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Evidence for domestication of the dog 12,000 years ago in the Natufian of Israel

THREE canid finds from the Natufian in the northern Israeli sites of Ein Mallaha (Eynan) and Hayonim terrace indicate a special man-animal relationship. These consist of a diminutive carnassial and mandible, and a wolf or dog puppy skeleton buried with a human. The finding of a puppy skeleton in such close association with man is of particular significance as an indication of a close relationship between man and dog.

A domestic animal is one whose breeding is largely controlled by man. Evolution of a domesticated species, therefore, results mainly from artificial selection, with natural selection playing a subsidiary part. The process of domestication implies the separating off of a breeding stock from its wild forebears. Most workers agree that the wild progenitor of the dog was the wolf *Canis lupus*¹⁻⁵.

A *Canis* skull from the Mesolithic site of Star Carr, England (9,538 ± 350 BP) was identified as a dog, on the basis of dental overlap². Lawrence³ identified dog from Idaho (USA, 10,400 BP) and from eastern Anatolia (~9,000 BP). More recently, Turnbull and Reed⁶ suggested that a mandible from the Zarzian (~12,000 BP) of Palegawra cave (Zagros mountains, Iraq) belonged to a dog, on the basis of dental overlap and small size.

The finds we report here come from the Natufian, an Epipalaeolithic culture (formerly referred to as a Mesolithic culture) and dates to 12,000–10,000 yr ago. The Natufians, whose culture was limited to the Levant, are considered to have been hunter-gatherers, and were the first peoples to live in circular dwellings in what were perhaps the earliest permanently settled villages. Their sites, compared with those of preceding periods are larger, occupying areas of 1,000 to 3,000 m², and contain numerous pounding stones (pestles and mortars) as well as, for the first time, large cemeteries. Art forms are also found, as is a highly sophisticated tool kit, consisting largely of micro-

liths, including lunates. They were the antecedents of the first agriculturalists in the region.

Bate's claim⁷ for the domestic status of a *Canis* skull from the Natufian of El Wad cave (Mount Carmel, Israel) could not be confirmed⁸. Recent excavations at two Natufian sites in northern Israel, Mallaha (Eynan) and Hayonim terrace, provide what we believe to be more concrete evidence for some kind of special relationship, perhaps domestication, between man and dog/wolf in this early period, around 12,000 BP.

The site of Mallaha, near the old Huleh lake in the upper Jordan valley, has been under excavation since 1955 (ref. 9). Two phases of Natufian occupation have been distinguished¹⁰: the canid osteological remains, a mandible from a living floor and a puppy from a tomb, both come from the lower one. This has so far revealed three superposed half-buried dwellings, originally probably circular and 9–11 m in diameter, whose northern halves are missing. The walls, some preserved to a height of more than 1 m, were built of limestone blocks, piled more or less vertically. The flint industry is characterised by lunates rarely less than 1.5 cm in length, most of which bear 'Helwan retouch', indicating an Early Natufian assemblage. Basalt pestles and mortars are fairly frequent, as are bone points, needles, pendants and some bone sickle handles.



Fig. 1 Tomb H. 104 at Mallaha, showing the human skeleton and puppy.

In the entrance to dwelling 131, the oldest so far excavated in Mallaha, a large slab of limestone was found on the floor. This has been interpreted to indicate the presence of a burial (H. 104, ref. 11) especially due to its proximity to a human skeleton which lay 25 cm below it. The human skeleton, whose sex cannot be determined because of the damage of the pelvis, lay flexed on its right side, and judging by the state of its dentition, was an old individual. Its left wrist was partially under its forehead, and hand upon the thorax of a puppy, which has evidently been buried complete with the human (Fig. 1). All the milk teeth of the puppy are fully erupted, and of the long bones exposed, a humerus has both epiphyses open, indicating that the age at

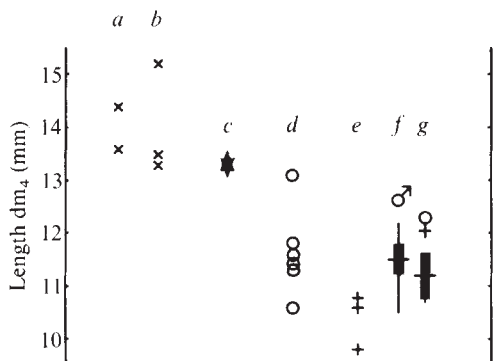
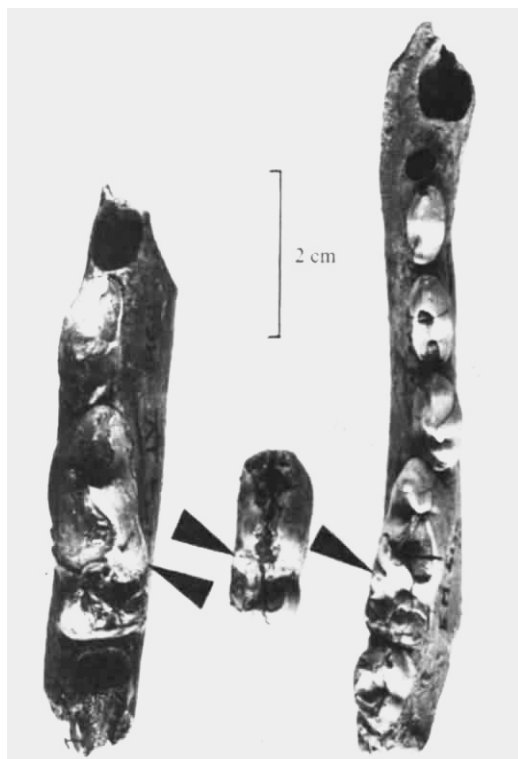


Fig. 2 Maximum length (mm) of the last lower milk molar (dm_4 , milk carnassial) of canid puppies. *a*, Two wolves from Turkey; *b*, three wolves from Israel; *c*, the Mallaha puppy; *d*, six dogs from Turkey, Israel and Egypt; *e*, three jackals from Turkey; *f*, 14 male jackals from Israel, range, mean \pm 95% confidence limits; *g*, six female jackals from Israel, range, mean \pm 95% confidence limits. (Data from Turkey supplied by S. Payne).

death was between 3–5 months¹², while the advanced state of wear of the lower milk carnassial makes an age of 4–5 months more likely. The upper teeth are too damaged to be measured, but the dm_4 which is intact, has a maximum crown length of 13.3 mm. Comparison with the same tooth of recent Israeli and Turkish wolves, jackals and dogs (Fig. 2) indicates that the fossil puppy was either a dog or a wolf, but not a jackal, being outside the size range of the latter.

An adult canid mandible was found in dwelling 131. It came from an undisturbed living floor, characterised by seven post holes, and lay not far from two hearths containing bones which included a human cranium and a pair of gazelle horn cores. The mandible is complete from canine to second molar and belongs to a large canid. The metaconid on the M_1 is poorly developed (Fig. 3) as in wolf and dog; unlike the jackal metaconid which protrudes lingually and is more prominent^{1,13}.

Fig. 3 Occlusal views of the Hayonim terrace carnassial (centre) and Mallaha mandible (right) compared with an Upper Pleistocene wolf mandible fragment (P_4 and M_1) from Ein Gev IV (Jordan valley, Geometric Kebaran A period). The M_1 metaconids are arrowed.



Osteological separation of the dog and wolf is problematical, but tooth crowding and smaller size have been used as criteria for the identification of dogs. It has frequently been claimed that dog jaws are slightly shorter than those of their wolf progenitors, resulting in a certain degree of dental overlap, particularly of the lower fourth premolar and the lower first molar^{2,3,6}. This dental overlap was analysed using an index of overlap (crown length of $M_1 \div$ alveolar length from P_4 to M_1). The value for the Mallaha mandible is 0.67, indicating some degree of overlap (Fig. 3). A collection of nine recent dogs from Israel and Egypt, however, gave values from 0.65 to 0.70 (mean 0.68) and a collection of 34 recent wolves from Israel gave values from 0.62 to 0.67 (mean 0.65), with six specimens actually possessing values of 0.67. Another index, the length $M_1 \div$ alveolar length of the lower premolars, showed a similar overlap between dogs and wolves. These indicate that dental overlap criteria are not very efficacious in dog–wolf separation, and are probably to some extent age dependent.

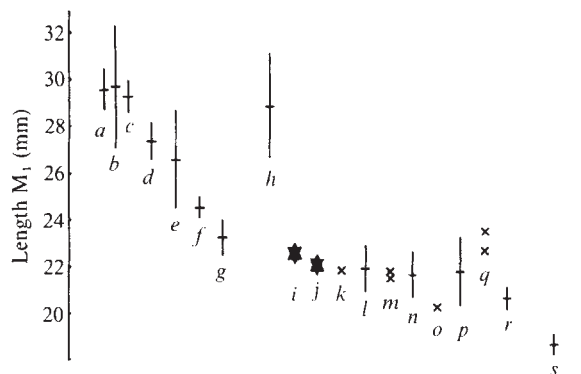


Fig. 4 Antero-posterior length of M_1 of recent and fossil canids. These show the north–south size cline in recent palaeartic wolves (*a* to *g*); the Pleistocene–Holocene diminution in the Levant (*h* versus *f*) and the wolf–dog differential (*f* versus *i* to *r*). Samples are represented by their mean \pm 95% confidence limits, single specimens by a star or cross. Recent wolves: *a*, Greenland and Ellesmere land, $n = 12$ (ref. 20); *b*, Russia and north Scandinavia, $n = 4$; *c*, Denmark, Holocene and recent, $n = 7$ (ref. 20); *d*, Turkey, $n = 9$; *e*, Zagros mountains, $n = 5$ (ref. 6); *f*, Israel, $n = 26$; *g*, Arabian peninsula, $n = 7$. Fossil wolves and dogs: *h*, Ksar Akil U. Pleistocene, $n = 4$ (ref. 21); Tabun B, $n = 1$ (ref. 7); and Ein Gev IV, $n = 1$ combined; *i*, Mallaha mandible M_1 ; *j*, Hayonim terrace M_1 ; *k*, Palegawra *Canis* (ref. 6); *l*, Jericho Pre-Pottery Neolithic to Early and Mid Bronze Ages, $n = 7$ (Ref. 17); *m*, Cayonu, east Anatolia, 9,000 BP (ref. 3); *n*, Korucutepe, east Anatolia, Bronze Age, $n = 12$ (ref. 22); *o*, Arad, north Negev, Early Bronze Age; *p*, Persian period of Israel, $n = 6$; *q*, two male dogs from Suez, Egypt; *r*, dogs from archaeological sites in Hungary, $n = 42$ (ref. 23). Recent jackals: *s*, Israel, $n = 24$.

The terrace of Hayonim, in the western Galilee, was excavated by O. Bar Yosef in 1966 and 1969, and by D. Henry in 1974–75 (ref. 14). Over a thin layer assigned typologically to the Geometric Kebaran A, lies a Natufian assemblage. From the lowermost level of this a single ¹⁴C date of 11,920 BP (SMU 231) is available. The canid tooth reported here is a lower carnassial from the trial trench (square D depth 30–50 cm, 1974 season's excavation) and is located within the Natufian. Its crown is chipped at the anterior end, and like the M_1 of the Mallaha mandible described above, is morphologically wolf-dog, with a poorly developed metaconid (Fig. 3).

The sizes of the M_1 's of both these finds are compared with other wolves and dogs both geographically with recent wolves from the Palaeartic region, and temporally with Near Eastern Upper Pleistocene to recent wolves and dogs (Fig. 4 and Table 1). The results of this analysis indicate firstly that recent wolves increase in size with increasing latitude in accordance with Bergmann's rule, and secondly that Upper Pleistocene wolves from the Levant were larger than recent ones, so that the wolf, like the mole rat, gazelle, goat, cat, fox, hyaena, wild boar and

Table 1 Recent and fossil canids, maximum length in millimetres of the lower carnassial, M_1

		N	Mean	s.d.
Recent wolves:				
Greenland and Ellesmere land ²⁰		12	29.6	1.46
Russia and north Scandinavia		4	29.7	1.67
Denmark, Holocene and recent ²⁰		7	29.3	0.76
Turkey		9	27.4	1.05
Zagros mountains, Iraq ⁶		5	26.6	1.7
Israel males and females		26	24.6	1.07
Israel males		25	25.0	1.54
Israel females		13	24.3	0.94
Arabian peninsula		7	23.2	0.73
Fossil wolves and dogs:				
Ksar 'Akil ²¹	Upper Pleistocene	4	28.8	2.66
Tabun B ⁷	Mousterian 40,000–45,000 BP	1	29.5	
Ein Gev IV	Geometric Kebaran 13,000–14,000 BP	1	28.6	
Ein Mallaha	Early Natufian c. 12,000 BP	1	22.6	
Hayonim terrace	Early Natufian	1	~22.2	
Palegawra ⁶	Zarzian 12,000 BP	1	21.9	
Jericho ¹⁷	Pre-Pottery-Neolithic-Bronze Age 10,000–4,000 BP	7	22.0	1.09
Cayonu East Anatolia ³	9,000 BP	2	(21.7 & 21.8)	
Korucutepe East Anatolia ²²	Bronze Age	12	21.7	1.53
Arad Israel, North Negev	Early Bronze Age 4,800 BP	1	20.3	
Israel	Persian period 2,500 BP	6	21.8	1.38
Male dogs, Suez, Egypt	Recent	2	(23.5 & 22.7)	
Archaeological sites in Hungary ²³	Neolithic–17th Century AD	42	20.7	1.62
Jackals, recent:				
Israel, males and females		24	18.7	0.88
Israel males		20	18.6	0.82
Israel females		12	18.6	0.89

aurochs decreased in size at about the end of the Pleistocene^{15–18}. Dogs from later archaeological sites in the Near East are even smaller than recent wolves. Thus three size classes of the wolf-dog line exist in Israel—Upper Pleistocene wolves, recent wolves and domestic dogs. The problem, therefore, is to which of the latter two size classes the Mallaha and Hayonim finds belong. Combining the two M_1 measurements, and comparing them with modern Israeli wolves, the probability that they belong to the latter is <0.01 (Student's t test) and we conclude that on this basis they are dog rather than small wolves.

Having distinguished three size classes for the Israeli Upper Pleistocene–Holocene wolf-dog line, we postulate two independent factors as having been responsible for each of the two size declines: (1) the temperature elevation at the end of the Pleistocene, which we associate with the difference between Upper Pleistocene and recent wolves, and (2) domestication resulting in the difference between recent wolves and dogs.

These finds are important in that they support evidence from other archaeological sites for interaction between man and canids in the Epipalaeolithic. The puppy, unique among Natufian burials, offers proof that an affectionate rather than gastronomic relationship existed between it and the buried person, an addition to our knowledge of the way of life of Natufian hunter-gatherers. The contemporary diminutive adult carnassials, of size equivalent to dog and not wolf, indicate that *Canis lupus* had, by the early Natufian, been subject to some degree of selective breeding by man. It would seem unlikely that taming alone would be sufficient to bring about this kind of change in the animals' dentition. We suggest, therefore, that domestication of the wolf occurred 12,000 years ago, before that of the food animals such as goat, sheep, cattle and pig, which were probably not domesticated until one or more millennia later¹⁹. If this hypothesis is correct, then together with Starr Carr in England, and Palegawra in Iraq, we might conclude that it was 'man-the-hunter' who first domesticated the wolf, another social carnivore.

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Note added in proof: The following dates pertaining to the puppy burial level at Mallah have been received from the University of Lyons radiocarbon laboratory: Ly 1660 11,590 ± 540 BP; Ly 1661 11,740 ± 570 BP; Ly 1662 11,310 ± 880 BP.

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