The bird in the hand...

D. W. Yalden
U. Albarella

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Abstract and Keywords
This chapter introduces the avian skeleton and the most important (easiest to identify, most robust) bones. Their differences from equivalent mammal bones are considered. The possibilities and difficulties of identifying bird bones to species are discussed and illustrated. Assigning dates to the bones is also briefly discussed, along with a brief overview of the main historical periods and the sorts of sites that have produced bird bones.

Keywords: bird skeleton, identifying bird bones, humerus, metacarpus, tibiotarsus, tarsometatarsus, time periods

...is worth two in the bush, says the old saying, generalizing the advice to a hunter of earlier times to concentrate efforts on the reliability of the catch already made. For the historical ornithologist, the equivalent reliable catch is a well-dated specimen of a well-identified bone. It should provide a firm indication that some particular species of bird, perhaps one now locally extinct, occurred at some particular site and time. It is important, though, to examine the uncertainties
surrounding both ‘well identified bone’ and ‘well-dated specimen’.

Identifying bird bones
Mammals are readily identified from their teeth, skulls, jaws, and other bones. The popular perception is that birds’ bones are so similar that they cannot be reliably identified. They are also much less robust than mammalian bones, leading to the equally popular perception that there is no valuable or significant subfossil or fossil record of birds. One of our main aims is to demonstrate that both perceptions are quite wrong. To do so, we must first discuss the bones of the avian skeleton, to concentrate on those of most value, and also address the genuine problems of identifying these bones in a group that contains many more species. Roughly, there are 9,500 species of bird in the world, as against 4,300 mammals; more parochially, there are about 200 breeding birds in Britain, but only 60 mammals (admittedly, these totals include the seabirds that nest on British cliffs, but omit the dolphins in the surrounding seas; the former are common in archaeological sites, whereas the latter are rather rare, and can only be loosely described as British).

What to identify?
The bird skeleton (Figure 1.1) is a highly modified version of a small dinosaur skeleton, and the very distinctive bones can readily be identified as bird bones, not easily confused with those of mammals. Even bats’ bones, which might be expected to resemble bird bones, are very different, because their wings are anatomically very distinct. A bird’s shoulder girdle forms a strong well-braced hoop, with a tall, pillar-like coracoid bone (absent in most mammals) running from the big sternum, with its distinctive keel, to the shoulder joint (Figure 1.2). The coracoid and scapula (a broad ‘shoulder blade’ in mammals, including bats, but a thin, more knife-like, blade in birds) together provide at their junction the socket (glenoid joint) for the humerus, the upper arm bone. The furcula, or wish bone (fused collar bones), is a V-shaped bone lying in front of the coracoids, often springy but sometimes
forming a very solid ‘V’. The humerus is one of the most distinctive bones and, being one of the most robust bones in the avian skeleton, one of the most useful to the practising archaeologist. Its head, the shoulder joint, bears a complex articular surface, with depressions on the dorsal side where wing-folding muscles insert (Figure 1.3). The prominent deltopectoral crest, where the main flight muscles attach, runs about a third or halfway along the anterior side, and there is a complex elbow joint at the distal end, all of which provide identification characters. It is gently curved in most groups, but has a very straight shaft in passerines. Of the two bones in the forearm, the radius is a thin straight bone, not very distinctive, but the (p.5)

Fig. 1.1 Bird skeleton, with some of the more important bones (for archaeological identification) identified: C Coracoid; CMC Carpometacarpal; F Furcula (= wishbone, fused clavicles); Fe Femur; P Pygostyle; R Radius; Sc Scapula; St Sternum; TMT Tarsometatarsus; Tt Tibiotarsus; U Ulna.
ulna is a stout, gently curved bone that supports the secondary flight feathers, and often has small bumps (nodes) that indicate the position of each feather. Birds have only two small wrist bones (we have seven), but then a bone in the hand, the carpometacarpal bone, which is another of the very useful bones for identification purposes. It represents three metacarpals (equivalent to three of the five bones of our palm), fused together in a distinctive manner with another wrist bone; it supports in life most of the primary flight feathers (those that make up the tip of the wing) (Figure 1.4). There are only four finger bones (phalanges) in (p.6)
The bird in the hand...

each wing, compared with the 14 that we have in each hand; they support the remaining wing tip feathers, but are tiny bones, no use for identification purposes. The main bones of the hind limb are equally distinctive and diagnostic. The pelvic girdle, the hip bone, is a wide thin bone, fused to the vertebrae dorsally but wide open ventrally. (p. 7)

**Fig. 1.3** Bird humeri, dorsal surface, to show variation, with oblique view of head, slightly enlarged. Selected to be of similar size, around 200 g (but owl and duck larger, about 300 g). GP Golden Plover; Mp Magpie; K Kestrel; SEO Short-eared Owl; GW Green Woodpecker; GyP Grey Partridge; P Puffin; Md Mandarin; D Dabchick. The deltopectoral crest (dp) is particularly prominent in Falconiformes (K); the shaft is bowed in Galliformes (GyP), Strigiformes (SEO) and Falconiformes (K) but rather straight in Charadriiformes (GP, P). The pneumatic fossa (pf) is particularly well developed, sometimes double, in Passeriformes (Mp).
The bird in the hand...

quite unlike the equivalent bone in mammals. One argument, though surely only part of the truth, is that it is open ventrally because birds lay such large eggs, relative to their body size, and those eggs have to pass out between the arms of the pelvic girdle. It is, however, a very thin sheet of bone, so rather fragile, and not much used in practical identification, except (p.8) that the bowl (acetabulum) that forms the hip joint is quite robust, and has some diagnostic value. The femur, the thigh bone, is perhaps the bird bone most like its mammal equivalent. However, it is very short, has a rather cylindrical head (more globular in mammals), and lacks the wide groove for the knee cap at the knee end – birds do not have a separate knee cap, though there is a narrow groove for the tendon from the equivalent muscle. The tibia, or shin bone (strictly, the tibiotarsus) is a very elongate bone with an irregular triangular-shaped proximal (knee) end and a sharply keeled pulley-shaped distal (ankle) end. Birds do not have separate ankle bones (they are fused to their neighbours), but they have a very

![Fig. 1.4 Bird carpometacarpi, to show variation. Species as Fig. 1.3, with addition of CD Collared Dove; Mh Moorhen. The bone results from fusion of metacarpals 1 (mc1), 2 (mc2, the stoutest) and 3 (mc3) with a carpal bone at the proximal (upper) end. An intermetacarpal process (imp) is present in Gallifomes (GyP), and in Passeriformes (Mp) and Piciformes (GW) it is fused to mc3. A strongly bowed mc3 and consequently wider intermetacarpal gap is characteristic of some orders.](image-url)
distinctive foot bone, the tarsometatarsus, which is the equivalent of the cannon bone in a horse or cow. It represents two or three ankle bones (tarsals) fused to three elongated foot bones (metatarsals) also fused together; the three separate pulleys at the distal end, for the toe bones, show its derivation. Birds run (or hop) on their toes, and what is commonly referred to as their ‘knee’ is in fact their ankle (we never see their true knee, which is enclosed in the muscles and feathers of the body). The toe bones are rarely of much use for practical identification, but while most birds have one short toe pointing back and three longer ones pointing forward, some have lost the hind toe, others have two toes forward and two back, yet others can move one of the toes forward or back. These differences affect the shape of the distal end of the tarsometatarsus, giving it added diagnostic value (Figure 1.5).

Passerines have the most distinctive tarsometatarsi, as a group: the three condyles at the distal end are small, evenly sized and evenly spaced alongside each other. In most birds, the condyles for the side toes are placed higher (more proximally) than the central one, though in raptors and owls the very large condyle for the inner (second) toe is aligned with the middle (third) toe, and the outer (fourth) toe has a smaller, more proximal, condyle; they have a facet for the hind (first) toe, which is strongly marked, because it is, of course, a large toe forming an important part of the grasping mechanism. Seen end on, the condyles form almost a semi-circle, with the outer and inner toes almost facing each other, as part of their prey-grasping mechanism. Passerines too show a distinct facet for the hind toe, an essential part of their perching mechanism. Waders overlap in size with passerines, and are equally well represented in many archaeological sites. Their tarsometatarsi tend, of course, to be long for their size, and have distinctively large, projecting, middle condyles. The condyle for the inner toe is displaced backwards relative to the other toes, and the front face of the bone is concave, grooved, for much of its length. Their relatives the auks and gulls have rather similar, though shorter, stouter bones, those of auks being widened, and flat-fronted, as part of their swimming function. Game birds by contrast have short, sturdy tarsometatarsi, with strong condyles for all three main toes; the condyle for the inner toe is distinctively bilobed in side view. Ducks and geese also have very short broad tarsometatarsi, but they are stout, rather flat, and have a distinctive hypotarsus carrying the tendons across the ankle joint (Figure 1.5).
Skulls, especially the beaks, are of course very diagnostic, just as are the skulls and teeth of mammals, because many groups are distinguished by their diet. Bird skulls are, however, so fragile compared with mammalian skulls, that they have only a limited practical value to the archaeologist. Perhaps paradoxically, palaeontologists, looking at much older specimens, are more often able to use them, for some deposits contain beautifully preserved complete skeletons, whereas the skeletons in archaeological sites are usually isolated bones – or fragments of them.

(p.9)

(p.10)

Among archaeological specimens, the two eagles have bills of very different shapes, much deeper in White-tailed than Golden, and Raven skulls, for instance, sometimes survive in archaeological sites.

In summary, the humerus, metacarpus, tibiotarsus, and tarsometatarsus are all quite robust bones, with a variety of anatomical features that are diagnostic to the ordinal level, at least. Other bones can be identified, but are either more fragile, so less likely to be preserved in archaeological sites
(remembering that they have to survive not only initial burial but also archaeological excavation), or are too similar between bird groups to be useful.

Fig. 1.5 Various types of tarsometatarsi associated with different types of feet. Species as Fig. 1.3. Right tarsometatarsi in dorsal (anterior), lateral and distal views. The three pulleys (trochleae) for the three main toes (2, 3, 4) are characteristically of even length and alignment in Passeriformes (Mp), and the well-developed hypotarsus (ht) is penetrated by 4–6 tendons. Note the strong base for the 1st toe in Piciformes (GW), and the curved appearance of the trochleae in distal view in Falconiformes (K) and Strigiformes (SEO).
Problems of identification
Given an example of one of the more distinctive bones, reasonably well preserved, from an archaeological site, how easy is it to identify it to species? Species differ particularly in size, though of course the distinctions can be obscured by individual and, in many species, by sexual variations. Groups of species - genera and families - differ also in minor morphological details. Orders differ very substantially in morphology, as is well illustrated by Cohen (1986) and by Gilbert et al. (1996). Thus identification tends to be a matter of assigning bones to Order, on morphology, and then using a combination of assessing size and checking the detailed morphological features to get close to a species identification. Fortunately, many of the important or interesting species from archaeological sites are either taxonomically isolated in Europe (e.g. Gannet, Crane), or combine distinctive morphology and size (e.g. Raven, Great Auk). In groups with few species which are very different in size (for instance, Cormorant, Shag, and Pygmy Cormorant), an identification of a decent bone, say a humerus or metatarsal, can be firmly made. The auks make a similar graded size series, from Great Auk, Guillemot, Razorbill, Puffin, Black Guillemot to Little Auk, with little overlap (Figure 1.6). In other cases, like the ducks, the morphological distinctions of at least some bones, like the metatarsals, allow ready separation of diving ducks (Aythya and Bucephala) from dabbling ducks (Anas), but the species within each of these groups are so similar that a firm identification is less likely. The Mallard is appreciably larger than other species of Anas, but close to Pintail, which overlaps Wigeon, then Gadwall and Shoveler; distinguishing these is difficult, though there are small morphological differences in some bones (Woelfle, 1967). Teal is distinctively smaller than all of them, but barely distinguishable from Garganey. The enormous variability added to this mix by the various breeds of domestic duck, all descendants of Mallard, merely adds to the confusion. Geese present a similar very common problem area. Pink-feet are distinctively smaller than Greylag, but the intermediate sized Bean Geese overlap both of them, and the slightly smaller White-fronted Goose overlaps extensively the Pink-foot in size. The fact that female geese are somewhat smaller than their mates adds to the variation, and therefore confusion. In a few cases, DNA extracted from the bones has been used to confirm their identity (Dobney et al., 2007). The Whooper and Mute Swan also overlap extensively in size, but
are usually morphologically distinguishable. For instance, the more terrestrial feeding activity of Whooper Swans is reflected in a broader distal end to the metatarsal bone, which is somewhat longer but more slender, on average, and the sternum, in particular, is readily distinguished by the cavity for the extended trachea, reflecting their ability to make trumpeting calls (Figure 1.7).

Fig. 1.6 Range of auk humeri, to show how sizes differ between relatives. GA Great Auk; G Guillemot; R Razorbill; P Puffin; LA Little Auk.
The archaeological record of birds is dominated by the bones of domestic species, ducks, geese and, especially, Domestic Fowl. Domestic Fowl are ‘gamebirds’ – both a legal and a taxonomic term – i.e. members of the order Galliformes. Close relatives (grouped in the family Phasianidae) include the Peacock, Pheasant, and Grey Partridge, also Guineafowl and Turkey. Not quite so close are their relatives in the grouse family Tetraonidae, including Red Grouse, Ptarmigan, Black Grouse, and Capercaillie, as well as the Hazel Hen in Europe. All of these are important food species for humans and other predators, with robust bones that occur regularly. They are important also archaeologically and historically. Many of the Phasianidae have been introduced to the British Isles, therefore should give evidence for or comply with dating. The Tetraonidae show important climatic, ecological, and geographical replacement, from northernmost Ptarmigan, through dwarf shrub/scrub Red Grouse, woodland edge Black Grouse, conifer forest Capercaillie, and deciduous woodland Hazel Hen, and therefore give evidence of climatic and ecological changes during postglacial times. This is evidently an important group from which to derive historical data and, as a group, well represented archaeologically. How easy is it to identify the various species? Fortunately, there are now a

Fig. 1.7 Mute (MS) and Whooper (WS) Swan sterna, in oblique anterior view, to show the excavated keel that houses the enlarged trachea (associated with its trumpeting call) in the Whooper Swan.
number of manuals that help, though they are not readily available. Domestic Fowl and Pheasant are quite close in size and morphology, so distinguishing their bones has attracted attention over many years (Lowe, 1933; Erbersdobler, 1968). Even when their sizes match (and breeds of Fowl are so variable that size is not a very reliable character), there are morphological characters that allow most major bones to be discriminated, so long as they are reasonably complete. The sternum, for instance, a major bone because it carries so much meat, has a distinctively shaped rostrum or anterior spine, differently shaped precostal processes, and numerous other differences of shape (Figure 1.8). The grouse are even more different in shape, though Black Grouse and Capercaillie are rather similar to each other. The cock Capercaillie is much bigger, though the hen is nearer to Black Cock in size – and occasionally, the two hybridize, just to add to the confusion. Capercaillie are more likely to be confused, on size, with Peacock or Turkey, but these two also differ in shape from it, and from each other. The smaller game birds are harder to differentiate reliably. For instance, Ptarmigan are closely related to Red Grouse, therefore morphologically similar, and although they are a little smaller, they do overlap in size. Though their metatarsi can be separated – Red Grouse are bigger – their humeri overlap in size, so that a large one will be Red Grouse, a small one Ptarmigan, but some in the middle of the size range will not be distinguishable. The partridges Perdix and (in southern Europe) Alectoris are close enough in size to these grouse to need careful scrutiny, though differences in shape do separate the families more readily. The Hazel Hen also falls into this size range, and is particularly close in size to Grey Partridge, though it differs in detailed shape (Kraft, 1972).

Among other species of particular interest for the study of British birds, Golden Eagle and White-tailed Eagle are not particularly closely related, so that in addition to size differences (White-tailed has much longer wings, and therefore wing bones), most bones can be distinguished morphologically. The metacarpal carries a spiral groove in the Golden Eagle, whereas the equivalent is straight in the White-tailed Eagle, the articular surface for the fourth (outer) toe is flat in the Golden but rounded and extends further distally in the White-tailed Eagle, and the coracoid has a much wider anteroventral corner in the White-tailed Eagle. One detailed
difference is remarkable – some of the toe bones of the White-tailed Eagle are fused, a very distinctive feature (Figure 1.9). The various falcons form a graded (p.13)
series, from the large Gyr, through Peregrine to Kestrel and Hobby and the small Merlin, which can be separated on size reasonably well, though Hobby and Kestrel overlap. The possible importation of exotic species for falconry could cause further confusion. The broad-winged Accipitridae are more difficult, because of extensive overlap in size between, for instance, kites and Hen Harriers, but morphological as well as size differences are demonstrated by Otto (1981) for the fore skeleton and Schmidt-Burger (1982) for the hind limb bones.

**Fig. 1.9** Eagle bones compared. A carpometacarpus: Golden Eagle (GE) has a spiral tendon groove (tg) on metacarpal 3 which is relatively straight in White-tailed Eagle (WtE). B, C, tarsometatarsus: more slender, curved laterally, with a smaller trochlea 4 and (C) a rhomboidal, but smaller, hypotarsus (ht), with a foramen in it, in Golden Eagle. D coracoid with a much smaller postero-ventral angle (pva) in Golden Eagle. E humerus: has a much deeper but narrower pneumatic fossa (pf) in Golden Eagle.
Waders form an interesting though minor (numerically) group of food species, of which Woodcock is much the most frequent. Because of its distinctive size, it can usually be identified readily. By contrast, distinguishing Golden Plovers from Grey Plovers is barely possible, (p. 15) though the former is much more abundant, more widespread (especially in winter), slightly smaller, and was subject to specific hunting techniques, so is surely the plover present in most sites. The Lapwing, which seems to be a similar sized bird, is actually appreciably larger; in most limb bones, and can be recognized quite readily.

The most difficult group, inevitably, is the passerines. Identifying them as passerines is fairly straightforward. The humerus, for example, has a complex arrangement of depressions, fossae, at its proximal end on the dorsal side, which among other things hold the wing-folding muscles. The shaft is straight (not bowed as in, for instance, similar-sized small waders), and the complex of condyles distally is also distinctive. The metatarsus ends in three very evenly sized trochleae, whereas in many birds the middle trochlea is larger and extends well beyond the two side-toes. The difficulty is in distinguishing passerines from each other. Even the Corvidae, which are so much larger than most passerines, pose problems.

**Fig. 1.8** Galliform sterna, to show diagnostic differences between species. Relevant anatomical features are labelled on the small drawing of the Red Grouse sternum in the centre: ai abdominal incision; ap abdominal process; cf coracoid facet; dpp dorsal precostal process; f foramen; k keel; r rostrum (manubrium); rf rib facets. The foramen in the rostrum is a characteristic galliform character. The enlarged oblique views of the rostrum and dorsal precostal processes highlight their different shapes and lengths; in Phasianidae (above) the processes are usually longer relative to the rostrum than in Tetraonidae (below), but are more upright in Guinea Fowl and Peacock. Q Quail; DF Domestic Fowl; GF Guineafowl; T Turkey; Pe Peacock; Ph Pheasant; GyP Grey Partridge; RIP Red-legged Partridge. RG Red Grouse; BG Black Grouse; Pt Ptarmigan; C Capercaillie.
in that Rook and Crow overlap substantially in size, as do Jackdaw and Magpie, though the detailed guide by Tomek & Bocheński (2000) allows better discrimination, on morphological characters and bone proportions. At least the Raven has a very distinctive size and morphology, as does Jay at the opposite end of the size range (so long as Nutcracker can be plausibly ignored; Azure-winged Magpie and Siberian Jay are much smaller). Among the smaller passerines, distinguishing, say Song Thrush from Redwing, or Blackbird from Fieldfare or Ring Ouzel is likely to be impossible, or only possible with the best of specimens and a good comparative collection or some additional skill, such as DNA typing. This would rarely be available, or worthwhile, in an archaeological context. It is though remarkable how quite subtle size differences can sometimes be detected. Most birdwatchers would not expect to tell Meadow Pipit from Tree Pipit on size, yet the Tree Pipit humerus is perceptibly larger. However, even such an osteologically distinctive species as Swallow overlaps substantially in size with House Martin.

In summary, distinguishing bones of passerines or waders to family level is usually possible, genera are usually separable, but specific identification is very tricky; reciprocally, identifications offered in bone reports should be treated circumspectly (Figure 1.10).

One point inevitably emerges from all these discussions: a reference collection is essential. Even a partial collection helps considerably to ensure at least the correct assignment of a specimen to its order. Hence anyone actively involved in identifying bird bones, whether from archaeological sites or owl pellets, soon finds themselves scavenging corpses from roads and beaches, asking zoos, bird hospitals, or vets for dead specimens, and hiding decaying specimens in pots to recover bones later. If a reasonably representative collection can be assembled, it is often possible to eliminate obviously wrong answers and get close to a right one. More likely identifications can then be checked at a national museum collection, perhaps at Tring (where the British Museum (Natural History) collection is housed), at the Royal Scottish Museum, Edinburgh, or in Cardiff, Dublin, or Belfast. Some local museums (e.g. Sheffield) and university departments (e.g. Archaeology, Southampton) also have good collections.
A couple of examples will illuminate this discussion. Back in the 1970s, an excavation at Abingdon yielded a collection of bird bones that were sent to Don Bramwell, then one of the few people with experience of identifying bird bones in Great Britain. It included two smallish metacarpi with a very distinctive anatomy – that is, they were potentially identifiable – but which fitted nothing in his quite extensive reference collection. Persevering, he realized that they were very similar to Cormorant and Shag, but much smaller, and he suggested that they would prove to belong to Pygmy Cormorant; they were sent to Tring, and so it proved (Bramwell & Wilson, 1979; Cowles, 1981; see p. 92). A more personal example actually involved an owl pellet analysis, of some Tawny Owl pellets from near Macclesfield. One of them included a large intact tarsometatarsus, much larger than the usual thrushes or Starling, which was evidently from a bird weighing about 200 g. What birds of that size might a Tawny Owl eat? One of the corvids, perhaps Magpie or Jackdaw, seemed most likely, but it was clearly not a passerine bone. A Black-headed Gull, Lapwing, or Golden Plover? No, it didn’t match any of them either. The site in question was a wet marshy one, and Water Rail (too small) or Moorhen (too big) were considered, and on morphology not a Rail anyway. The problem was left on one side for some weeks, but then a thought occurred. A Kestrel weighs about 200 g, and sure enough the morphology when checked was exactly right. Throughout the compilation of records that underlies this book, we have, for the most part, had to accept the identifications offered by the original identifiers. A few collections (p.17) have been reviewed, most notably by the late Colin Harrison (see especially Harrison, 1980a, 1987a), but many are lost, or at least untraceable, and in any case there are far too many for all to be re-examined. Some groups would benefit from restudy, and there are some good PhD research topics suggested by our account. If we can present our review as a working hypothesis of what we think is known,
and stimulate others to challenge it by further study, we will have succeeded in a major objective.

**Fig. 1.10** Size range of a selection of passerine humeri, to illustrate the difficulties of separating related species. The crosses indicate one standard deviation of the sizes in modest samples (mostly 5–10) of reference skeletons (except only 1 Dipper (D)). Passerines readily divide into a smaller group (warblers, chats, finches, etc) of 5–25 g body mass, and a larger group (thrushes, larks, starlings) of 50–110 g, with few species (e.g. Dipper) in between. Within these groups, hirundines (House Martin HM, Swallow Sw) have short, stout humeri, but overlap. Seed-eaters (Tree Sparrow TS, House Sparrow HS, Yellowhammer YH) have stouter humeri than insectivores (Great Tit GT, Meadow Pipit MP, Pied Wagtail, PW). In the larger group, Skylark (Sk) and Redwing (Rg) overlap in size, but the pneumatic fossae are very shallow in larks, deeper in thrushes. Song Thrush (ST) and Starling (St) are similar lengths but differ in morphology. Note the complete overlap of Blackbird (B) and Fieldfare (F) (and Ring Ouzel). Mistle Thrush is distinctively larger. At the opposite end, Goldcrest (G) is indistinguishable from Firecrest, and Blue Tit (BT) is likely to overlap other small tits. Wren (W) overlaps Willow Warbler and Chiffchaff (after Dissaranayake 1992).
Problems of dating

Dating can be absolute or relative, direct or indirect. Absolute dates (years in the historical record) can come from documents and artefacts, or from the specimens themselves. Annual rings in trees and layers in lake deposits give absolute dates, and they are direct dates of the layers in question. Bones lying in a lake deposit might be dated indirectly from the layers in which they lay, though it would be a remarkable event to be able to do so. The best known way of obtaining direct dates of organic materials, including bones, is radiocarbon dating. Plants incorporate a small amount of radioactive carbon ($^{14}$C) in the carbon dioxide they use to synthesize material, and animals eat these plants. The minute amount of radioactive carbon decays with time, such that the amount left after 5,560 years is halved. The rate of radioactive decay is not affected by temperature, pressure, chemical, or biological changes, so the rate of decay gives a direct measure of the time that has passed since the plant absorbed the carbon dioxide. Because the amount of radioactive carbon is so small, it effectively vanishes after about 40,000 years and the technique cannot be used on older material, but that is quite long enough to estimate time for the archaeological period, the last 15,000 years or so, that interests us here. There is a further complication, that the dates provided do not exactly match calendar years as one goes back in time; at the end of the Last Glaciation, about 10,200 years ago according to the radiocarbon clock, careful analysis of tree rings and other sources of direct dates suggests that the correct date was more like 11,700 years ago. Radiocarbon years are usually quoted as ‘years b.p.’ (before present), while absolute calendar dates, usually termed calibrated dates, are quoted as ‘years BP’ or even ‘years BC’ (for which, take off 1950 years, because radiocarbon dating works from a baseline of AD 1950). We have quoted the radiocarbon dates, as presented by the original accounts, throughout this account.

There is a further problem with radiocarbon dating, that it is expensive (currently, about £100 per date), so more frequently relative dates are used. If bones occur in obvious archaeological contexts, a twelfth century castle, perhaps, or a Bronze Age barrow, it is often sufficient to assign them that appropriate cultural date. In practice, most bones are dated this way. There are some obvious pitfalls to doing this. Bones might have been dropped into a ditch that was dug into earlier
layers, conferring on them apparent dates that are much too early. Some deposits, particularly loose scree in cave sites, are rather ‘porous’, so that bones work their way into earlier layers, or are carried there by burrowing animals such as Badgers and Foxes. However, for the great bulk of bird bones from conventional archaeological sites, relative dating works well. For earlier archaeological periods, the time spans are greater, because cultures changed more slowly (lasted a longer time) (Table 1.1), but the more recent times, with such very datable artefacts as coins and jewellery, even direct documentary evidence, give more precise dates.

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The geological timescale used to date fossil birds is reasonably familiar, at least in general. Birds evolved from small bipedal dinosaurs in the Jurassic period, 194 to 135 million years ago (Ma). The earliest certain bird, *Archaeopteryx*, dates to the Upper Jurassic, about 150 Ma (Chapter 2). Birds from the succeeding Cretaceous, 135 to 65 Ma, are known from Spain, China, Mongolia, and the USA, but are scarce in Britain. Nor are there Palaeocene (65 to 55 Ma) fossil birds from Britain. However, in the Eocene London Clays, about 54–47 Ma, a substantial avifauna of some 55 or more species has been found (Feduccia, 1996). There is then another gap in the British fossil bird fauna, through the Oligocene, Miocene, and most of the Pliocene, until a few specimens turn up at the top of the Pliocene, about (p.19) 2 Ma. The Pleistocene, the period of the ice-ages, covers the last 1.8 Ma. Because of the
frequent cycles of glacial and interglacial times, a strict chronology is hard to apply in our latitudes; succeeding ice sheets wiped out the traces of earlier ones, while deposits tend to be confined to individual sites, and hard to correlate across the country, let alone to elsewhere in the world. Deep sea cores, which retain a complete record, suggest as many as nine glacial and nine interglacial periods (Shackleton, 1977; Shackleton et al., 1991) but it is hard to recognize as many as four of each in Britain. A simplified system of Anglian, Wolstonian, and Devensian (Last) Glaciations, but Cromerian, Hoxnian, pre-Ipswichian, and Ipswichian (Last) Interglacials separating them, plus the mild Flandrian or Postglacial period in which (p.20) we are living, gives a loose template against which to present the accumulating knowledge of our early bird faunas (cf. Stuart, 1982; Yalden, 1999).

In Britain, and for this book, the last 15,000 years form the period of most interest, because the maximum spreading of the ice sheet in the Last (Devensian) Glaciation at about 20–18,000 years ago (20–18 ka) wiped out most biological activity in this country. Our present fauna and flora has arrived since then (Chapter 3). Initially, as the ice retreated about 15,000 years ago, in the Late Glacial period, a flora of open-ground species, wormwood, grasses, sedges and herbs, was able to colonize. By about 12,000 b.p., birch scrub covered much of southern Britain. Human hunters, of the Upper Palaeolithic (Old Stone Age) culture, spread into what is now Great Britain, leaving their food remains and stone tools in caves in places such as the Gower Peninsula in South Wales, the Mendip Hills in Somerset, and Creswell Crags on the Derbyshire/Nottinghamshire border. However, the climate then deteriorated again for a short period. Ice caps formed on the Scottish mountains again, and spread as far as Loch Lomond, so geologists call this period the Loch Lomond Readvance; it is better known by the archaeologists’ term, the Younger Dryas (because Mountain Avens Dryas octopetalla is a plant commonly preserved in sites of this age). At about 10,200 b.p. (probably about 11,700 BP), the climate suddenly improved, to herald the warm Postglacial period, also known as the Flandrian or Holocene, in which we are fortunate to find ourselves. This climate change was very rapid: about an 8°C rise in mean summer temperatures in 50 years or less. It took the forest vegetation some 2,000 years to spread back into Britain, but animals reacted much more quickly. Beetles
provide the best documentation of this, but what information we have of birds, mammals, and indeed humans matches the evidence from insects. The humans who returned were still hunters, using stone tools, but of a new culture, the Mesolithic (Middle Stone Age). Their encampment at Star Carr near Scarborough is one of the first post-glacial sites that is both well dated and informative about the birds and mammals then living in Britain. As woodland spread back across the landscape, lowland Britain may have become too thickly wooded to provide easy hunting conditions, though archaeologists and ecologists are still arguing about this. There must have been clearings along river valleys and the coast, perhaps more widely. Either way, the fine flint arrowheads and tiny flakes that Mesolithic people used to barb spears are frequently found in the uplands, in the Pennines, for example, and they may have hunted deer and Aurochs (wild cattle) in the more open glades and woodland edges that surrounded the less tree-covered uplands. They clearly used coastal sites to gather fish and molluscs, as well as birds and seals, for instance on Oronsay. Their only domestic animal was the dog, already domesticated from the Wolf.

As the ice caps had melted in the post-glacial period, so sea level correspondingly rose to drown the Doggerland that formerly extended across to Germany and Denmark. Probably this happened by around 8,000 b.p., drowning much coastal foraging habitat and many Mesolithic sites in the process. About 5,500 b.p., however, the New Stone Age (Neolithic) culture spread into what were by then the British Isles. This culture originated in the Middle East, about 9,000 years ago, and spread more quickly westwards through the Mediterranean areas of southern Europe than northwards. However, it certainly reached the Atlantic and North Sea coasts by around 6,000 b.p.. We do not know much about the ships used by these people, but they evidently were competent sailors, carrying not only themselves but their domesticated livestock, sheep, goats, cattle, and pigs, as well as cereals and other plants to (p.21) sustain an agricultural existence. They arrived in both Ireland and Great Britain about 5,800 b.p. (4,600 BC), and the Mesolithic way of life died out very suddenly. Both the mammal remains at early Neolithic sites (Yalden, 1999) and analysis of the carbon isotopes in human bones (which indicate the difference between terrestrial and marine diets) show that these ancient Britons quickly gave up
their hunter-gatherer existence and exploited instead the new crops and livestock (Richards et al., 2003). These new farmers slowly cleared some of the forest, so providing open habitats for farmland birds, creating both open pasture, especially on the downlands of southern Britain, and cereal fields. By 4,500 b.p., they were creating large monuments such as Stonehenge in essentially open countryside, more appropriate for Skylarks than Chaffinches. Their tools though were still made of bone, antler, and especially flint, as mined for example at Grime's Graves, in Norfolk, using antler picks. Metal tools, initially copper and then bronze, were added to their armoury around 4,100 b.p, (about 2,500 BC) and then iron tools appeared about 2,700 b.p. (i.e. about 880 BC). The Celtic peoples, the Ancient Britons, using these iron tools were invaded by Roman peoples temporarily in 55 and 54 BC, under Julius Caesar, and then more permanently under Claudius in AD 43. The Romans in turn retreated as their capital was threatened around AD 410, leaving a Romano-British culture threatened, then displaced in England, at least, by Anglo-Saxon invasions from northern Germany and Denmark. The Anglo-Saxon society that emerged from the Dark Ages was itself threatened by Viking invasions in the period AD 800–1000, before being subsumed by those Vikings who had settled in Normandy, the Normans, after AD 1066. The Mediaeval period, covering the thirteenth to sixteenth centuries, and the Post-mediaeval seventeenth to twentieth centuries, complete the cultural sequence. In Ireland, which the Anglo-Saxons never settled, the Christian Celtic cultures survived through, despite Viking invasions and settlement, while in Scotland the interactions of Anglo-Saxons (in the south), Picts, Scots (Celts invading from Ireland), and Vikings (especially in the islands) produce a more complex chronology than in England. Never-the-less, for the purposes of this account of the bird life of these islands, the succession of cultural periods, Upper Palaeolithic, Mesolithic, Neolithic, Bronze Age, Iron Age, Roman, Anglo-Norman, Mediaeval, and Post-mediaeval, provides us with the broad timescale we use here to describe and evaluate the changes in bird faunas. Most archaeological sites, and the bird remains contained in them, can be allocated at least to these broad periods.

Sources of bones
Bones are poorly preserved in acid sands or peats, better preserved in limestone caves or the silts of flood plains. Some early bird specimens come from maritime clays, and some of
The earliest Pleistocene archaeological sites (Boxgrove, Swanscombe) are in coastal or riverine gravels. Most of the Late Glacial sites are caves in limestones, particularly in Carboniferous Limestones of the Mendip Hills of Somerset, the equivalent outcrops of Devon and South Wales, including the Gower Peninsula, and in the Peak District, shared between Derbyshire and Staffordshire. Permian (Magnesian) Limestones at Creswell Crags on the Derbyshire/Nottinghamshire border have also yielded important evidence. Post-glacial history is more usually represented at conventional archaeological sites, such as the Mesolithic camp site at Star Carr, the Iron Age village at Glastonbury, and the famous Irish eighth century site of (p.22)

![Map of archaeological sites yielding bird bones: heavily clustered in England, thinly sampled in Ireland, Man, Scotland and Wales, but note the strong sample of Orkney sites. Older (Pleistocene/Late Glacial) sites are mostly](image-url)
Lagore. With the Roman settlement, many of the best faunas come from excavations of conventional castles, villas, and other buildings. The Anglo-Saxons seem to have abandoned the cities that the Romans built, living at least initially in small farmsteads such as West Stow. As their population increased, they too developed towns, and the excavations of Ludenwic (London) and Hamwic (Southampton), not to mention the important series of excavations at Eoforwic/Jorvik (York), have given us much useful information about bird life of those times. With the Norman invasion came another episode of castle-building, and excavations of, for example, Launceston, Stafford, and Wakefield Castles have also provided extensive bird faunas. In analysing these faunas, we have a data base of over 9000 records (8,953 as of 17 March 2004, when we started writing, with about 200 added since). These identify a species at a site and age/layer; from 740 sites, mostly archaeological sites but including the Pleistocene sites from gravels and caves. The most abundant record comes from England (594 sites), because most archaeological and cave sites are there, but Ireland (27), Man (four), Scotland (80, including 19 on Orkney, two on Shetland and nine in the Hebrides) and Wales (28) are also represented, as are the Channel Isles (with just four sites) (Figure 1.11).

Conclusions
Most larger bones of larger species of birds can be recognized reliably, though access to a good reference collection is invaluable. The relevant manuals are also important aids. Species in more diverse groups are more difficult to identify reliably; conversely, identifications offered in published literature, including this book, need to be accepted with some caution. For the most part, we have had to accept the identifications offered by the original describers, there being simply too many for us to have checked them all. Dating is usually achieved by reference to the archaeological context, which in turn requires that the excavation was carefully conducted. In many cases, only larger bones were extracted and identified. On the one hand this is convenient, as the larger species are also more readily identified, but on the other, the result is a double bias against the record of the smaller species, particularly the passerines: these are difficult to identify, and their remains are only reliably recovered if the sediments from archaeological excavations have been sieved.
The bird in the hand...