EXPLOITATION DES ANIMAUX SAUVAGES A TRAVERS LE TEMPS
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The effects of sedentism on the exploitation of the environment in the Southern Levant

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RÉSUMÉ

Les implantations sédentaires et les communautés agricoles du Levant méridional se sont développées à partir de sociétés de chasseurs-cueilleurs épipaléolithiques. Les changements sociaux et économiques liés au passage de la prédation à la production se font jour avec l'apparition de la culture natoufienne : sédentarité, récolte intensive de céréales sauvages et mise en réserve. Toute diminution de la mobilité des groupes humains, à une époque ou un endroit donnés, se traduit dans les assemblages archéologiques par une modification du niveau trophique (comportements plus omnivores et élargissement du spectre des matières consommées). Le mode alimentaire ne peut être compris qu'à la lumière de la transformation ponctuelle de petite communautés humaines mobiles en sociétés plus complexes et structurées. Les principales conséquences sur le long terme sont :

1. le mode de subsistance devient plus restrictif en raison de la nécessité qu'ont les communautés sédentaires d'exploiter leurs ressources dans une aire géographique limitée ; les groupes humains ont alors un mode d'utilisation plus spécialisé des paramètres biotiques, ce qui provoque une diversification du spectre des restes animaux, parmi lesquels on trouve de petits et micromammifères, des oiseaux, des reptiles, des poissons et des grands pulmonés ;
2. l'un des phénomènes les plus intéressants qui résultent des occupations natoufiennes au Levant méridional est la brusque apparition des espèces commensales aux environs des habitats ; la disponibilité permanente de nourriture ou d'abris attire des populations de certaines espèces anthropophiles ; la faible diversité zoologique diminue la compétition interspécifique ; les environnements commensaux créent des isolats qui favorisent la spéciation *in situ (Mus domesticus, Passer domesticus, Canis familiaris*, qui sont parmi les plus anciens commensaux connus) ;
3. les plus anciennes preuves de modification génétique de populations naturelles par le choix des sexes lors de la chasse (*Gazella gazella*, Bovidae) ont été observées dans des sites natoufiens

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localisés à l'étage méditerranéen du Levant méridional. Cet abattage très sélectif a provoqué une sensible diminution allométrique de la taille, qui peut s'expliquer par une longue pression anthropique dans une aire géographique relativement limitée.

ABSTRACT

The sedentary settlements and agricultural communities of the southern Levant developed out of the Epi-Paleolithic hunter-gatherers, way of life. Social and economic changes from the foraging mode of subsistence are clearly visible with the appearance of the Natufian entity, when sedentism, intensive harvesting of wild cereals and some storage took place. Any shift of human populations into a less mobile life cycle, in any time or any place, the consequential change in the trophic level (more omnivorous and wider spectrum dietary behavior) will be represented in the fossil record. The way to food production can be only understood in the light of the punctuational shift of small and loose human communities into higher complexed social structures. The main consequences of long-term occupation are :

1. exploitation of a much wider spectral array of animals and plants,
2. appearance of commensal species around the Natufian habitations,
3. the earliest evidences ; for genetic manipulation of natural populations by intentional sex culling of *Gazella gazella* (Bovidae).

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From Nomadism to Sedentism

The sedentary settlements and agricultural communities of the southern Levant developed out of the Epi-Paleolithic hunter-gatherers, way of life (Hovers, 1989 ; Hovers *et al.* 1988). Social and economic changes from the foraging mode of subsistence are clearly visible with the appearance of the Natufian entity, when sedentism, intensive harvesting of wild cereals and some storage took place (Henry, 1983, 1989). Gilead (1991) emphasized the ephemeral nature and high residential mobility of Upper Paleolithic human groups. It has been suggested, based on environmental reconstructions and theoretical considerations (Hovers *et al.*, 1988), that Kebaran groups practiced logistical mobility and longer periods of site occupation. Cementum increment analyses of gazelles by Lieberman (1991) have shown that the Natufian inhabitants of Hayonim cave, and other Natufian sites, occupied their villages throughout the year, unlike their predecessors during the Kebaran period, who used their sites most likely between November and February.

The transition from a situation in which the entire population within a given area was spontaneously organized from bands of hunter-gatherers to relatively large societies of sedentary foragers is probably one of the best examples of an abrupt increase in the socio-economy of man. Belfer-Cohen (1991) argued that the shift to sedentism in the Levantine sequence took place within a short time span which explains why archaeologists have great difficulties in identifying the transition phase between the Geometric Kebaran complex and the Early Natufian. Hence sedentism seems to be a very late phenomenon in human evolution. Bar-Yosef and Belfer-Cohen (1989a) agree that the irreversible transformation of several families, extended families, or even small bands into higher social organization acquired new properties, such as labor division, formation of task groups or intergroup identification.

The Natufian entity emerged within a relatively limited area ; from the Euphrates in the north (Moore, 1989) to the Negev highlands in the south and the Jordanian plateau in the east (Bar-Yosef and Belfer-Cohen, 1989a ; Henry, 1985, 1989). Most of the « Early » and « Middle » Natufian sites were found within the Mediterranean and Irano-Turanian phytogeographic regimes, and its core area mainly along the pistacia-oak belt (fig. 1). It seems that the Natufian areal was increasing in time when they dispersed into marginal, and eventually into desert areas (Henry, 1985, 1989 .; Betts, 1989 ; Garrard *et al.*, 1988). Yet these peripheral sites were much smaller in size (Bar-Yosef and Belfer-Cohen, 1989a), and were probably inhabited by populations with higher mobility pattern.

Anthropologic and biologic evidences show that during this period relatively large human communities indeed occupied long term bases, that may be considered as one of the earliest stages of sedentism. The shift from ephemeral and/or seasonal occupation to a prolonged habitation of relatively large communities had a far reaching and profound impact on the proximate biotic environment.

Nomadism versus sedentism

While nomadism, or mobility, was the rule in human behaviour throughout his major part of history, in analogy, vagility among other mammals seems to be an uncommon behavioral pattern. High mobility in mammals is normally found among species which either constitute a dominant component within the ecosystem, like elephants, rhinoceroses or top carnivores ; or among species living in large herds, in which case the whole colony behaves as a dominant ecological component, such as a large herd of herbivores (Bertram, 1974 ; Damuth, 1981). It is hence surprising that man, who became in later prehistoric times such a dominant factor in the ecosystem, in a certain time and a certain place shows a punctuational shift from mainly a nomadic way of life with ephemeral occupation of habitats into a sedentism during the Natufian of the southern Levant.

The essential strategy of large carnivores is to maximize their prey size and minimize the amount of energy invested in high frequency predation (Harestad and Bunnell, 1979, Shipman and Walker, 1989). This is obvious, as the act of predation, or « a kill », is a high energy consuming event, and hence should be efficient and seldom. Yet, in order to detect large prey they have to be able to cover large foraging areas, and therefore they became essentially vagile animals. The only way to decrease mobility, or to reduce the foraging area, and to establish a more sedentary behavioural pattern, is to shift into predation of smaller animals, and to become less specialized or more omnivorous (fig. 2). Therefore, in analogy, we may expect that sedentism in man should have changed his exploitation behaviour towards including a broader spectrum of food resources, to rely on greater diversity of food resources, to become more vegetarian or, in general, gain more omnivorous habits.

Under a sedentary way of life we would expect to see the necessary ecological effects manifested in the exploitation and feeding behaviour of these human populations. Generally, if more carnivorous species that spend less time on feeding but cover larger home ranges shift into a more restricted exploitation area, they will have to spend more time on feeding and will widen their food spectrum. Shifting into different nomadic strategy will always cause changes in their feeding behaviour (Bertram, 1974 ; Damuth,

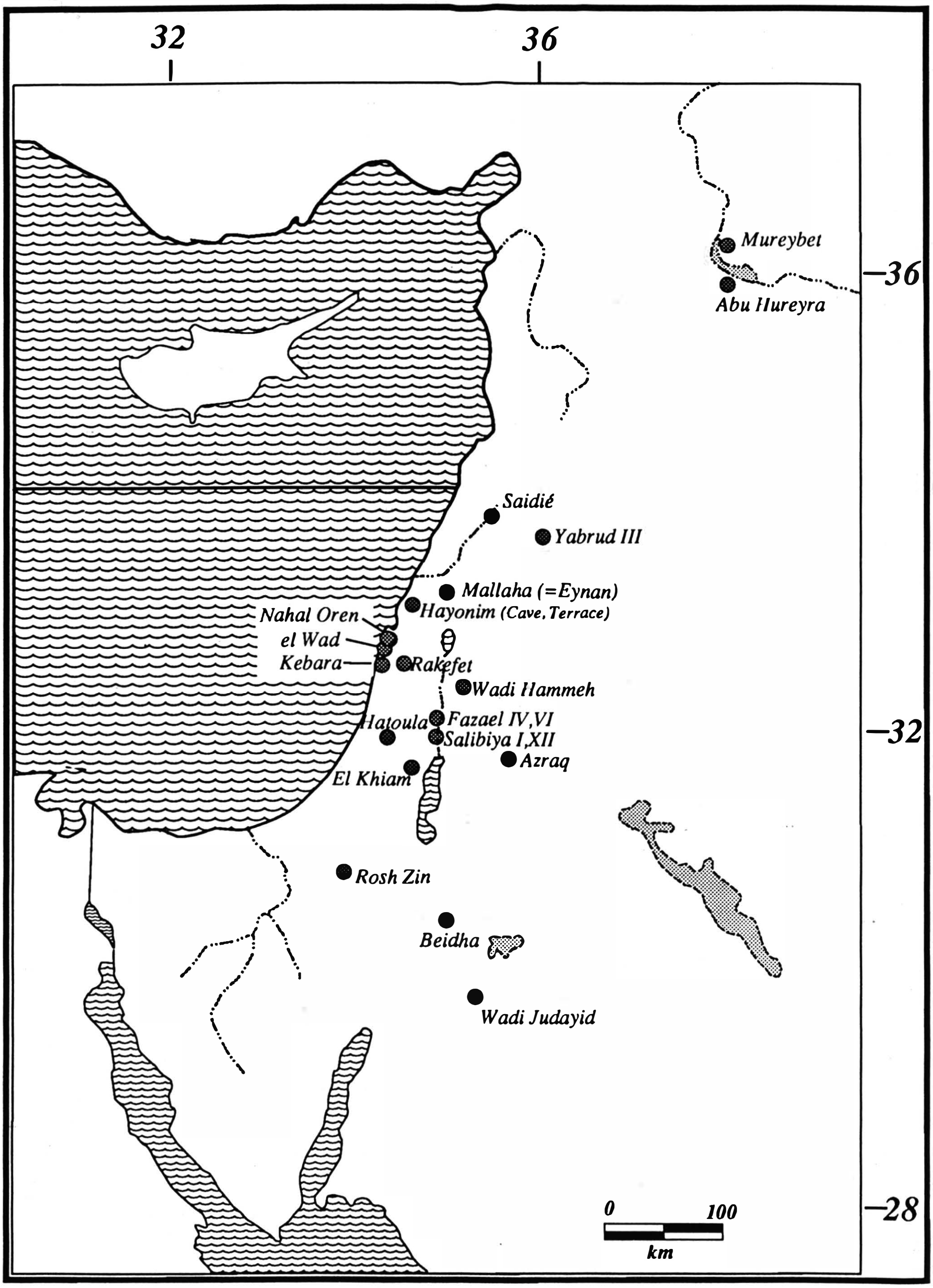

Fig. 1. A map of the southern Levant showing the main Natufian areal within the Mediterranean and Irano-Turanian regimes, where essential sedentism took place.

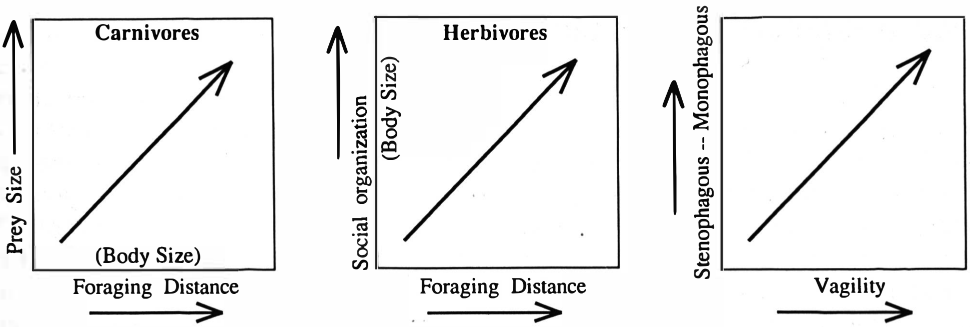

Fig. 2. Reducing foraging areas or decreasing mobility is very often associated with a shift into smaller prey by large carnivorous mammals, and vice versa (Harestad and Brunnel, 1979 ; Shipman and Walker, 1989). Larger herbivores display larger foraging distances. Dietary specialization is as a rule positively correlated with body size. Decrease mobility in human populations forced them into greater omnivority.

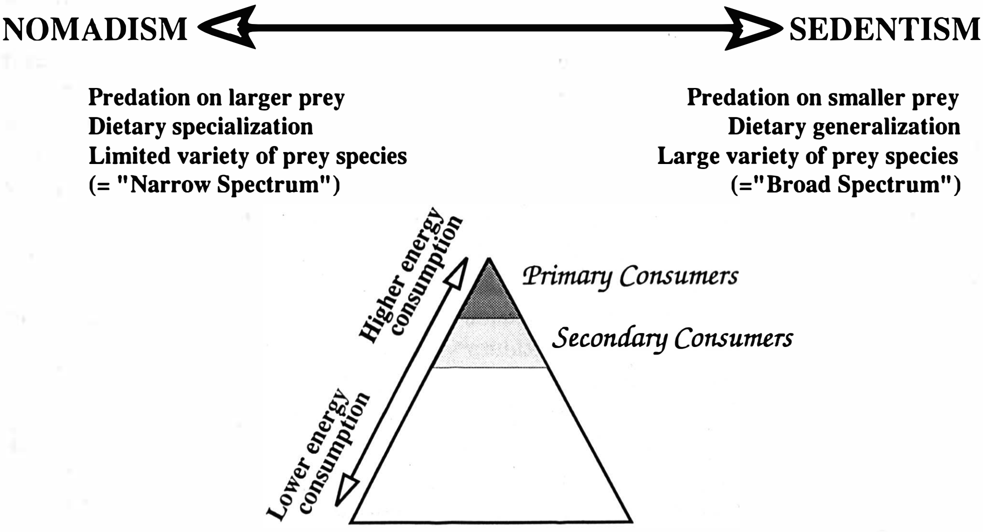

Fig. 3. Shifting to different foraging strategy causes changes in the dietary behavior. A shift from more carnivorous to more omnivorous dietary behaviour, or from higher to lower trophic level, decreases energy consumption (less rewarding food) (Odum, 1971). This type of shift in the foraging and dietary strategy in human populations during the Natufian period was due to a drastic change in their socio-economic organization and sedentism.

1981 ; Harestad and Bunnell, 1979). We may expect a similar change in the ecological attitude of humans, suppose their feeding behaviour was more carnivorous during most of the history of the genus *Homo* (Binford, 1981 ; Potts, 1988 ; Shipman, 1986 ; Shipman and Walker, 1989). This is due to the basic ecological rule which states that whenever an organism shifts into a lower stage in the ecological pyramid, or from a stage of a primary consumer to a secondary consumer (= from more herbivorous to less herbivorous dietary system), it will loose energy (Odum, 1971) (fig. 3). Hence, any shift of human populations into a less mobile life cycle will bring about a change in the trophic level.

Degradation of the Habitats

A prolonged occupation of a site by a group of people will cause an enormous drain on the vicinity areas, which ultimately will turn into a barren land. High exploitation of the resources, killing off the game, and spending more time just to maintain constant level of food intake within the limited area available for the people, will utterly alter the natural habitats around the sites (Tchernov, 1991). A centripetal ecological gradient will be created by the intensive anthropogenic activities around the site. It is expected that the nearest belt to the occupational site will be constantly and extensively used by the inhabitants. Ecologically it will be completely devoid of plants and animals. The peripheral belts around the core of the site will show gradual relaxation in the exploitation of the resources, but the width of these ecological belts will fluctuate according with the seasonal changes in the carrying capacity of the area. Habitats will gradually turn to be more natural in the outer belts, so that hunting can be experienced only at a certain distance from the site. It is important to emphasize that the constant degradation of biological resources from and around early human settlements created a unique and isolated mini-ecosystem that was virtually devoid of most plants and animals, but opened new niches and opportunities for preadapted colonizers.

Therefore, sedentism forced people to live under severe conditions, and it is not relevant whether the area was rich or poor at the beginning of the occupation of the site ; very soon any kind of habitat will be attenuated by the constant impact of the local people. In order to overcome the over-exploited region, more satisfactory technology for food gathering and meat retrieval should have been adopted if people « decided » to keep on living in the same place, in order to avoid, for instance, competition and friction with other groups of people outside their territory. Practising much higher storage technique is another effect of a sedentary way of life. Under these circumstances, especially when the area around the site has no sufficient or constant supply of food to support the local inhabitants, there will be an advantage to develop symbiotic relationships with nomadic people. Indeed, connection with remote populations is evidenced particularly from the conchological record from all Natufian sites (Mienis, 1987 ; Bar-Yosef, 1992), showing that trading with remote regions was highly experienced during this period, and that obligate socio-economic mutualism has been already established between nomadic and sedentary populations.

Broadening the Dietary Spectrum and Specializing on particular Animals

Increase in the exploitation of a large spectral array of animal species, grains and plants could have only be the consequences of over usage of an area and draining the food resources for a long period of time (Tchernov, 1992). The traditional sources of animal species hunted for meat under these conditions became insufficient so that sedentary human populations were enforced to rely on much less energetically (amount of meat per catch) rewarding animals, and many small species became newly and highly represented in all Natufian layers. But it is not only the almost revolutionary broadening of the exploited animal species, but the specialization toward hunting certain small species like *Lepus* (fig. 4) and *Alectoris* (fig. 5), waterfowl, reptiles and fishes remains in extremely high proportions and throughout the year.

Thus the early sedentary populations were not only shifted into a broader dietary spectrum, and rely on a greater proportion of smaller (« lower ranked ») animal species, as argued by many archaeologists (like Winterhalder, 1981 ; but see also Speth and Scott, 1989 for more references), but the earliest « villagers » continued to practise intensive and specialized hunting of large game. Yet, contrary to earlier periods, they gradually focused their hunting experience on a single species, which in the southern Levant was almost exclusively *G. gazella* (Legge, 1972 ; Davis, 1983 ; Henry, 1985, 1989 ; Bar-Yosef and Belfer-Cohen, 1989a,b ; Tchernov, 1992).

A significant increase in the species diversity of terrestrial molluscs, birds and reptiles is shown (Tchernov, 1992) along the sequence of Hayonim Cave, from the Aurignacian through the Kebaran to the Natufian. The great majority of the species were used for food, but by « broad spectrum » we also comprise other functions than food. Although most of the species were not edible due to their minute sizes, they do represent the high motivation of these people for collecting « objects ». Along with many other species that were either little, or not at all, used before the Natufian (many species of birds (Pichon 1984, 1987, 1989), different species of reptiles (*Ophisaurus apodus*, chameleons, snakes), became an integrative part of the food resource with time, but abruptly increased in the Natufian period. Fish was never in much favor with the eastern Mediterranean human populations, however, there is an obvious increase in the amount of marine fish brought to the Natufian sites, where it reached a significant level (Tchernov, 1992). It is, however, also obvious from the fossil record that there is a decrease in the representation of carnivores in all the Natufian deposits, where they are highly predominated by a few commensal or semi-commensal species, like foxes and dogs.

Exploitation of Gazelles

Much work has been done in the last two decades toward the reconstruction of Natufian gazelle exploitation systems (Davis, 1978 ; Henry *et al.* ; 1981 ; Henry, 1989). Legge (1972) was the first to suggest that the Natufians practised sophisticated manipulative techniques in gazelle exploitation. Based on gazelle age profiles, Legge suggested that this species may have been domesticated. Davis (1978) refuted this theory, pointing out the natural behaviour of the gazelle makes it extremely unlikely that it was ever herded as a domesticate. One thing all agree on however is the preponderance of gazelles in all Natufian sites.

It is apparent there is preference for this species during this time period as *G. gazella* bones are consistently more numerous than those of other ungulates regardless of the local environment (Henry, 1975) (tables 1,2 ; fig. 6). As it appears unlikely that gazelles were domesticated, their high relative frequencies in Natufian deposit may be the results of preferential hunting practices (Davis, 1978). Henry argues that the observed bias has its basis in the settlement and demographic patterns of the Natufians themselves.

Gazelle remains in Natufian layers always significantly outnumber all other ungulates (tables 1.2 ; fig. 6). The exceptional high frequency of gazelles was striking enough for

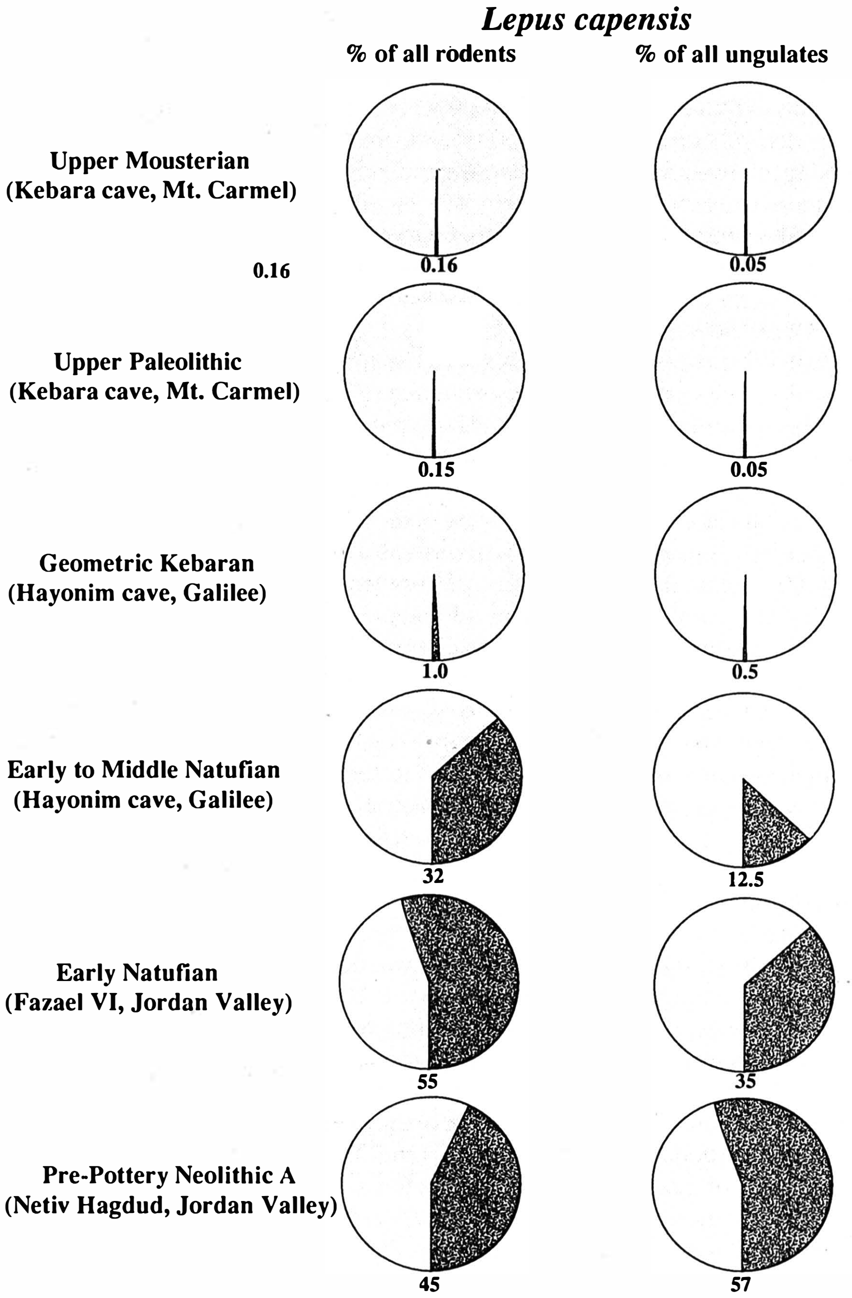

Fig. 4. Relative frequencies of *Lepus capensis* (MNI based on Pm_1 ; in %). 1. In relation to all rodents (MNI of M_1). 2. In relation to all ungulates (based on MNI of M_1).

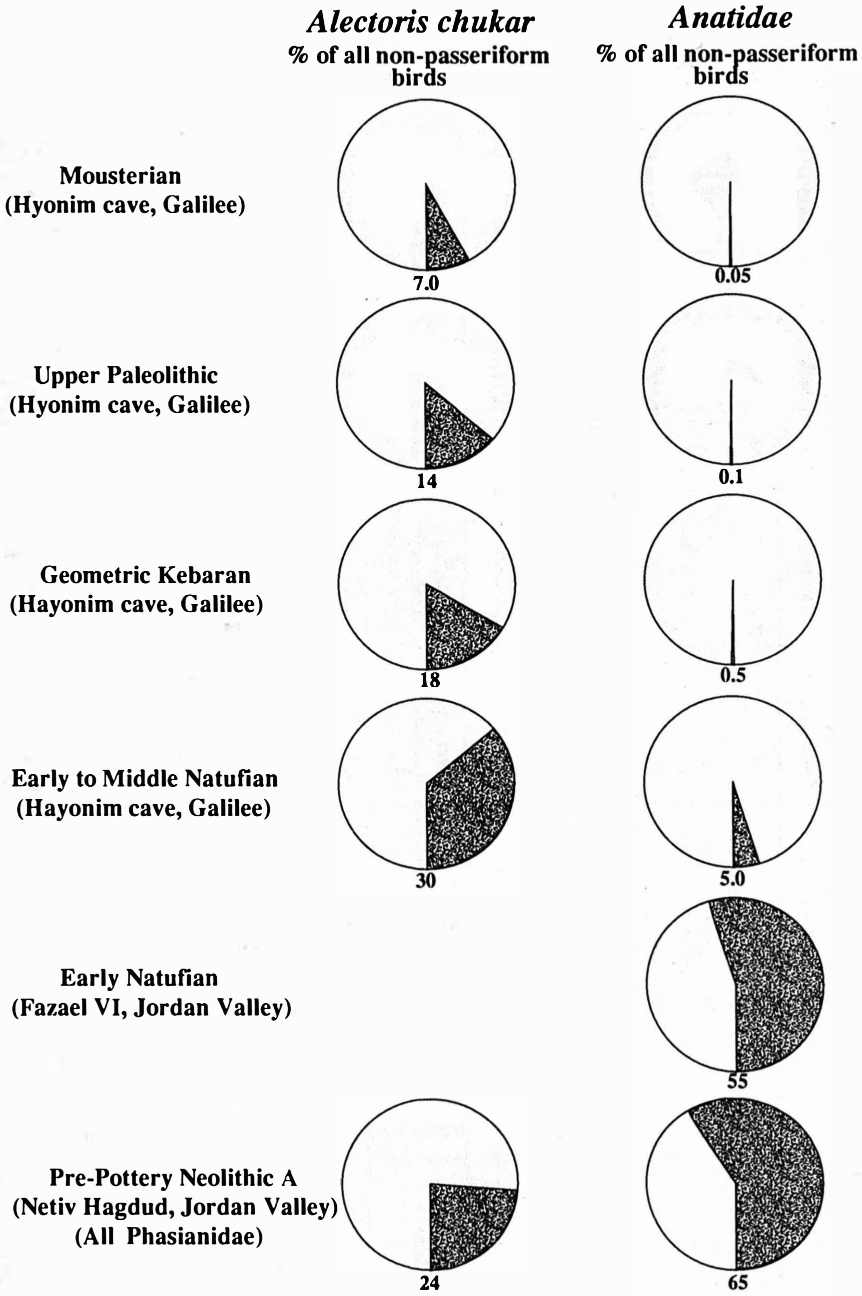

Fig. 5. a. Relative frequencies of *Alectoris chukar* (in %) in relation to all birds (based on MNI of humeri).
b. Relative frequencies of Anatidae (in %) in relation to all birds (based on MNI of humeri).

Natufian Sites	Fazael VI[a] (Early Natufian)		Mallaha (= Eynan)[b] (Early Natufian)		Hayonim Cave[c] (Early Natufian)		El-Wad[d] (All stages)		Hayonim Terrace[c] (Later Natufian)		Hayonin Terrace[e] (Later Natufian)		Salibiya I[f]	
SPECIES	NISP	%	NISP	%	MNI	%	NISP	%	MNI	%	NISP	%	NISP	%
Capra aegagros	3	3,6	42	5,6	6	6,0	1	0,7	4	2,4	21	0,42	5	1,6
Gazella gazella	63	76	495	65,8	59	58,4	121	89,7	107	64	3768	83,30	286	89,4
Bos primigenius	1	1,2	37	4,9	5	5,0	-	-	10	6,0	3	0,06	3	0,9
Sus scrofa	5	6,2	44	5,8	3	2,9	1	0,7	9	5,4	40	0,90	19	5,9
Equus spp.	-	-	-	-	1	1,0	-	-	1	0,6	-	-	-	-
Cervidae	10	12	135	17,9	26	25,7	12	8,9	35	21,2	690	15,30	7	2,2
Alcelaphus buselaphus	-	-	-	-	1	1,0	-	-	-	-	1	0,02	-	-
Capra aegagros/Gazella gazella	0,047	4,7	0,084	8,4	-	-	0,008	0,80	-	-	-	-	0,017	1,7

Natufian Sites	Salibiya I[f]		Nahal Oren[g]		Mallaha (= Eynan)[b] (Late Natufian)		Mallaha (= Eynan)[b] (Late Natufian)		Hatoula[c] (Layers 4-5) (Late Natufian)		Hatoula[h] (Layers 4-5) (Late Natufian)	
SPECIES	NISP	NISP	%	MNI	%	NISP	NISP	%	MNI	%	NISP	%
Capra aegagros	5	3	0,2	4	6,0	36	36	2,5	2	3,00	8	0,34
Gazella gazella	286	1039	77,4	38	70,0	941	941	65,5	47	70,75	2288	97,66
Bos primigenius	3	44	3,4	3	5,9	53	53	3,7	4	6,00	17	0,72
Sus scrofa	19	34	2,6	8	13,2	136	136	9,5	2	3,00	14	0,60
Equus spp.	-	-	-	1	1,2	-	-	-	-	-	-	-
Cervidae	7	218	16,4	12	16,4	270	270	18,8	11	16,75	-	-
Alcelaphus buselaphus	-	-	-	1	1,2	-	-	-	1	1,50	16(*)	0,68
Capra aegagros/Gazella gazella	0,017	0,003	0,3	-	-	0,038	0,038	3,8	-	-	0,004	0,40

Table 1. The number of identifiable specimens and the relative frequency of ungulate species in several southern Levantine Natufian sites. (a) Horwitz and Tchernov, unpublished data ; (b) Bouchud, 1987 ; (c) Cope (1992). Total number of specimens are not available ; (d) Tchernov in Valla *et al.*, 1986 ; (e) Davis, in Henry *et al.*, 1981 ; (f) Crabtree *et al.*, 1992 ; (g) Legge, 1972 ; Noy, *et al.*, 1973 ; (h) Davis, 1986 ; (*) Re-analysis of Hatoula material by Cope (1992 and *in verbis*) has shown that all cervids were misidentified by Davis (1986) as « ?Alcelaphus ».

PERIOD AND SITES	Hayonim Cave[a] (in %)	Hayonim Terrace[a] (in %)	Mallaha (Eynan)[a] (in %)	Nahal Oren[c] (in %)	Hatoula[a] (Layers 4-5) (in %)	Hatoula[a] (Layers 2-3) (in %)	Nahal Oren[c] (in %)
SPECIES AND RELATIVE FREQUENCY	NATUFIAN				PPNA		
Gazella / All Other Ungulates	58,4	64,0	55,4	83,3	71,0	71,0	84,0
Gazella Male / Gazella Female	80,0	76,0	71,0	-	60,0	50,0	-
Immature Gazella / Mature Gazella	36,0	37,0	36,0	54,7	61,0	62,5	51,9
Capra / All Other Ungulates	6,0	2,4	2,5[b]	-	3,0	4,0	-
Capra Male / Capra Female	-	-	-	-	-	-	-
Immature Capra / Mature Capra	-	-	-	-	-	-	-
Dama / All Other Ungulates	5,9	15,2	-	-	4,0	-	-
Capreolus / All Other Ungulates	19,8	9,0	-	-	8,5	-	-

Table 2. The relative frequency of *Gazella gazella*, *Capra aegagros*, *Capra ibex*, *Dama mesopotamica* and *C. capreolus* in relation to all other ungulates; the relative frequency of mature vs. immature gazelles and goats and male to female gazelles in several Natufian sites in the southern Levant. ; a. Cope (1992, and unpublished thesis) ; b. Bouchud (1987) for the late Natufian ; c. Legge, 1972; Noy *et al.*, 1973.

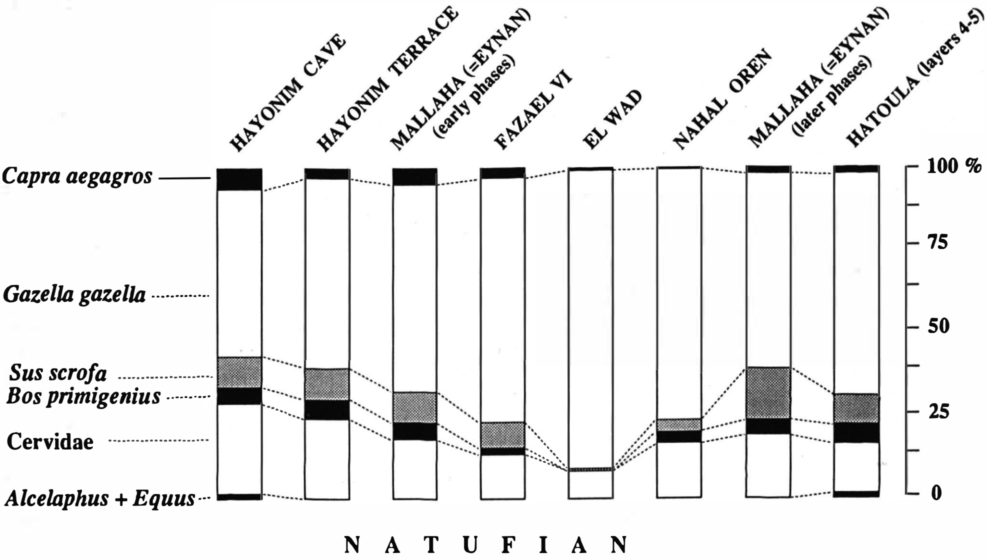

Fig. 6. Relative frequencies of ungulate species in different Natufian sites. The predominance of gazelles is obvious throughout the sequence of the Natufian period.

its pronounced bias over other large mammals, to make many archaeozoologists wonder about this phenomenon and try to explain and speculate on it in different conjectures (Legge, 1972, who argued that they were herded as domesticates : Davis, 1980, 1983, 1985 ; Henry, 1989 ; Cope-Myashiro, 1992). All of them, however, agreed that there is an apparent preferential hunting for gazelles over other large game, regardless of their local environment. Intensive sex culling is another unique phenomenon for the Natufian culture. The Natufians exerted highly sophisticated male selection culling on the local populations. The representation of males in the Natufian sites fluctuate between 60-80 %, dependent on site and date table 3 ; fig. 7). Immature gazelles in most Natufian sites show a demographic curve which is much above the normal age profile (Baharav, 1974) (table 3 ; fig. 8).

The result of this long period of human interference in gazelle mating systems was pronounced dwarfism and allometric change in a high percentage of individuals (Cope-Myashiro, 1992). Certain elements such as astragali and metapodia seem most affected by diminution while humeri were the least. The allometric changes thus produced closely resemble those seen for populations of ungulates isolated on islands. Allometric changes of this type are also similar to those seen for domestic ungulates. The genetic consequences of extensive culling of males is a far reached intra-population inbreeding due to the drastic fall in the number of males available for the females in a panmyctic population. If less males copulate with more females, homozygosis will consequently increase. A hunting pattern that effectively removes 80 % of

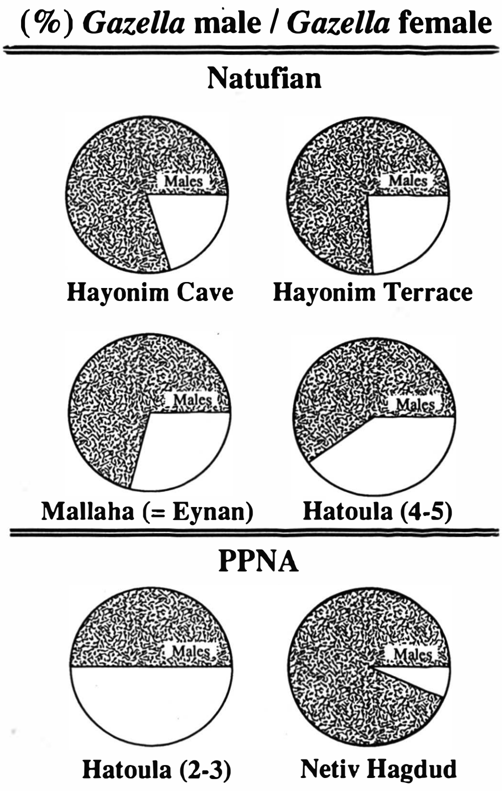

Fig. 7. Most Natufian sites in the southern Levant have shown a strong bias in favor of male gazelles (Cope-Myashiro, 1992). This phenomenon still exists in several PPNA sites.

PERIOD AND SITES	Hayonim Cave(a) (in %)	Hayonim Terrace(a) (in %)	Mallaha (Eynan)(a) (in %)	Nahal Oren(c) (in %)	Hatoula(a) (Layers 4-5) (in %)	Hatoula(a) (Layers 2-3) (in %)	Nahal Oren(c) (in %)	Netiv Hagdud(d) (in %)
SPECIES AND RELATIVE FREQUENCY	NATUFIAN					PPNA		
Gazella / All Other Ungulates	58,4	64,0	55,4	83,3	71,0	71,0	84,0	90,1
Gazella Male / Gazella Female	80,0	76,0	71,0	-	60,0	50,0	-	95
Immature Gazella / Mature Gazella	36,0	37,0	36,0	54,7	61,0	62,5	51,9	15
Immature Capra / Mature Capra	-	-	-	-	-	-	-	-
Dama / All Other Ungulates	5,9	15,2	-	-	4,0	-	-	0,8
Capreolus / All Other Ungulates	19,8	9,0	-	-	8,5	-	-	-

Table 3. The relative frequency of *Gazella gazella*, *Dama mesopotamica* and *C. capreolus* in relation to all other ungulates; the relative frequency of mature vs. immature gazelles and goats and male to female gazelles in several Natufian and PPNA sites in the southern Levant. a. Cope (1992, and unpublished thesis) ; b. Bouchud (1987) for the late Natufian ; c. Legge, 1972; Noy, et al., 1973 ; d. Tchernov, unpublished data.

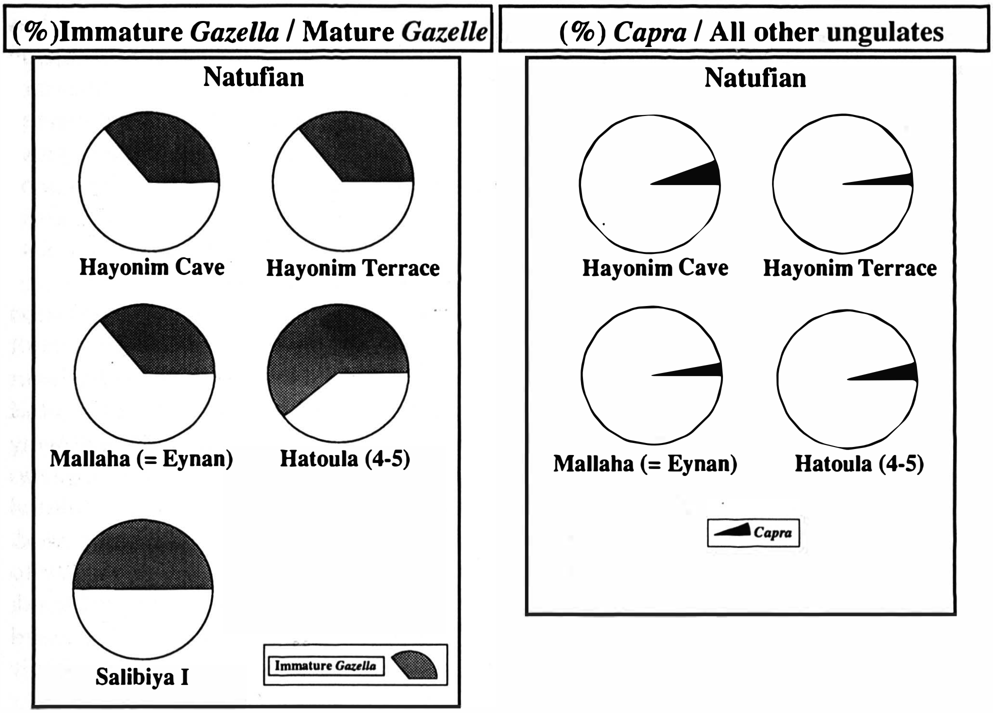

Fig. 8. The relative frequency of immature vs. mature gazelles, in several Natufian sites. It is only in Salibiya I that the age profile of gazelles approaches the present natural situation.

potentially reproductive males would affect the gene pool, severely limiting natural selection through female choice and in a sense imposing a kind of reproductive isolation on the population. Wright (1978) extended the modes to include interference with mating through « sexual or ethological » isolation. In this instance, evolution would involve a relaxation of selection against deleterious traits, *i.e.* foreshortened extremities, which appeared to be one of the major symptoms of domestication and for protected domesticates such potentially damaging allometric changes appear tolerable. However for populations of wild *G. gazella*, whose only protection is flight, such a trait would unlikely be retained under normal conditions of natural selection. The essence of animal domestication may be the loss of female choice, in proto-domestication female choice is severely restricted but not lost completely. As *Gazella gazella* males are territorial and their mobility is relatively very limited (Baharav, 1983a, b, c), gene flow between the affected population and the « natural » populations should have been greatly restricted, augmenting the effect of genetic drift even more and explaining the abrupt morphogenetic changes that the local gazelle populations underwent during this period. Cope-Myashiro (1992) argued (and see also Horwitz *et al.*, 1991) that all the skeletal elements, for instance in Hayonim Terrace, were affected at least to a certain degree, but some of them underwent disproportional diminution, like astragali, distal metapodials and last phalanxes. This artificial interference in the natural selection of the gazelle populations caused also an abnormal range of variability and hence very high v (= variance) values.

In proto-domestication and perhaps earliest domestication, where selection is less directed, stored genetic variability within the population is released, producing phenotypic results similar to that seen in true domestication. However even in response to human produced isolating mechanisms, such as intensive male culling, it is expected that phenotypic differences between populations should respond in varying degrees dependent on the genotype, environmental impact on the phenotype as well as gene flow between populations. For these reasons degrees of diminution vary from population to population. Culling practised by Natufian peoples represents an intermediate area between management of wild animals and true domestication.

Cope-Myashiro (1992) suggested that the Natufian strategy for gazelle exploitation was to keep the animals in a semi-wild state, perhaps with some degree of predator protection and then in communal hunting and drives cull young males of the bachelor herds. A stable supply of grain was the catalyst leading to the necessity of more control over gazelles. Also , as the primary target, they culled expendable young males allowing females to live and produce the important meat staple. This control over the sex ratio of a species, which is not suitable for actual domestication, may have created a cultural climate conducive to the acceptance of imported domestics in the succeeding period. Such a strategy would have the advantage of preserving the populations' ability to increase, while allowing hunters to harvest them at will. The females were perceived, hence, as a stable production basis. This pattern of gazelle procurement decreased toward the end of the period, but shown again during the PPNA, as demonstrated in Netiv Hagdud (Bar-Yosef *et al.*, 1991).

It is clear that the gazelle was a special animal to the Natufians in every aspect of procurement and treatment. The possibility that this species was afforded some degree of reverence or religious symbolism cannot be discounted. The special attitude of the Natufian people toward gazelles may be demonstrated in three different but interdependent aspects :

Sedentism and Commensalism

When a new habitat was created by the Natufians within and around the primeval villages, a confrontation between humans and other species came into an abrupt reality. At this moment we face a severe competition among the species with similar or (partly) overlapping niches. Sedentary people and those highly hierarchical competitors which are basically omnivorous and catholic (mice, rats, wolves, sparrows, etc.) found themselves co-occurring broadly in and around the anthropogenic sites, the result of which, and on an evolutionary scale, during a relatively short period, was the development of indirect commensal relationships.

Coexisting species interact with each other through their common environment, change it and thus create a closed feed back reaction. Their common presence within their common habitat may either improve or detract the environment of other species, or has (almost) no effect on the environment of other species ; a phenomenon which represents a special case of mutualism : commensalism. A situation where one species (like Homo sapiens) improves the environment for the recipient species, and does it with (almost) no cost to itself may be considered a clear case of commensalism. In case of commensals any increase in the population density of the host (humans in our case) improves the environment of the highly ranked consumer, which consequently will increase its own population density. This situation eventually creates an overall positive feedback loop. Because commensalism may be defined as a special case of cooperation where one species is completely indifferent to the other, the equilibrium line of the recipient population will rise proportionally to the population density of the host (sedentary humans). This process requires a long-term undisturbed environment.

As long as the area was occupied by people, high tension and sensitive ecotone existed between the occupational complex and the natural habitats around. There will be left only a few species which possess the right colonization characters (Safriel and Ritte, 1983) that would enable them to occupy the new habitat but have also the possibility to co-exist with people. These species are able to benefit by using the human habitats and consequently might shut down their gene exchanges with the outside populations. Indeed, one of the most interesting phenomen that followed the long term occupation of the Natufian sites is the abrupt appearance of commensals around human habitations (Tchernov, 1984, 1991, 1992). Once a more constant availability of food and/or shelter was provided, it could have attracted fostered (commensal) populations of certain species which would consequently gain an advantage over non-commensal (« wild ») populations. Such one-sided symbiosis may increase the survivorship rate, especially of juveniles, of the active commensal partner due to :

1. Constant supply of food (yet quantity and timing unpredictable) which will immediately decrease intra-specific competition of the animal populations that occupy the newly created habitats.

2. A predation-protected habitation ; in particular an increase in the availability of well sheltered nest and birth sites.

3. The proximity of intensive human activities may largely deter most of the other coexisting species. As a consequence low species diversity around the sites will decrease inter-specific competition of those species that succeeded to co-exist with humans. The size and duration of human settlements directly influences the commensal species. With further augmentation of human settlements the density of the commensal populations increases causing still further exclusion of non-commensal species.

The most abundant commensals in the Middle East are *Mus domesticus, Rattus rattus, Rattus norvegicus* (late colonization), and *Acomys cahirinus* (restricted to semi-arid and arid regions), which belong to the Muridae, Rodentia ; *Passer domesticus* (Ploceidae, Passeriformes), and *Columba livia* (Columbiformes). Carnivores like the jackal (*Canis aureus*) and the fox (*Vulpes vulpes*) may show accidental to more permanent associations with man in rural regions (a stage intermediate to plesiobiosis and early commensalism). The domestication of the dog, however, which could have been the consequence of an earlier commensal relationship between wolves and man, later has played an important role in human behaviour until today (fig. 9). In regions where *Tatera* (Berbillidae) exists (mainly in arid to semi-arid areas in central Asia and Mesopotamia) it is usually found as a commun commensal.

According with many biological reports on the distribution and behavioural ecology of the « *Mus musculus* » group of species (*M. domesticus, M castaneus, M. bactrianus, M. musculus*), this is the only group among the genus *Mus* which established permanent commensal populations (Auffray *et al.*, 1988, 1990). In the southern Levant the

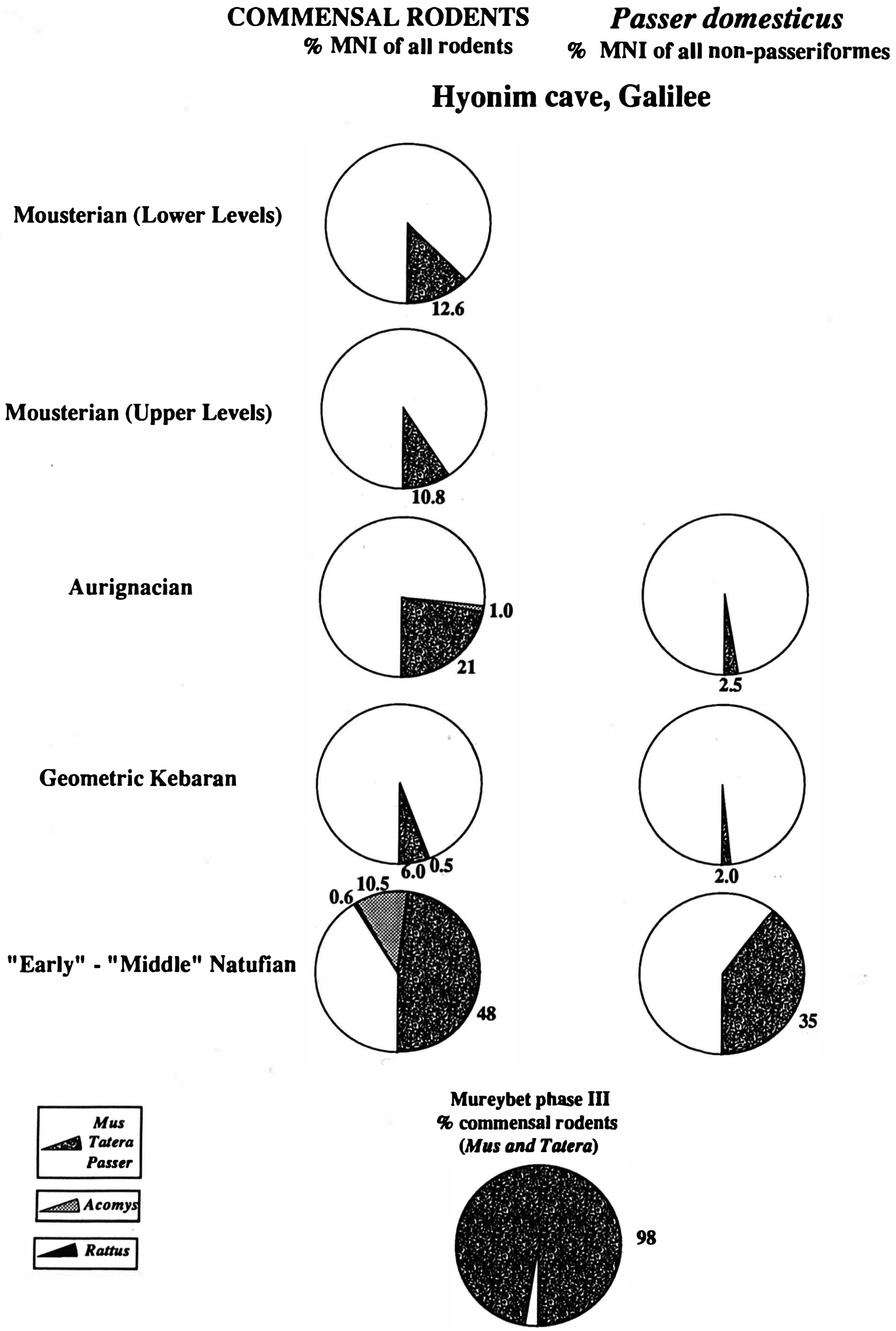

Fig. 9. Relative frequencies of commensal rodents (*Mus*, *Rattus* and *Acomys*, Muridae) and *Passer domesticus* (Ploceidae) from the Middle Paleolithic to the Natufian period.

distribution and ecology of *Mus domesticus* and *Mus macedonicus* are very clear : the first one is essentially commensal, and the second species mainly occurs in non-anthropogenic habitats. Competition between these two species may well be the origin of the commensalism of the house mouse. Indeed the earliest known *Mus domesticus* was described from the Natufian sites of Israel ; a biological segregation that can only take place in an isolated habitat for quite a long period, long enough to hamper gene flow with the ancestral populations in order to induce full speciation. These behavioral and morphological, as well as genetic adaptation of *Mus domesticus* for human habitations could have taken place as a long-term steady process within those early human dwellings, a habitat that was conspicuously isolated.

Natufian Sedentism - A shift to Higher Level of Complexity

The transition from a situation in which the entire population within a given area was spontaneously organized from bands of hunter-gatherers to relatively large societies of sedentary foragers is probably one of the best examples of an abrupt increase in the socio-economy of man. How and why the complexed Natufian culture of essentially sedentary life emerged from a world of hunter-gatherers is a basic question pertaining to human evolution. A spontaneous increase in the organizational level of human communities in a certain place and at a certain period was followed by a swift augmentation in communication, exploitation devices and subsistence.

Wenke (1981) was seeking for the reason for the sudden « unexplainable » appearance of cultural complexities and argued that with the appearance of complex cultures we encounter kinds of group interaction, methods of transmitting cultural characteristic forms of social control, and many other elements that contrast with those of the Pleistocene, and that cannot be explained to any great degree with existing ecological principles. There are other arguments that try and simulate the impact of climatic changes on Levantine environment as well as the various models offered as explanation for the cultural transitions which led to the establishment of farming communities by about 10 000 BP. According to Bar-Yosef (1989) it was the onset of wetter conditions around 10 300-10 000 B.P. that enabled the well established Natufian settlements within the Mediterranean belt to expand their knowledge as intensive users of wild cereals and successfully practise cultivation. Such an abrupt climatic change together with a period of social stress was suggested as a logical explanation for the decision made by Geometric Kebarans to become sedentary, or considerably less mobile, than their predecessors (Bar-Yosef and Belfer-Cohen, 1989a). Kelly (1983) argued that one of the factors leading to more complex societies was the limiting movement of populations, either due to natural conditions or to social causes, such as the presence of neighboring groups. Territorial behaviour practices by various groups are inferred from the spatial distribution of the sites and the stylistic differences in their lithic assemblages (Hovers *et al.*, 1988). Hayden (1990) pointed out that « in contrast to earlier hunter/gatherers highly competitive individuals with accumulative personality emerged in the new resource-rich communities, and they used the competitive feast as a means of developing, extending and consolidating their power ». He further argued that it is in the context of these « accumulators » and the feasting complex that the first domesticates generally appear. Yet, in the reality of the southern Levantine domesticates appear a long time after the earliest sedentism ; it took more than 1 000 years until the first domesticates emerged.

We do not have any evidence that the abrupt sedentism of the Natufians and the punctuational increase in their socio-economic status were indeed the outcome of agglomerations of small settlements into larger ones, or through extinction of many small settlements and an *in situ* growth of a few small settlements into much larger societies. Moreover, during the late Kebaran (Bar-Yosef and Belfer-Cohen, 1989a ; Byrd, 1989) there was no way to expansion, dispersal or immigration, as the number of settlements, and the distribution density of occupational sites, was too high for any population movement.

Self-assembly describes the ability of macromolecules to organize themselves spontaneously. Similarly polypeptide chains possess the ability to convert the one-dimensional information by spontaneously folding into globular conformations that are biologically active. This transformation is the result of physico-chemical processes intrinsic to the molecules. Other macromolecules and whole cell organelles also had the ability to self-assemble. There is a reluctance to accept the phenomenon that animals self-assemble into societies, and that it is guided by the same universal rules from the level of elementary particles to that of human societies.

That new and higher ordering can be derived from a fluctuation in a system was originally introduced by Nicolis and Prigogine (1977). From their definition we understand that self-organization would not occur if the concerned system was in a stationary state. Thus the system should have been in another state of order in order to be organized autonomously. Prigogine (1978) has called it a dissipative structure, which is defined as the macrostructure that appears in a non-equilibrium open system. As this definition indicates, it was originally devised in the field of thermodynamics. Living systems as thermodynamic systems, by extracting energy from their environment, and thus counteracting entropy (= negentropy), display dissipative structures, which at present has been applied to other fields such as chemical reactions (Nicolis and Prigogine, 1977), ecosystems (Allen, 1976), urban development and economics (Allen *et al.*, 1978 ; Silverberg, 1984). Dyke (1988) argued that if human institutions and systems indeed display dissipative structures we have to identify structures and relate their ability to sustain, maintain and reproduce themselves according to the resources (material and energy) available to them, which resources flow by and through the system. He further suggested that from an economic point of view families, villages, cities, regions, provinces, states, etc., all the way up to nations seem to be perspective candidates for investigation as dissipative structures. However, progress of the theory has been especially remarkable in natural sciences. Morowitz (1968) already stressed that, since organisms are open thermodynamic systems, there are no particular energy constraints on increasing biological complexity and organization.

There is nothing in Darwinism or Neo-Darwinism which enables us to predict a long unidirectional increase in complexity, because increase complexity may not, by itself, confer greater fitness for the organism. There is no change in the performance (= fitness) of any organism regardless of its level of complexity. What is the benefit the individual will gain by relating to a socialized group ? Was his fitness so low before ? Will its inclusive fitness become higher ? Higher energy consuming systems do not increase the inclusive fitness of their individuals. In high complex societies where decision making is extremely centralized (Dunnell, 1988), it is difficult to see when exactly natural selection works, yet certainly not on the individual level. I argue that the increase in the complexities of human systems, and consequently the proximal needs for ever more elaborated technologies and devices, for more efficient exploitation of the resources, was not driven by intrinsic human traits, not even by biological rules, and apparently beyond « conscious decisions » made by people, but by higher natural laws. All one can say is that all that happened ever since the first living being appeared must have been in the direction of increasing complexity. « Nowhere to go but up » (as Thomas Hood argued) has nothing innate in the biological principles that will explain why integration occurs at all, or why the average level of complexity continues to rise.

Between the two existing contradictory dogmas of how to explain the constant irreversible increase in human technology, exploitation of the resources, interactions with the biotic and abiotic environment, social structure and consciousness, we usually understand the earlier stages as being the consequence of biological laws, while the later stages of our development are propelled by the inner and innate human forces and laws utterly detached from natural phenomena, yet with no demarcation between the shift from one set of laws to another. Or is there any shift at all ? As all beings are classed in a serial order of complexities, the rise in the order of highly socialized humans plays an integral part in the inevitability of this order, and therefore it is not at all surprising that the laws of thermodynamics have led us along the road of increasing complexity from an ape-like level into a hyper-social organization and conscious being. Human societies underwent analogically similar shifts from a simple organization where the individual carry the complete code necessary to produce in full the human phenotype (Dunnell, 1988).

The energy expenditure within a social unit is always higher in a more complex social organization. Although it was rarely quantified, it seems to be universally correct for all organisms ; the higher the social organization is, the higher is the energy incorporation of the individual within its social system. Indeed, many anthropologists and sociologists today recognize socio-cultural systems as group entities at their own ontological stage of organization with emergent features.

Through increase of social complexities, adopting novelties in technology and subsistence, increasing pressure on the habitats, the anthropogenic factor turned to be the unique causal agency and forcing mechanism promoting environmental changes which far exceed the limits of that which had and would have naturally occurred if man was not here, and in a tempo that is speeded up immeasurably. Human interference in biological systems, much like large scale abiotic impacts, will reverse the successional development of biological systems, shifting them into early stages of complexity, or a less mature status, with lower energetic flow and higher thermodynamic equilibrium. The abrupt transition from mobility to sedentism during the Epi-Paleolithic period is one of the best examples of a punctuational increase in socio-economical status and consequently an increasing impact on the biosystems.

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Discussions

M. Teichert : In 1961, I participated to an expedition to Mongolia. We rode together with Mongolian hunters for over 200 km from the last settlement in the Chentei Mountains. There, a Mongolian hunter killed an elk (*Alces alces*). From this animal, we brought back with the horses over 50 kg of meat to the settlement, but no bones. I think that in early historic times the hunters killed large animals far from the settlement and brought back the meat and not the bones. It is possible therefore that bones from large animals can be underrepresented on the settlements.

E. Tchernov : Indeed, ethnography is a discipline that may sometimes be powerful enough to allow deduction and speculations of past behavioural patterns of human beings. Yet this procedure should be taken very carefully, as there is no linear connection between the tribal behaviour in the past and the present behaviour of « primitive » groups of people, and hence is far from being dogmatic and trivial. A deduction from present behavioural patterns of specialized groups of people may be misleading. I know of a very few contemporaneous groups of people who are obligatorily dependent on bone material as a major, or even minor, source for fabrication of artifacts. After all, we passed already the Bronze Age and the Iron Age long ago. Subsequently, and followed by a dramatic increase in man's socio-economic organization since then, other materials replaced bones and stones. There is hardly a reversal evolution in the technology of man. For a successful exploitation of the resources today, one cannot seriously rely on bones as raw materials for modern tools. I know very little about the Mongolians, but logically it should be conceded that, if a group of people has no need for bones, why should they bother to schlep the corpse *in toto* back to the site, when they are able to discard the redundant weight and bring net food. The Natufian and early Neolithic people were heavily dependent on bone material for everyday life. Getting rid of bones on the hunting grounds is totally illogical for these people during these periods.