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Identification of fallow deer remains on the basis of its skeletal features: taxonomical considerations

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ABSTRACT – *The separation of the fossil remains referable to the Cervidae is an important purpose for paleontologists and archeozoologists. Most of the Eurasian Pleistocene localities yield deer remains belonging to species with very similar morphological features. If the fossil material is fragmented and/or lacks antlers remains it is often very difficult to recognize the different species. In this paper some morphological features that allow the separation between the European fallow deer (Dama dama) and the red deer (Cervus elaphus) in the postcranial elements are proposed. These features can be extended to all the Pleistocene fallow deer and can be considered as peculiar of the genus Dama.*

RIASSUNTO – [Identificazione dei resti di daino sulla base delle caratteristiche morfologiche dello scheletro: considerazioni tassonomiche] – *La determinazione delle caratteristiche morfologiche distintive che permettano la separazione dei resti fossili appartenenti a diverse forme della famiglia Cervidae è di estrema importanza soprattutto nei giacimenti nei quali i resti si presentano scarsi e/o frammentari. Ciò è complicato dalla notevole uniformità nella morfologia delle varie parti scheletriche e dal fatto che la separazione delle diverse forme di cervidi è basata quasi esclusivamente sulle caratteristiche dei palchi. In questo lavoro vengono proposte alcune caratteristiche morfologiche che permettono la separazione del daino europeo (Dama dama) dal cervo nobile (Cervus elaphus), negli elementi dello scheletro postcraniale. Le differenze esaminate sono comuni anche nelle altre forme dainine vissute durante il Pleistocene e possono costituire una ulteriore prova a favore di una separazione a livello generico di questi cervidi.*

INTRODUCTION

The fallow deer is a very common faunal element in the Pleistocene localities of Eurasia and sometimes, especially during the Late Pleistocene, it is the most represented species. The fallow deer taxonomy is based above all on its antler structure and morphology, as in all cervids. Their antlers show a characteristic palm both in fossil and living specimens that allow to discriminate them easily from the other cervids. However, in most of paleontological sites it is very rare to collect complete antlers (or peculiar parts of antlers) that allow a sure attribution to the fallow deer. This problem often led to generic or unreliable attributions while, on the contrary, it would be very important to recognize one form from another for the high biochronological significance of cervids.

Almost all the Pleistocene localities yielding fallow deer yield also red deer remains. The latter one usually shows different size and antler morphology from the fallow deer but both these cervids show very similar morphological features in the skeleton elements. This problem led us to recognize the morphological features that allow the separation between *Cervus elaphus* and the Pleistocene fallow deer forms in most of the skeleton elements.

The identification of the peculiar morphological features which distinguish the red deer from the fallow deer in the skeleton elements has another important aim in the taxonomical point of view. In fact, the attribution of the fallow deer to a distinct genus is still discussed by zoologists and paleontologists. According to some authors (Honacki *et al.*, 1982) the species *dama* must be considered into the genus *Cervus sensu stricto* with other cervids as the red deer and the sika deer. Other authors prefer to consider *Dama* as a subgenus of *Cervus* (Flerov, 1952). The writer and most of the authors however, refer the fallow deer into the genus *Dama*, separated from the other cervids (Sickenberg, 1965; Leopardi & Petronio, 1976; Lister, 1984; Montulet, 1984). The number and the proportions of the peculiar morphological features of the red deer and the fallow deer may be useful to justify the separation between these cervids at the specific, subgeneric or generic level.

PECULIAR MORPHOLOGICAL FEATURES OF RED DEER AND FALLOW DEER IN SOME SKELETON ELEMENTS

The recognition of peculiar morphological features in the skeleton elements was only partially

examined among cervids (Flerov, 1952; Lister, 1990). The knowledge about this subject is thus still the same since Heintz (1970) published the general morphological differences between Cervids and Bovids. The identification of different morphological features among species of the same family was possible with the observation of the numerous fossil and living bones collections stored in various European zoological and paleontological Museums and Institutes.

They may show the «average» morphologies, i.e. the most frequent ones, even if sometimes these morphologies may be more or less evident. Moreover, the most representative morphological features will be shown even if they are not the only present in the skeleton of the examined species. Finally, the numerous morphological differences in the antlers and in the skull, already discussed by other authors (Geist, 1971; Chapman & Chapman, 1975; Leonardi & Petronio, 1976; Lister, 1990 *inter alios*), will be not examined.

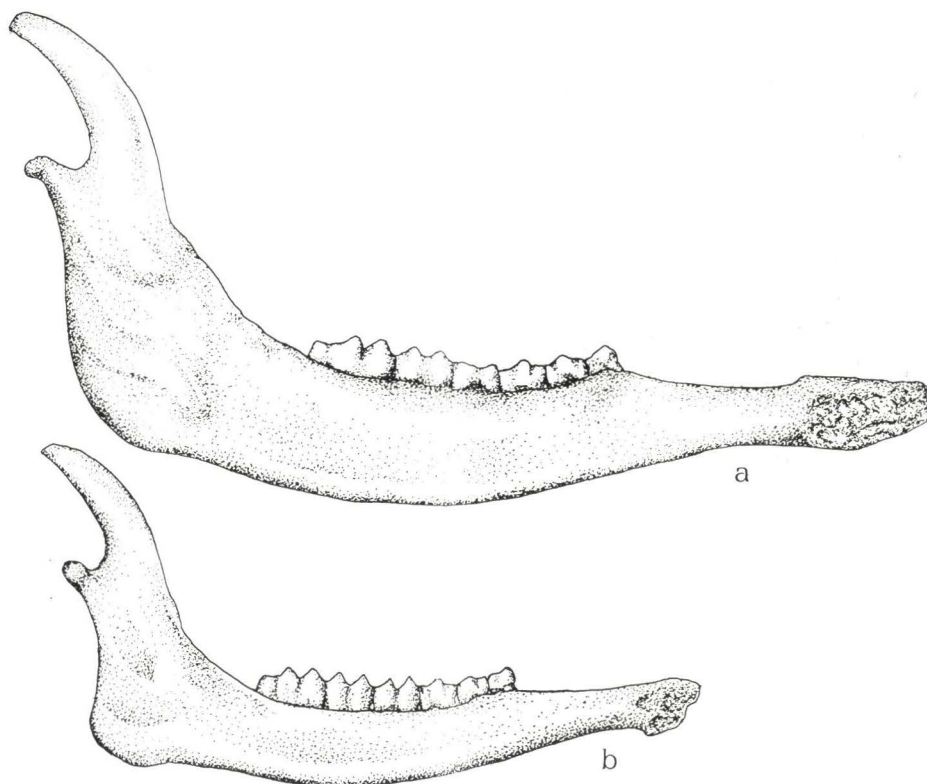
In the general point of view, the living fallow deer is always smaller than the red deer. In the post-cranial bones, *Dama dama* always shows a less rounded morphology, with more definite articular surfaces and more slender diaphyses than *Cervus elaphus*.

MANDIBULA, TEETH AND SPINAL COLUMN

In the general point of view, the mandibula of the fallow deer is brief and short (Text-fig. 1); the diastema seems to be shorter than in the red deer; the horizontal ramus of *Dama dama* is more straight and more convex below the dental row; in *Cervus elaphus* instead, the horizontal branch is more rounded and less convex below the dental row. The mandibular angle is always right in the fallow deer while it is always obtuse in the red deer. The mandibular foramen is at the same height as the dental row in *Dama dama* while it is always above the dental row in *Cervus elaphus*. Finally, the articular surface of the mandibular condyle seems to be more outlined in the fallow deer.

The teeth show a low crown both in *Dama dama* and in *Cervus elaphus*.

The upper molars have a squared shape with well developed styles. A strong *cingulum* is developed in the upper molars of *Cervus elaphus* (above all in M^2 and M^3); this *cingulum* is more developed anteriorly, it comprises the entostyle and reaches the posterior edge of the hypocone. It is less evident and less developed anteriorly in *Dama dama* and the posterior *cingulum* seems to be less frequent;



Text-fig. 1 - Left mandibles of *Cervus elaphus* (a) and *Dama dama* (b) in lateral view.

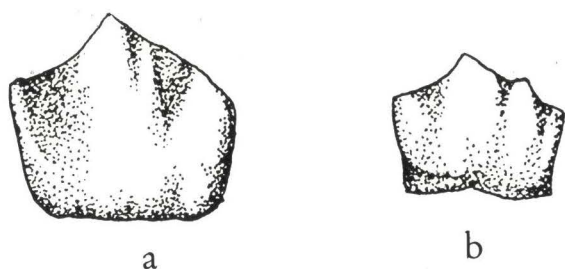
moreover, in the latter species these *cingula* never comprise the entostyle which is poorly developed and projecting interiorly. The premolar-molar length ratio is usually higher in the red deer than in the fallow deer. The molar lobes are less rounded in *Dama dama* and in this cervid the outer surface is higher. If we consider the relative height of paracone, metacone, protocone and hypocone in the upper teeth and of protoconid, metaconid, entoconid and hypoconid in the lower teeth, we notice that the chewing plane is more sloping in *Dama dama* than in *Cervus elaphus*.

The *cingulum* is rarely present in the lower teeth of the red deer and is scarcely developed only in the anterior edge of the protoconid, above all in M_3 . The fallow deer always shows an anterior *cingulum* variably developed and rarely a posterior *cingulum*. The ectostylids generally lack in *Cervus elaphus* while they are present although scarcely developed in *Dama dama*, above all in M_1 .

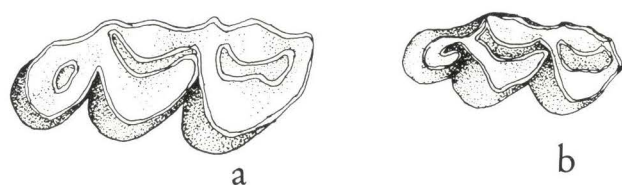
The lower premolar-lower molar length ratio is higher in *Cervus elaphus* than in *Dama dama* as in the upper teeth. P_2 is shorter and more rounded in the fallow deer and this species seems to have a more complex chewing surface than the red deer (Text-fig. 2).



Text-fig. 2 - Second lower right premolars of *Cervus elaphus* (a) and *Dama dama* (b) in occlusal view.



Text-fig. 3 - Fourth lower left premolars of *Cervus elaphus* (a) and *Dama dama* (b) in medial view.



Text-fig. 4 - Third lower right molars of *Cervus elaphus* (a) and *Dama dama* (b) in occlusal view.

P_4 of *Dama dama* always show a posterior stylid (parastylid) that generally never reaches the chewing surface (Text-fig. 3). This stylid lacks in *Cervus elaphus* that often shows a more molarized P_4 .

The third lobe of M_3 shows a more «receding» morphology and seems to be more separated in *Dama dama* than in *Cervus elaphus* (Text-fig. 4).

The spinal column seems to be rather stiff, above all in the dorsal-sacral part. Generally, there are no easily recognizable morphologies in the spinal column that differentiate between *Dama dama* and *Cervus elaphus*, with the exception of size; moreover, these cervids have the same number of vertebrae, with the exception of the caudal vertebrae that are 10-12 in the fallow deer and generally 9-10 in the red deer.

The same consideration is done on the ribs and on the sternum elements that do not show any peculiar morphological difference between *Cervus elaphus* and *Dama dama*.

SCAPULA AND HUMERUS

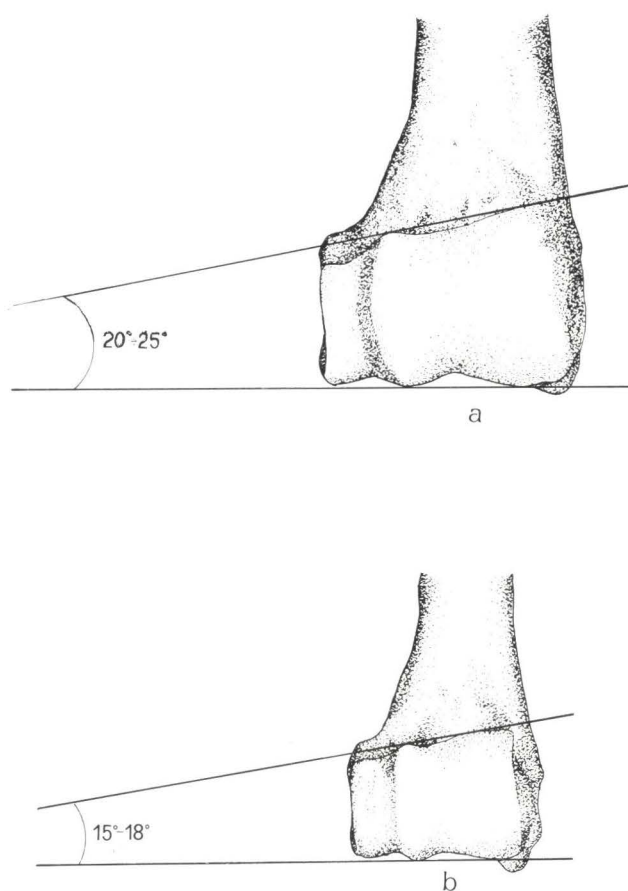
There are no evident features allowing the distinction between the fallow deer and the red deer in these bones. In the scapula, *Dama dama* seems to show as an average a coracoideum process more separated from the glenoid fossa than *Cervus elaphus*. However, this feature can be observed only in borderline cases and usually it is not easily recognizable.

Also in the humerus it is very difficult to recognize peculiar morphological features of the examined cervids, with the exception of size. Besides, it is rather normal that two strictly related forms do not show substantial morphological differences in the stylopodium elements (humerus and femur); in fact, the morphological changes, which imply evolutionary changings, are more evident in the more distal limb elements (zygopodium and, above all, autopodium) while the proximal limb elements are more conservative.

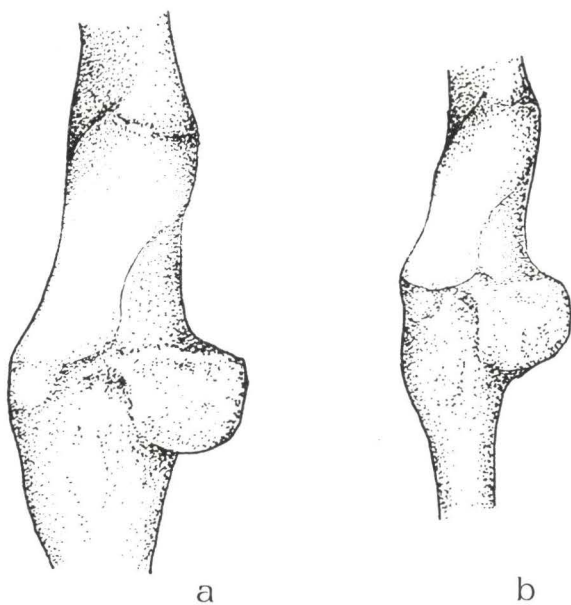
A careful analysis reveals that the trochlea of the humerus is directed externally with a more acute angle in *Dama dama* (about 15-18°) than in *Cervus elaphus* (about 20-25°) (Text-fig. 5).

RADIUS AND ULNA

The most relevant feature in the ulna is the lateral edge profile that is more straight in *Cervus elaphus* while it is more rounded in *Dama dama* (Text-fig. 6); moreover, the articular surface for the humerus trochlea seems to be wider in the red deer than in the fallow deer.



Text-fig. 5 - Left humerus distal epiphyses of *Cervus elaphus* (a) and *Dama dama* (b) in frontal view.

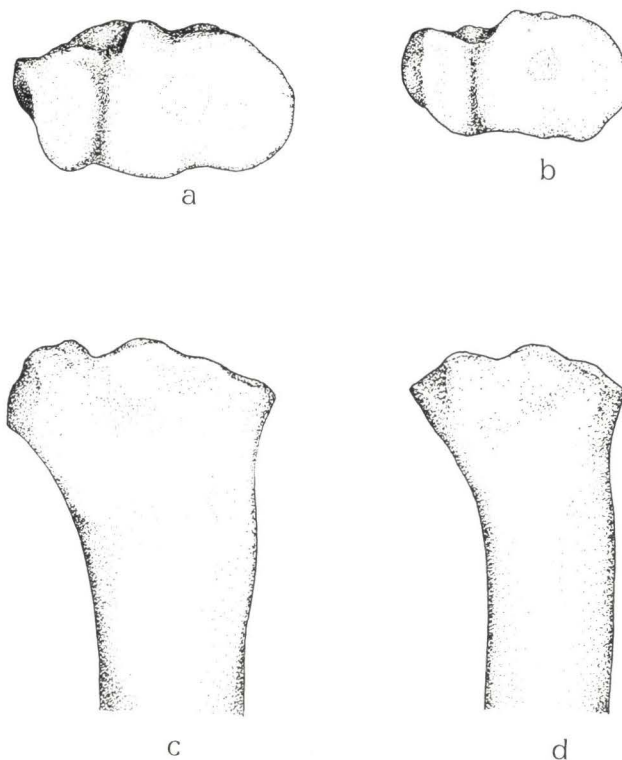


Text-fig. 6 - Left ulna proximal epiphyses of *Cervus elaphus* (a) and *Dama dama* (b) in frontal view.

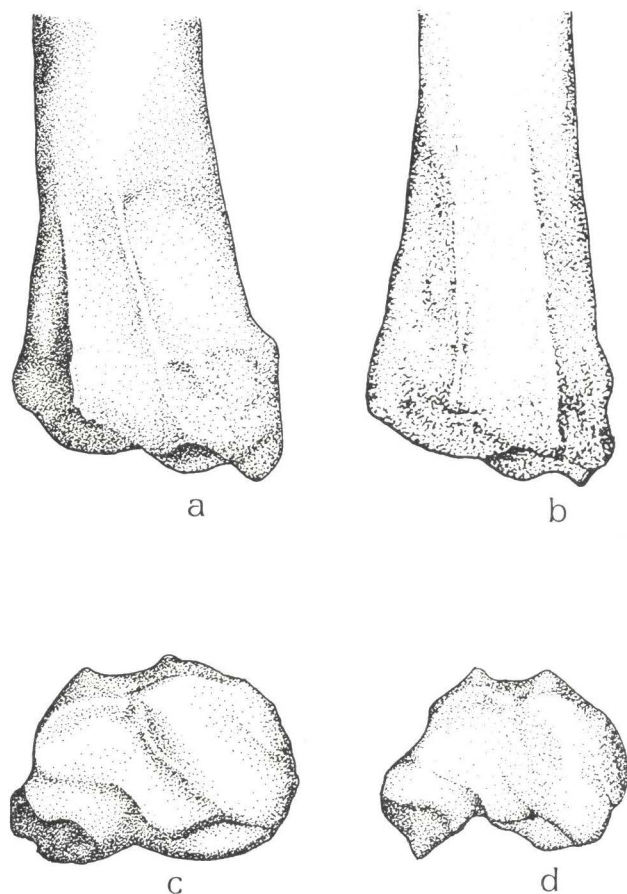
In the proximal radius epiphysis the posterior edge of the sinuvial fossa may be observed it is much deeper in *Cervus elaphus* than in *Dama dama* (Text-fig. 7 a, b); moreover, the lateral radius tuber is higher and more externally directed in the fallow deer, while this tuber is lower than the minor articular surface for the trochlea in the red deer (Text-fig. 7 c, d).

There are no evident differences in the radius diaphysis, with the exception of size.

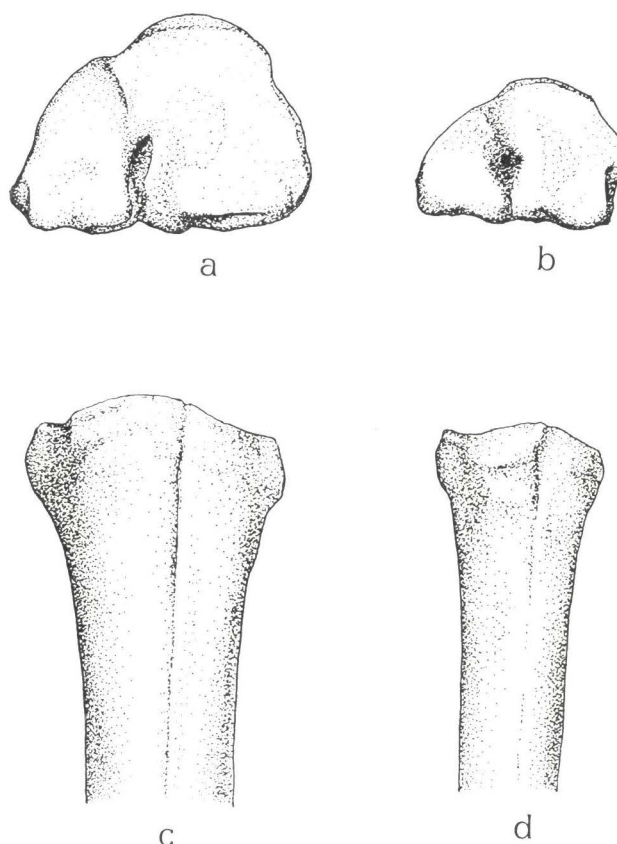
In the distal epiphysis, the styloid radius process is more projecting than the articular surfaces in *Cervus elaphus* (Text-fig. 8 a, c), while they are at the same level in *Dama dama* (Text-fig. 8 b, d); moreover the two longitudinal crests are directed more externally in the red deer than in the fallow deer (Text-fig. 8 a, b). The fallow deer shows a more articulated and cutted profile in the posterior edge beyond the styloid ulna process; the red deer shows instead a more straight and lacking of a relevant groove posterior surface profile beyond the styloid ulna process (Text-fig. 8 c, d). Finally, the distal connection between ulna and radius seems to be lower in *Cervus elaphus* than in *Dama dama* (Text-fig. 8 c, d).



Text-fig. 7 - Right radius proximal epiphyses of *Cervus elaphus* (a, c) and *Dama dama* (b, d) in superior view (a, b) and in frontal view (c, d).



Text-fig. 8 - Right radius distal epiphyses of *Cervus elaphus* (a, c) and *Dama dama* (b, d) in frontal view (a, b) and in inferior view (c, d).



Text-fig. 9 - Left metacarpus proximal epiphyses of *Cervus elaphus* (a, c) and *Dama dama* (b, d) in superior view (a, b) and in frontal view (c, d).

CARPAL BONES AND METACARPUS

There are no clear differences in the morphology of carpal bones between *Dama dama* and *Cervus elaphus*, with the exception of size; in fact, the structure and the articulations of these bones are rather stiff in both species and have an indential arrangement, as in most Cervids.

The proximal epiphysis of the metacarpus shows the sinuvial fossa always posteriorly opened in *Cervus elaphus* while in *Dama dama* this fossa is closed, because the capitate-trapezoid and uncinat articular surfaces tend to join posteriorly. Moreover, the ridge dividing the latter mentioned articular surfaces cuts symmetrically the sinuvial fossa in the fallow deer; this ridge is instead almost parallel to the lateral edge of the sinuvial fossa in the red deer (Text-fig. 9 a, b).

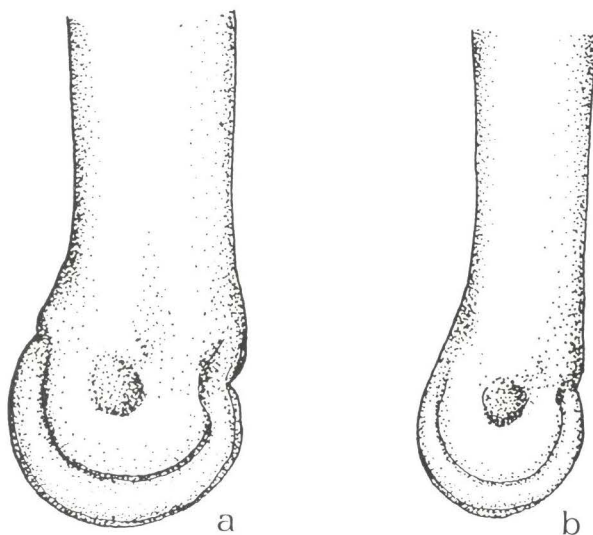
The tuber on the anterior proximal edge of the third metacarpal is well defined in the fallow deer while it decreases gradually in the red deer (Text-fig. 9 c, d). The diaphysis is more slender as a rule in *Dama dama* than in *Cervus elaphus*.

The antero-posterior diameter of the distal epiphysis is always at the condyles level in *Dama dama* whose condyles develop from the diaphysis with a «drop» morphology; the antero-posterior distal diameter is of the same size in *Cervus elaphus* both at the condyles level and above the condyles, below the end of the interosseus medium channel (Text-fig. 10). Finally, the metapodial distal epiphyses tend to be more projecting from the diaphyses in the living fallow deer but this feature is not well defined in the fossil population of this cervid.

PELVIS AND FEMUR

The distinguishing morphological features between *Cervus elaphus* and *Dama dama* are few and not easily recognizable in the pelvis.

The acetabulum seems to be more rounded in the red deer while it seems lightly lengthened posteriorly in *Dama dama* (Text-fig. 11). Moreover, the inner edge of the insertion mark of the leg cranial rectum is thinner, «as a thin sheet», in the



Text-fig. 10 - Left metacarpus distal epiphyses of *Cervus elaphus* (a) and *Dama dama* (b) in medial view.

fallow deer, while this edge is constituted in a wider and flatter surface in the red deer (Text-fig. 11).

As already told for the humerus, it is very difficult to recognize peculiar differences distinguishing *Dama dama* from *Cervus elaphus* in the stylopodium element, in fact also the femur shows almost identical morphological features in the two forms.

In the proximal epiphysis of femur a wider projecting of the trochanter convexity is sometimes observable, at the articular head level, in *Cervus elaphus*. The diaphysis is thinner in the fallow deer than in the red deer.

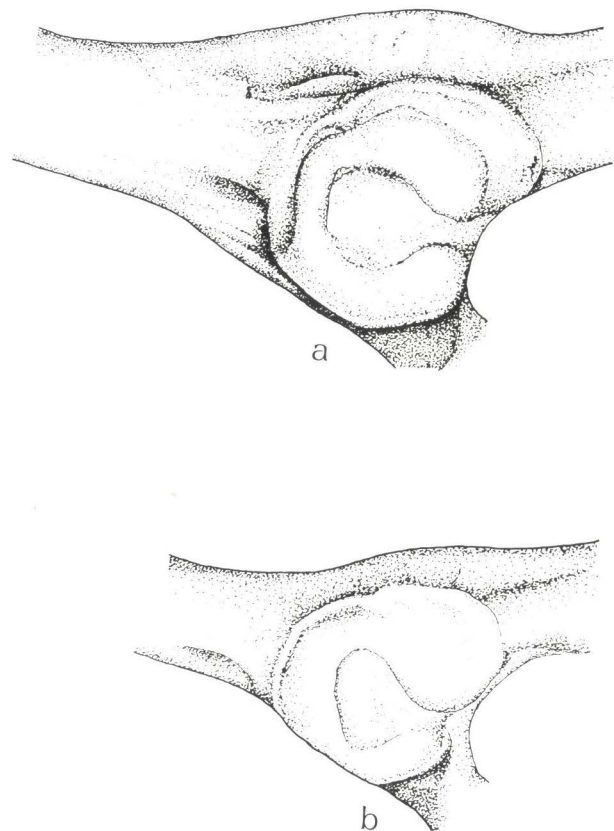
The intercondyloid fossa in the distal epiphysis seems to be more bell-shaped in *Dama dama* but this feature is rather variable in the single cases and it is not easily recognizable.

TIBIA

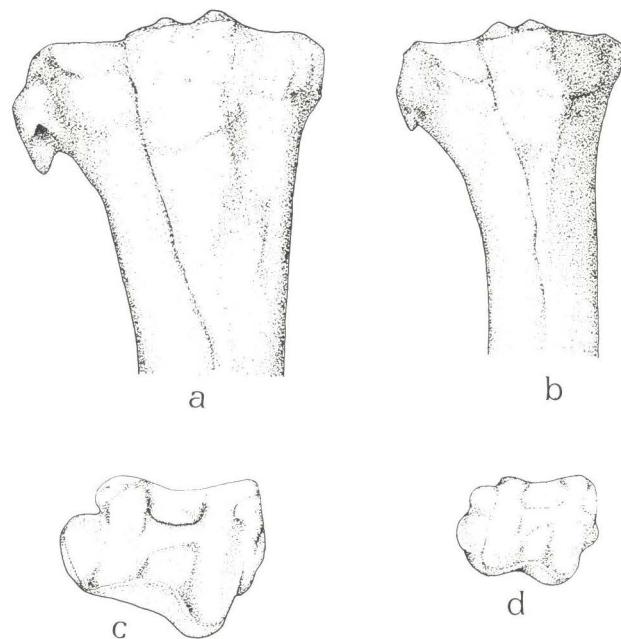
In the proximal epiphysis, as already stated by Lister (1990), the spinal tubercles have the same height in *Dama dama* while the medial tubercle is always higher than the lateral one in *Cervus elaphus* (Text-fig. 12 a, b); moreover, the lateral tuberosity is more developed and projecting in the red deer than in the fallow deer.

The diaphysis is less column-shaped, thinner and with a greater torsion in *Dama dama*.

In the distal epiphysis, the fibular incision is well defined in *Cervus elaphus* and clearly divides the two small lateral articular surfaces; on the contrary, the fibular incision is still well defined in *Dama dama* but it is occupied by a small crest that joins the two lateral articular surfaces (Text-fig. 12 c, d).



Text-fig. 11 - Pelvis (acetabulum zone) of *Cervus elaphus* (a) and *Dama dama* (b) in lateral view.



Text-fig. 12 - Right tibia proximal epiphyses of *Cervus elaphus* (a) and *Dama dama* (b) in frontal view and left tibia distal epiphyses of *Cervus elaphus* (c) and *Dama dama* (d) in inferior view.

TARSAL BONES

There are no clear differences between the red deer and the fallow deer in the large and in the small cuneiforms.

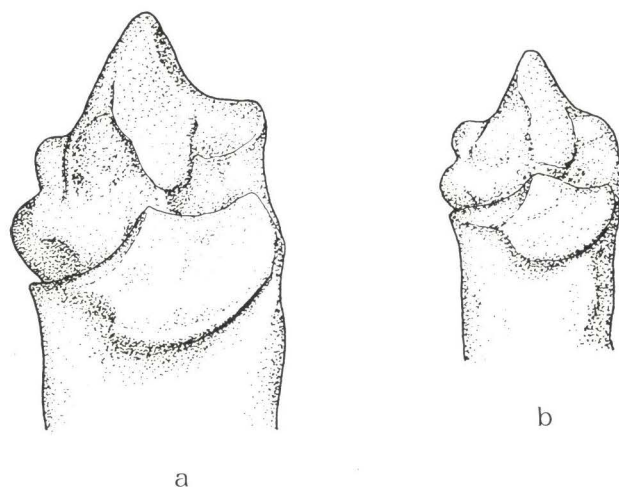
The posterior articular surface for the metatarsus in the scaphocuboid is comparatively more lengthened in *Dama dama*; moreover, this deer shows a higher and more sloping medial edge while *Cervus elaphus* shows a more rounded medial edge.

In the calcaneum of *Cervus elaphus* a *sustentaculum tali* wider than the articular surface for the astragalus plantar trochlea is often recognizable. In *Dama dama* however, the *sustentaculum tali* seems to be less wide and less elongated (Text-fig. 13).

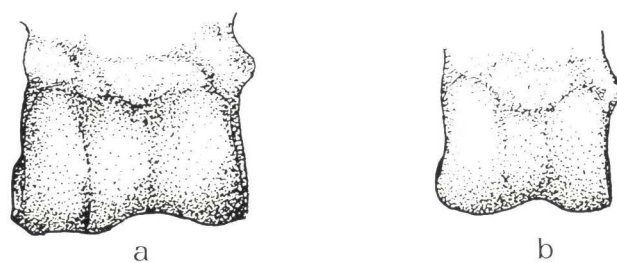
There are no evident morphological differences in the astragalus of *Dama dama* and *Cervus elaphus*, with the usual exception of size and of the more definite articular surfaces in the fallow deer. The only rather common feature is the proceeding of the distal trochlea superior margin in posterior view, that is straight in *Cervus elaphus*, while it is usually bell-shaped in *Dama dama* (Text-fig. 14).

METATARSUS

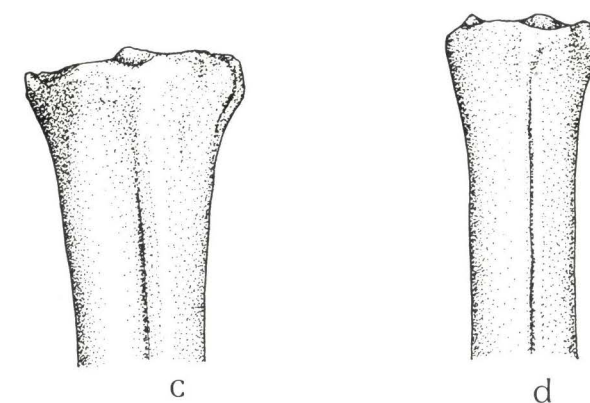
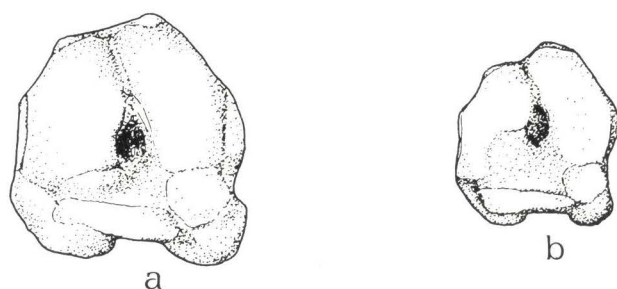
The articular surface for the small cuneiform is on a higher level in *Dama dama* and this surface ends posteriorly with a tubercle that is the highest part of the proximal epiphysis. This tubercle lacks in *Cervus elaphus* or it is lightly developed and the highest part of the proximal epiphysis is at the level of the scaphocuboid posterior articular surface, in the medial edge (Text-fig. 15 a, b). Moreover the posterior articular surface for the scaphocuboid is



Text-fig. 13 - Left calcaneum (*sustentaculum tali* area) of *Cervus elaphus* (a) and *Dama dama* (b) in medial view.



Text-fig. 14 - Left astragalus distal epiphyses of *Cervus elaphus* (a) and *Dama dama* (b) in posterior view.



Text-fig. 15 - Left metatarsus proximal epiphyses of *Cervus elaphus* (a, c) and *Dama dama* (b, d) in superior view (a, b) and in frontal view (c, d).

wider and more lengthened in the fallow deer than in the red deer. The anterior articular surface for the scaphocuboid is lower or at the same level than the large cuneiform articular surface in *Cervus elaphus*; in *Dama dama* it is usually the contrary, that is the anterior articular surface for the scaphocuboid is higher than the articular surface for the large cuneiform (Text-fig. 15 c, d).

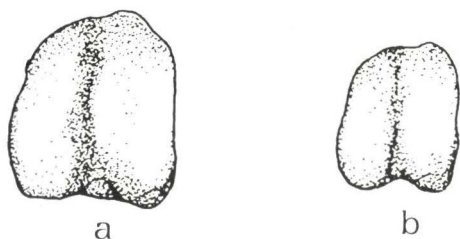
The diaphysis is thinner and laterally narrower in the fallow deer than in the red deer. In the distal

epiphysis of *Dama dama* the already observed «drop» morphology in the metacarpus can be noticed again even if less developed (see Text-fig. 10). The metatarsus of *Dama dama* shows two rounded crests, one medial and one lateral, above the articular condyles: this feature led to a discoid and more compressed section in the fallow deer than in *Cervus elaphus* where it is clearly elliptical. As in the metacarpus, *Cervus elaphus* shows the same width of the antero-posterior distal diameter both at the condyles level and above the condyles, below the end of the interosseum channel. The maximum antero-posterior distal diameter in the metatarsus of *Dama dama* is instead always at the condyles level.

PHALANXES

In both anterior and posterior first phalanges of *Cervus elaphus*, as already described by Lister (1990), a surface connecting the two articular areas can be recognized; these areas are instead clearly divided in *Dama dama* by a posterior incision (Text-fig. 16).

There are no clear morphological features in the second and third phalanges that allow the determination of the red deer or the fallow deer, with the exception of size.



Text-fig. 16 - First phalanx proximal epiphyses of *Cervus elaphus* (a) and *Dama dama* (b) in superior view.

CONCLUSIONS

The morphological features of the skeleton elements are rather conservative in Cervids, with the exception of the particular adaptations of the endemic forms.

This study on the peculiar morphological features of the red deer and the European fallow deer, allow to show several characters allowing the discrimination between the two forms even when there are only fragmentary bones. Moreover, this separation is possible even when there are no clear size difference, as happens between *Dama clactoniana* and *Cervus elaphus* in most Middle and late

Middle Pleistocene European localities (Di Stefano, 1995, 1996).

The morphological features analysis of the examined cervids can provide further data for justifying their taxonomic separation. In fact, according to the writer, the differences shown can justify the separation at a generic level between the red deer and the European fallow deer is already believed by some authors. With regard to this subject, the molecular biology technique and the chromosomal maps on the living elements are clearly promising and can provide objective data for the Cervid classification (Todd, 1975; Cronin, 1991) or for intraspecific variations (Gustavsson & Sundt, 1968, 1969; Pemberton & Smith, 1985; Cronin, 1992). Notwithstanding this, it seems right to continue with the «classic», morphological and biometrical, techniques. These techniques, in addition with the data provided (Chapman & Chapman, 1969; Lister & Chapman, 1988), cannot be replaced by others, at the moment, for the analysis of fossil material.

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