Archaeofauna 2 (1993): 191-204

BIRD BONE TAPHONOMY FROM THE INSIDE OUT: THE EVIDENCE OF GULL PREDATION ON THE MANX SHEARWATER *Puffinus puffinus*

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ABSTRACT: During a visit to the island of Skomer, South Wales, UK, in July 1992, we saw many dead manx shearwaters, assumed killed by great black-backed gulls *Larus marinus*, with distinct pattern of damage to the carcass. In this paper we describe and illustrate the traces of damage seen on the bones and the sequence of disarticulation of the carcass. The gulls make a distinctive gash in the sternum, and some less distinctive breaks in some other bones. The first part of the carcass to become disarticulated is the head, which has often been turned inside out by the gull. This is followed by the legs, which become detached from the body separately. The two wings and pectoral girdle remain in articulation longest, after all the flesh has been removed.

Past work on bird bone taphonomy has used the evidence of surface preservation of the bones and the ratios of the main anatomical elements. Though the Skomer birds provide some support for the hypothesis of Ericson that birds from natural deposits will be represented mainly by their wing bones, this may be an oversimplification. The anatomical distribution of two small archaeological groups is considered, from the Udal North, Hebrides, Scotland, and from Launceston Castle, Cornwall, England. The context of both suggests an anthropogenic origin, but anatomical distributions are very different.

Measurements of the humerus, ulna and tarsometatarsus are given in Appendix 1. The tarsometatarsus length is compared with an earlier sample from the same island.

KEYWORDS: MANX SHEARWATER *Puffinus puffinus*, GULL PREDATION, BIRD BONE, TAPHONOMY, ARCHAEOLOGICAL FINDS, MEASUREMENTS

RESUMEN: Durante una visita a la isla de Skomer, en el Gales meridional (Reino Unido), durante julio de 1992, detectamos la presencia de numerosos cadáveres de pardela pichoneta, presumiblemente muertas por la acción del gavión (*Larus marinus*), con un peculiar patrón de daños, apreciable en las carcasas. En este trabajo describimos e ilustramos las señales de ataque en los huesos así como la secuencia de desarticulación del cuerpo. Las gaviotas realizan un corte peculiar en el esternón y otra serie de fracturas menos características en otra serie de huesos. La primera porción del cuerpo en desarticularse es la cabeza, a quien, con frecuencia, la gaviota vuelve del revés. A continuación vienen las patas posteriores que se separan del tronco de forma independiente. La cintura pectoral y ambas alas son las zonas que durante más tiempo permanecen en conexión anatómica, después de haberse eliminado la carne.

Los trabajos de tafonomía aviar han hecho uso preferente, hasta la fecha, de la conservación de restos en superficie y de las relaciones entre los principales elementos anatómicos. Aunque los ejemplares de Skomer apoyan en cierta medida la hipótesis de Ericson de que las aves en depósitos naturales se encuentran principalmente representadas por huesos alares, tal aseveración no deja de ser en exceso simplista. Así, en dos pequeñas muestras ornitoarqueológicas, de aparente origen antrópico, procedentes de Udal North (islas Hébridas, Escocia) constatamos dos muy diferentes patrones de representatividad esquelética. Las medidas de los húmeros, ulnas y tarsometatarsos aparecen recopiladas en el Apéndice 1. La longitud del tarsometatarso se compara con una muestra más antigua de la misma isla.

PALABRAS CLAVE: PARDELA PICHONETA *Puffinus puffinus*, DEPREDACION GAVIOTAS, TAFONOMIA, HUESOS, AVES, MUESTRAS ARQUEOLOGICAS, MEDIDAS

INTRODUCTION

During a visit to the island of Skomer, South Wales, in July 1992, we saw the many dead manx shearwaters. We collected a sample for study, and in this paper describe the traces of damage left on the bones, and the sequence of disarticulation of the carcass. Such observations can contribute to understanding the taphonomy of the bones of manx shearwaters and other birds found on archaeological sites, and the question of whether or not the bones are anthropogenic in origin.

In the second part of the paper previous work on bird bone taphonomy is reviewed, and the anatomical distribution of two small groups of shearwater bones is discussed.

THE SHEARWATER COLONY ON SKOMER

Skomer is one kilometre from the Dyfed peninsula, off the south west tip of Wales (Figure 1). It has the second largest breeding colony of manx shearwaters in the world, after the island of Rhum in the Hebrides, Western Scotland. Along with its sister island, Skokholm, one kilometre to the south-east, it has been the study site for much of what is known about the species' population biology (Lockley, 1942; Brooke, 1990). These studies also considered predation and mortality. There are approximately 100,000 breeding pairs on Skomer. Adult birds return during March, with the first eggs being laid during May. By late June the young are hatched, with fledging taking place during August and September. The parent birds return at night for nest building, incubation and feeding the chicks, and leave the island before dawn. They lay the eggs in burrows in the light sandy soils. This is thought to keep the temperature constant and to hide the eggs and chicks from predators. The island is no longer farmed (Evans, 1990) and has no mammalian predators. The breeding populations on islands which have been colonised by ground predators, mainly rats, are much reduced or have disappeared.

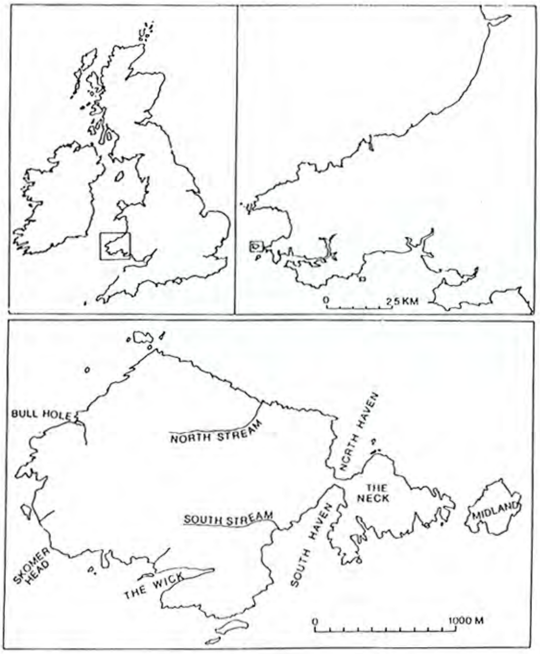

FIGURE 1 - Location of Skomer island.

THE SAMPLE

Human movement on the island, a National Nature Reserve, is restricted, but dozens of part carcasses and a few which were almost complete were seen lying on the ground in the immediate vicinity of the path round the island which visitors follow. The carcasses were concentrated into discreet areas which seemed to have little or no bearing on the distribution of burrows. We collected from all round the island except the Neck. A total of 33 complete and part carcasses was collected. Carcasses in a range of different stages of disarticulation were selected. They were cleaned for study at the Faunal Remains Unit, Department of Archaeology, Southampton. The remains were raised to boiling point in water, and when the temperature had dropped to 37°C a proteolytic enzyme, Neutrase, was added; they were then left for between three days and three weeks. The bones were then gently brushed and rinsed clean.

THE PREDATOR

It seemed likely that only one predator was involved, but the restrictions on movement precluded any search for predator nest sites. During his research on the breeding shearwaters of Skokholm, Lockley each morning found corpses of birds slain by great black-backed gulls, which he identified from the tell-tale inverted skin. Subsequently, the coincidence of nest sites of the great black-backed gull and dead shearwaters was reported by Corkhill (1973). The birds collected by us also had the inverted skin with the head inside out (Figure 2), and were found in discrete groups, so we are confident that the predator of this sample is the great black-backed gull. The damage to the sternum, described below, also fits this conclusion. There is another possible cause of mortality of the shearwaters on Skomer: the disease Puffinosis, but this was ruled out as the cause of death of these birds as it is suffered mainly by the chicks when they emerge from the burrows in September.

DAMAGE TO THE BONES

The clearest traces are on the sternum. All but one of the 20 collected have some damage, which takes the form of pecking away part of one side of the bone (Figure 3B). At its least, seen on only three bones, the damage consists of a hole in the sternal keel. Those with most severe damage (four) have lost most of the bone other than the proximal end with the coracoidal groove. The peck marks are the most obvious and most characteristic trace of gull damage: some marks and the gouges removed from the bone match the shape of a gull's bill, and suggest that the method of attack was a stab or peck in the breast. That this is indeed the method by which the great black-backed gulls attack and kill the shearwaters is confirmed by the observations of Corkhill.

Other bones which are sometimes damaged are the furcula, scapula, coracoid and tibiotarsus. Eight out of 18 of the furculae are damaged or broken, either cracked on one side (Figure 3A), or completely broken. Of the 35 scapulae, 11 are cracked or broken, and of the 36 coracoids, 28 have the sternal border broken off. The long cnemial crest on the tibiotarsus is also frequently damaged; over half are either cracked or broken through. Just one skull collected is damaged: it is severely crushed on the left and right parietal, as is the mandible from the same bird. No damage is visible on any of the wing bones collected, or on other leg bones.

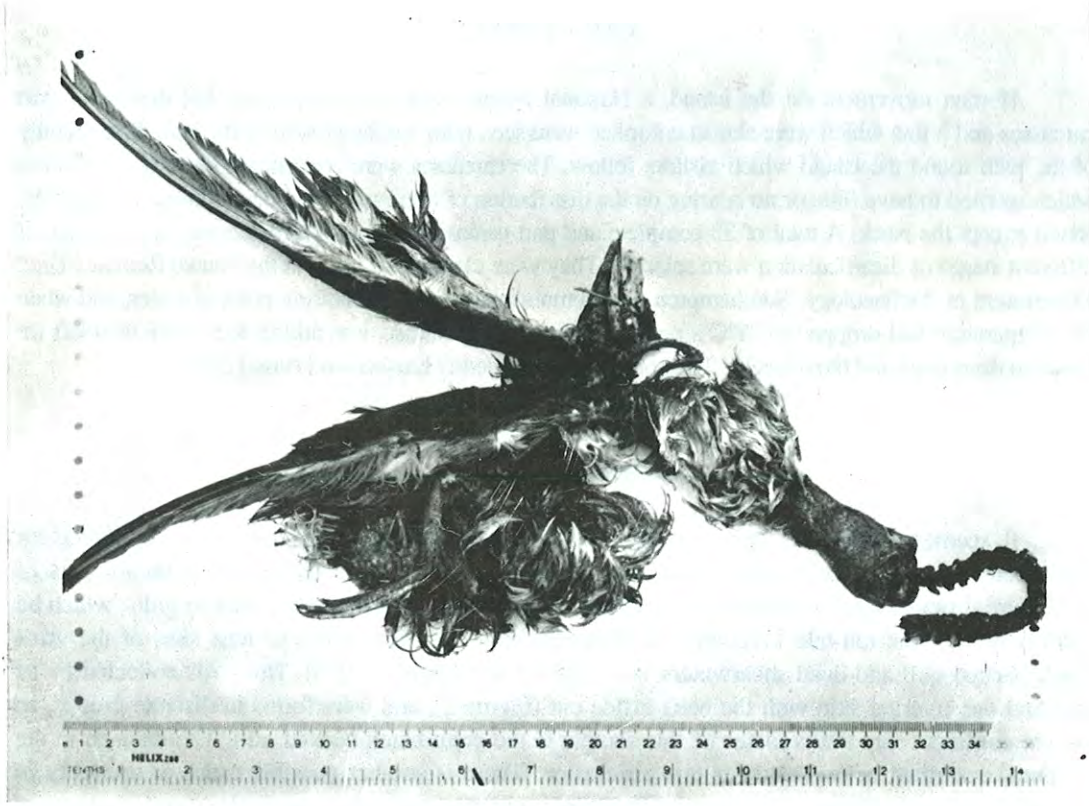

FIGURE 2 - Carcass of manx shearwater killed by a great black-backed gull. The skull is inside out in the skin, the muscle has been eaten, but most of the skeleton survives, held together by skin and ligaments.

The evidence of the bones confirms that the birds were killed by gulls. There is a single carcass which leaves room for doubt, as it has no visible damage on the sternum, furcula, or scapulae, but the sternal border of the coracoid is snapped off.

The further feature of damage inflicted by the gulls which does not affect the bones themselves: they turn the carcass inside out, leaving the head back to front inside the skin, having severed the vertebral column (Figure 2).

SEQUENCE OF DISARTICULATION

The sequence of disarticulation and the relative rate of disarticulation was established by analysis of the bone most often found in articulation in our sample. The first part of the skeleton to disappear is the rib cage; only one of the carcasses found has an almost complete rib cage. The cervical vertebrae then separate and disperse. Skin and ligaments retain the legs attached to the rest of the skeleton for a time. Next each leg from the femur down separates from the rest of the carcass.

We found no examples where these remained in articulation with the synsacrum and with each other, but separate from the rest of the skeleton. The head then separates from the trunk.

The stage during which the carcasses survive as a pair of wings still joined by the sternum, furcula, scapula and coracoid (Figure 4) is a very long lasting one, to judge from the numbers of carcasses seen in this condition, and from descriptions by other workers on Skomer. It is clear that the ligaments of the wing are stronger and resist decay for longer than the others.

DISCUSSION

The damage to the sternum and furcula are characteristic of slaughter by a gull, and the traces are sufficiently distinctive that it would be safe to infer that bones recovered from ancient sites with similar damage were casualties of bird predation, rather than human predation. A long gash in the sternum may distinguish it from the damage caused by a raptor, with a shorter bill. The damage to the scapula, coracoid and tibiotarsus is much less distinctive. Humans or bird predators can damage the parts of the pectoral girdle when disarticulating these bones, or the tibiotarsus if it is roughly pulled or broken apart from the femur, and such traces are quite common on bones from human food remains from early settlements. The sternal border of the coracoid in particular is very commonly damaged. The sternum is unfortunately only rarely recovered in anything like an intact form from excavated sediments.

Turning the skin inside out and leaving the head back to front could in theory be recognised in a fossil or sub-fossil bird, if recording of bones *in situ* is carried out in sufficient detail to show this. On many sites disturbance or compaction of the sediments would distort the association.

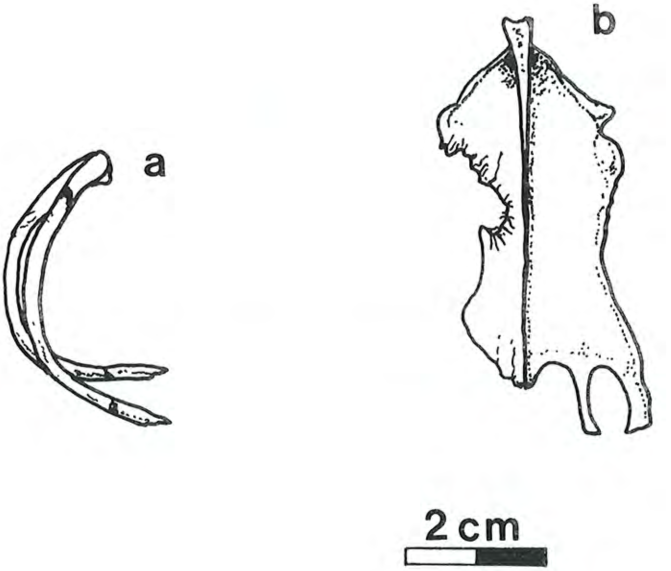

FIGURE 3 - Furcula (a) and sternum (b) of manx shearwater showing damage caused by great black-backed gull.

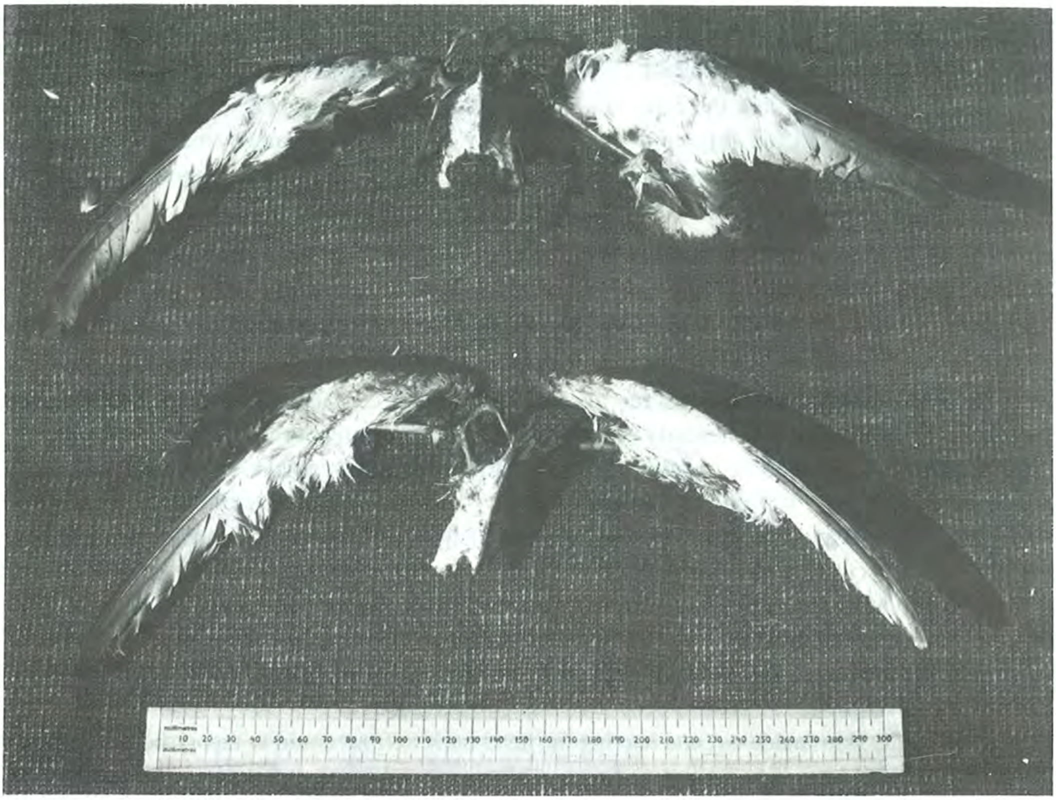

FIGURE 4 - Two part skeletons of manx shearwater comprising the pectoral girdle and wings. Most were found in this condition.

A complete articulated pectoral girdle is not a typical condition in which to find bones of birds eaten by man. Though both humans and gulls will consume the muscle on the sternum, humans are more likely to disarticulate the bones of the pectoral girdle, if only because cooking makes it easier to separate the bones when eating the bird.

BIRD BONE TAPHONOMY

There have been two different approaches to interpreting the taphonomic history of bird bone finds, which have had the aim of identifying whether the predator was humans or other birds. Surface texture is one area of study: bones from bird pellets have a less eroded surface texture than those which derive from human meals (Andrews, 1990; Armour-Chelu, 1988). A second method of analysis has been to examine differences in the numbers of skeletal elements found (Mourer-Chauviré, 1983; Bramwell et al., 1987; Ericson, 1987; Livingston, 1989). These studies have identified contrasts between different assemblages, but proposed conflicting interpretations.

The anatomical elements found in a fissure interpreted as the former eyrie of a golden eagle (Bramwell et al., 1987) included few wing and leg bones, and the most common anatomical elements were the coracoid, scapula and sternum. The interpretation favoured was that the limb bones were eaten: "Complete digestion of these smaller (sic) bones is perhaps more likely". These results do not fit well with the finds from Skomer, and it seems that we should not expect fully consistent results when the circumstances of the find and the predator are so different.

A useful method of analysis has been to contrast the ratio of wing and leg bones (Ericson, 1987; Livingston, 1989). Ericson, counting the humerus, ulna and carpometacarpus to represent the wing, and the femur, tibiotarsus and tarsometatarsus to represent the leg, found that wing bones predominated in natural accumulations. The Skomer shearwaters support this conclusion and suggest that the reason for the disproportion is that the wing bones remain in articulation longer than the leg bones in a carcass not subjected to butchery and cooking.

However, studies of birds from three Nevada sites in the USA suggest that the picture is more complicated. Using the same six bones, Livingston found that the ratio of wing bones of small duck *Anas* sp. was similarly high (81% and 74%) in two assemblages, one anthropogenic and the other derived from owl pellets. Further, when survival in different families and different species from human settlement debris was analysed, ratios varied widely. These suggest instead that density of bone elements was the underlying property which most governs bone survival, a case well accepted in mammal bone taphonomy (Brain, 1976). There is great scope for experimental work, and for analyses of more human midden accumulations on different species.

ARCHAEOLOGICAL FINDS

The anatomical distribution of two small groups of shearwater bones from archaeological sites is now discussed in the light of the Skomer finds and previous work.

Most finds of manx shearwaters have been made on settlements round the west and north coast of Scotland (see eg review in Serjeantson, 1988). At most sites numbers of bones are small, but the manx shearwater is the second most common bird, after the gannet *Sula bassana*, at Buckquoy (Bramwell, 1977), on Mainland Island of the Orkney archipelago, and at Udal North (Serjeantson ND, Serjeantson, 1988), on North Uist, Hebrides, Scotland. More surprising are finds from inland sites: there is a single bone from sixteenth century deposits at Baynards Castle, London (Bramwell, 1975), a collection which is otherwise mainly ducks and waders, and 10 from AD C13TH and C14th deposits at Launceston Castle, Cornwall, England (Albarella & Davis, in prep.).

At both sites the circumstances and context of the finds are such that we can be confident that the birds were collected for food. Capture of manx shearwaters and other seabirds is well documented around the English and particularly the Scottish coasts and islands from the time of the earliest written records. They were collected both for local consumption and for trade. They were captured and exported from their breeding colonies on the Isle of Man (from where the birds derive their name), the Faroe Islands, the Hebrides (Baldwin, 1974), Orkney, Shetland (Fenton, 1978, 510), and the Scilly Isles (Brooke, 1990). In early times when rents and dues were paid in agricultural produce, they formed part of the rents of the Hebridean islands of Mingulay, Barra and Rhum (Elwes, 1869), and part of the feudal dues of the Scilly islanders of south west England.

The context of the finds also suggests strongly that the bones are from birds which were consumed. At the Udal the bones were found with food remains among the debris from a settlement, some 400 m from the shore. Even more than the Udal, the context of the Launceston finds effectively rules out any origin other than human, as the castle is on the mainland 20 Km from the nearest coast. One tibiotarsus is from an inmature bird: the bone is as long as the adult bones and the distal end is ossified, but the proximal end is unfused and porous in texture. In the nineteenth century, fledgling chicks were selected for capture in August and September, by which time they have reached adult size, and are "so very fat that you would take it to be wholly fat" (quoted by Fenton, 1978, 511). It is especially unlikely that a bird at this stage of development could have been found near the castle naturally. Here too the bones are with others which are clearly food remains.

At the Udal, if the same six elements analysed by Ericson and Livingston are counted, 78% of the bones are from the wing and 22% from the leg (Table 1). Radii, and coracoids were also found. The tarsometatarsus from phase VII-IX was found with three foot phalanges. All the sediments were sieved. The most obvious interpretation of the imbalance is that wing bones are larger and more robust than the leg bones.

The Launceston sample is much more selected, consisting as it does of 10 bones, all of which are tibiotarsi, six complete, and four broken mid-shaft. The lack of other parts of the skeleton here is difficult to explain. Differential survival cannot account for the survival of the tibiotarsus over the humerus and ulna, both relatively long and robust, so the explanation must lie elsewhere. Equally, partial recovery due to the failure to sieve the deposits in bulk cannot explain the absence of wing bones, though could account for the lack of femora, a relatively small bone in the procellariformes. The presence of leg rather than wing bones could be taken to confirm Ericson's conclusion that these are more common in humanly generated deposits, the likely explanation here being that wings were removed before the birds were packed for storage and transport.

	Udal V-VI	Udal VII-IX	Udal IXc-X	Udal XI-XIII	Udal total	%	Launceston C13th/C14th	%
HUMERUS		4	3	2	9			
ULNA		5		2	7			
CARPOMETACARPUS		1	1		2			
subtotal wing					18	78.3		
FEMUR	1				1			
TIBIOTARSUS	1			2	3		10	
TARSOMETATARSUS		1			1			
subtotal leg					5	21.7		100
wing+leg					23		10	
CORACOID		2			2			
RADIUS		4		1	5			
total	2	17	4	7	30		10	

V-VI AD C14TH -C15TH; VII-IX C1160-1300; IXc-X c800-1160; XI-XIII c300-800

TABLE 1 - Anatomical distribution of bones of manx shearwater *Puffinus puffinus* from Medieval deposits at the Udal, Outer Hebrides, Scotland and Launceston Castle, Cornwall, England.

The tibiotarsi from Launceston bones were also examined for damage. Part or all of the cnemial crest is broken off in each specimen where the proximal end survives. As discussed above, this part of the bone is so fragile that it is liable to break under any pressure, and, if not broken before deposition, is only too likely to fracture under pressure from compaction of the sediments in which it is buried. The midshaft breaks could well have been made by humans, though they show no very clear chops or cuts at the break points.

CONCLUSION

The study of the Skomer birds has helped to illuminate some of the processes of damage to birds killed by agents other than man. In our present state of understanding of bird bone taphonomy, anatomical distribution alone cannot provide an answer to whether bones were accumulated by humans or other animals, but may have a part to play. At the Udal and Launceston, the context of the finds was the most important evidence for their origin. Nevertheless, just as with mammals, analysis of the anatomical elements and of damage to the bones both have important parts to play in identifying the origin of the bones.

ACKNOWLEDGEMENTS

We thank Stephen Sutcliffe, Warden of Skomer Island National Nature Reserve, for permission to collect carcasses, Simon Davis and Umberto Albarella for permission to examine the manx shearwater bones from Launceston Castle. Umberto Albarella, Simon Davis and Kevin Rielly kindly commented on earlier version of the paper and we are grateful for their suggestions.

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Appendix 1. MEASUREMENTS

With notable exceptions, there have been few metrical studies of disarticulated bones from modern bird populations, and we are of the opinion that publication of such measurements is useful to researchers engaged in the identification and analysis of bird bones from archaeological sites.

Measurements were taken of the humerus (Table 2), ulna (Table 3), and tarsometatarsus (Table 4). On the ulna the measurement points (Figure 5) are Bp (cf Driesch, 1976, p118, Figure 56b) and GL (56e); on the tarsometatarsus they are GL, Bp, SC and Bd (62b); and on the humerus, GL, Dip, SC and Bd (54c). It can be assumed that all specimens are adult or first year birds; none of the bones show the porosity or unfused condition which would be present at that time of year on the bones of the chicks.

Tarsometatarsus length can be compared with a sample measured by Brooke (1990, 20):

	MEAN LENGTH	S.E.	N
Brooke	45,9	0,17	50
This sample	43,4	0,33	28

The mean length varies by 2.5 mm. This may be accounted for by differences in age class or sex, but it is also possible that the result of the Brooke sample is greater because the bones were still in articulation and unskinned when measured, as his illustration (Figure 2.1) of how the measurements were taken shows. The standard error (S.E.) is greater in this sample no doubt because the sample is smaller.

spec no		GL	Bp	SC	Did
1	R	71.9	6.8	3.3	7.4
1	L	72.2	6.7	3.4	7.4
2	R	72.7	6.6	3.3	7.4
2	L	72.7	6.6	3.3	7.4
3	R	72.3	6.9	3.5	7.5
3	L	72.4	6.8	3.4	7.5
4	R	67.9	6.5	3.2	7.0
5	R	73.8	6.8	3.3	7.6
5	L	73.7	6.7	3.4	7.5
6	R	70.6	6.6	3.3	7.3
6	L	70.9	6.6	3.3	7.2
7	R	72.0	6.5	3.2	7.5
7	L	72.2	6.3	3.2	7.4
8	R	73.5	6.7	3.4	7.4
8	L	73.4	6.6	3.5	7.4
9	R	75.9	7.0	3.4	7.8
9	L	75.9	7.0	3.3	7.8
10	R	71.0	6.7	3.2	7.3
10	L	70.9	6.7	3.2	7.4
11	R	72.4	6.7	3.4	7.4
11	L	72.3	6.7	3.4	7.5
12	R	71.4	6.9	3.3	7.3
12	L	71.6	6.8	3.3	7.4
13	R	71.5	6.7	3.3	7.4
13	L	72.6	6.7	3.3	7.4
14	R	74.7	6.6	3.1	7.5
14	L	74.4	6.6	3.2	7.4
15	R	72.2	6.7	3.3	7.1
15	L	72.4	6.6	3.3	7.2
16	R	71.0	6.3	3.2	7.1
16	L	71.1	6.3	3.2	7.1
17	R	68.7	6.3	3.1	6.9
17	L	68.9	6.3	3.2	6.9
18	R	72.1	6.5	3.1	7.2
18	L	72.1	6.4	3.1	7.4
19	R	72.1	6.7	3.2	7.5
19	L	71.9	6.7	3.2	7.5
20	R	74.0	6.7	3.4	7.3
20	L	73.9	6.7	3.3	7.4
21	R	72.6	6.7	3.3	7.3
22	R	75.4	6.8	3.2	7.4
22	L	75.3	6.7	3.3	7.3
23	R	71.7	6.8	3.3	7.5

TABLE 2 - Measurements of the ulna.

spec no		GL	Bp	SC	Bd
1	R	44.1	5.9	1.7	5.1
1	L	43.8	5.9	1.7	5.2
2	R	44.3	5.7	1.5	4.8
2	L	44.2	5.7	1.6	5.0
3	R	44.1	5.8	1.6	5.3
3	L	44.0	5.7	1.8	5.2
4	R	39.0	5.2	1.2	4.5
4	L	39.1	5.1	1.2	4.6
5	R	44.8	5.2	1.3	4.8
5	L	44.6	5.1	1.3	4.7
6	R	42.6	5.3	1.4	4.6
7	R	42.7	5.3	1.3	4.8
7	L	42.9	5.2	1.7	4.9
9	R	46.1	5.8	1.3	5.3
9	L	45.8	5.8	1.4	5.3
10	R	41.7	5.3	1.4	4.7
10	L	41.2	5.2	1.5	4.8
13	L	43.0	5.3	1.3	4.6
17	R	42.4	4.9	1.3	4.7
17	L	42.2	4.8	1.3	4.7
26	R	41.8	5.3	1.5	4.8
27	L	44.4	5.7	1.7	4.8
28	R	44.5	5.4	1.3	5.1
29	L	46.1	5.6	1.2	4.7
30	L	44.2	5.4	1.3	4.8
31	L	43.9	5.3	1.3	4.7
32	R	44.7	5.4	1.3	4.8

TABLE 3 - Measurements of the tarsometatarsus.

spec no		GL	Dip	SC	Bd
1	R	79.9	19.0	5.4	10.9
1	L	80.2	19.1	5.5	10.9
2	R	78.3	19.9	5.6	11.2
2	L	78.4	19.8	5.5	11.1
3	R	80.4	19.8	5.9	11.6
3	L	80.5	19.9	5.8	11.5
4	R	75.2	18.2	5.2	10.3
5	R	80.1	19.9	5.7	11.1
5	L	80.2	20.1	5.7	11.0
6	R	77.9	20.3	5.9	11.1
6	L	78.0	20.2	5.9	11.0
7	R	78.2	19.2	5.4	10.8
7	L	78.4	19.2	5.4	10.6
8	R	80.2	19.2	5.3	10.9
8	L	80.3	19.2	5.3	11.0
9	R	83.8	20.9	5.8	11.4
9	L	84.2	21.0	5.9	11.0
10	R	76.4	19.8	5.3	10.9
10	L	76.6	19.7	5.3	10.9
11	R	81.1	19.5	5.6	11.0
11	L	81.3	19.4	5.6	11.0
12	R	78.7	20.6	5.9	11.2
12	L	78.9	19.9	5.9	11.0
13	R	78.2	19.9	5.5	11.1
13	L	78.6	19.5	5.7	10.7
14	R	80.2	19.9	5.4	10.9
14	L	80.3	19.8	5.4	10.8
15	R	77.8	19.0	5.9	10.7
15	L	77.9	19.1	5.9	10.7
16	R	77.1	19.3	5.2	10.4
16	L	77.4	19.5	5.2	10.5
17	R	74.6	18.7	5.2	10.1
17	L	74.8	18.9	5.2	10.0
18	R	79.7	19.7	5.4	10.8
18	L	79.8	19.8	5.4	10.8
19	R	79.0	20.3	5.6	11.0
19	L	79.1	20.4	5.6	11.0
20	R	80.4	20.0	5.8	11.0
20	L	80.4	20.1	5.8	11.0
21	R	78.1	19.2	5.6	10.7
22	R	82.0	19.9	5.8	11.1
22	L	82.3	19.9	5.9	10.9
25	L	80.6	18.9	5.3	10.2

TABLE 4 - Measurements of the humerus.

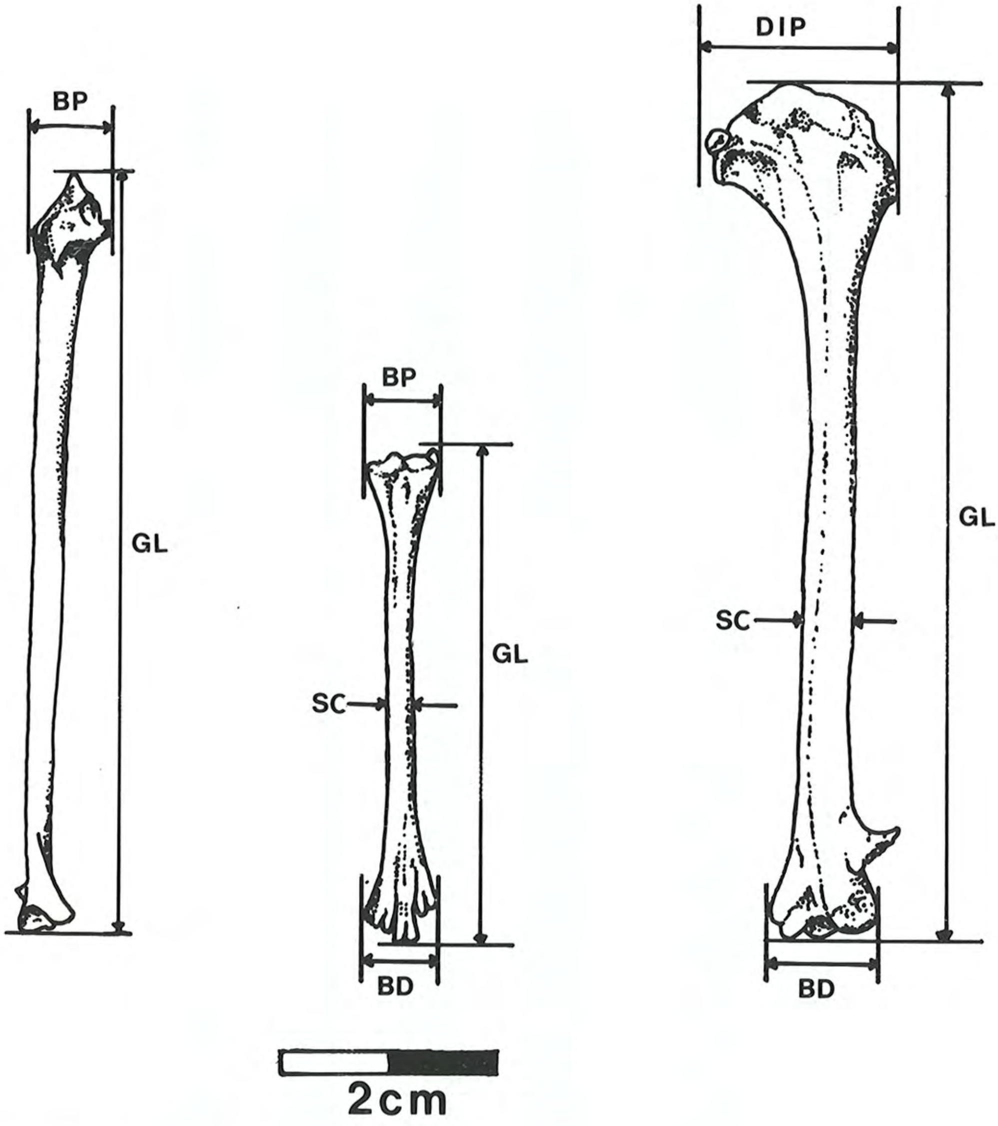

FIGURE 5 - Measurements points on the ulna, tasometatarsus and humerus.