the mature birds, or they would look very funny objects, and the flight feathers are certainly dead long before the bird is half-grown. Has this ever been noticed with the Mallee-Fowl (*Leipoa ocellata*)?