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GIANT DEER.

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A MONOGRAPH

ON THE

BRITISH PLEISTOCENE MAMMALIA

VOL. III; PART III.

THE GIANT DEER.

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MONOGRAPH

ON

THE BRITISH MAMMALIA

OF THE

PLEISTOCENE PERIOD.

THE GIANT DEER.

Order—UNGULATA.

Suborder—ARTIODACTYLA.

FAMILY—CERVIDÆ.

Genus—CERVUS.

Species—*Cervus giganteus* (Blumenbach), Lydekker.
Cervus (*Megaceros*) *hibernicus*, Wilde, Ball.
Cervus megaceros, Hart, Adams, Newton.
Megaceros hibernicus, Owen, Carte.

A COMPLETE list of synonyms is given by Woodward and Sherborn, 'British Fossil Vertebrata,' pp. 332—3. In addition to the misnomer Irish Elk, the animal has been termed the Irish Giant Deer and the Giant Fallow Deer. In the following pages the terms Irish Giant Deer, the Giant Deer and the *Megaceros* are all employed.

I. HISTORICAL INTRODUCTION.

It is not to be wondered at that the remains of an animal so conspicuous as the Irish Giant Deer or *Megaceros*, and occurring in such large numbers, attracted attention in Ireland at a very early date, the first account being T. Molyneux's description (1)[1] in 1697 of a fine skull with antlers found at Dardistown near Drogheda. Molyneux, in a paper very remarkable for the time at which it was written, showed clearly that the antlers were not in any way related to those of the Elk, but believing the American Moose, an animal with which he was imperfectly acquainted, to be distinct from the Elk, he proposed to refer the Irish bones to that species. He suggested an epidemic distemper as a cause of the animal's extinction.

The earliest reference to the occurrence of the Irish Deer in England is T. Knowlton's (1746) (5) description of a skull with antlers found at North Dreighton in Yorkshire. Pennant (1781) (9) pointed out differences between the antlers and those of the Elk and quoted measurements. The Elk is not the only living animal to which

[1] Numbers in parentheses refer to the bibliography.

other early writers have assigned *Megaceros* antlers, for both Pallas (7) and Buffon adopted the view that they were those of Reindeer.

The earliest Continental record is that of L. D. Hermann (1731) (4), who, as Cuvier reports, gives poor figures of remains from Massel in Silesia. Camper (1784) (10) was the first to point out differences not only between the antlers, but the skeleton of Irish Deer and Elk. Other early continental writers on the subject are von Rochow (1781) (8) and de Razoumowsky (1789) (11).

Parkinson (1811) (12) mentioned a number of localities where remains of the Giant Deer were found, and alluded to the antlers from co. Clare presented to Charles II and now at Hampton Court.

Goldfuss (1821) (13) issued a full description of the skull with measurements, and again compared it with that of the Elk ; Cuvier (1826) (15) also gave a general description of the skull, his account being based on an example found in the Isle of Man and now in the Edinburgh Museum. He further showed clearly that the Giant Deer was widely distributed on the European continent. Desmarest (1822) (14) also contrasted the skull and antlers with those of the Elk. The remains of the Irish Giant Deer were described by Oswald (17) and Hibbert (18) from the Isle of Man as early as 1825.

The active study of the remains in Ireland itself was inaugurated by J. Hart (1825) (16), who set up in the Museum of the Royal Dublin Society[1] a skeleton from Rathcannon, co. Limerick, comparing it in great detail with that of the Elk. He first used the name *Cervus megaceros*. A second paper published in 1838 dealt with the method of occurrence of the Giant Deer, but was chiefly concerned with describing the anatomical characters. Weaver (1825) (19) recorded the finding at Dundrum, co. Down, of *Megaceros* remains associated with recent shells, whence he drew conclusions as to the modern character of the deposit. Several general questions relative to the Irish Giant Deer, such as the growth of the antlers, the question as to its contemporaneity with man and the conditions under which skeletons were found, were now attracting attention, and some of these subjects are dealt with in a paper by Scouler (1838) (24).

The fact that the nearest relative of the Giant Deer is the Fallow Deer was first recognized by Hamilton Smith (1827) (20), who in his classification of Deer grouped the two together in the subgenus *Dama*.

Hitherto such authors as had considered the subject were inclined to believe that the female Giant Deer, like the female Reindeer, was provided with antlers. Phillips (1836) (22), however, from an examination of a collection of bones found near Waterford, was able to show that the female was without antlers.

The contemporaneity of *Megaceros* with Man was maintained by H. D. Richardson (1846) (31), who stressed the incorrectness of styling the *Megaceros* the Irish *Elk*.

[1] The collections of the Royal Dublin Society and of the Royal Irish Academy have been incorporated in the National Museum of Ireland.

Mantell, writing in 1851 (35), had no doubt as to its contemporaneity with Man, and even suggested that it was exterminated by the Celtic tribes.

Several important contributions by Owen belong to this period. In his 'Report on the British Fossil Mammals' (26), presented at the Cork meeting of the British Association in 1843, a comparison is made of the antlers of the Irish Giant Deer, Fallow Deer and Elk. In 1846, in his 'British Fossil Mammals and Birds' (30), Owen gave by far the fullest account of the Giant Deer which had hitherto been published, and in 1848, in a paper (33) describing remains from Essex, he produced evidence of its contemporaneity with the extinct Pleistocene mammals—a fact which had been called in question by Richardson. The output of papers by Irish writers continued, Oldham (1849) (34) describing bones from Kiltiernan, and W. R. Wilde (1859) (42) mentioning the existence of sixteen crania in the Academy collection at Dublin.

In 1859 appeared H. Denny's important paper (40) entitled "On the Claims of the Gigantic Irish Deer to be considered as Contemporary with Man." In this paper many interesting points are considered, including the distribution of the Irish Deer in the British Isles and elsewhere, the reason for the remarkable assemblages of individuals within certain limited areas, and the causes of its extinction.

A number of British records belong to the next few years. Thus, in 1859, J. McEnery (41) recorded *Megaceros* from Kent's Cavern, Torquay, and in 1861 R. Howse (43) described an imperfect skeleton from South Shields and a pair of antlers found after a storm at the mouth of the Tees. N. Moore (1867) (50) recorded *Megaceros* from the Cambridgeshire Fens. Dawkins, in his classical paper "On the Distribution of British Post-Glacial Mammals" (1869) (52), recorded it from nine caves and eight river deposits in England and Wales. G. Busk (1875) (58) described the remains of several individuals from a bone-cave at Creswell Crags, Derbyshire.

The question as to the contemporaneity of *Megaceros* with Man is alluded to by J. B. Jukes (1864) (46) in a paper "On Some Indentations on Bones of a *Cervus megaceros* found . . . near Legan, co. Longford."

Papers by R. J. Moss (1876) (61) and G. Porte (1877) (62) refer to the remarkable discovery of *Megaceros* remains at Ballybetagh, co. Dublin, where the bones of a hundred animals were found. Many of these are now in the National Museum of Ireland. Porte lays stress on the erroneous character of the idea still prevalent, that the skeletons occur in *bogs*, and brings forward some fresh suggestions as to the cause of the destruction of so many of these animals, and of the great preponderance of the male.

In 1878 appeared the first of a series of papers by Leith Adams referring to the Giant Deer. Many of the points on which he lays stress are discussed in the sequel. General accounts of the known facts relating to the Irish Giant Deer are given by G. H. Kinahan (1883) (79) and V. Ball (1885) (81), and both allude to the finding of bones in association with flint implements at Ballynamintra, co. Waterford. Ball

gives a list of some of the other chief localities where bones have been found in large numbers.

W. Williams (1878) (65) and (1881) (77) contributed important papers dealing, among other matters, with the cause of death of the *Megaceros* when found in large numbers, with the possible cause of its extinction, and of the frequent occurrence of the skull without the rest of the skeleton.

Although A. Savin (1878) (64) had recorded *Megaceros* from the Forest Bed of Cromer, E. T. Newton (1880) (70) and (1882) (78) hesitated to admit it to the list of Forest Bed animals. Osborn (1910) (122), in his account of the Forest Bed fauna, groups *C. dawkinsi* of Newton and *C. verticornis* of Dawkins as members of the Giant Fallow Deer phylum.

T. Rupert Jones in 1881 (75) reported the finding forty years previously of *Megaceros* in the peat of Aldermaston, Berks. This record of its occurrence in peat is interesting, but in view of the long lapse of time between the find and its publication the record should be received with caution.

The section of Lydekker's 'Catalogue of the Fossil Mammals of the British Museum,' which contains the Irish Giant Deer, was published in 1885, and his important account of the various continental races included in 'Deer of all Lands' in 1898.

Measurements by W. H. Potter (84) of the chief skeletons in Irish and English Museums were printed in the 'Field' in 1888, and in 1890 the publication of Woodward and Sherborn's 'Catalogue of British Fossil Vertebrata' rendered available a most useful series of references to the literature.

Although papers were published by Rathke (1842) (25) and von Eichwald (1845) (27), comparatively little attention was paid to the Giant Deer on the continent from the time of Cuvier and Goldfuss till early in the second half of the nineteenth century, when Cornalia (1851–71) (38) and Gastaldi (1861) (44) described examples from various parts of Northern Italy. Cornalia showed that the Giant Deer was a contemporary of Man in the valley of the Po, which is probably second only to Ireland as regards the abundance of its remains. Rütimeyer (1883) (80), in a comprehensive paper dealing with the mutual relations of deer, has a section on *Megaceros*.

During the present century there have been numerous continental records such as those of Hagmann (1908) (119) from Alsace, Martelli (1908) (117) from Italy, Dietrich (1909) (121) from Swabia, Schweder (1913) (128) and Grevé (1913) (129) from Russia, and Chomenko (1915) (133) from the Caucasus. Other references will be found in the bibliography.

The most interesting point connected with these continental records has, however, been the recognition by Pohlig and Nehring of certain distinct races. Pohlig (89), in his comprehensive paper (1892) on the Deer of the Thuringian "diluvial" travertine, recognizes two chief continental varieties, *Cervus* (*Euryceros*) *germaniæ* and *Cervus* (*Euryceros*) *italiæ*, which are considered in the sequel (pp. 15—17).

Other interesting antlers are described by Gastaldi (1875) (60), Nehring (1891) (87), and Pohlig (1894) (94). A paper by Pocock (1912) (127) on antler growth in the Cervidæ bears on *Megaceros*, and will be referred to in the section dealing with antlers.

Among the more recent British records are those by Kermode and Herdman (1904) (109) from the Isle of Man, and by Bemrose and Newton (1905) (110) from Hoe Grange Cave, Longcliffe, Derbyshire. A very complete account of the occurrence of the Irish Giant Deer in the Isle of Man is given by Lamplugh (1903) (108).

During the present century important papers have been published on the continent describing deer ancestral to or related to the Irish Giant Deer. Papers by Stehlin (1912) (125), Joleaud (1912) (126), Hescheler (1909) (120), Soergel (1927) (139), and Frentzen and Speyer (1928) (140) fall within this category. They are referred to in the sequel. Hescheler's paper includes a very full general account of the Giant Deer, while in Soergel's there are some novel conclusions regarding the homology of the tines.

While it might have been supposed that the relatively close relationship between the Irish Giant Deer and the Fallow Deer was beyond dispute, in 1906 Lönnberg (112) maintained the almost abandoned opinion that the Giant Deer is an ally of the Reindeer, considering it no more related to the Fallow Deer than to the Elk, such resemblances as exist being due to specialization rather than to affinity. Lönnberg based his opinion in part on the character of the vomer, which he maintained to be fully ossified and firmly united to the palatine, and, as in the Reindeer, completely dividing the nares. Lönnberg's paper was replied to by Lydekker (1906) (115) and Scharff (1907) (116), who considered that the retention by the Irish Giant Deer of part of the proximal ends of digits II and IV, as well as the distal ends, while the Reindeer retains only the distal ends, makes any theory of the close relationship between the Irish Giant Deer and Reindeer untenable. As regards the vomer, Lydekker points out that its ossification may be correlated with the weight of the antlers, while Scharff states that in several skulls examined by him the vomer, though thickened, is free from the palatines.

Sir H. H. Johnston's 'British Mammals' (1903) (107) contains a full and admirable account of the Irish Giant Deer, as does Millais' 'British Deer and their Horns' (1897) (99), while shorter accounts are given in the latter author's 'Mammals of Great Britain and Ireland' (1906) (113), and in a paper by Scharff (1924) (137).

II. DISTRIBUTION OF THE IRISH GIANT DEER IN THE BRITISH ISLES.

The following lists of localities in Great Britain and Ireland in which *Megaceros* remains have been found are based on those given in Woodward and Sherborn's 'Catalogue of British Fossil Vertebrata.' It would probably be impossible, even if desirable, to record all the Irish localities where *Megaceros* remains have been met

with. Leith Adams states that it is doubtful if there is a county where they have not been found. The Deer probably reached Ireland from Scotland through the Isle

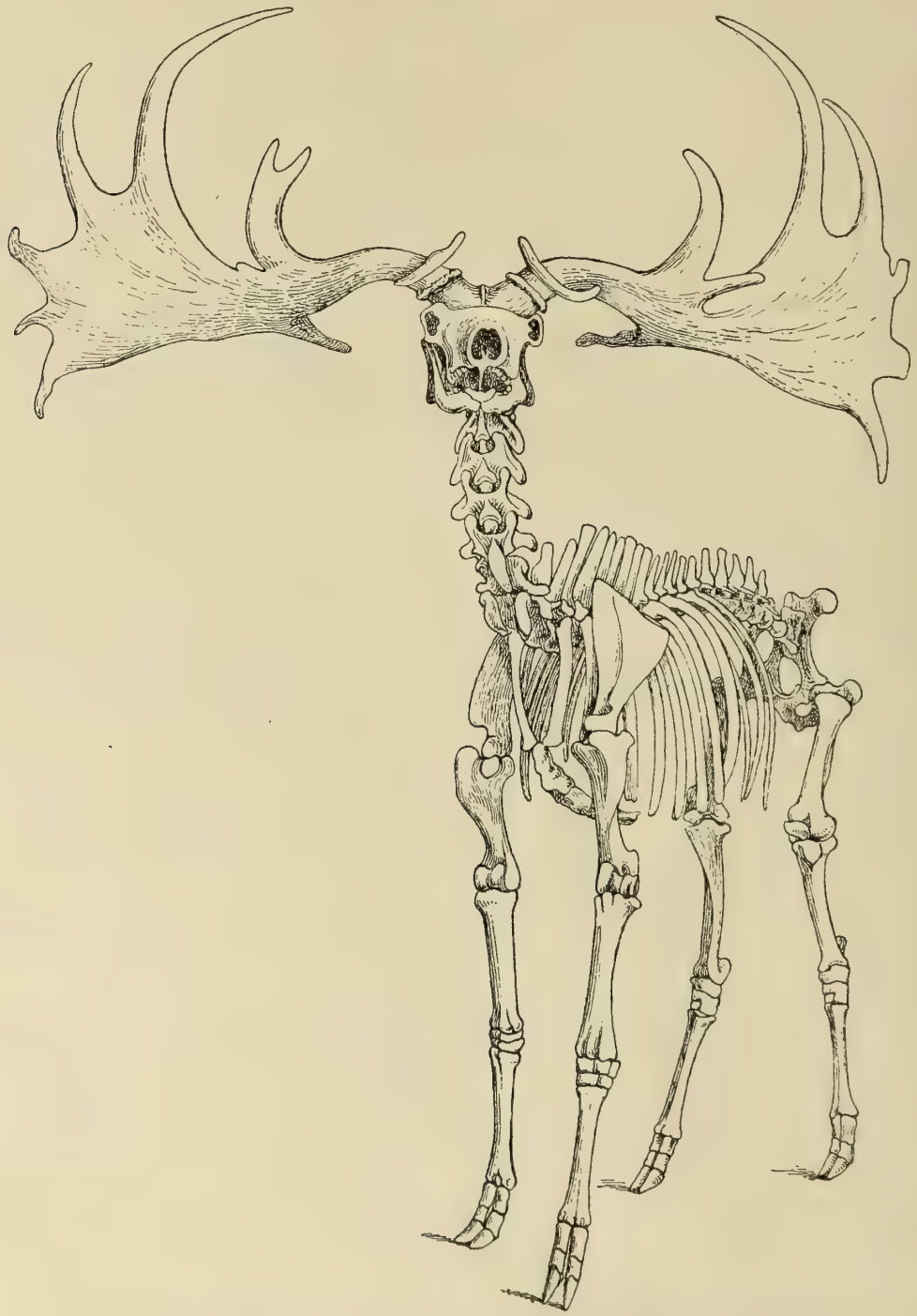


Fig. 1.—Half front view of a skeleton from Limerick now in the Zürich Polytechnic. Drawn from a photograph taken by Dr. Arnold Heim and reproduced by permission of Dr. K. Hescheler.

of Man. It does not seem to have been plentiful in Scotland, and has been found chiefly in the south-west. It has been met with in Denmark, France, Germany,

Austria, Hungary, Northern Italy, and as far eastward as the caves of Altai in Siberia and as far south as the Caucasus.

No specimens have been found in England comparable in perfection with those from Ireland, and no place can compare with Dublin for the number and excellence of the *Megaceros* remains. A list of those in the Science and Art Museum (now National Museum of Ireland) published in 1881 enumerated three complete skeletons, 72 skulls in the great majority of cases with the whole or part of the antlers, and numerous shed antlers. Many specimens have been added since the publication of this list. Other skeletons in public institutions in Dublin are those of Trinity College and the College of Science.

For a general list of skeletons and antlers, see pp. 48—50.

Records.

Great Britain.

Caves.

Bleadon, Somerset.
Brixham, Devon.
Caldy Island, South Wales.
Cheddar, Gough's Cave.
Creswell Crags, Derby.
Hoe Grange, Derby.
Hutton, Somerset.
Kent's Cavern, Torquay.
Kirkdale, Yorks.
Long Hole, Gower.
Spritsail Tor, Gower.
Ravensbarrow Hole, near Holker Old Park, Lancs.
Vale of Clwyd, North Wales.
Wookey, Somerset.

River Deposits, etc.

Aldermaston, Berks.
Audley End, Essex.
Aylesford, Kent.
Barnwell, near Cambridge.
Barrington, near Cambridge.
Bedford.
Brentford.
Burwell Fen, near Cambridge.
Chesterton, near Cambridge.
Clacton, Essex.
Cowthorpe, Yorks.
Coldingham, Berwick.
Dogger Bank.
Erith, Kent.
Folkestone.
Fulbrook, Warwick.
Grantchester, near Cambridge.
Grays, Essex.
Happisburgh, Norfolk.
Hilgay, Norfolk.
Ilford, Essex.
Ipswich.
Jarrow Dock.
Knighton-on-Teme, Worcester.
London.
Loxbrook.
Lulham, near Peterborough.
Maybole, Ayr.
Newmarket.
North Sea off Lowestoft.
Oxford.
River Rye, a tributary of the Derwent.
Seaton Snook, Durham.
Skipsea near Hornsea, Yorks.
South Shields.
Stanway, Glos.
Twerton, near Bath.
Ufton, Berks.
Walton, Essex.
Wastwater (stated to have been found near).
Westbury, Wilts.
Whittlesey Mere, Cambridge.
Wigtown Bay.

Ireland.

Caves.

Ballynamintra, Waterford.
Cappagh, Waterford.
Doneraile, Cork.
Edenvale, Clare.
Kilgreany, Waterford.
Killowen, Wexford.
Shandon, Waterford.

River Deposits, etc.

Ask Bog, N.E. of Gorey, Wexford.
Ballybetagh, Dublin.
Ballinderg, near Athlone.
Ballymackward, Fermanagh.
Ballynamore, Londonderry.
Belfast.
Buttevant, Cork.
Cappagh, Waterford.
Cappoquin, Waterford.
Castlebellingham, Louth.
Chapelizod, Dublin.
Cloggy Bridge, Cavan.
Cloone, Leitrim.
Dangan River, Meath.
Dee River, Louth.
Drogheda, Louth.
Drumsna Bridge, Leitrim.
Dundrum, Dublin.
Dundrum, Down.
Dungarvan, Waterford.
Dunmow, Galway.
Dunslaughlin Meath.
Enniscorthy, Wexford.
Enniskerry, Wicklow.
Howth, Dublin.
Johnstown Castle, Wexford.
Killowen, Wexford.
Kilskeer, Meath.
Kiltoghert, Leitrim.
Knocklong, Limerick.
Legan Bog, Longford.
Leighlin, Carlow.
Lough Derg, near Mountshannon, Galway.
Lough Gur, Limerick.
Lough Naglack, near Carrickmacross, Monaghan.
Mobarnan, near Fethard, Tipperary.
Mullingar, West Meath.
Naul Bog, Dublin.
Newton Stewart, Tyrone.
Portumna, Galway.
Rathcannon Bog, Limerick.
Schiale, Limerick.
Strokestown, Roscommon.
Tuam, Galway.
Turloughmore, Galway.
Turvey, near Dublin.
Waterford.

The list of Irish localities has been kindly revised by Dr. R. F. Scharff.

Isle of Man.

Balla Lheaney, Andreas.
Ballaterson, Ballaugh.
Close-y-garey, near St. John's.
Strandhall.
Kentraugh.

III. OCCURRENCE OF THE IRISH GIANT DEER.

A. Conditions of its Occurrence.

Although Hart (16), writing as early as 1825, showed clearly that the *Megaceros* skeletons do not occur in bogs or peat, but in the marl which is so commonly found underlying the peat, the error as to its occurrence in peat-bogs was hard to get rid of, and was attributed by Porte (62), writing in 1877, to the custom of giving the

general name of "bog" to every place where peat is cut for fuel. But while Porte stated that he was not able to learn of a single case of the Irish Deer being found in a real bog, Kinahan (79), as a result of his inquiry into the question, was convinced that the remains are sometimes found in peat.[1] It is pointed out by Adams (1878) (63) that it is in the marly deposits or blue clay found at the bottom of the numerous lakes now silted up, which existed in Ireland prior to the period of peat formation, that the *Megaceros* remains chiefly occur.

Kinahan refers to the occurrence of *Megaceros* in esker gravels in cos. Meath and Galway. Porte describes remains found beneath lacustrine deposits embedded among water-worn boulders.

B. Possible Explanations of the Co-occurrence of Numbers of Skeletons.

The co-occurrence of a number of skeletons has sometimes been attributed to the animals having entered the water to wallow, or to escape the plague of flies at certain seasons of the year, and being unable to get out; or to their being drowned while attempting to cross a frozen lake; or to their having taken refuge in a snow-drift on a frozen lake when the weight of the herd broke the ice. It is suggested by Denny (40) as an explanation of the remarkable numbers of *Megaceros* found in certain localities, that the animals formerly ranged over a wider area but were forced to congregate by the gradual submergence of the land. A somewhat similar suggestion had previously been made by Cumming (29) with regard to *Megaceros* in the Isle of Man.

More often the association of many skeletons has been thought to result from the animals becoming mired, either when drinking or when fleeing from predaceous enemies, such as man or wolf, as is suggested by Scouler (1838) (24). This theory, as Porte (1877) (62) remarks, may be sometimes correct, but is difficult to reconcile with the occasionally wide dispersal of the bones, or with the frequent finding of the skulls and antlers without the rest of the skeleton, or, as is noted by Adams, with the fact that none of the bones show tooth-marks. Porte considered that the Ballybetagh herd could not have been mired. Had this happened, the remains would have been found in the lacustrine strata, and not, as was the case, entirely below them. Also, on this occasion, when the remains of 110 stags were found, several skulls occurred together without any other bones. Such accumulations may be due to driftage.

Adams (1880) (73), alluding to the commonly perfect condition of the antlers, suggested that the animals were sometimes bogged during the rutting season, when stags became much excited and took to the water in pursuit of a hind or a rival.

[1] On the subject of the finding of *Megaceros* in peat Dr. Scharff writes to me as follows: "I believe where the Giant Deer has been obtained in the turf (peat) it was either washed out from the marl deposit, or its original position was disturbed by bog movements such as occur in some localities."

The most satisfactory explanation of the occurrence of such a mass of skeletons as was found at Ballybetagh is that offered by Williams (77). The lake in which the skeletons occur occupied a hollow in the boulder clay with the sides sloping at an angle of sometimes as much as 45°. The lake formed a natural trap which the animals could easily enter, but from which escape was extremely difficult, partly owing to the steepness of the sides, partly to the depth and tenacity of the clay forming the floor of the lake. As the author points out, the large number found may be accounted for on the supposition that one or two lost their lives in this fashion every season. It is unnecessary to assume that the animals were destroyed as a herd.

The suggestion by C. Reid (96) in the following paragraph also bears on this question :

" Those familiar with the pools containing *Chara* will be well aware of the appearance of shallowness and of a solid floor, which is so deceptive. The *Chara* and *Potamogeton* may grow from a depth of several feet, but they often appear to form a carpet of bright green turf a few inches under the surface of the clear water. Any animal treading on this turf would immediately plunge head foremost into the water, and the wide-branching antlers of *Cervus megaceros* would become entangled amid the *Chara* stems, and still tougher Pondweeds, so that the animal would have scarcely a chance to escape."

Porte says that the condition of the antlers—full-grown, but showing in the burr and constriction round the base preparation for the fall—proves that the season of the year at which the animals perished was the end of April (supposing the habits of the Irish Giant Deer to be the same as those of Deer in Ireland at the present day).

c. Cause of its Special Abundance in Ireland.

The immense numbers of this magnificent Deer in Ireland and the fact that it considerably exceeded its continental relatives in size, show clearly that the conditions in Ireland must have been exceptionally favourable to it, both as regards climate and in other respects. The scarcity of great Carnivora has always, as by Adams (1881) and Ball (1885), been considered a chief cause of its abundance, the Lion and Cave-bear not having been found in Ireland and the Hyæna very rarely. Dr. Scharff writes : " They probably lived in an open prairie country and were comparatively free from enemies. Hyænas were not to be feared, for they probably became extinct (in Ireland) sooner than the Giant Deer. The tremendous sweep of the heavy antlers was a powerful defensive weapon against the Wolf, which was always abundant in Ireland. It would seem that Man camped mostly near the sea among the hills, and may only have arrived in Ireland when the Giant Deer was on the verge of extinction."

Among the localities where the Giant Deer has occurred in special abundance are the following : margin of Lough Derg, near Mountshannon, Galway ; Killowen Wexford ; Ballybetagh Bog, near Kiltiernan, Dublin ; Ask Bog, N.E. of Gorey, Wexford.

D. Possible Cause of the Frequent Occurrence of the Skull without the Rest of the Skeleton.

A possible explanation is suggested by Williams, who, writing in 1881, remarked that in the previous thirty years nearly a hundred skulls had been found in Ballybetagh bog, but scarcely six skeletons. He stated that the atlas vertebra was in almost every case found with the skull, and suggested that when the carcase decayed, the head and antlers separated off with the atlas and sank, while the rest of the carcase was carried away by currents out of the lake. In one case the legs were found with the skull, the trunk having apparently floated away.

E. Cause of the Preponderance of the Skulls of the Male.

It has always been recognized that this is probably to be attributed to the great weight of the antlers causing the male to be more frequently bogged. According to Porte, a possible cause of the 36 skulls found at Ballybetagh being all male is that the animals perished through some sudden catastrophe when the stags and hinds herded apart. Dr. Scharff suggests in a letter that possibly the Deer went into Ballybetagh lake, which is one of the highest localities where they have been found, merely to escape the plague of flies at certain seasons of the year, and then got mired occasionally in the weeds.

The preponderance of male skulls may sometimes be more apparent than real, for Dr. Scharff writes: "When a skull without antlers is found during the digging for peat, it is generally broken up and considered worthless, being often mistaken for a horse's skull, whereas the stags' skulls are known always to fetch a good price."

F. Concerning the Contemporaneity or Otherwise of the Irish Giant Deer with Man in the British Isles.

The question as to the contemporaneity of the Irish Giant Deer with Man is one which has attracted naturalists from the earliest times, and although the clearness of the continental evidence for contemporaneity, particularly in France and Croatia, has caused the interest in the subject to be now mainly historical, it may still be well to state the opinions and arguments of the various writers on the subject.

Molyneux, the earliest describer of the Irish Giant Deer, says that it became extinct in Ireland so long ago that no tradition of its former existence survives. Owen (30), who discusses the subject, remarks that "the total silence of Cæsar and Tacitus respecting such animals renders their existence and subsequent extirpation by the savage natives a matter of the highest improbability." Later writers have held conflicting views. Thus, Richardson (1846) (31) maintained that it was contemporary with Man and hunted by him for food and clothing, and as evidence of its relatively recent extinction stated that he had often peeled the periosteum off the bone. Mantell (1851) (35) considered that it was probably exterminated by the Celtic tribes. The evidence available at the time of writing (1859) was assembled by Denny (40)

without adding any fresh arguments. Jukes (1864) (47) described some indentations on limb-bones, which he believed could only be produced by a cutting instrument; but Carte, in the discussion on Jukes's paper, attributed the indentations to pressure and friction, and in 1867 described bones from Lough Gur showing indentations which he thought due to the same cause. Ball (1885) and Ussher allude to the occurrence of long bones split as if for the extraction of marrow, in association with stone implements in Ballynamintra Cave, co. Waterford. Adams, in 1878, stated that none of the bones showed that man or beast preyed on the animal, and in 1880, in his paper on "Recent and Extinct Irish Mammals" (73), expressed the belief that there was no valid evidence showing the contemporaneity of *Megaceros* with Man in Ireland. Later in the same year, however, he changed his opinion, and in a communication consisting of preliminary notes by himself and Ussher, recorded the occurrence at Shandon of implements made from the undoubted bones of Irish Giant Deer. A year later (1881), in describing the bones from Ballynamintra Cave, co. Waterford, he recorded (76) the finding in association with hammerstones of bones of *Megaceros* split as if for the extraction of the marrow, and stated that it could scarcely be doubted that the regularity of fracture was due to their having been split for the purpose. An examination of these bones, which are now in the National Museum at Dublin, and comparison with others in the same collection, lead one to doubt whether the splitting may not be due merely to the natural processes of weathering and decay. Similar split bones have been found in the Clare caves. There is some evidence of the co-occurrence of Man and *Megaceros* in the Isle of Man, and in England *Megaceros* bones have been found associated with human remains at Kent's Cavern, Torquay, while in France it was constantly hunted by Man.

Some of the more recent writers on the subject have believed in its survival to a late date. Thus, Sir H. H. Johnston (106) was of opinion that it probably lasted in Ireland to the end of the Neolithic period, J. G. Millais (112) that it may have become extinct only in Recent or Prehistoric times. He alludes to a skull in his possession in the forehead of which is a deep cut, evidently made by a hatchet.

G. Possible Causes of the Extinction of the Irish Giant Deer.

A long succession of writers, ranging from Molyneux (1697) to Sir H. Johnston (1903), have discussed this question, and the following suggestions have been made:

1. That dense herds of these big animals may have been attacked by some microbial disease.
2. That human hunters perhaps by pits, perhaps by huge drives, which sent herds over precipices or into bogs, were the chief cause.
3. That its disappearance is due to a change in climatic conditions.
4. That its extinction is due to over-specialization in structure, possibly leading to sterility.

The first of these causes was advocated by Molyneux (1697). He rejects the theory of the Noachian flood, suggesting that extinction may be due to "certain ill-constitution of air in some of the past seasons long since the Flood, which may have occasioned an epidemic distemper." He quotes examples of such distempers affecting Reindeer in Lapland. Any which survived the epidemic, he suggests, were killed by human hunters. Eichwald (1845) favoured the view that it was exterminated by Man.

The third of these suggested causes was maintained by Williams, who considered that the deposit of clay overlying that containing the *Megaceros* remains is of glacial origin, and hence that cold was the cause of the animal's extinction. In this conclusion he is supported by much modern opinion.

From the analogy of many groups of animals in which over-specialization either in size or in some other respect is closely followed by extinction, it seems probable that here is to be found the most important cause of the extinction of the Irish Giant Deer.

H. Distribution of the Giant Deer in Time.

Although, as has already been mentioned, Pohlig derives the Giant Deer from *Cervus dicranius* of the Upper Tertiary, no discovery has as yet definitely carried back the race to an earlier date than the Upper Pliocene. Both in England and on the continent, especially in Italy, remains of this date are well known. In England ancestral Fallow Deer like *Cervus verticornis* are found in the Red Crag and Forest Bed of East Anglia, and forms like *C. belgrandi*, intermediate between early Fallow Deer and Giant Deer, occur in the Forest Bed. In Italy ancestral Fallow Deer are found in the valley of the Po. Numerous records of Giant Deer (*Cervus* (*Euryceros*) *germaniæ*) from Northern and Western Germany show that these animals had a wide distribution in that part of Europe prior to the last great increase of cold in Magdalenian times. There does not, however, appear to be any clear evidence that the Giant Deer survived in northern continental Europe into post-Magdalenian times.

Numerous records show that the Giant Deer was widely distributed in England during Palæolithic times and spread thence to the south-west of Scotland and the Isle of Man, whence it probably reached Ireland. Though recorded from the peat in several localities[1] there is little evidence of its survival in Great Britain as late as Neolithic times. It is, nevertheless, commonly quoted as the sole extinct member of the Palæolithic fauna which survived, attaining its maximum in the Irish deposits of the period, and persisting, so it has been claimed, even to Prehistoric times.

Whether it survived the latest period of refrigeration is not so clear as was once thought to be the case. To take first the *Megaceros*-bearing deposits of the Isle of

[1] Owen ('Brit. Foss. Mamm.,' p. 466) records it from the peat of Hilgay, Norfolk; Seeley ('Quart. Journ. Geol. Soc.,' xxii, 1864, p. 479, and 'Geol. Mag.,' 1866, p. 499) alludes to its presence in the peat of the Fen country; N. Moore ('Ann. Mag. Nat. Hist.,' xx, 1867, p. 77) to its presence in the Fens.

Man, which closely resemble those of Ireland. The nature and age of these deposits are exhaustively discussed by Lamplugh (108), and the conclusion is reached that *Megaceros* must be regarded as "either a late glacial or early post-glacial inhabitant according to the limits, in any case arbitrary, which we may assign to the Glacial period." With regard to the Irish deposits, Williams has suggested that the *Megaceros* marls were accumulated during a mild and genial interlude which followed the main melting of the ice, and was succeeded by a return of glacial conditions. J. Geikie was inclined to accept the view that the *Megaceros* beds are of interglacial age, and Lamplugh says: "It would be rash to deny the possibility of the *Megaceros* marl being the product of a genial interval between two cold periods." It may be doubted whether even in Ireland it survived the increased cold of Magdalenian times.[1]

IV. ORIGIN, RACES AND AFFINITIES OF THE GIANT DEER.

Though there is little evidence available, it is possible that the Giant Deer was not of European but of Siberian origin, and that it migrated westward under the influence of the increasing cold, of which the later Pliocene beds afford proof. On the other hand, Pohlig (89) derives *Megaceros* from *Cervus dicranius*, a small Upper Tertiary form with a wide distribution in the Mediterranean region.

The earliest fossils attributed to the race of the Giant Deer are the fragmentary antlers described by Owen (37) and by Dawkins from the Red Crag of Suffolk. It may be doubted whether the former specimen is sufficiently well preserved to justify any definite conclusions concerning it. Soergel agrees with Dawkins in attributing the latter specimen to *Cervus verticornis*.

Various authors have described the several "races" into which it is possible to divide the Giant Deer, one of the most comprehensive accounts being that of Lydekker (100), who recognized five races, the German, Irish, Italian, French and Forest Bed races.

The earliest race is that of the Forest Bed, to which such forms as *Cervus verticornis* are referable. The antlers are short, directed upwards and outwards, with palmation generally slight and a simple brow tine. Some of the early forms described from Italy, such as the simple antlers with short tines described by Alessandri from Monteferrato, seem to belong, as Soergel suggests (130), to an animal closely allied to *C. verticornis*.

C. dawkinsi from the Forest Bed, which is commonly grouped with *C. verticornis*, has a more expanded palm, and is perhaps, as Soergel suggests, more closely related to *Alces* than to *Megaceros*.

[1] Since writing this sentence I have been shown the as yet unpublished script of a paper by Dr. J. W. Jackson on the animal remains of the Kilgreany Cave, Waterford, in which he writes: "With regard to the giant Irish deer, there appears to be good evidence that it did not long survive, if at all, the last cold phase, which is generally regarded as of early Magdalenian date."

Another early form is that described by Stehlin (125) as *Cervus* (*Megaceros*) *dupuisi* from the Pleistocene of Rosières, near St. Florent. This was a relatively small animal, about as large as a Red Deer, but it resembles *Megaceros* in the fact that a cross-section of the mandible is wide and rounded below, while that of the Red Deer is deeper, narrower and more pointed below. A related form, *Cervus pachygenys* (Pomel), is considered by Stehlin to be more primitive than *C. dupuisi* in respect of the small size of the antlers, while as regards the depression of the antlers and the length of the molars it seems to be more highly specialized than *C. dupuisi*. Joleaud (126) has also described *C. pachygenys*, which he considers identical with Lydekker's *C. algericus*, and agrees as to some of its characters being archaic and others highly specialized. He suggests that it and *Megaceros* may have had a common ancestor, and regards it as worthy of subgeneric distinction under the name of *Megaceroides*.

Fig. 2.—Fragmentary skull and antlers of a young individual from co. Limerick (no. 17 Nat. Mus., Dublin). Both antlers are broken; the right one retains the brow tine which springs at the very base of the antler and already shows flattening. The left antler retains the 2nd tine. The most interesting features shown are the conspicuous pedicels from which the antlers spring. In old animals the antlers spring directly from the skull-wall.

Many important occurrences of the Giant Deer have been recorded from the interglacial and other deposits of the Rhine Valley and from Northern and Central Germany, which show that *Megaceros* had a wide distribution prior to the last great advance of the ice. It occurs associated with *Machærodus*, *Hippopotamus*, *Rhinoceros merckii* and *Elephas antiquus* as a member of the warm Chellean fauna, and is found also in Mousterian and Aurignacian deposits.

The German examples, which are seen in nearly all the Rhineland museums, have been described by Nehring, Pohlig, Soergel, Frentzen and Speyer and others, and there has been difference of opinion as to how they should be grouped and as to the systematic rank of the divisions adopted. Pohlig has grouped all the German examples together as *Cervus* (*Euryceros*) *germaniæ*, which he considers worthy of specific distinction from *C. hibernicus*. The chief distinguishing features of *C. germaniæ* are: (1) the antlers are smaller, have a narrower palm, and are more upwardly directed than in *C. hibernicus*, and consequently have a smaller span; (2) the tines

on the front border of the palm are much less developed than in *C. hibernicus*, and all those of the palm are characterized by a sharp inward bend. The brow tine is commonly well developed and sometimes bifurcated, and a wide gap separates it from the second tine, which commonly springs close to the palm. In some cases there is no back tine.

A variety was described by Nehring (87) to which he applied the name *Cervus ruffi*, regarding it as a distinct race. The antler to which this name was originally applied, and which was found near Kottbus, has a well-developed somewhat spoon-shaped brow tine and a long second tine, but only slight indications of a back tine. The

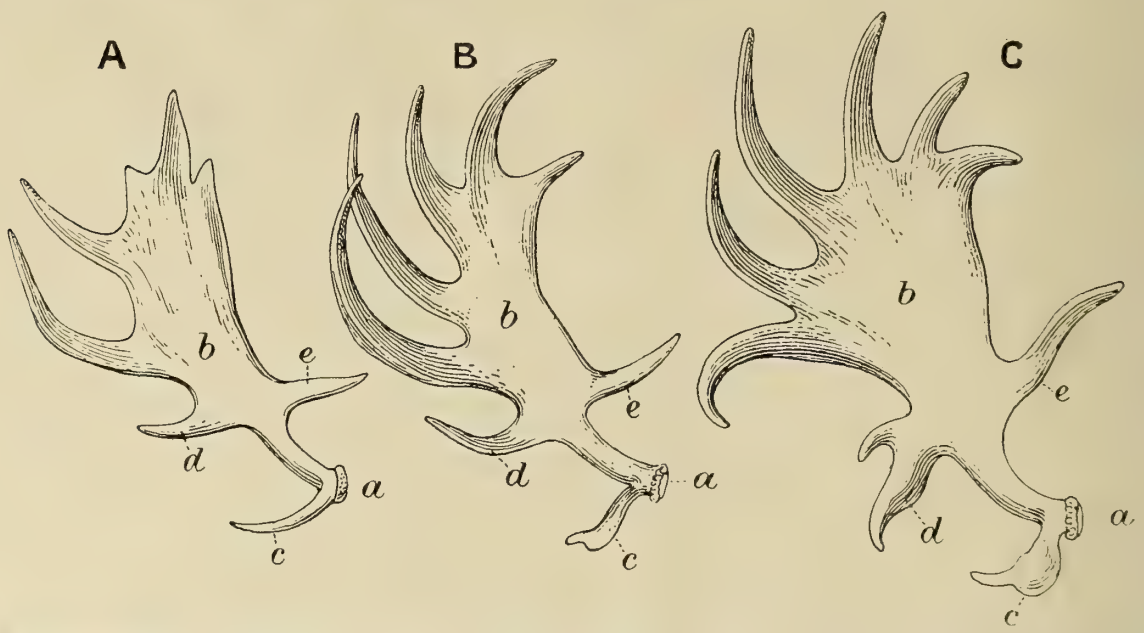


FIG. 3.—Stages in antler growth, after Owen, locality not stated. *a*, rose; *b*, palm; *c*, brow tine; *d*, 2nd tine sometimes regarded as a bez tine; *e*, back tine. The above lettering is retained in all the figures of antlers. Owen gives a full description which is quoted in the text (p. 24).

palm is not very much expanded, and four well-developed tines spring from its termination rather than from either the anterior or posterior border. The probably young antlers shown in Text-fig. 4 bear a considerable resemblance to those of the *ruffi* type, and it seems likely, as Frentzen and Speyer suggest, that Nehring's specimen may have belonged to a young individual. A second example attributed to *Cervus ruffi* by Nehring has a well-developed back tine. His figure is reproduced in Text-fig. 31, A, p. 60. Specimens described by Dietrich (120) from Canstadt and Jarotschin (Poland) are of essentially the same type. The fine antlers from Knielingen described by Frentzen and Speyer (139) are considered by these authors to represent an extreme development of the *ruffi* type connecting it with the *dama* type of antler. The resemblance to the antlers of *C. dama* lies particularly in the fact that a series of tines springs from the posterior border (Text-fig. 12, *b*). These are strongly bent backwards and upwards as in the typical *germaniæ* variety.

The Italian race *Cervus* (*Euryceros*) *italiæ* of Pohlig (Text-fig. 12, *a*) does not differ very markedly from the German race. Lydekker (101) states its characters in the following terms: "Relatively small, and antlers comparatively simple; palmation narrow, much inclined upwards so that much of the outer surface is seen in front view; all the tines small, and those above the bez (*i. e.* second tine of the nomenclature adopted here) few in number and placed near the summit of palmation."

In the Forest Bed and in the Pleistocene of Clacton, Essex, are found the antlers of other deer connecting the Fallow Deer and the Giant Deer. Thus, *C. browni*, Dawkins, from Clacton, is clearly an ancestral Fallow Deer. *C. belgrandi*, originally described by Lartet and now well known from the splendid antlers described by Harmer (106) from the Forest Bed of Pakefield (Text-fig. 12, *c*), is a much larger and more specialized form, occupying, as its describer claims, a central position between

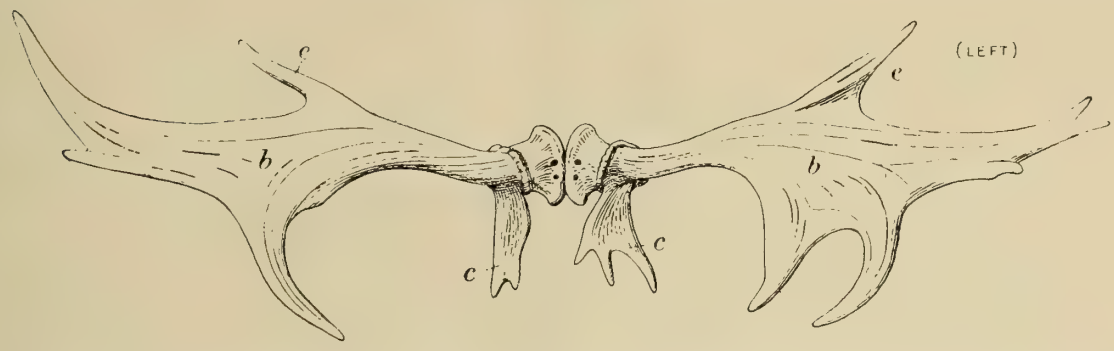


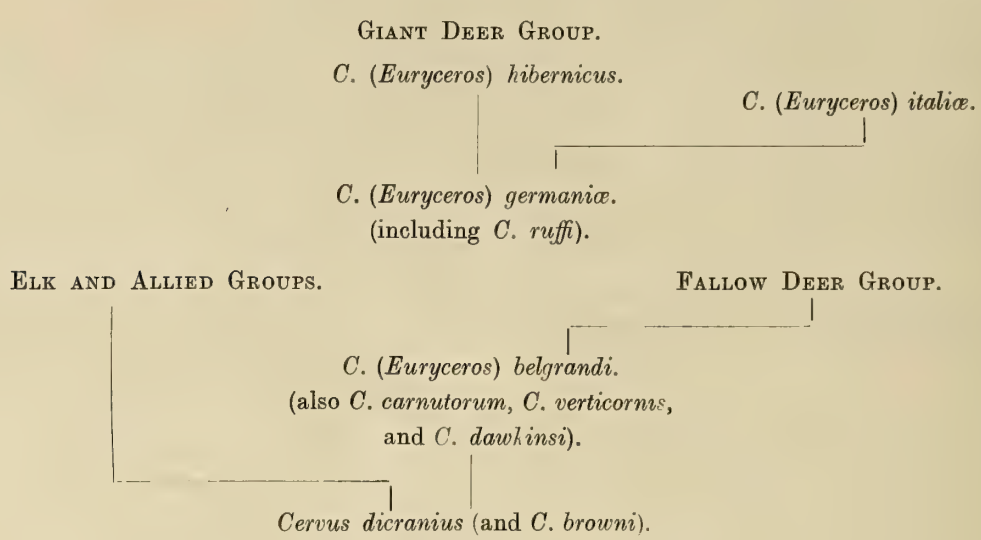
Fig. 4.—Young antlers from "Ireland" seen from above (Brit. Mus. Nat. Hist.). In this remarkable pair of young antlers the brow tine (*c*) is terminated by two points in the right antler, and by three in the left. There is no 2nd tine, but the back tine (*e*) is well developed; the palm is narrow and tapers rapidly. Only two tines in the right antler and three in the left spring from its anterior part, which ends with one point in the right antler and two in the left. The length of the pedicel is an indication of the youth of the animal. The left antler is not unlike that of the variety *ruffi* of Nehring.

C. browni and *dama* on the one hand and *C. giganteus* on the other. It differs from *dama* and most early forms in the relatively horizontal position of the beam, which is very long, sharply bent forwards and expanded suddenly into a very broad palm, the edge of which is marked by many slight irregularities, but bears no definite tines.

Another type of antler is that from the sands of Mosbach near Biebrich on the Rhine, described by Soergel (130) (Text-fig. 12, *d*) as *C.* (*Megaceros*) *mosbachensis*. The beam is short and stout and is continued into a palm which, to judge by the figures, suggests a resemblance to that of *C. dawkinsi*. Two tines on the right and one on the left antler spring near the burr.

While the recognition of one or more continental races in addition to the Irish race is clearly desirable, attention may be called to the pertinent comment of Scharff, that some of the continental authorities do not sufficiently realize the extreme variability of the *Megaceros* antlers, and tend to found races and varieties on insufficient grounds.

Pohlig's table of affinities of the Giant Deer and its allies, as quoted in an abbreviated form by Hescheler (120), is as follows (the names in brackets are those of related forms not in the table as given by Hescheler):



V. DESCRIPTION OF THE SKELETON.

A. The Skull (Plates I and II).

The characters of the skull in the Cervidæ are very constant. In the Irish Giant Deer, as in others, there is a prominent occipital crest, and the face is less sharply bent down on the basicranial axis than in many Artiodactyls. The parietal completely fuses with its fellow at an early age. The posterior half of the united frontals has a longitudinal ridge which, as Owen points out, bears some resemblance to the median prominence of the Giraffe. There is a deep depression, the suborbital or lachrymal fossa, in the lachrymal bone, which is large and takes a considerable part in the formation of the side of the face in front of the orbit. The post-orbital bar is complete, and the orbit is prominent and nearly circular. There are conspicuous supraorbital foramina. A vacuity, variable in size, occurs between the anterior end of the frontal and the lachrymal, partly bounded in front by the nasal and maxilla. The premaxilla is a V-like bone owing to the large size of the anterior palatine foramen. The nasal process of the premaxilla does not reach the frontal. The posterior palatine foramen is very small. The paroccipital process is long. The external auditory meatus is conspicuous.

There are certain differences between the male and female crania in addition to those directly concerned with the antlers. In the male there is a ridge crossing the posterior part of the frontal, which is lacking in the female. On the other hand, the median longitudinal ridge on the frontals in the female is far more conspicuous than in the male. The condyles are smaller in the female than in the male.

Stehlin (110) says that a way of distinguishing the mandible of the Irish Deer from that of an Elaphoid Deer of similar size is furnished, not by the dentition, but by a section of the mandible. In the Giant Deer a cross-section of the mandible is thick and rounded, in an Elaphoid Deer it is flattened, narrower towards the lower border and relatively deep.

(*a*) Measurements of Cranium.[1]

—	Skull of male, no. 28968 (Brit. Mus.).	Skull of female. no. 18095 (Brit. Mus.).	Skull of female, 59, 1915 (Nat. Mus., Dublin).
1. Length from intercondylar notch to anterior end of skull	47·0	43·25	45·2
2. Extreme width across zygomatic arches.	23·4	22·2	21·0
3. Transverse measurement at infraorbital foramen	9·25	8·35	..
4. Measurement across orbits at fronto-lachrymal suture	18·2	15·9	16·7
5. Measurement across occipital condyles	10·7	10·05	9·7
6. Measurement across external auditory meatus	..	15·2	16·0
7. Width of palate, measurement taken external to last molar	14·2	13·8	13·7
8. Length of palate from posterior limit of palatine suture to anterior palatine foramen	21·5	20·0[2]	19·7
9. Antero-posterior diameter of orbit	6·3	5·9	5·6
10. Measurement between supraorbital foramina	12·15	10·25	10·95

[1] In the following tables all measurements are quoted in centimetres.
[2] Partly by estimate.

B. The Antlers.

(*a*) *Description.*

The astonishing size of the antlers constitutes by far the most remarkable feature of the Irish Giant Deer. This is mainly due to the great expansion of the beam into a crown or palm, which in a case mentioned by Owen measured 30 inches across.

Of the tines, three, namely, the brow tine, the second tine and back tine, spring from the beam, the remainder from the crown or palm. The first tine to be given off is the brow tine from the anterior margin of the beam. This tine, which tends to be downwardly directed as in the Reindeer, though to a far less marked extent, is very variable. It may sometimes, particularly in young individuals, be simply pointed (Text-fig. 3 A, *c*), it is sometimes forked near its termination, but is as a rule more or less flattened and shovel-like, ending with three or four short projections (*cf.* Text-figs. 4 and 9).

The beam early gives off from its posterior surface a tine which varies much in length and point of origin, and may very rarely show a tendency to bifurcate (Text-fig. 8, C, *e*), while occasionally it is absent. It is the only tine which normally springs

FIG. 5.—Young antlers from Ballybetagh, co. Dublin, all in the National Museum, Dublin. **A** (No. 94). Front view of right antler. **B** (No. 264 (1906)). Front view of right antler. **C** (No. 43). Left antler seen from above. **D** The same, front view. **A** has a simple cylindrical brow tine slightly forked at the end. Only four tines spring from the palm, two from its anterior face and two from its distal end. **B** is remarkable for the fact that what is probably to be regarded as the 2nd tine (*d*) springs from the beam immediately adjacent to the brow tine (*c*). In the left antler (not figured) the 2nd tine is normal. The antler figured in **C** and **D** has a narrow beam or palm from which a series of tines radiate.

from the posterior surface, while from the anterior surface spring a series of tines varying in number according to the animal's age.

According to the nomenclature usually accepted at the present day there is no bez tine, though Owen and Flower and Lydekker regard the second tine springing from the anterior margin as a bez tine. Soergel's study of the German specimens leads him to the conclusion that the tine usually regarded as the brow tine (Augsprosse) of the middle and later "diluvial" Giant Deer is really the downwardly-directed equivalent of the second tine (Eissprosse) of early forms.

In some cases the true brow tine is apparently represented by a vestige (" oriment," " offer ").

In normal antlers a series of about five long curving tines follow the second tine along the anterior border and distal end of the beam. Their disposition is variable, but they tend to curve backwards and inwards over the skull. The last tines of the series are the most variable and may be much shorter than the others. Occasionally two tines, instead of springing separately from the palm, may arise from a broad common base (Text-fig. 9, C), while on other occasions a tine may give off a small branch from about half-way up (Text-fig. 9, C), or very rarely may fork at the end. The posterior face of the beam bears no tines and is normally smooth, but occasionally in abnormal antlers irregular projections may occur along it (Text-fig. 10, C).

The extraordinary variability of the antlers may best be appreciated by an examination of the figures. Many irregular and abnormal antlers exist, some of the most remarkable being shown in Text-figs. 10 and 11. It has been claimed that bifurcation and flattening of the tines affords an indication of advancing age, but in the case of the brow tine bifurcation and flattening is a normal feature and may commence early. The figures accompanying this Monograph show that bifurcation may affect any of the tines.

Although there is no proof, it seems probable that certain very massive antlers with a reduced span and shortened tines are those of aged animals. Such antlers are represented by Text-fig. 10, D, and one of their features is a tendency to flattening and bifurcation of the second tine.[1]

One of the most reliable indications of the animal's age is afforded by the springing of the antler. In young animals it is borne on a distinct pedicel (Text-fig. 2), but in old individuals this is much reduced, the antler springing almost directly from the surface of the skull. A strengthening ridge may, as is mentioned by Owen, be developed along the under-surface of the beam in exceptionally large antlers, such as those at Knowle, near Sevenoaks.

It has been stated that there is a tendency for the left antler to be larger than the right. This claim finds no support from an examination of the large series of antlers

[1] Dr. Scharff agrees that the antlers figured in 'Land and Water,' April 16th, 1892, are those of an aged individual. The antlers are stated to be in the Derby Museum, but I am informed by Mr. F. Williamson, the Curator, that this is not now the case.

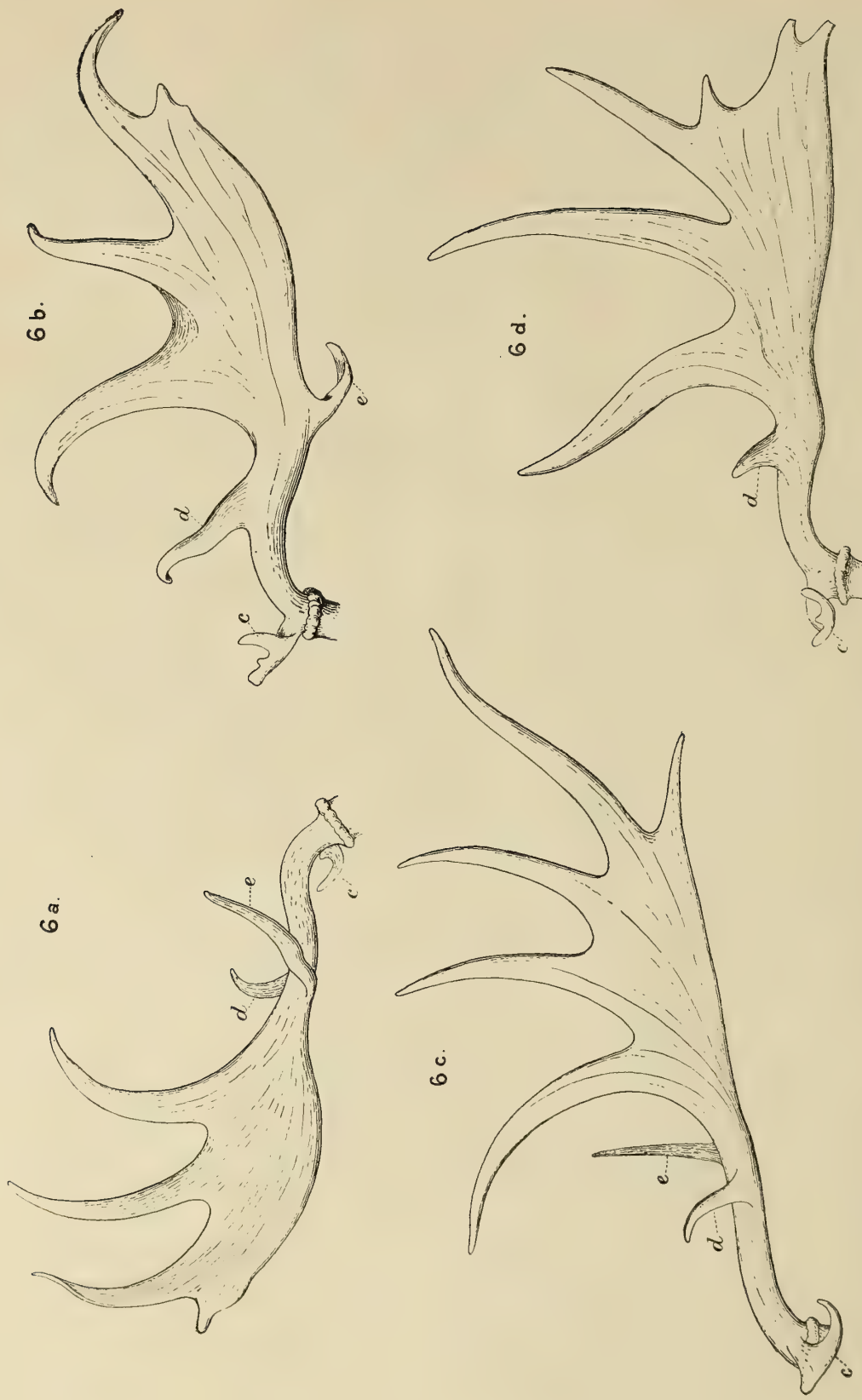


FIG. 6.—**A** Left antler of the skeleton from "Ireland" set up in the gallery of the British Museum (Nat. Hist.). The view is taken from behind, and is intended to show the length of the tines springing from the anterior face of the palm. **B** Antero-inferior view of the same antler. The flattened and branched character of the brow tine (*c*) and the strong tendency of all the tines to curve near their ends are clearly shown. **C** Antero-inferior view of left antler of skull from "Ireland" (M. 2323, Brit. Mus., Nat. Hist., above wall-case 18). Four very long tines spring from the anterior face of the palm. **D** Antero-inferior view of left antler of skull from "Ireland" (M. 2324, Brit. Mus., Nat. Hist., above wall-case 14). The back tine is invisible. The palm bears three long tines on its anterior face and is terminated by three short points. In **A**, **B** and **D** there is some foreshortening owing to the specimens having been drawn from a slightly oblique angle.

FIG. 7.—The antlers shown in figures **A**, **C** and **D** were all obtained and supplied by Messrs. Williams & Son, of Dublin, and the figures are drawn from photographs taken before they left Messrs. Williams's establishment. **A** From Limerick, sold to Dr. F. Krantz, of Bonn, and by him to the Jesuit College, Louvain, Belgium. The brow tine bifurcates and the right back tine shows some sign of bifurcation. **B** From "Ireland," now in the City Museum, Glasgow. **C** From Limerick, now in the Geneva Museum. The left antler is somewhat abnormal and irregular. **D** From "Ireland," belonging to Lord Castletown, and preserved at Granston Manor, Ballacolla.

at Dublin. The left brow tine is, however, in some cases larger than the right, as is commonly the case in the Reindeer.

(*b*) *Young Antlers.*

Cuvier alludes to the lack of knowledge of the young antlers, and Owen (1846) makes a somewhat similar remark. It is a singular fact that these statements are even now nearly as true as when they were originally made. In the great collection at Dublin, although there are a few antlers (*cf.* Text-figs. 2 and 5) which are not fully grown, there are no complete examples of really young ones. Owen, however, figures three antlers which he remarks "appear to indicate progressive epochs in the age of the animal." His figures and descriptions are appended, the lettering being altered in accordance with that adopted here :

"The first (Text-fig. 3, A), which apparently corresponds with the state of the antlers in the fourth year in the Fallow Deer, is five feet in length and fourteen inches across the palm ; it presents a simple cylindrical brow antler (*c*) ; a short and simple bez antler (*d*) ; the hind branch almost straight, and only two long branches from the fore-part of the palm, which terminates in three short straight obtuse points, the middle being the longest. The second figure (Text-fig. 3, B) shows an expansion and flattening of the brow antler, an elongation of the bez antler and of the anterior branches of the palm, and the prolongation of the three terminal points into branches, the total number of branches being eight. The length of the antler, following the curve, is six feet ; the greatest breadth of the palm fifteen inches. This form of antler corresponds with that at the fifth year in the Fallow Deer. In the third figure (Text-fig. 3 C) the brow antler is expanded and bifurcate ; the bez antler is likewise expanded and forked, but this is a very rare variety. The palm is much increased in breadth and sends off six branches besides the posterior one, the number of points in this antler being eleven. The length of the antler, following its curve, is seven feet, the breadth of the palm thirty inches. Such an antler would indicate the *Megaceros* to have reached the prime of its age, like the 'crowned Hart' of the seventh or eighth year."[1]

(*c*) *Comparison of the Antlers with those of other Deer.*

As *Megaceros* antlers have been compared with those of the Elk, the Reindeer and the Fallow Deer, it may be well to indicate the points of resemblance and difference.

In the Elk the antlers agree with those of *Megaceros* in their depressed position and in the great expansion of the crown or palm. The antlers differ from those of all

[1] It is probable that the antlers figured by Nehring, on which he founded his race *C. ruffi*, may, as he at first concluded, have belonged to a young individual.

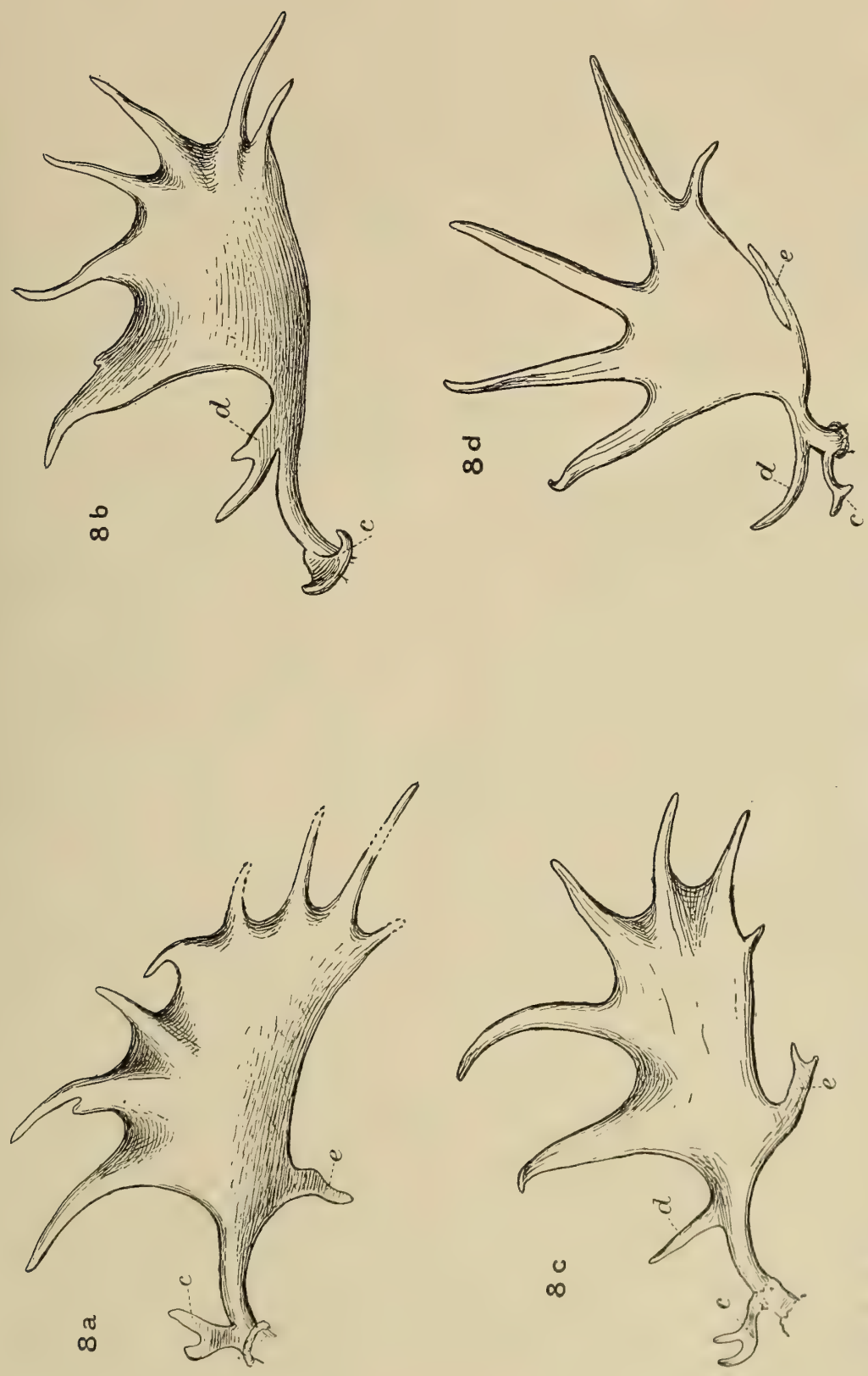


FIG. 8.—**A** Antero-inferior view of left antler of the skeleton from Lough Naglack, near Carrickmacross (Monaghan), presented by the Marquis of Bath (Nat. Mus., Dublin). The brow tine is forked and there is no 2nd tine springing from the beam. Dotted lines indicate restored parts. **B** Antero-inferior view of left antler of the skeleton from Rathcannon (Limerick) presented by Archdeacon Maunsell (Nat. Mus., Dublin). The 2nd tine is forked. The back tine, though present, is invisible. **C** Antero-inferior view of left antler of skeleton from Lough Gur, Limerick, now in the Geological Museum of Trinity College, Dublin. Both brow and back tines are forked. **D** Left lower view of left antler of the skeleton from the Isle of Man, now in the Royal Scottish Museum, Edinburgh.

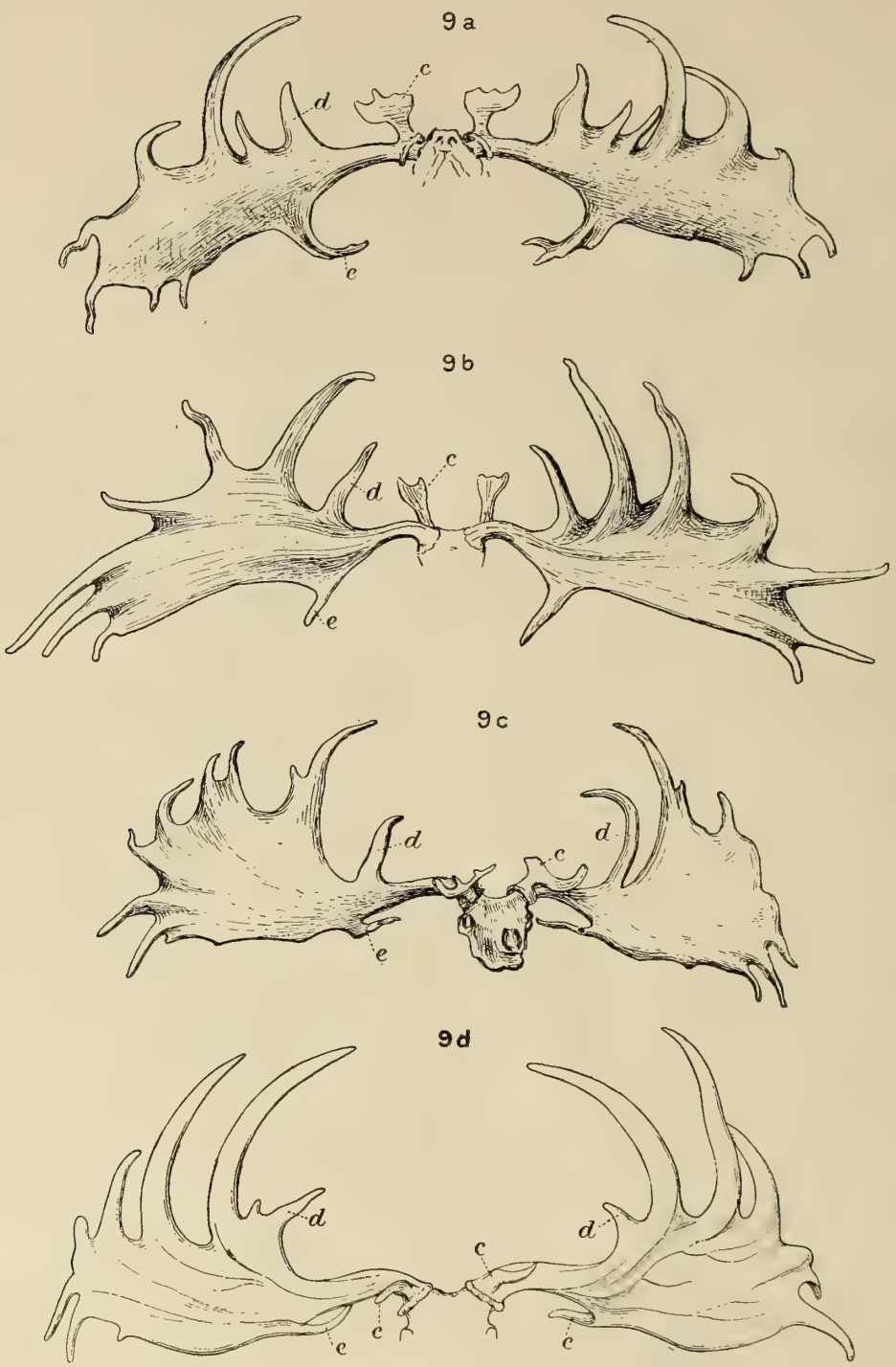


FIG. 9.—The antlers shown in figs. **A**, **C** and **D** are all from Ireland, but no further information as to the locality is available. **A** Antero-inferior view of the antlers at the College of Science, Dublin. The right brow tine is remarkably flattened, the left back tine is forked. The second tine springs from the commencement of the beam. **B** Anterior view of the antlers belonging to the skeleton from Lough Gur, Limerick, mounted in a crouching attitude in the Geological Museum of Trinity College, Dublin. The right brow tine is bifurcated, the left is terminated by three short points. **C** Antero-inferior view of the antlers of the skeleton formerly belonging to Sir Edmund Loder, Bart., and now at Selehurst, Horsham (Capt. W. W. Otter). The 2nd tine of the left antler is of exceptional length, and those of the right antler tend to arise in pairs from broad outgrowths of the palm. **D** Anterior view of antlers formerly belonging to Sir Edmund Loder, Bart., and now at Selehurst, Horsham (Capt. W. W. Otter). The right antler has scarcely any indication of a brow tine, and in both antlers the 2nd tine (*d*), which is very short, springs close to the tines of the beam, which are exceptionally long.

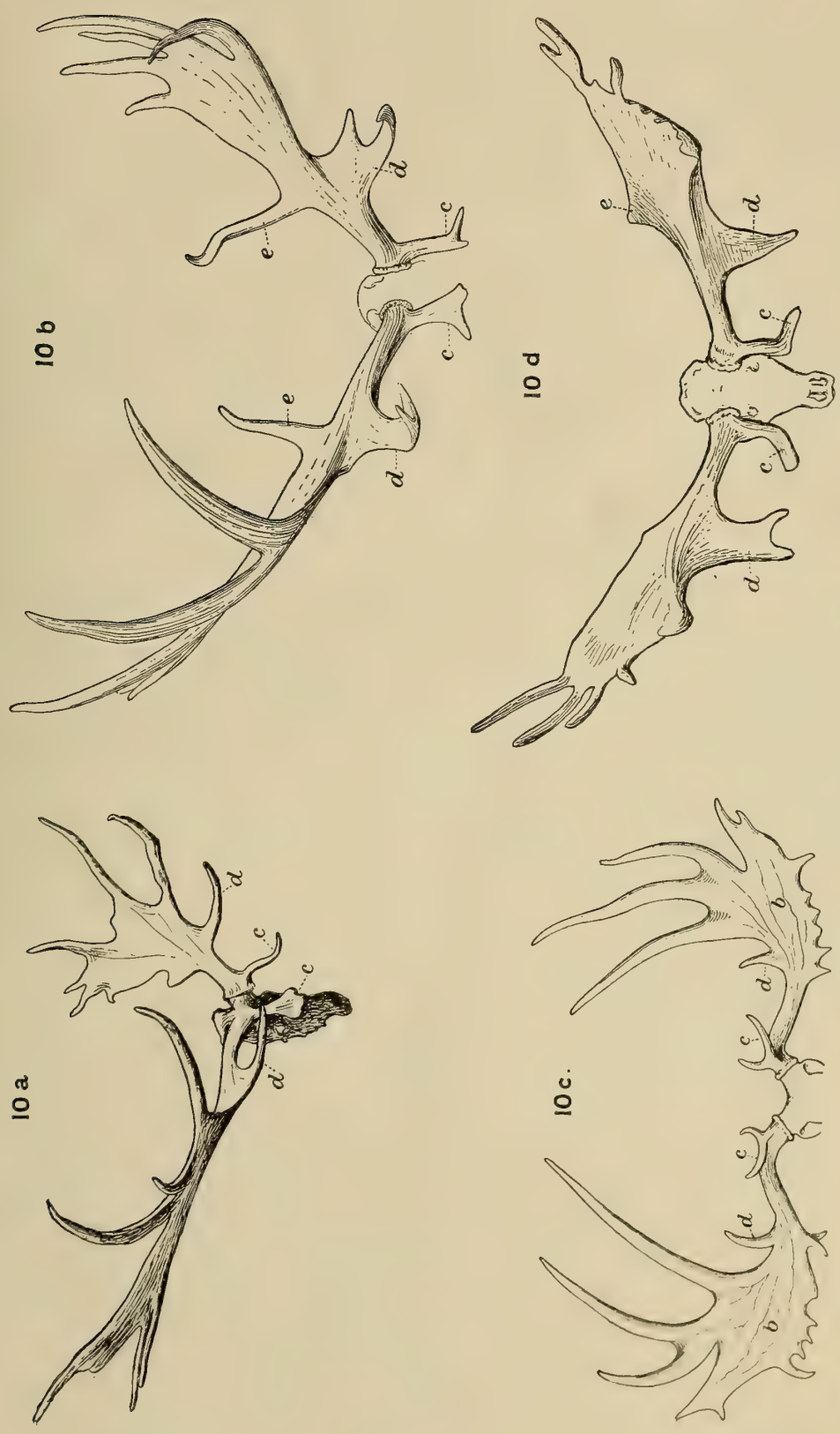


FIG. 10.—Somewhat abnormal antlers. **A** Antlers from "Ireland" supplied by Messrs. Williams & Son of Dublin to Dr. F. Krantz of Bonn, and by him to H. Flemming of Hamburg. The left antler is irregular, especially as regards its posterior border. **B** Front view of the antlers of the skeleton from Limerick now in the Zoological Museum of the University of Zürich. The photograph was taken before the specimen left Dublin. The specimen is remarkable for the flattening and bifurcation of the 2nd tine (*d*) in each antler. **C** Antero-inferior views of antlers from Ireland supplied by Messrs. Williams of Dublin to Dr. F. Krantz of Bonn (after H. Pohlig). The brow and 2nd tines are normal. Of the long tines springing from the anterior face of the palm, the 2nd and 3rd arise from a short base common to both; the 4th is abnormal in being bifurcated. The posterior surface of the palm is very abnormal in bearing a series of about six short points. **D** Front view of abnormal antlers from "Ireland" sold by Messrs. Williams of Dublin to Sir Edmund Loder, Bart., and now at Selehurst, Horsham (Capt. W. W. Otter). The 2nd tines (*d*) spring from an abnormally broad base and the right one is bifurcated. The back tine (*e*) is scarcely indicated. Several short projections spring from the anterior face of the palm, but several of the larger tines which the illustration shows terminating the palm are much restored. (Figured in Millais' "British Deer," p. 19.)

true Deer in the absence of the brow tine and in the expansion of the branch corresponding to the bez. They further differ from those of *Megaceros* in the fact that it is from the anterior part of the palm or crown that the tines spring.

In the Reindeer the antlers agree with or rather exceed those of *Megaceros* in the length and flattened or branched character of the brow tine. The beam, which is greatly branched, differs from that of *Megaceros* in showing no tendency to become flattened.

The Fallow Deer agrees with *Megaceros*, of which it is the nearest living ally, in the expanded character of the beam, and in the fact that the tines spring from the posterior face of the beam. It differs from most specimens of *Megaceros*[1] in the fact that the brow tine is cylindrical, not flattened. It further differs from the Irish race of the Giant Deer, and agrees with some of the continental races in having the antlers directed upwards and forwards instead of extending horizontally.

(*d*) *Dimensions.*

Very numerous measurements of the antlers have been published, especially by Rowland Ward, Millais and Potter ; and certain measurements obtained from various sources are quoted in the descriptions of some of the antlers figured. Only a general value, however, can be attached to such measurements, partly because unless they are all taken by the same person it is very difficult if not impossible to secure absolute consistency, partly because certain measurements, particularly of the span, may largely depend on the amount of " restoration " to which the tines have been subjected. Miss D. M. A. Bate kindly allows me to quote the following measurements made of specimens in the British Museum :

Measurements of Antlers of Cervus giganteus Blumenbach in the British Museum (Natural History), in Feet and Inches.

Brit. Mus. No.	Maximum span.	Greatest length of outside curve.	Circumference immediately above brow tine.	Left antler.	Right antler.
On mounted skeleton (? 15282) Ireland	8′ 11¾″	R. 5′ 5″ L. 5′ 1¼″	10″ 9½″	Tips of 2 tines restored	3 outer tines restored
15602, b, Ireland .	8′ 3″	R. 5′ 6″ L. 5′ 10½″	11½″ 10½″	Complete	Extreme tip of 1 tine restored.
M. 2324, Ireland .	6′ 1″	R. 5′ 2″ L. 5′ 2″	10″ 10″	,,	Ditto.
8085 . . .	9′ 7½″	R. 5′ 7″ L. 5′ 6¾″	9½″ 9½″	Tip of 4 tines restored	Tips of all tines restored.
M. 2323, Ireland .	9′ 7″	R. 6′ 3½″ L. 6′ 9½″	10½″ 10½″	Complete	Extreme tips of 3 tines restored.

[1] The relatively few specimens with a cylindrical brow tine seem to be in the main young individuals.

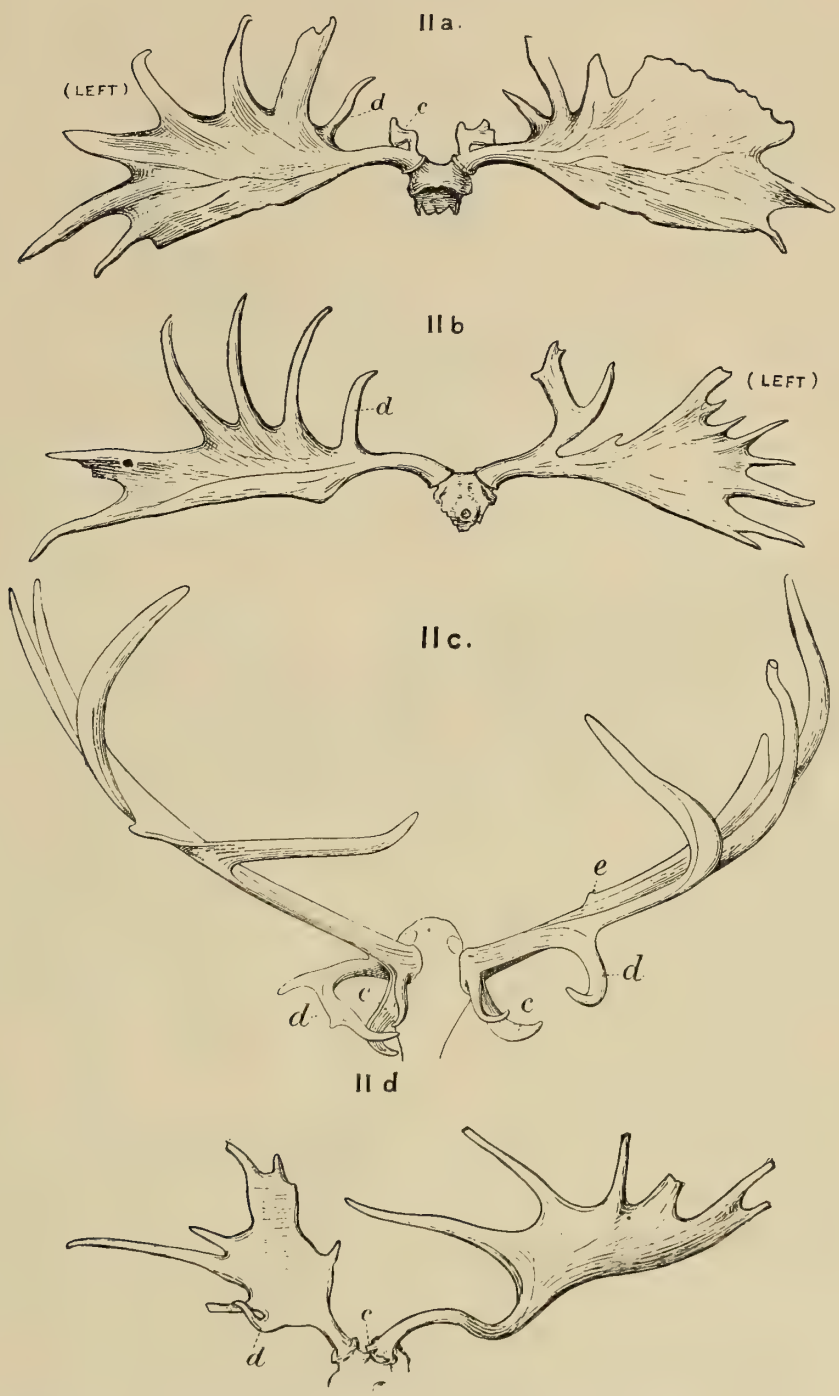


FIG. 11.—Abnormal antlers. **A** Antlers from Knocklong, Limerick (No. 83, Nat. Mus., Dublin), seen from above. In each antler the 2nd tine (*d*) springs close to the first tine of the palm. No back tines occur. The left antler is relatively normal, but the right antler has the greater part of the anterior border ending in a straight, slightly irregular edge instead of being drawn out into tines. **B** Anterior view of antlers from Lough Gur, Dublin. This abnormal specimen, now in the National Museum, Dublin, was figured by V. Ball. Brow and back tines are absent, but in other respects the right antler is normal. The blade or palm of the left antler is described by Ball as bifurcated. The smaller part, which may represent the 2nd tine, is itself bifurcated, one of the branches showing further subdivisions. The larger part has no tines on its anterior face, but terminates in a series of eight points or short tines. **C** Front view of antlers belonging to J. Purefoy Poe, of Harley Park, Callan, co. Kilkenny, and believed to have been found in the neighbourhood. The brow tines (*c*) are remarkably forked, and in the right antler the 2nd tine (*d*) is long and branched and abnormal in arising close to the brow tine. There is a slight indication of a left back tine (*e*). **D** Left lower view of antlers (No. 79, Nat. Mus., Dublin) from Tipperary. The left antler is very abnormal, particularly as regards the length, slenderness and sharply bent character of the beam. There is a small brow tine (broken off) but no back or 2nd tine. The right antler, in which the beam is normal, has a second tine (*d*), but no brow tine.

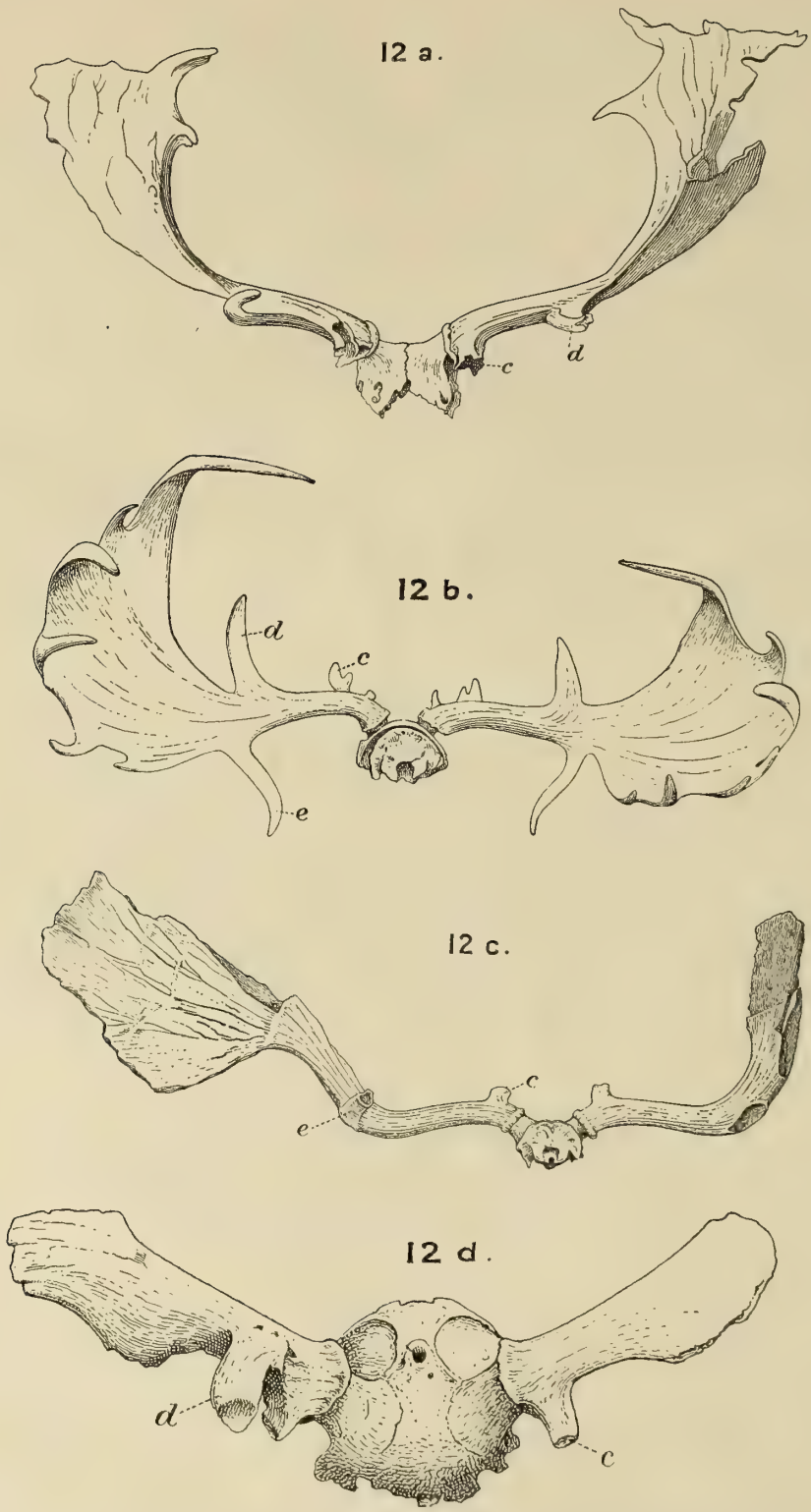


FIG. 12.—Antlers of early forms of Giant Deer. *a*, *Cervus* (*Euryceros*) *italiæ*; after Gastaldi, seen from in front. *b*, *Megaceros* (*Euryceros*) *germaniæ*, Pohlig; from Knielingen (Landessammlung für Naturkunde, Karlsruhe); after Frentzen and Speyer, seen from below. *c*, *Cervus belgrandi*, Harmer; from the Forest Bed, Pakefield, near Lowestoft (British Museum), after Harmer, seen from behind. *d*, *Cervus* (*Megaceros*) *mosbachensis*, Soergel; from Mosbach (Naturhistorisches Museum, Mainz); after Soergel, seen from above.

Owen mentions that a skull and antlers in the Museum of the Royal College of Surgeons in London weighed 87 lb., and that the average weight of the skull without the antlers or mandible is $5\frac{1}{4}$ lb. This gives $81\frac{3}{4}$ lb. as the weight of the antlers—an astonishing amount of bony material to be produced annually and discarded.

(*e*) *Classificatian of Deer Based on the Antlers.*

Brooke's classification of the Cervidæ based on the structure of the manus and pes was universally accepted till Cameron[1] in 1892 proposed to replace it by one based on the antlers. He divided the Cervidæ into three sections :

1. For the Reindeer with antlers in both sexes.
2. For the Elk with laterally extended antlers.
3. For the remainder with erect or suberect antlers found only in the male. This group he further subdivided into—
   - (*a*) A group including the typical Old World Deer and the Wapiti, with a normal brow tine springing from the outer side of the beam, and—
   - (*b*) A group including the typical New World Deer (except the Wapiti), the Roe and one or two others. In these the first tine is considered not to be comparable to the brow tine as it arises from the inner side of the beam.

Cameron's classification is accepted by Lydekker.

Pocock, from a study of the antler development in an American Deer (*Odocoileus*), shows that the first tine arises externally, but gradually assumes an apparently more internal position as growth proceeds. Hence he concludes that the term " brow tine " is equally applicable in Old World and American Deer.

c. Dentition (Plate II, and Text-figs. 13, 14).

The teeth in the Cervidæ, as in all Ruminants, are very uniform in number, and those of the Irish Giant Deer conform to the usual formula of—

$$\text{i.}\ \frac{0}{3}\quad \text{c.}\ \frac{0-1}{1}\quad \text{pm.}\ \frac{3}{3}\quad \text{m.}\ \frac{3}{3}.$$

The molar and premolar teeth are much less markedly hypsodont than in cattle, but have the normal selenodont grinding surfaces characteristic of Ruminants. Owing to their large size they are liable to be confused with those of *Bos,* but Owen points out the useful distinguishing feature, that in both upper and lower molars a small accessory column on the inner side in the groove between the two main lobes of the tooth is confined to the base of the groove in *Megaceros* while in Bovidæ it is much longer.

[1] 'Field,' 1892, pp. 265, 703, 741, 860.

Upper Dentition.

The premolars and molars form a continuous series (Pl. II, fig. 1); all the members of which are similar in character, but the premolars are little more than half the size of the molars. The character of the grinding surface is better realized from figures than from descriptions, but its peculiar irregularity depends primarily on a dorsal infolding of the enamel, which after wear forms an irregular depression sometimes partly occupied by cement and surrounded by an enamel rim. External to this rim is the dentine forming the bulk of the tooth, while finally the prominent outer border consists of enamel. In the premolars the infold

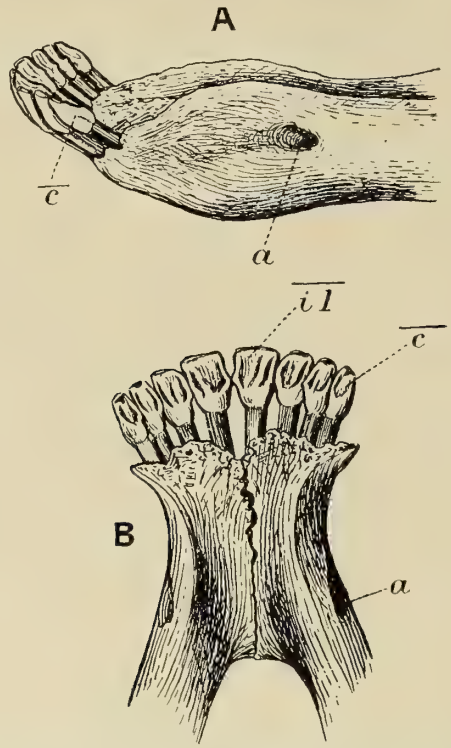


Fig. 13.—Anterior end of mandible with incisor and canine teeth. **A** Left side view; **B** seen from above; half natural size. From Mullingar (Nat. Mus., Dublin). *a*, mental foramen for passage of a branch of the 5th nerve.

of enamel has the posterior portion nearly or completely isolated from the remainder according to the state of wear of the tooth. In the molar teeth a sharp infold of enamel from the inner side greatly modifies the whole grinding surface, and gives the dorsal infold the character of a double crescent. The molar teeth have four roots, the premolars two on the inner, but one on the outer side.

Lower Dentition.

The three incisors and the incisiform canine have long tapering roots and expanded chisel-like blades, which together form a continuous cutting edge. The upper surface of the blade is marked by a depression. The teeth project conspicuously forward,

and a considerable part of the root is not enclosed in the alveoli in the specimens examined.

There is a gap of eleven or more centimetres between $\overline{c.}$ and $\overline{pm.\ 2}$, $\overline{pm.\ 1}$ being absent. The premolar and molar teeth steadily increase in size throughout the series (Pl. II, figs. 2—4). While in the molars a deep transverse groove on the outer side of the tooth meeting a less conspicuous one on the inner side almost bisects the tooth, the premolars have no such conspicuous grooving. The enamel infoldings into the crown of the tooth are crescent-shaped in the worn molars, but not in the premolars. The last molar has a conspicuous third lobe, and in all the molars a small cusp springs just above the alveolus on the outer side of the tooth.

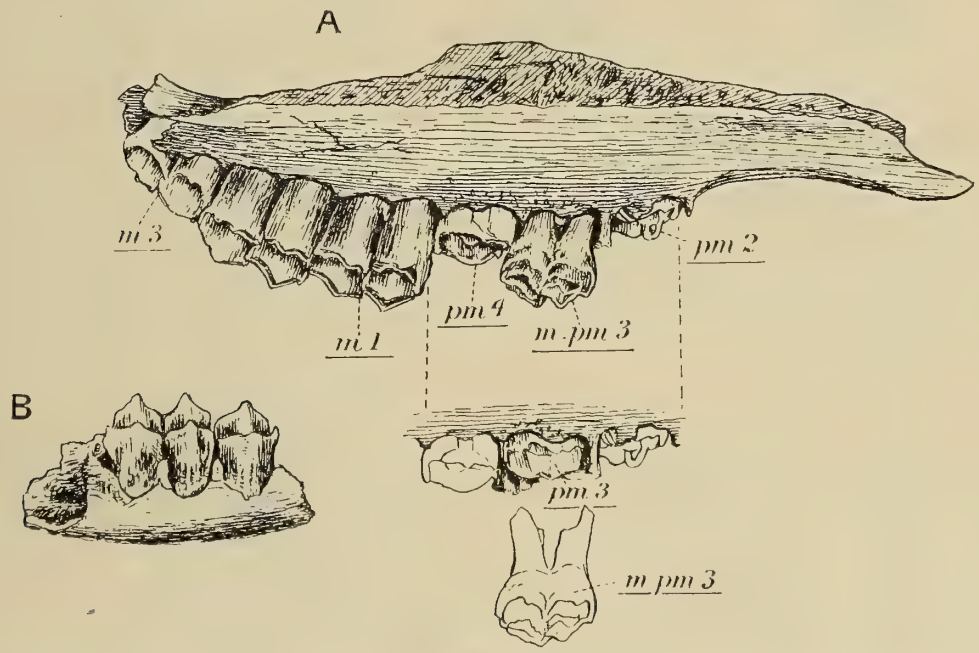


Fig. 14.—Milk dentition. **A** Inner view of left maxilla showing a milk tooth (m. pm. 3) in addition to the permanent dentition. From Carlow. **B** Left lower third milk premolar. From Doneraile. Both half natural size (Nat. Mus., Dublin).

Milk Dentition.

This is imperfectly known, but a maxilla (Text-fig. 14A) in the National Museum, Dublin, has m. pm. 3 just about to be shed, and a second fragment has $\overline{m.\ pm.\ 3}$ (Text-fig. 14B). The former specimen is from Carlow, the latter from Doneraile Cave.

D. The Vertebral Column.

Cervical Vertebræ.—In the male these are distinguished by their great size and massive character in correlation with the weight of the antlers. The cervical vertebræ of the female, in correlation with the absence of the great antlers, are considerably smaller than those of the male.

The *atlas* (Text-fig. 15A and B) has specially deep articulating surfaces for the condyles of the skull, and rather short but massive transverse processes thickened

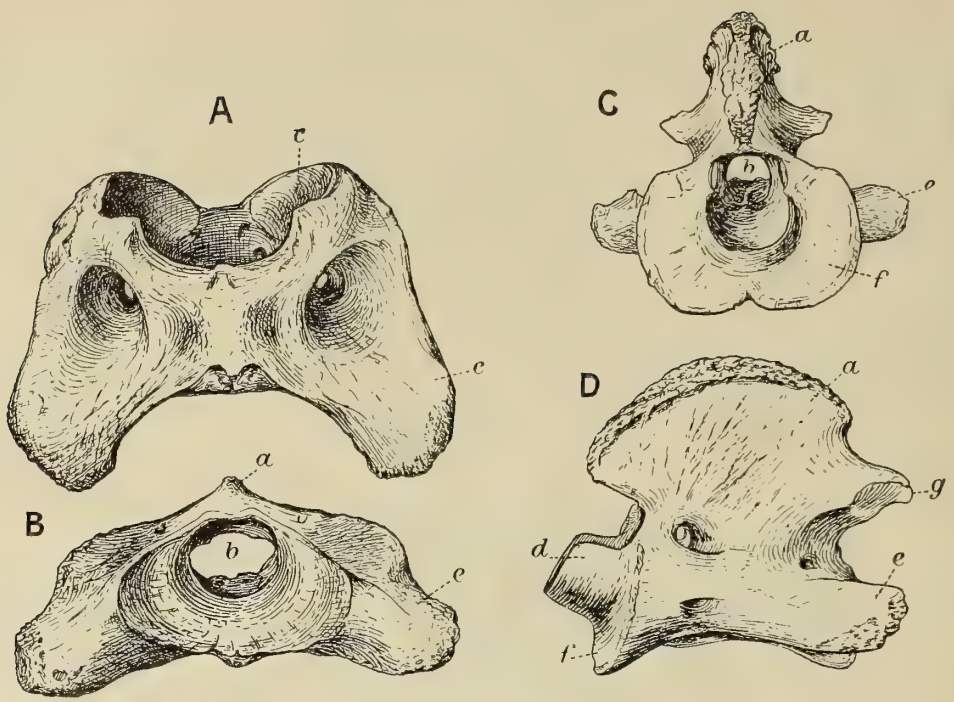


Fig. 15.—**A** Atlas seen from above; **B** atlas, front view; **C** axis, front view; **D** axis, left side view; ¼ natural size. From Rockbarton, Kilmallock, Limerick (Nat. Mus., Dublin). *a*, neural spine; *b*, neural canal; *c*, surface for articulation with condyles of skull; *d*, odontoid process; *e*, transverse process; *f*, surface for articulation with atlas; *g*, post-zygapophysis.

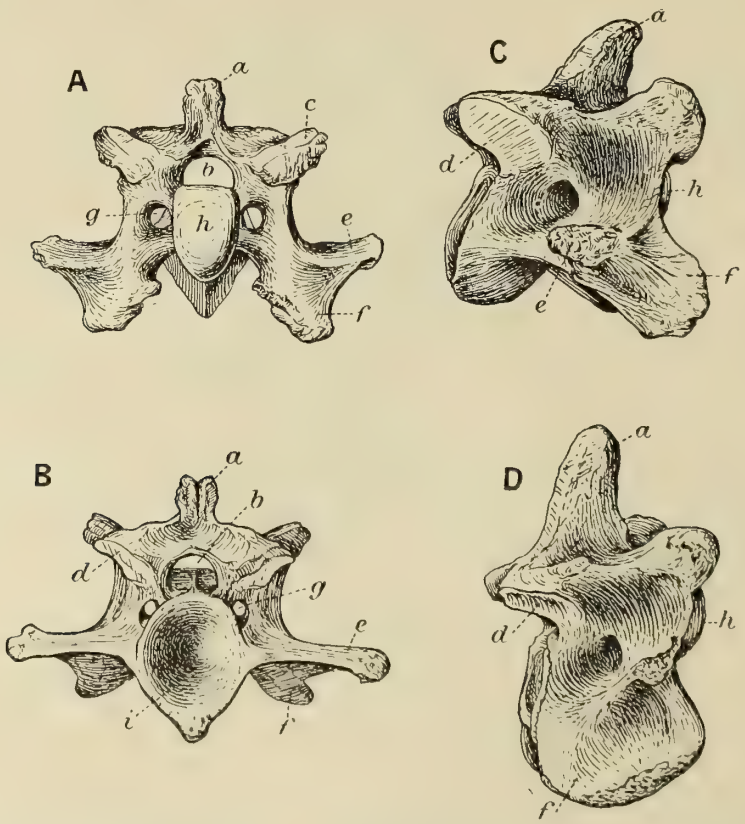


Fig. 16.—Cervical vertebræ. **A** 5th, front view; **B** 5th, posterior view; **C** 6th, right side view; **D** 7th, right side view. All ¼ natural size. All from Rockbarton, Kilmallock, Limerick (Nat. Mus., Dublin). *a*, neural spine; *b*, neural canal; *c*, prezygapophysis; *d*, postzygapophysis; *e*, transverse process; *f*, inferior lamella of transverse process; *g*, vertebrarterial canal; *h*, anterior face of centrum; *i*, posterior face of centrum.

at the ends. The foramina on the upper surface for the passage of the spinal nerves are very conspicuous. The *axis* (Text-fig. 15C, D) differs less from the other cervical vertebræ than is usually the case. It has the usual scoop-like odontoid process characteristic of Ruminants. The neural spine is not very high. The remaining five cervical vertebræ (Text-fig. 16) are much alike. The neural spines are short, particularly in the case of vertebræ 3 and 4; the transverse processes give off a strong projection anteriorly, which in the case of vertebræ 3 and 4 is forwardly-directed; in 5, 6 and 7 it becomes more massive and is directed downwards and forwards, and becomes an inferior lamella.

All the measurements of vertebræ given in the following tables are of the male, unless otherwise stated.

MEASUREMENTS OF THE CERVICAL VERTEBRÆ.

	Set M. 2971, Brit. Mus. (J. E. Lee coll.).	Skeleton from Enniscorthy (Sedgwick Mus., Cambridge).	No. 254, 1904 (Nat. Mus., Dublin).
ATLAS.			
1. Maximum width	21·2	22·5	23·2
2. Median dorso-ventral diameter	9·3*	9·3	8·75
3. Extreme width of condylar articular surface	10·8	..	11·05
AXIS.			
1. Length from anterior end of odontoid process to postero-ventral extremity of centrum	15·4	..	15·9
2. Height from base of centrum to top of neural spine	12·7	13·5	15·35
3. Diameter across transverse processes	16·8	17·5	19·6
4. Diameter across articulating surfaces for atlas	10·6	11·55	11·8
5. Diameter across post-zygapophyses	8·15	9·9	10·45

* From end of spine to end of hypapophysis.

MEASUREMENTS OF CERVICAL VERTEBRÆ.

	3rd cervical.				4th cervical.				5th cervical.				6th cervical.				7th cervical.			
	Set M. 2971, Brit. Mus. (J. E. Lee coll.).	Skeleton from Enniscorthy (Sedgwick Mus., Cambridge).	Rockbarton, Kilmallock, Limerick, 254, 1904 (Nat. Mus., Dublin).	Female skeleton from Lough Gur, Limerick (Nat. Mus., Dublin).	Set M. 2971, Brit. Mus. (J. E. Lee coll.).	Skeleton from Enniscorthy (Sedgwick Mus., Cambridge).	Rockbarton, Kilmallock, Limerick, 254, 1904 (Nat. Mus., Dublin).	Female skeleton from Lough Gur, Limerick (Nat. Mus., Dublin.)	Set M. 2971, Brit. Mus. (J. E. Lee coll.)	Skeleton from Enniscorthy (Sedgwick Mus., Cambridge).	Rockbarton, Kilmallock, Limerick, 254, 1904 (Nat. Mus., Dublin).	Female skeleton from Lough Gur, Limerick (Nat. Mus., Dublin.).	Set M. 2971, Brit. Mus. (J. E. Lee coll.).	Skeleton from Enniscorthy (Sedgwick Mus., Cambridge).	Rockbarton, Kilmallock, Limerick, 254, 1904 (Nat. Mus., Dublin).	Female skeleton from Lough Gur, Limerick (Nat. Mus., Dublin).	Set M. 2971, Brit. Mus. (J. E. Lee coll.).	Skeleton from Enniscorthy (Sedgwick Mus., Cambridge).	Rockbarton, Kilmallock, Limerick, 254, 1904 (Nat. Mus., Dublin).	Female skeleton from Lough Gur, Limerick (Nat. Mus., Dublin).
1. Width across transverse processes	17·25	19·5	19·7	13·3	17·2	19·9	19·8	14·0	19·3	20·1	20·6	14·0	16·0	17·9	18·25	11·3	19·5	16·6	15·1	13·4
2. Width across post-zygapophyses	9·7	10·9	10·05	7·7	10·1	11·35	10·8	7·7	10·0	10·75	10·20	7·5	10·25	11·3	11·15	9·0	9·8	10·7	10·15	8·4
3. Length of centrum*	10·5	..	10·4	..	10·05	..	10·75	..	9·7	..	11·1	..	9·6	..	10·5	..	10·0	..	9·35	..

* Measured from centre of anterior convexity to centre of posterior concavity.

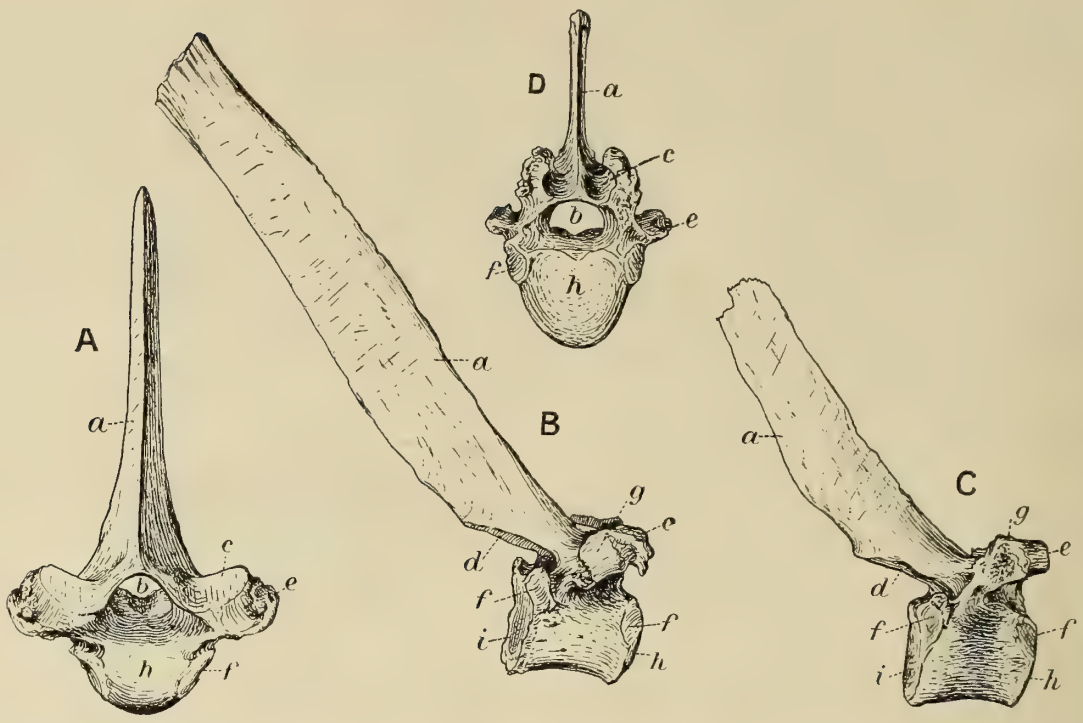


Fig. 17.—Thoracic vertebræ. **A** 1st, front view; **B** 3rd, right side view; **C** 11th, right side view; **D** 15th, front view; all ¼ natural size. From Rockbarton, Kilmallock, Limerick (Nat. Mus., Dublin). *a*, neural spine; *b*, neural canal; *c*, prezygapophysis; *d*, postzygapophysis; *e*, transverse process; *f*, surface for articulation with head of rib; *g*, surface for articulation with tubercle of rib; *h*, anterior face of centrum.

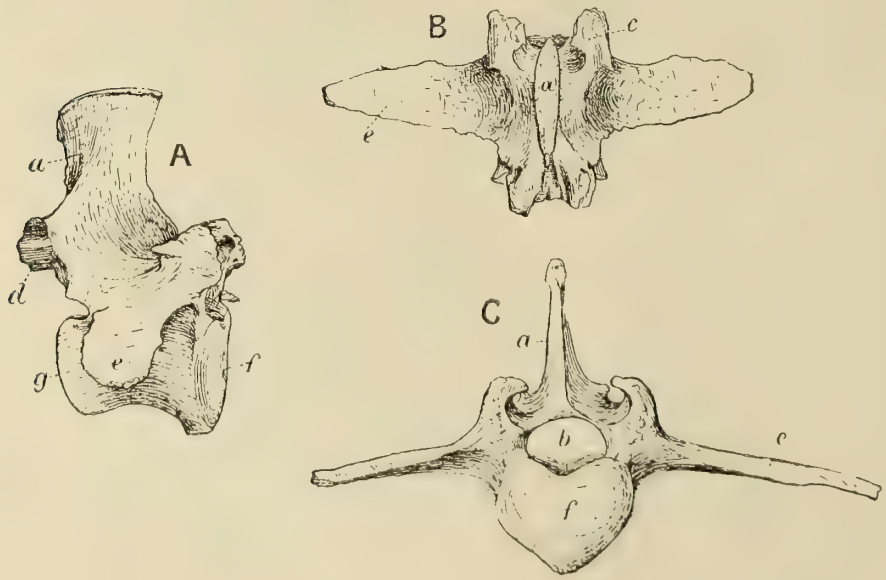


Fig. 18.—Lumbar vertebræ. **A** 2nd, right side view; **B** 2nd, seen from above; **C** 5th, seen from in front; ¼ natural size. From Rockbarton, Kilmallock, Limerick (Nat. Mus., Dublin). *a*, neural spine; *b*, neural canal; *c*, prezygapophysis; *d*, postzygapophysis; *e*, transverse process; *f*, anterior face of centrum; *g*, posterior face of centrum.

Thoracic Vertebræ (Text-fig. 17).—These number thirteen. The spines increase in length from 1 to 3. Vertebræ 4 and 5 have very long spines, but in the succeeding vertebræ the length of the spines rapidly decreases. The spines of vertebræ 1–11 are backwardly-directed to a greater or lesser extent. Those of vertebræ 12 and 13 are practically vertical and resemble the spines of lumbar vertebræ. The centra throughout are short, nearly cylindrical and very uniform in length.

Measurements of Thoracic Vertebræ.

(All No. 254 [1904] from Rockbarton, Kilmallock, co. Limerick, in the National Museum, Dublin.)

	1st.	4th.	7th.	9th.	11th.	14th.
1. Height from notch between pre-zygapophyses to top of neural spine . .	21·8	36·6	29·0	21·5	20·3	15·4
2. Width across transverse processes .	14·25	10·5	10·9	10·3	10·7	8·5
3. Width across pre-zygapophyses . .	10·5	8·5	7·0	6·5	6·8	..

Measurements of Lumbar Vertebræ.

(Details as with thoracic vertebræ.)

	1st.	3rd.	5th.
1. Length of centrum	7·1	7·1	7·25
2. Measurement across transverse processes	17·6	25·0	27·0
3. Height from mid-central point of centrum to top of neural spine . . .	16·25	16·15	15·3

Measurements of Sacrum.

	No. 15, 1915, Dublin.	No. 254, 1904, Rockbarton, Kilmallock, co. Limerick.
1. Length of sacrum	23·2	25·85
2. Height to top of neural spine of 2nd true sacral	10·8	12·9
2. Measurement across transverse processes of 1st sacral . . .	22·5	24·0

Lumbar Vertebræ (Text-fig. 18).—The five lumbar vertebræ all have the neural spines abruptly truncated, and the centra very uniform in length. The transverse processes are long and straight, taper slightly towards their terminations, and are as a rule directed slightly forwards.

Sacral and Caudal Vertebræ (Text-figs. 19, 20).—There are two sacral and three pseudosacral vertebræ. Both sacral and pseudosacral have rather large neural spines,

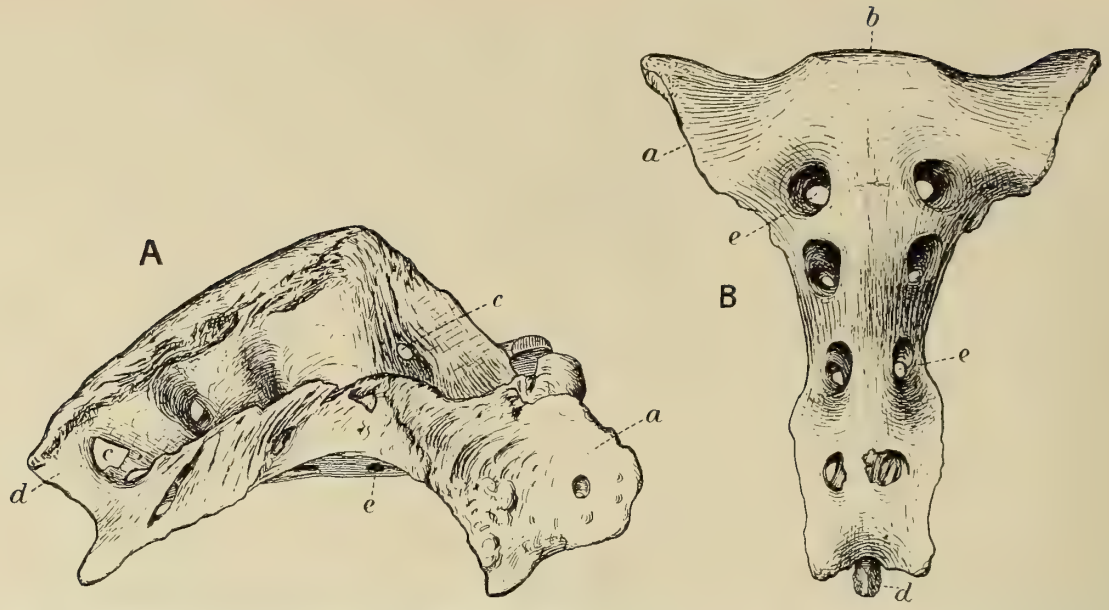


FIG. 19.—Sacrum. **A** Right side view; **B** lower surface; $\frac{1}{4}$ natural size. From Rockbarton, Kilmallock, Limerick (Nat. Mus., Dublin). *a*, articular surface for ilium; *b*, anterior face of centrum of 1st sacral vertebra; *c*, gaps between partially coalesced neural spines of sacral and pseudosacral vertebræ; *d*, neural spine of last pseudosacral vertebra; *e*, foramen for exit of spinal nerve

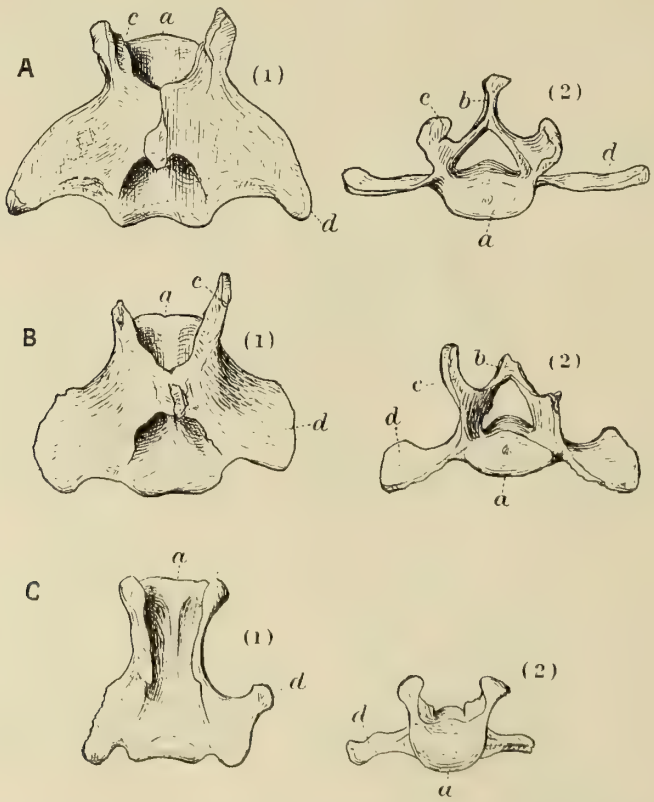


FIG. 20.—Free caudal vertebræ. **A** The first; **B** the second; **C** the third, (1) seen from above, (2) front view. Drawn from casts in the National Museum, Dublin, of the original specimen from Lough Gur, Limerick, now at Trinity College, Dublin. $\frac{2}{3}$ natural size. *a*, anterior surface of centrum; *b*, neural spine; *c*, prezygapophysis; *d*, transverse process.

the tops of which merge into one another. The short transverse processes also merge. The anterior tail-vertebræ have only rarely been obtained and the terminal vertebræ have apparently never been found.

E. The Ribs and Sternum (Text-fig. 21).

There are thirteen pairs of ribs, the anterior being rather wide and flattened.

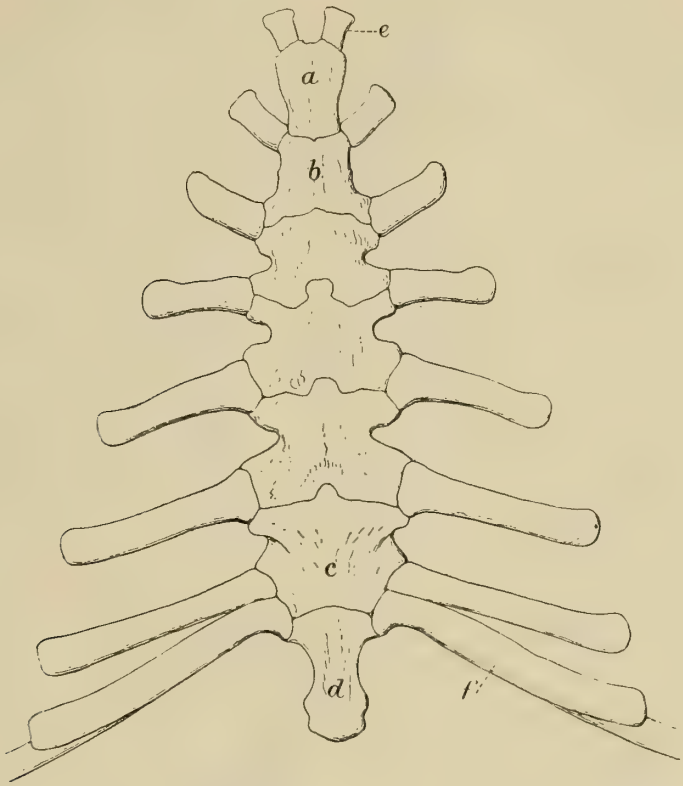


Fig. 21.—Sternum of the female skeleton from "Ireland" set up in the British Museum (Nat. Hist.). $\frac{1}{6}$ natural size. *a*, presternum; *b*, first sternebra of mesosternum; *c*, last sternebra of mesosternum; *d*, xiphisternum; *e*, first sternal rib; *f*, last sternal rib. The figure as drawn is somewhat foreshortened.

F. The Shoulder Girdle (Text-fig. 22).

The scapula has a well-marked spine, but the acromion is not prominent. The outline is nearly that of an isosceles triangle, as in Ruminants in general.

Measurements of the Scapula.

	Skeleton from Enniscorthy (Sedgwick Mus., Cambridge).	Rockbarton, Kilmallock, Limerick, 254, 1904 (Nat. Mus., Dublin).
1. Length along line of spine .	45·02	49·3
2. Maximum width . . .	28·6	27·3
3. Width at neck. . . .	7·65	7·4

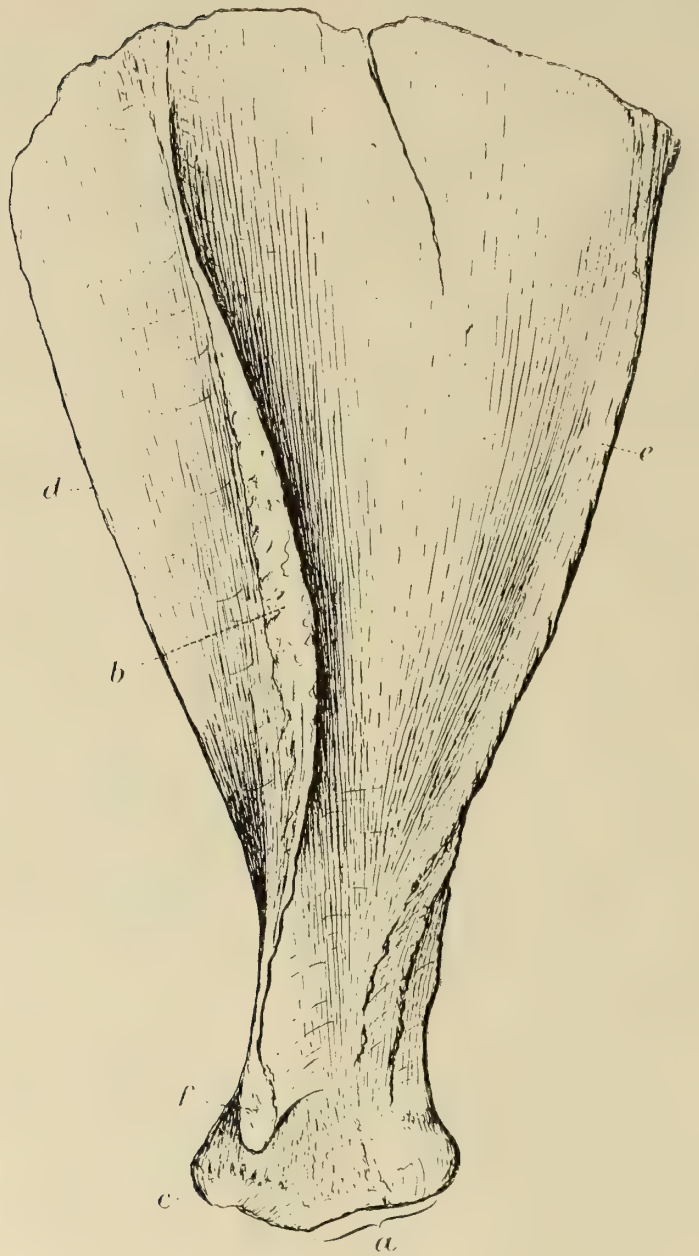


Fig. 22.—Left scapula seen from outer side. $\frac{1}{3}$ natural size. From Rockbarton, Kilmallock, Limerick (Nat. Mus., Dublin). *a*, glenoid cavity ; *b*, spine ; *c*, coracoid process ; *d*, coracoid border ; *e*, glenoid border ; *f*, acromion.

G. The Anterior Limb (Text-figs. 23—26).

In the *humerus* (Text-fig. 23) the tuberosities and deltoid ridges are not very prominent. The great tuberosity is blunt and not much inwardly-directed. The condyle is strongly marked, and the anconeal fossa is deep. There is no supratrochlear foramen.

The *radius* (Text-fig. 24) is a large bone having the form commonly found in swift-footed ungulates. The ulna has a large olecranon, but the lower half, which is firmly united to the radius, is reduced to a thin splint-like bone.

FIG. 23.—Right humerus. **A** Antero-internal view; **B** Outer (right side) view. ⅓ natural size. From Rockbarton, Kilmallock, Limerick (Nat. Mus., Dublin). *a*, head; *b*, great tuberosity; *c*, lesser tuberosity; *d*, deltoid ridge; *e*, trochlear surface; *f*, external condyle; *g*, internal condyle.

The *carpus* (Text-fig. 25A) has the arrangement characteristic of the Ungulata vera. There is no centrale; the magnum articulates with the scaphoid and is separated from the cuneiform by the meeting of the unciform and lunar. All the carpal bones

strongly interlock. The *manus* has the normal Ruminant feature of the union of metacarpals 3 and 4 to form the cannon-bone. The Irish Giant Deer belongs to the

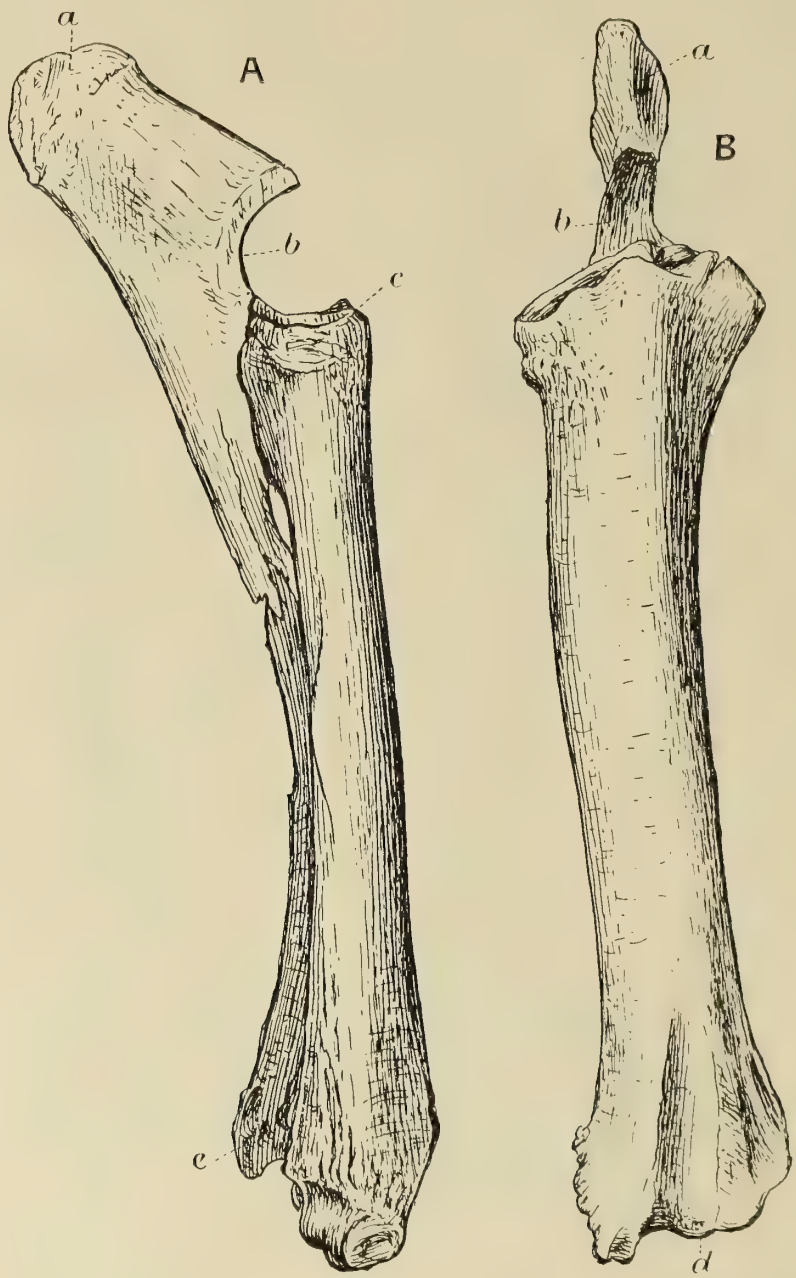


FIG. 24.—**A** Left radio-ulna seen from right side; **B** the same seen from in front; $\frac{1}{3}$ natural size. From Rockbarton, Kilmallock, Limerick (Nat. Mus., Dublin). *a*, olecranon; *b*, surface for articulation with trochlea; *c*, proximal end of radius; *d*, distal end of radius; *e*, distal end of ulna.

plesiometacarpal section of the Cervidæ, in which the proximal part of the second and fifth metacarpals persists in the form of a short splint. Distally the second and fifth digits are represented by the full series of three small phalanges.

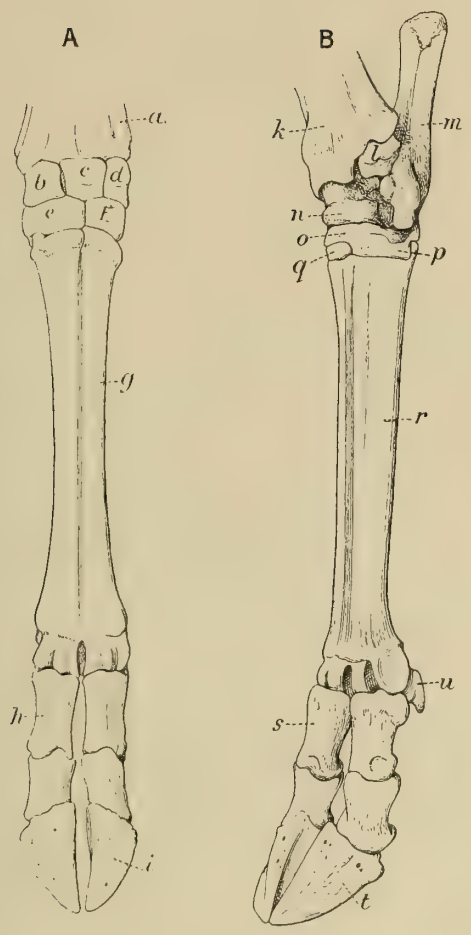


FIG. 25.—**A** Left manus seen from in front, and **B** left pes antero-lateral view of the female skeleton from "Ireland" in the British Museum (Nat. Hist.); $\frac{1}{6}$ natural size. **A** *a*, radius; *b*, scaphoid; *c*, lunar; *d*, cuneiform; *e*, magnum trapezoid; *f*, unciform; *g*, 3rd and 4th metacarpals fused; *h*, proximal phalanx of 3rd digit; *i*, ungual phalanx of 4th digit. **B** *k*, tibia; *l*, fibula; *m*, calcaneum; *n*, astragalus; *o*, navicular portion of naviculo-cuboid; *p*, cuboid portion of naviculo-cuboid; *q*, external cuneiform; *r*, 3rd and 4th metatarsals fused; *s*, proximal phalanx of 3rd digit; *t*, ungual phalanx of 4th digit; *u*, sesamoid bone.

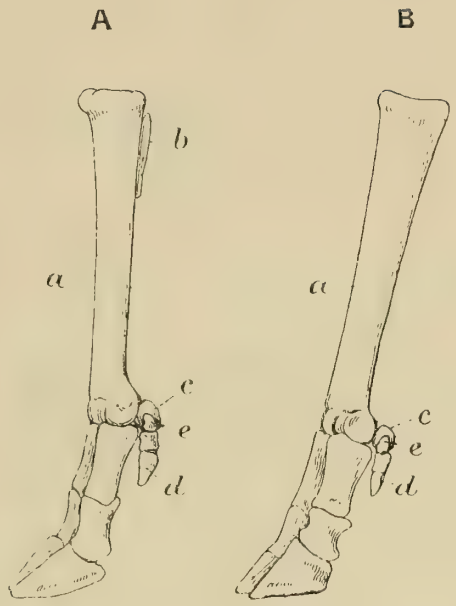


FIG. 26.—**A** Left manus and **B** left pes, of the skeleton from Ireland in the Museum at Selehurst, Horsham (Capt. W. W. Otter), antero-lateral view. *a*, 3rd and 4th metacarpals (or metatarsals), fused; *b*, vestige of proximal end of 5th digit; *c*, sesamoid bone; *d*, ungual phalanx of 5th digit; *e*, proximal phalanx of 5th digit.

TABLE OF MEASUREMENTS.

	Skeleton from Enniscorthy (Sedgwick Mus., Cambridge).	Rockbarton, Kilmallock, Limerick, 254, 1904 (Nat. Mus., Dublin).
HUMERUS.		
1. Extreme length	41·35	40·3
2. Maximum transverse diameter at distal end	10·15	9·8
3. Antero-posterior diameter of shaft at highest point in deltoid ridge	6·9	9·65
RADIUS.		
1. Extreme length	37·7	38·45
2. Width at proximal end	10·2	10·05
3. Width at distal end	10·05	9·05
ULNA.		
1. Length (not measured along curvature)	48·7	47·2

THE MANUS.

	Skeleton from Enniscorthy (Sedgwick Mus., Cambridge).
1. Length of cannon-bone (metacarpals 3 and 4)	31·4
2. Transverse measurement at proximal end of cannon-bone	7·1
3. Transverse measurement at distal end of cannon-bone	7·4
4. Length of 1st phalanx, measured in middle of outer side	7·2
5. Length of 2nd phalanx, measured in middle of outer side	4·9
6. Length of ungual phalanx, measured along outer edge	7·1

H. THE PELVIC GIRDLE (Text-fig. 27).

The pelvis has the somewhat narrow form characteristic of Ruminants. The *ilium* is widely expanded anteriorly, but narrows much in front of the acetabulum. The *pubis* is a small bone. There is a long symphysis ischii. The ischial tuberosities are very prominent, as is usual in Ruminants. The obturator foramen is oval and of moderate size.

MEASUREMENTS OF THE RIGHT INNOMINATE BONE.

	Skeleton from Enniscorthy (Sedgwick Mus., Cambridge).	Rockbarton, Kilmallock, Limerick. 254, 1904 (Nat Mus., Dublin)
1. Maximum length	51·0	55·0
2. Length from middle of edge of acetabulum to middle of supinator border of ilium . .	24·0	25·5
3. Width of expanded portion of ilium. . .	20·0	24·2
4. Dorso-ventral measurement of ilium at narrowest point in front of acetabulum . .	5·4	5·1
5. Length of symphysis	19·9	19·25
6. Dorso-ventral measurement of ischium at narrowest point behind acetabulum . .	6·6	6·0

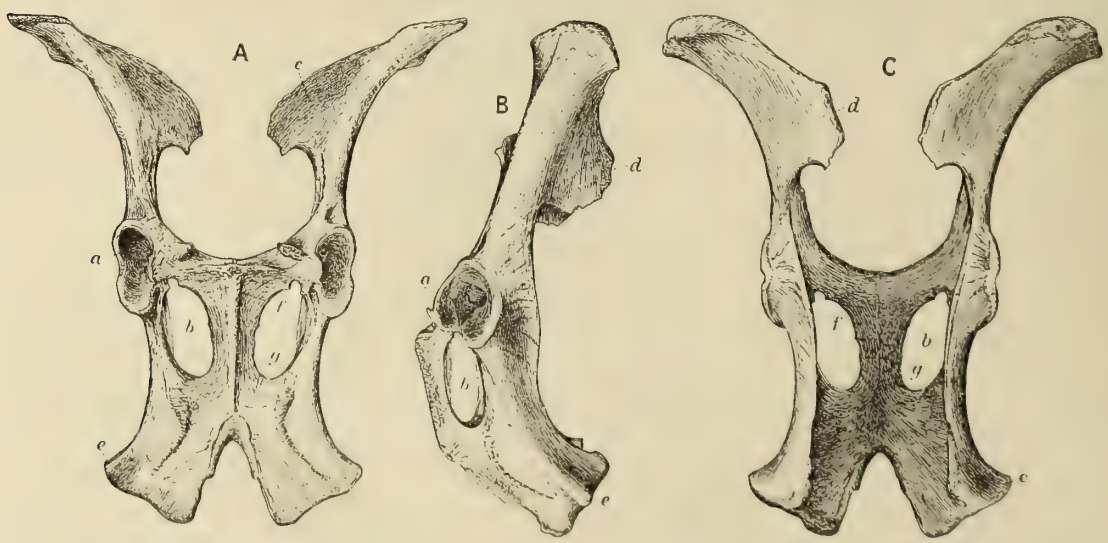


FIG. 27.—Pelvis. **A** Seen from below. **B** Left side view. **C** Seen from above. $\frac{1}{8}$ natural size. From Rockbarton, Kilmallock, Limerick (Nat. Mus., Dublin). *a*, acetabulum ; *b*, obturator foramen ; *c*, gluteal surface of ileum ; *d*, iliac surface of ilium ; *e*, ischial tuberosity ; *f*, pubic symphysis ; *g*, ischial symphysis.

I. The Posterior Limb (Text-figs. 28—30).

The *femur* (Text-fig. 28) has very slight indications of a neck. The great trochanter is very large, the lesser very small, and as in other Artiodactyls there is no 3rd trochanter. The upper end of the *tibia* (Text-fig. 29) is characteristically bent.

In the character of the digits the *pes* (Text-fig. 25B) is analogous to the manus. The *astragalus* has both proximal and distal surfaces pulley-like as in other Artiodactyls.

Table of Measurements.

	Skeleton from Enniscorthy (Sedgwick Mus., Cambridge).	Rockbarton, Kilmallock, Limerick, 254, 1904 (Nat. Mus., Dublin).
Femur.		
1. Length measured from head to internal condyle	43·7	45·2
2. Transverse diameter at condyle	12·3	11·8
3. Transverse measurement across head and great trochanter	17·0	15·5
Tibia.		
1. Length	43·7	46·3
2. Right to left diameter at proximal end	13·1	12·2
3. Antero-posterior diameter at proximal end measured from notch between articular surface for femur to top of crest	10·5	10·2
4. Right to left diameter at distal end	8·75	8·2

	Skeleton from Enniscorthy (Sedgwick Mus., Cambridge).
The Pes.	
1. Length of calcaneum	17·8
2. Maximum transverse diameter of calcaneum (oblique measurement)	8·6
3. Right to left diameter of astragalus measured at tibial articular surface	5·3
4. Length of cannon-bone	33·8
5. Transverse measurement of cannon-bone at proximal end	6·5
6. Transverse measurement of cannon-bone at distal end	7·1
7. Length of 1st phalanx measured in middle of outer surface	7·3
8. Length of 2nd phalanx measured in middle of outer surface	4·8
9. Length of ungual phalanx measured along inner edge	7·1

FIG. 28.—Right femur. **A** Seen from behind. **B** Front view. $\frac{1}{3}$ natural size. From Rockbarton, Kilmallock, Limerick (Nat. Mus., Dublin). *a*, head; *b*, great trochanter; *c*, lesser trochanter; *d*, internal condyle; *e*, external condyle; *f*, trochlear surface.

FIG. 29.—Right tibia. **A** Front view; **B** seen from behind. $\frac{1}{4}$ natural size. From Rockbarton, Kilmallock, Limerick (Nat. Mus., Dublin). *a*, surface for articulation with condyles of femur; *b*, cnemial crest.

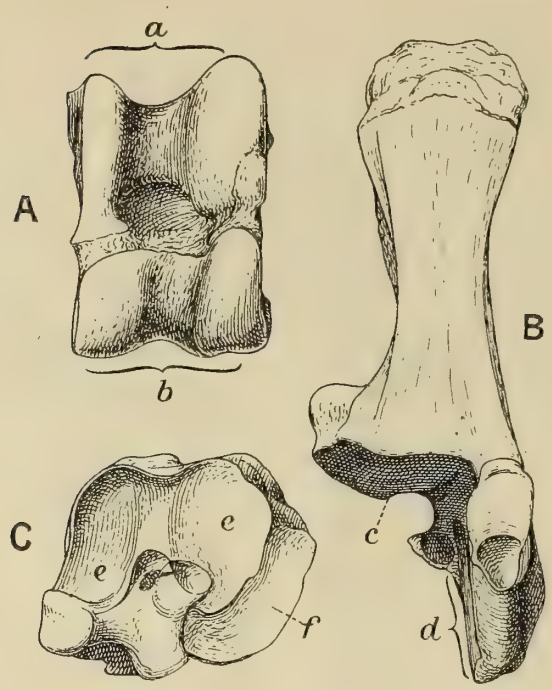


FIG. 30.—**A** Left astragalus seen from in front. *a*, surface (condyle) for articulation with the tibia; *b*, surface for articulation with the naviculo-cuboid. **B** Left calcaneum seen from in front. *c*, surface for articulation with the upper surface of the astragalus; *d*, surface for articulation with the outer surface of the astragalus. **C** Right naviculo-cuboid seen from above. *e*, surface for articulation with the astragalus; *f*, surface for articulation with the calcaneum. All half natural size and all from "Ireland" (British Museum (Nat. Hist.), Nos. M. 2339, 18151, 18038).

VI. LIST OF IRISH GIANT DEER SKELETONS AND ANTLERS.

The list of antlers preserved in England is by no means complete, while it is impossible to prepare an even approximately complete list of those in Ireland. Dr. H. Stokes of Dublin writes: "There are many heads in private houses all over Ireland, I would guess several hundreds."

SKELETONS.

A. *In the British Isles.*

(1) In public institutions:

London, British Museum (Nat. Hist.), S. Kensington (2, one of them female); Royal College of Surgeons Museum.

Edinburgh, Royal Scottish Museum.

Dublin, National Museum of Ireland (4, one disarticulated); Trinity College (3); College of Science Museum.

Belfast, City Museum.

Birmingham, City Museum; University Museum.

Cambridge, Sedgwick Museum.

Cardiff, National Museum of Wales.

Glasgow, City Museum.
Leeds, City Museum.
Liverpool, City Museum.
Oxford, University Museum (a second skeleton in store).
Sheffield, City Museum.
Tring, Zoological Museum.
Warwick, Town Museum.
York, Yorkshire Museum.
Douglas Museum, Isle of Man.

(2) In private possession :

Marquess of Londonderry, Mount Stewart, co. Down ; Mr. J. Gaisford St. Lawrence, Howth Castle, co. Dublin ; Lord Powerscourt ; Dr. H. Stokes, Dublin ; Col. Vernon, Clontarf Castle, co. Dublin ; Mr. A. Heber-Pe cy, Hodnet Hall, Salop ; Capt. W. W. Otter, Selehurst, Horsham.

B. *On the Continent.*

In the Museums of Amsterdam, Basel, Berlin, Dijon, Frankfort, Hamburg, Lyons, Paris, Stuttgart, Vienna, Zürich.

C. *In America.*

Berkeley University Museum, California.
Chicago, Field Museum.
Cleveland, Ohio, Museum of Natural History.
Denver, Col.
Harvard University Museum, Cambridge, Mass.
New York, Columbia University Museum ; American Museum of Natural History.
Yale University Museum, Newhaven, Conn.

ANTLERS.

A. *In the British Isles.*

(1) In public institutions :

London, British Museum (Nat. Hist.), S. Kensington (6) ; Royal College of Surgeons Museum ; Geological Society, Burlington House (2).
Aberdeen, Marischal College.
Birmingham, City Museum.
Brighton, Municipal Museum (2).
Bristol, City Museum (2).
Cambridge, Sedgwick Museum.
Derby, Municipal Museum (2).
Dublin, National Museum, 32 skulls with antlers, 14 shed antlers.

Eton College Museum (imperfect).
Exeter, Royal Albert Memorial Museum.
Halifax, Belle Vue Museum (one antler).
Hull, Municipal Museum (2).
Leeds, City Museum (2).
Leicester, Municipal Museum.
Maidstone, Municipal Museum (imperfect).
Liverpool, City Museum (2).
Manchester, University Museum.
Penzance, R. Geol. Soc. of Cornwall.
Oxford, University Museum (3).
Reading, Town Museum.
Saffron Walden.
Sheffield, City Museum.
Warrington, Municipal Museum.
York, Yorkshire Museum.

(2) In private possession :

Duke of St. Albans, Duke of Westminster, Marquess of Londonderry, Earl of Besborough, Lord Sackville (Knowle, Sevenoaks), Lord Powerscourt, Mrs. Donaldson Hudson, Mrs. Graham Lloyd, Mr. J. G. Millais, Mr. G. C. Whittaker, Sir Peter Walker, Capt. W. W. Otter, Selehurst, Horsham (formerly belonging to Sir Edmund Giles Loder, Bart.).

The above are quoted by Rowland Ward.

Sir G. Abercrombie, Forglen, Turriff, Aberdeen (2) ; Lord Rothschild, Tring (2) ; Miss J. Cunningham, Bute House, Brook Green, Hammersmith ; Sir Ernest Wills, Littlecote, near Hungerford ; Capt. Desmond Buxton, Catton Hall, Norwich.

The following is a very incomplete list of those in private possession in Ireland :

Lord Castletown ; Marquess of Cunningham ; Marquess of Headford ; Marquess of Londonderry ; Royal Dublin Society ; Lord Dunraven ; Lord Dunsany ; General Franks, Ballyseadden, Limerick (2) ; Lord Holmpatrick, Abbotstown, Dublin ; Mr. Kirkpatrick, Lucan, Dublin ; Mr. J. Gaisford St. Lawrence, Howth Castle, Dublin (2); Mr. J. Purefoy-Poe, Harley Park, Callan, Kilkenny ; Dr. H. Stokes, Dublin ; Capt. Perceval, Hazlewood House, Sligo ; Mr. J. Walker, Rathcarrig, Sligo ; Capt. Bruen, Oak Park, Carlow ; Mr. E. Eustace Duckett, Castlemore, Tallow, Carlow ; Sir Arthur Ball, Merrion Square, Dublin.

B. *On the Continent.*

In the Museums of Berne, Bonn, Brussels, Buda-Pest, Darmstadt, Dijon, Dresden, Frankfort, Karlsruhe, Louvain, Mainz, Munich, Paris, Strasburg, Worms.

VII. CONCLUSION.

This must take the form of the acknowledgment of the large amount of help which I have received.

To the National Museum of Ireland, Dublin, through Mr. A. W. Stelfox, I am greatly indebted for the loan of a large collection of notes, pamphlets and illustrations which Dr. R. F. Scharff had assembled when in charge of the collection. To Mr. Stelfox I am also indebted for much personal help in the Museum.

Captain W. W. Otter has most kindly helped in every way in the examination of the collection made by the late Sir Edmund Loder, Bart., and now at Selehurst, Horsham. I have to thank him for permission to figure three pairs of antlers from Selehurst, Lord Castletown for those at Granston Manor, Ballacolla, and Mr. J. Purefoy-Poe those at Harley Park, Callan.

The Curators of nearly all the chief museums of the British Isles together with Dr. Revilliol of Geneva. Dr. Wysogorski of Hamburg and Dr. K. Hescheler of Zürich, have kindly replied to inquiries concerning the specimens under their respective charge, and Dr. F. Corner has lent me specimens from his collection. Messrs. W. Williams & Son, of Dublin, the only exporters of Irish Giant Deer, have allowed me to reproduce several photographs taken prior to the specimens leaving their establishment. Dr. F. Krantz, of Bonn, to whom many of Messrs. Williams's specimens were sold, has most kindly informed me as to their present whereabouts. Dr. Barnum Brown has given me information about specimens in American museums.

Sir Sidney Harmer, Dr. K. Frentzen, Dr. K. Hescheler, Dr. H. Pohlig and Dr. W. Soergel have all allowed me to reproduce illustrations from papers by them.

Mr. C. Davies Sherborn and Mr. B. H. Soulsby have most kindly helped me with many points connected with the bibliography.

Miss D. M. A. Bate, of the Natural History Museum, South Kensington, and Sir Arthur Smith Woodward, have helped me much in various ways. But above all I have to thank Dr. R. F. Scharff, our chief authority on the Irish Giant Deer, who has taken the keenest interest in the progress of this monograph. I cannot overstate my indebtedness to him.

Mr. James Green has once more placed his artistic skill at my disposal in the preparation of the plates and many of the figures, while for the drawings of the Dublin specimens I am indebted to Miss E. E. Barnes.

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THE FALLOW DEER.

Cervus dama.

It is still not very clear when the Fallow Deer became an inhabitant of Britain and what claim it has for inclusion in the British Pleistocene fauna.

Several authors have cited it as occurring in the Forest Bed, but as Newton[1] remarks, the determination is based on fragments which might equally well belong to other species.

It is not the purpose of this memoir to discuss critically the Forest Bed Cervidæ, which have been described in Sir W. Boyd Dawkins's memoir.[2] It is, however, clear that *dama*-like deer, such as *Cervus savini*, are found in the Forest Bed. Whether or not any of these forms are to be regarded as actual varieties of *Cervus dama* is not, perhaps, a matter of much importance. The balance of opinion is probably against the inclusion of *Cervus dama* proper as a member of the Forest Bed fauna.

The antlers from the Middle Pleistocene of Clacton, Essex, described by Dawkins as *Cervus browni* were separated by him from *C. dama* owing to the possession of a tine on the anterior face of the antler above the 2nd tine.[3] Sir V. Brooke[4] pointed out that this tine is occasionally present in Fallow Deer, and figured examples from Greece and Sardinia which show it. He also mentioned a case in which one of his own Fallow Deer produced antlers bearing this tine. Hence he argued that *C. dama* and *C. browni* were identical, and that under the latter designation the early occurrence of the Fallow Deer in England has been to some extent obscured. Dawkins at first accepted Brooke's[5] contention, but afterwards considered[6] that the occasional presence of this additional tine in *C. dama* had best be regarded as due to reversion, and that a separate species or variety intermediate between *C. savini* and *C. dama* may be recognized in *C. browni*. Millais[7] was also of the opinion that *C. browni* is a Fallow Deer.

[1] 'Geol. Mag.,' 1880, p. 452.

[2] Pal. Soc., "The Pleistocene Mammalia," pt. vi (1887).

[3] *Ibid.*, pl. iv, fig. 3*e*.

[4] 'Nature,' xi, pp. 210—11.

[5] *Ibid.*, p. 226.

[6] Pal. Soc., "The Pleistocene Mammalia," pt. vi (1887), p. 17.

[7] 'Mammals of Great Britain and Ireland' (1906), p. 371.

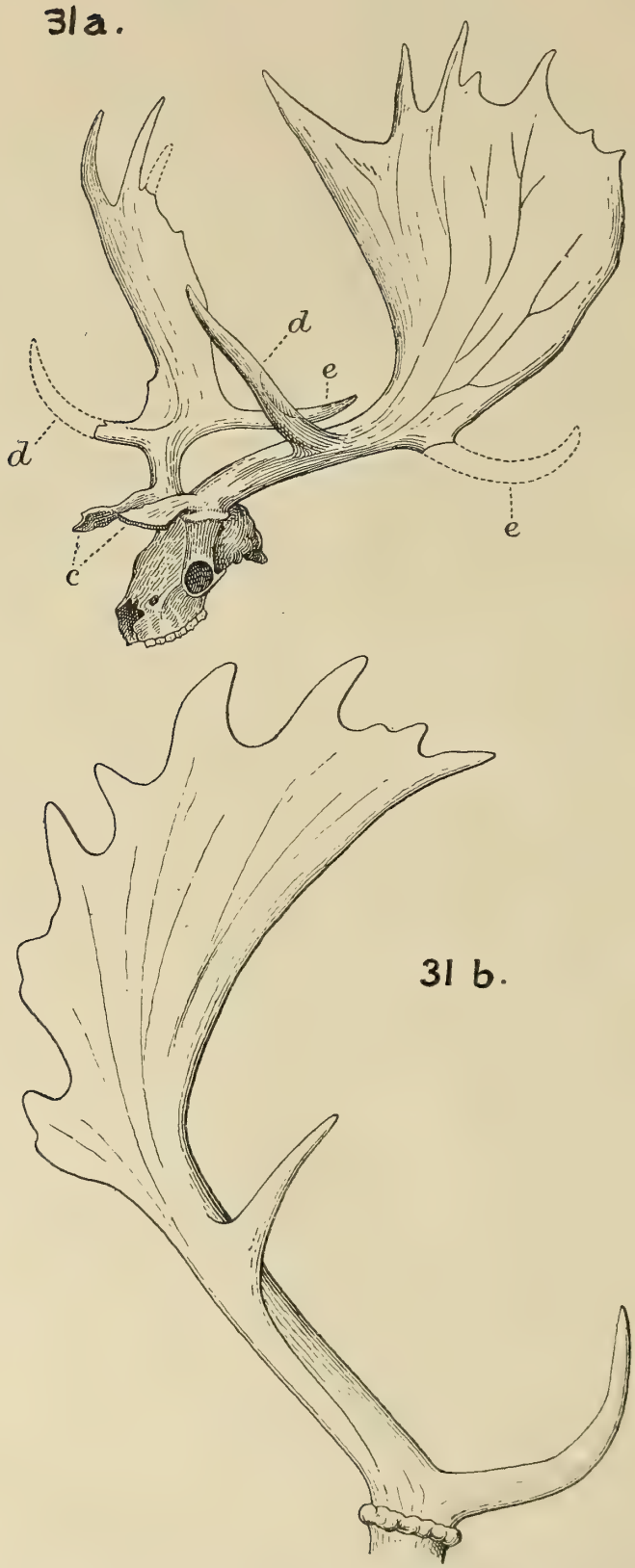

FIG. 31.—**A** Skull and antlers of *Cervus megaceros* var. *ruffi*, Nehring, antero-lateral view, from the Rhine near Worms; Paulus Museum, Worms. After Nehring. **B** Antler of Fallow Deer, *Cervus dama*, from the peat of Clapton, Essex (M. 4104, Brit. Mus. Nat. Hist.).

The evidence for the recognition of *C. dama* as a member of the Palæolithic fauna is inconclusive, and there has been much difference of opinion on the subject. Owen[1] says that there is no decisive evidence of it as coeval with *Megaceros* and Red Deer. He alludes to Buckland's record of fragments of palmated antlers from Kirkdale and Paviland, and to others from the peat at Newbury and from the clay and lignite at Bacton, but remarks that such specimens are far from yielding satisfactory grounds for identification.

Dawkins does not include the Fallow Deer in his list of Post-glacial mammals,[2] and Woodward and Sherborn[3] say of it, "not a British fossil." Osborn[4] does not admit it as a member of the 3rd or Upper Pleistocene fauna, including it only in the 4th or Post-Pleistocene fauna. On the other hand there is evidence of its presence in Palæolithic deposits. W. W. Cordeaux[5] records it from Newnham, near Cambridge; and the Sedgwick Museum, Cambridge, has a series of bones and fragments of antlers from the gravel at Newmarket.

Perhaps the most important piece of evidence as to the occurrence of the Fallow Deer in Britain in Pleistocene times is afforded by the remains from the cave at Hoe Grange, Derbyshire, described by Bemrose and Newton.[6] A great number of bones, teeth and fragmentary antlers were found which from their small size the authors attributed with some hesitation to the Fallow Deer. In the discussion on the paper Dawkins expressed scepticism, pointing out that not much importance could be attached to measurements of bones and teeth in such a variable group as the Cervidæ.

The British Museum has an antler (Text-fig. 31, B) said to be from the Neolithic of Clapton, Essex. Dr. Frank Corner has two metapodials from the high terrace gravels of Dovercourt Park, and it is difficult to avoid the conclusion that they belong to *C. dama*. The evidence at present available as to its occurrence in Britain seems to be, that while (as *C. browni*) it is a member of the Forest Bed fauna and occurs sparingly in the Palæolithic deposits, it did not survive to Neolithic times. It was reintroduced into Britain possibly, as Millais suggests, by the Phœnicians, possibly, as in the opinion of most of those who have alluded to the subject, by the Romans.

Jeitteles[7] assembled a large number of records of *C. dama* from strata at different horizons in various parts of Europe, and claimed that they proved the wide distribution of the animal in prehistoric times. Dawkins[8] commented on the uncritical

[1] 'Brit. Foss. Mamm.,' p. 483.

[2] 'Quart. Journ. Geol. Soc.,' xxiv (1868), pp. 511—16.

[3] 'British Fossil Vertebrata,' p. 330.

[4] 'Age of Mammals,' 1910, p. 428.

[5] 'Proc. Camb. Phil. Soc.,' iii (1880), p. 348.

[6] 'Quart. Journ. Geol. Soc.,' lxi (1903), p. 32.

[7] "Der zoologische Garten," August, 1874; see also translation by Sclater, 'Nature,' xi, p. 71.

[8] 'Nature,' xi, pp. 112—14.

acceptance of many of these records, and concluded that the supposed introduction by man of the Fallow Deer into Northern Europe was not disproved by them. There seems no doubt as to its having been an inhabitant of the Iberian Peninsula at an early date. Busk and Falconer[1] record it from the caves of Gibraltar, Pacheco[2] from the Spanish Pleistocene, and the latter shows that the wall-figures in the caves of Peño di Candamo indicate its presence there in Magdalenian times.

[1] 'Quart. Journ. Geol. Soc.,' xxi (1865), p. 365.

[2] 'Mem. Com. Invest. Palæont. Prehist.,' xxiv, p. 177 (Madrid).

PLATE I.

Irish Giant Deer.

Cervus giganteus.

Cranium.

(Two-fifths natural size.)

Fig.

1. Dorsal } view of a female cranium (M. 2326) from "Ireland," in the British
2. Palatal } Museum.

a. Occipital condyle.
b. Anterior palatine vacuity.
c. Fronto-lachrymal vacuity.
d. Posterior palatine foramen.
e. Supra-orbital foramen.

Reynolds, Giant Deer.

1. × $\frac{2}{5}$

2. × $\frac{2}{5}$

J. Green, photo. del.

C. Whittingham & Griggs Ltd Imp

CERVUS GIGANTEUS.

Cranium.

PLATE II.

Irish Giant Deer.

Cervus giganteus.

Cranium and mandible.

(Fig. 3 two-thirds natural size, the remainder two-fifths.)

Fig.

1. Cranium (M. 2326) seen from right side.
2. Outer side of left mandibular ramus (M. 2328).
3. Inner side of part of right mandibular ramus (M. 26124), with roots of the teeth exposed.
4. Palatal view of left lower premolars and molars of M. 2328.

All from Ireland and in the British Museum (Natural History).

a. Occipital condyle.
b. Paroccipital process of exoccipital.
c. Fronto-lachrymal vacuity.
d. Sagittal crest.
e. Postorbital bar.
f. Coronoid process.
g. Mandibular process.
h. Mental foramen.
i. Alveolus for canine.

J. Green, photo. del.

C. Whittingham & Griggs Lt^d Imp.

CERVUS GIGANTEUS.

Cranium and Mandible.