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COMMUNAL ROOSTS OF EGYPTIAN VULTURES (*NEOPHRON PERCNOPTERUS*): DYNAMICS AND IMPLICATIONS FOR THE SPECIES CONSERVATION

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SUMMARY.-*Communal roosts of Egyptian Vultures* (Neophron percnopterus): *dynamics and implications for the species conservation.* Since 1986, 14 summer Egyptian Vulture communal roosts have been found in N Spain (Navarra, Aragón) and S France. The maximum number of observed birds in the eight main roosts oscillated from 33 to 200. Three birds equipped with radiotransmitters and 264 individuals banded with PVC rings showed that a a bird can visit several roosts in the course of the same season. The Egyptian Vultures settled in roosts get most of their food at neighboring livestock carcass sites and dump sites. From 35% to 50% of the observed birds in summer had immature plumage (1-3 years old). The roosts are visited by non-breeding birds born at places farther than 165 km and by breeding adults from an area of a minimum of 25 km radium. The survival rate of the birds visiting the roosts in their pre-adult stage (up to 4 years of age) was 18.6%. An estimated significative fraction of the Iberian population of non-breeding Egyptian Vultures concentrate at the summer communal roost sites. Up to present these roosts have not been subjected to any active conservation measures by the Navarra and Aragón Governments.

RESUMEN.-*Dormideros comunales de Alimoche* (Neophron percnopterus): *dinámica e implicaciones para la conservación de la especie.* Desde 1986 se han encontrado 14 dormideros comunales estivales de Alimoche en el norte de España (Navarra, Aragón) y sur de Francia. El número máximo de aves observadas en los ocho dormideros principales osciló entre 33 y 200. Tres aves equipadas con radioemisores y el marcaje de con anillas de PVC de 264 ejemplares mostraron que un ave puede visitar varios dormideros en la misma estación. Los alimoches asentados en dormideros obtienen la práctica totalidad de su alimento en muladares y basureros situados en las cercanías. Del 35 al 50% de las aves observadas en verano presentaban plumaje inmaduro (1 a 3 años de edad). Los dormideros son visitados por aves no reproductoras nacidas a más de 165 km de distancia y por adultos reproductores de un área mínima de 25 km de radio. La supervivencia en la etapa preadulta (hasta 4 años de edad) de las aves que visitaban el dormidero fue del 18.6%. Se estima que una fracción muy importante de la población ibérica de alimoches no reproductores puede concentrarse en los dormideros comunales estivales. Hasta el momento estos dormideros no han sido objeto de ninguna medida de conservación activa por parte de los Gobiernos de Navarra y Aragón.

INTRODUCTION

The strategies for raptor conservation are mostly centered on the protection of nesting habitats, reproductive processes and, more seldom, at reducing adult bird mortality. Nevertheless, it is more and more evident the need of

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protecting the birds throughout their maturation process and, even more, the places where the bird predadult or immature periods take place (Ferrer 1992, 1993).

In social species immature and adult individuals use to concentrate in communal roosts (see review in Allen & Young, 1982). The protection of these singular areas has become a basic piece in the conservation programs for several great raptors, such as the Bald Eagle (*Haliaetus leucocephalus*), in the United States (Riley, 1983). However, this strategy has not been considered in raptor conservation programs in Europe. It is partly due to the lack of information on the existence of communal roosts and their dynamics.

The Egyptian Vulture is a rare species all over Europe, and Spain holds two thirds of their number in the continent (1324-1373 pairs; Perea *et al.*, 1990). As other vulture species it tends to be social in the areas where food availability is high. As a consequence of both factors, gregarism and food abundance, the species meets in communal roosts in numbers that can be very high. So, in XIXth century a concentration of 500 Egyptian Vultures in one tree near Istambul was recorded, as well as another of more than 200 individuals on telegraphic poles in Port Sudan (Cramp & Simmons, 1980). In western Europe roosting sites were almost unknown; so, until the eighties only the Doñana (20 individuals) and Minorca (47 individuals) winter roosts have been reported (Congost & Muntaner, 1974; Donázar, 1993).

A series of summer roosting sites were later discovered in Spain and have been studied by this research team since 1986. In a former paper (Ceballos & Donázar, 1990) roost-tree selection, diet and annual evolution of individuals in a roost are detailed. In the present article information on new roosts is offered, and the still partly provisional results about individual space and habitat use, roost dynamics, and individual survival and recruitment are detailed. Finally, the present conservation conditions of the already known roosting sites are examined.

MATERIAL AND METHODS

Research work has been carried out in Navarra and Aragón (N Spain) since 1986 up to date. In addition, information from other regions has been collected. The study area covers around 20,000 km^2 on the Ebro valley and Pyrenees mountain range. Climates is cold and humid towards the Pyrenees were rainfall reaches > 2,000 mm/yr. In the Ebro valley rainfall is < 400 mm/yr.. Mountains are covered by forests whereas the Ebro valley is covered by cultivated lands with some pseudosteppe vegetation. Further descriptions of the study area can be found in Ceballos & Donázar (1990), and Tella (1991).

In the course of spring in 1987 three (two non-breeding adults and one inmature) Egyptian Vultures were captured at Las Bardenas roost. They were banded with PCV rings and plastic wing marks, and equipped with a radiotransmitter. The intensive monitoring of the birds in the following three months allowed us to determine their home range (calculated as the minimum convex polygon) and habitat selection. For the study of habitat selection in foraging activities eight different habitats were characterized: irrigated farmland, farmland, shrub, wood, rock, corral, livestock carcass sites, and refuse dumps. Habitat availability and habitats chosen by the birds (by % time spent foraging in every one of them) were later compared by means of

Chi-square tests.

At the largest roost weekly counts were carried out throughout 1988 (February-September), and 1991, 1992, 1993 and 1994 (July-September). Three age categories regarding plumage were distinguished: adults (individuals with definitive plumage, 4 years old or older), subadults (individuals with intermediate plumage, 1 to 3 years old) and young (quite dark plumage, recently fledged nestlings). During august of 1994 we carried out simultaneous censuses at the eight main roosts. We registered the age of each bird and read all the PVC rings.

Since 1987, 227 Egyptian Vulture nestlings have been banded with PVC rings in three different geographical areas (Bardenas Reales, Middle Depression of the Ebro Basin, and Middle Area of Navarra); 27 non breeding individuals were captured near Las Bardenas roost and 10 breeding adults from Las Bardenas Reales area. During the sistematic monitoring of the roost NA-1 (Bardenas Reales) we looked for PVC rings. Aditionally, PVC rings were read in non-sistematic vistis to other roosts.

RESULTS

Situation and characteristics of the roosts

At present we know of eight great roosts in Navarra and Aragón (Huesca and Zaragoza): NA-1: Las Bardenas Reales (a maximum of 200 Egyptian Vultures observed), HU-1: Huesca (196), NA-2: Leyre (130), HU-2: Río Veral (101), Z-1: Ejea de los Caballeros (60), Z-2: Peñaflor (46), NA-3: Sangüesa (33) and Z-3:Peñalba (33). Appart from the main roosts there are other five of little importance, where Egyptian Vultures have sporadically been observed and which are considered as satellites of the former; the maximum number of Egyptian Vultures observed in the last ones ranged from 3 to 15 individuals. There is as well a small roost site at Baigorry, Departement of the Pyrénées Atlantiques, where a maximum number of 24 Egyptian Vultures meet (Jean S. Devisse, pers.comm.). Finally, and for some years, we have known of roosts, with wintering birds, in Menorca and Doñana (see above).

All the roosts are found on trees, mainly pines. At the Leyre roost Egyptian Vultures indistinctly use a replanted pine grove and great limestone cliffs. One of the satellite roosts is set on a clay cliff. A detailed study comparing the characteristics of the trees used by Egyptian Vultures with other trees chosen at random in the same areas revealed that the birds actively selected the largest trees and preferably the dead ones. All the roosts were or are found close to (less than 3 km) a stable source of food, either a refuse dump or a livestock carcass site (see Ceballos & Donázar 1990 for more information).

Use of space

The immature Egyptian Vulture, an individual about two years old, and one of the adults used Las Bardenas Reales roost as an activity center and prospected relatively close zones, being the size of their home ranges (minimum convex polygon) respectively 39 and 95 km^2.

The second adult shifted roosts often, in an evening the distance was more than linear 80 km. This individual used both Las Bardenas and Río Veral roosts

as activity centers and it visited Leyre and Ejea de los Caballeros roosts. In a whole its home range reached 523 km2.

Observations of some of the 264 individuals banded with PVC rings and/or wing marks revealed that the birds would often visit several roosts throughout the season (Figure 1). This fact corroborates that the Navarra, Aragón and Aquitania roosts are highly inter-related and that there is an important flow of birds among them.

Use of habitat

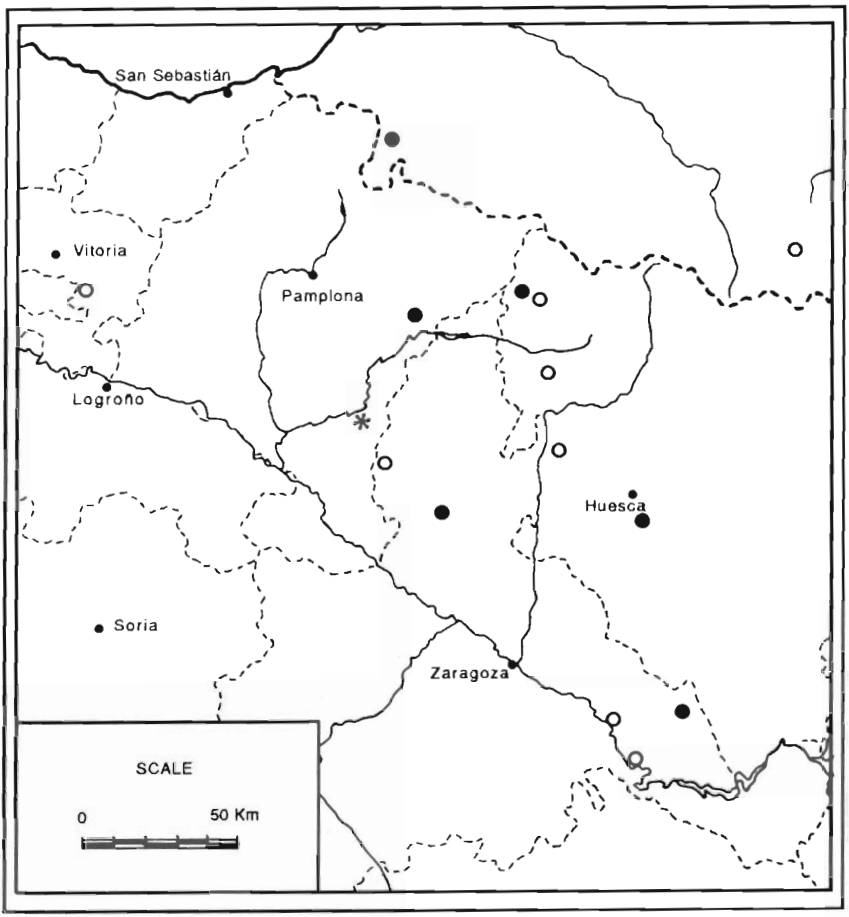

FIG. 1.- Localization of the Egyptian Vultures observed at least once at the main roost (*). Filled circles: localizations at other roosts, open circles: other localizations.
[Lugares donde se han localizado alimoches que habían sido observados en el dormidero principal (*). Círculos negros: localizaciones en otros dormideros; círculos blancos: otras localizaciones].

The comparison among the percentage of observations of the three Egyptian Vultures feeding in every kind of habitat and their availability has shown that the birds actively selected the carcass piles and refuse dumps placed in the neighbourhood of the visited roost sites (Figure 2). The aplication of Chi-square tests revealed that irrigated farmland, farmland, and woods were significantly ($p<0.05$) evited by two of the three birds. The three studied birds selected significantly the livestock carcass sites, and the vulture that had a refuse dump near his roost selected significantly this area for foraging activities. Corrals, shrubs and cliffs were used in relation to their availability.

Besides (see Ceballos & Donázar, 1990), the study by pellet analysis of the food ingested by the birds in the main roosts confirms that hen, pig and sheep carcasses are the main source of food; on the other hand, refuse remains are often found in pellets from roosts set near refuse dumps.

It can then be said that the Egyptian Vultures settled in roosts get the whole of their food from refuse dumps or livestock carcasses sites near their roosts. In fact, in one of those deposits near Las Bardenas roost up to 120 Egyptian Vultures have been observed feeding at a heap of hen carcasses, and at the refuse dump close to Río Veral roost more than 40 individuals feeding among refuse plastic bags can often be seen.

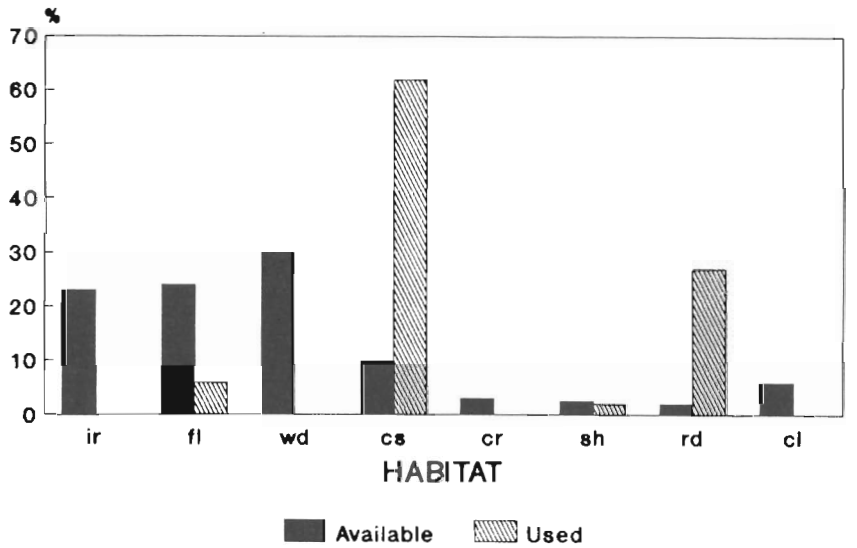

FIG. 2.- Foraging habitat selection by three roosting Egyptian Vultures. The percentage of available habitat and of the time that the birds spend at foraging activities in each habitat is shown: ir=irrigated farmland, fl=farmland, wd=wood, cs=livestock carcass site, cr=corral, sh=shrub, rd=refuse dump, cl=cliff.

[*Selección del hábitat de alimentación por tres alimoches que frecuentaban dormideros. Se muestrra el pocentaje de hábitat disponible y el porcentaje de tiempo que las aves dedecican a comer en cada hábitat: ir=regadío, fl=secano, wd=bosque, cs=muladar, cr=corral, sh=matorral, rd=basurero, cl=cortados*].

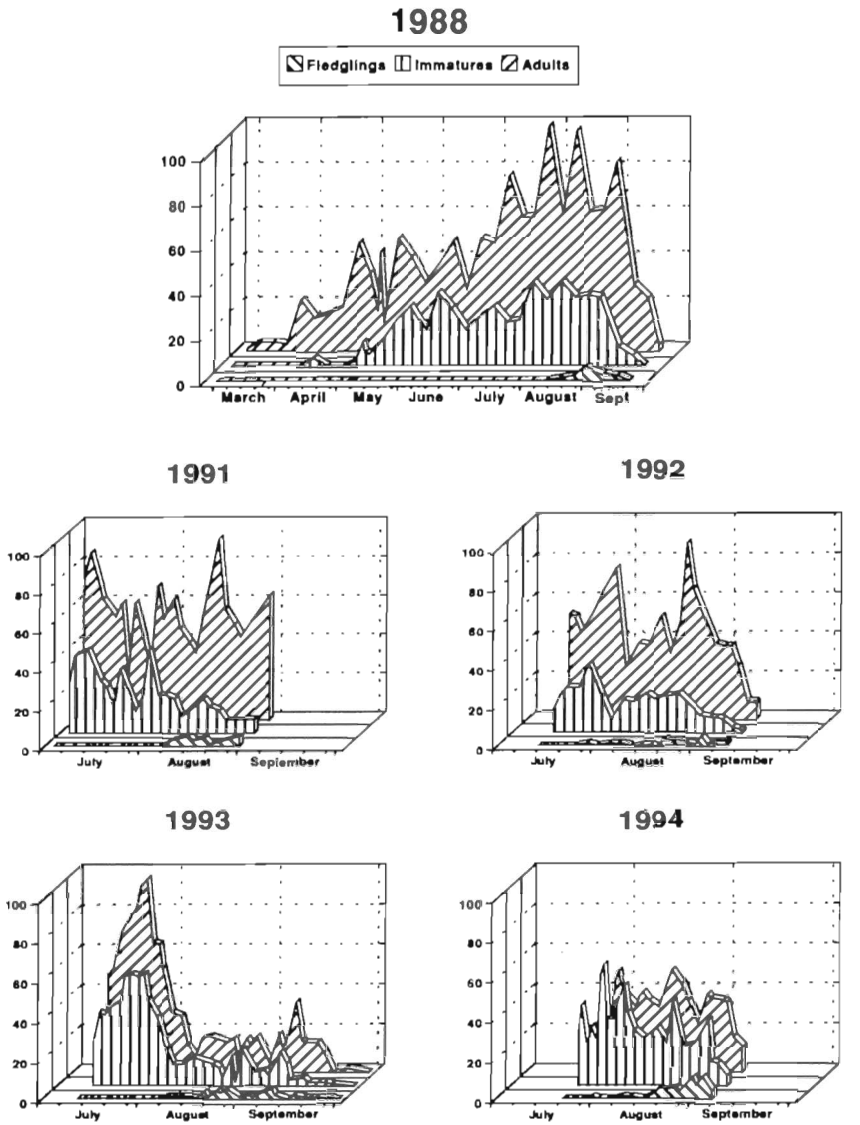

FIG. 3.- Variations in the number of Egyptian Vultures observed at Las Bardenas roost. [*Variaciones en el número de alimoches presentes en el dormidero de Bardenas Reales*].

Variations in the number of individuals

In 1988, the first Egyptian Vultures arrived at the roost NA-1 (Bardenas) in the last week of February. The number of individuals progressively increased until it reached its maximum at the end of July and early August. A quick decrease began later until the last Egyptian Vultures disappeared at the end of September (Figure 3).

From a total of 1.757 observed Egyptian Vultures in 1988, 72.6% were adults, 26.6% subadults and 0,8% young. Adults were the first to arrive at the roost, at the end of February. Subadults did not arrive until May, their number increasing later in a way parallel to that of adults; in that period (May-September) subadults were 38.4% of all the Egyptian Vultures in the roost. The young arrive at the roost during the weeks after their first flights (August-September) and immediately before their first migration. The young and subadults left the roost site a week before the adults did.

Since 1991, 2-3 weekly controls of this roost have been performed from July to September. The results of these last 4 years agree with what was observed in 1988. As a whole, in summer the percentage of subadults in the roost ranged from 35% and 50% of the total number of Egyptian Vultures.

The strong weekly oscillations in the total number of Egyptian Vultures, detected at Las Bardenas roost, are common to the remaining roosts. So, during the 4 simultaneous censuses of the main roosts carried out in the first fortnight of August of 1994, the number of individuals reported in Huesca ranged from 65 to 137, from 58 to 88 in Leyre and from 22 to 101 in Río Veral. However, the total number of Egyptian Vultures observed in the 8 roost sites remained practically constant, the figures ranging from 309 to 352. This last fact indirectly evidences the already commented flow of Egyptian Vultures among roosts.

Recruitment of individuals

The PVC ring control at Las Bardenas Reales roost during the weekly controls in 1988 and 1991-94 has let us know that the roost is periodically visited by breeding adults in an area of a radius of at least 25 km. Eight of the ten banded adults that nest in this area visited the roost once at least. The visits took place indistinctly, when the birds had nestlings of a medium or large size in their nests, or when breeding was unsuccessful.

The visits of Egyptian Vultures born in the three geographical areas where nestlings have been banded with PVC rings have also been detected, some of them at more than 165 km far from the roost site (Figure 4). On the other hand, individuals with metal rings only, and subsequently not from the study areas, are often observed.

The systematic monitoring along these 5 years has let us verify that on average 0.83% of 1 year old banded individuals, 15.13% of two years old individuals and 15.0% of the 3 year-old Egyptian Vultures come back every year. Therefore 30.96% of the nestlings born in the previous three years come back. Since the age composition of the subadult group is directely related to the recruitment rate of every age, we can estimate that 2.68% of individuals in immature ones are one year old, 48.87% two years old, and 48.45% three years old (Figure 5). In the simultaneous censuses carried out in August 1994 a total of 168 individuals with immature plumage was detected which would be

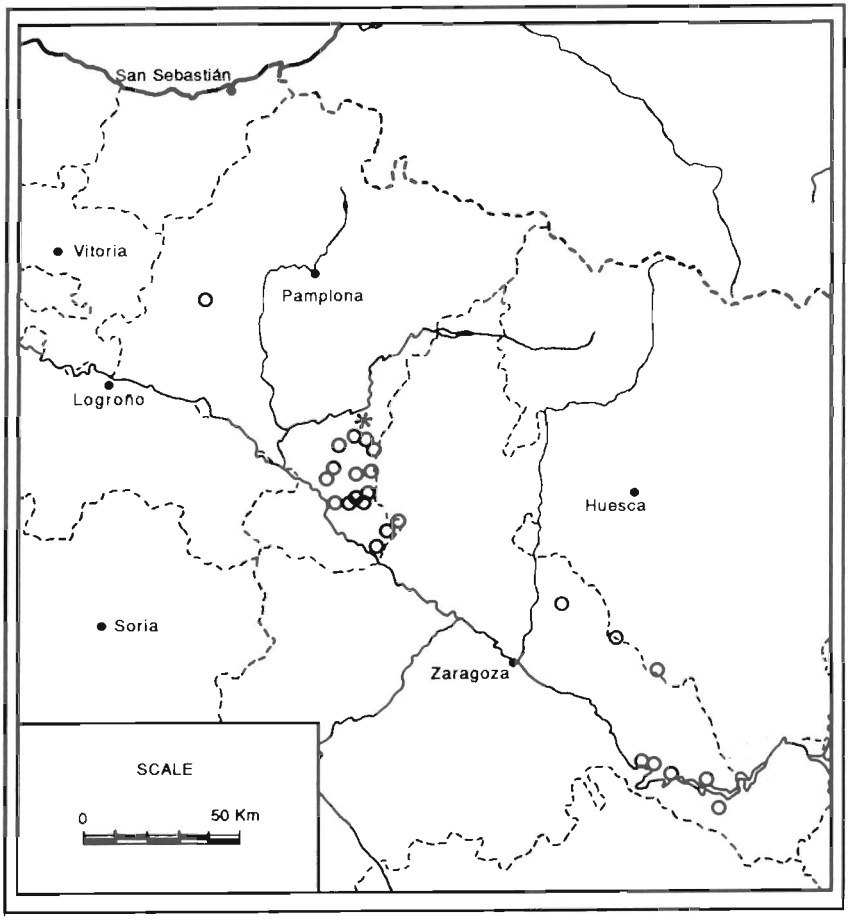

FIG. 4.- Places where the immature Egyptian Vultures observed at roost (Bardenas Reales) were born.
[*Lugares donde habían nacido los alimoches inmaduros que se observaron en el dormidero de Bardenas Reales*].

equal to 543 chicks born. Presuming a productivity of 1 chicks per pair of Egyptian Vulture, the Navarra and Aragón roosting sites would be holding the productivity of 543 pairs. However, according to our data (unpubl.), average productivity in 1991-93 at Las Bardenas has been 0.59 chicks/pair, and 0.66 chicks/pair at the zone of the Ebro Middle Depression. So, if we apply a closer productivity to the known data (0.5 chicks/pair), the 8 main roosts would receive the production of 1,085 pairs of Egyptian Vultures.

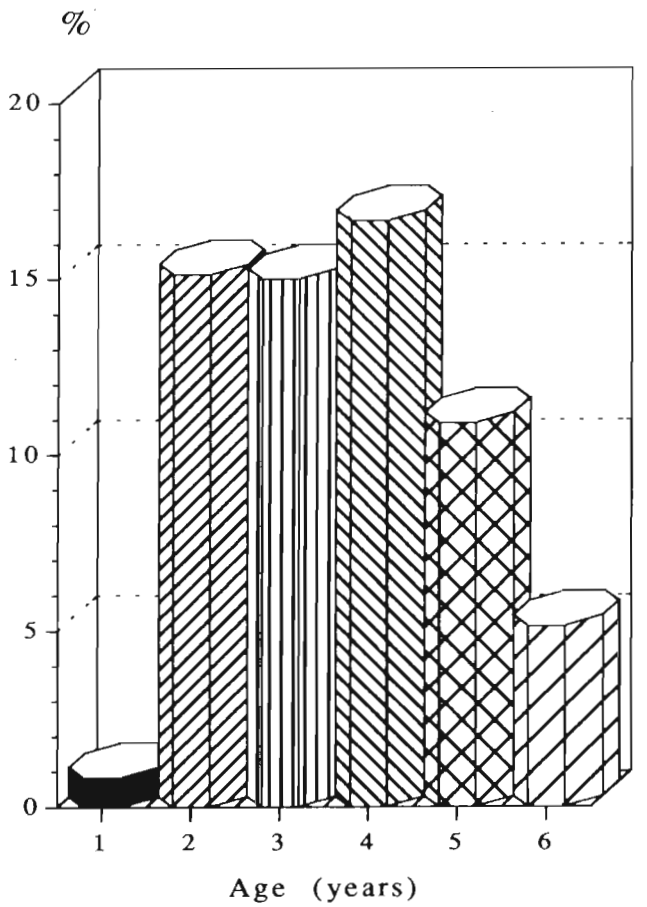

FIG. 5.- Percentage of banded Egyptian Vultures that came back to the roosting sites every year.
[*Porcentaje de alimoches anillados que regresan cada año a los dormideros*].

Survival

In accordance to the repeated controls of individuals banded with PVC rings it has been estimated which is the survival of the chicks born in the area until they attain adult plumage (4 years): the global preadult survival is estimated as 24.0% at age of 2 years, 22.5% at 3 years, and 18.6% at 4 years (adults). Those are minimal figures, since it is understood that all the live Egyptian Vultures have the same possibilities of being observed at the roost.

DISCUSSION

The summer communal roosting sites that at present exist in the North of Spain are the largest ones nowadays known for the species in the whole Western Palearctic. The simultaneous censuses made in August 1994 revealed that al least some 352 birds concentrated in them, which is similar to the 13% of the breeding population of the Iberian Peninsula (estimated in about 1,350 pairs, Perea *et al.*, 1989). There are still two more roosts, in this case winter and middle sized ones, on Minorca Island (Congost & Muntaner, 1974) and in the Guadalquivir Marshes (see Donázar, 1993).

Egyptian Vultures are highly selective when choosing roost sites, they will always set them near important and predictable food sources (refuse dumps and livestock carcass sites, and more seldom areas very rich in wild rabbits), and they preferably select big dead trees for resting (see Ceballos & Donázar, 1990; Tella, 1991). All this shows that roosting sites adjust to very precise local conditions, both from a trophic and substratum availability points of view. The need of a general quietness opposite to human presence is to be added. Although they may sometimes settle in areas highly transformed by agricultural practices, all the roosts are found at points where human presence is occasional, at least in an average radius of 200-300 m around the roost. Altering trophic or quietness conditions brings serious consequences. Three of the known roosts have disappeared since 1989, occurring at the same time of a DHV (hemorragic pneumonia) outbreak in rabbits, the main component of the Egyptian Vulture's diet in those localities (Tella, 1991b). On the other hand, in the largest roost known we have detected massive bird shifts after the continuous human presence in the zone of the roost-trees.

According to our estimates, the known estival roosts recruit the immature individuals born in a population of about one thousand pairs. The total population in Spain is estimated in about 1,350 breeding pairs (Perea *et al.*, 1990). It can then be inferred that the studied estival roosts may be recruiting immature non-breeding individuals from quite a good part of the Iberian Peninsula population, and thus, from western Europe. On the other hand these roosts are visited very often by breeding adult individuals from areas less than 20 km far. In addition, the survival rate in the pre-adult stage by the individuals visiting the roosts was 18.6 %, which means a number higher than expected according to what happens with other great raptors whose survival rates is not usually higher than 10% in the pre-adult stage (see Hiraldo *et al.*, 1979). It can then be thought that from the point of view of the species conservation all over Europe the importance of roosts is remarkable. The tendency of non-breeding individuals from large areas to concentrate in certain zones under favourable conditions is well known for other raptors (Newton, 1979), as it is with the Bald Eagle; this fact has made include the conservation of concentration points (Riley *et al.*, 1983) in the strategy for the species conservation. In other species it has been proved that keeping trophic resources in the concentration areas reduces juvenile mortality; the closing of a refuse dump where a great number of young Bald Eagles used to feed increased their mortality up to 90% in their first year (Sherrod *et al.*, 1976 cited by Riley *et al.*, 1983). In other scavenger species the decline of numbers at a roosting site has been also related with the reduction of food availability in close areas (Taylor, 1983).

Finally, it should be remarked that the known roosts in the Ebro Basin and Pyrenees are related among themselves as a sort of «net». The indidivuals often shift roosts, and they may visit several of them in the same season. Most banded individuals showed this behaviour that cannot apparently be related to resource availability as it has been proposed for other species (Caccamise & Morrison, 1986). In our case, the trophic resources are practically constant throughout the season in all the points (authors, unpubl.). There probably exists a strong socialization component in these behaviours (Juillard, 1977; Rabenold, 1986; Parker *et al.*, 1995), but by now there is no more available information on the subject. Apart from it, our results clearly reveal that the species conservation requires supraregional strategies that should consider the protection of all the known roost sites.

CONSERVATION STATUS

Up to present, the Egyptian Vulture communal roosts discovered in Navarra and Aragón are not protected by the Administration at all. Only the limestone cliffs where the LEYRE roost occasionally settles are inside a Natural Reserve, but it is not the same with the replanted pine grove. On the other hand, an important number of livestock carcass sites which the roosts rely upon, are illegal, and the legal ones are not guaranteed to stay (Table 1). The lack of interest on the side of the Autonomous Administration has prevented trying to legalize the carcass deposit that maintains the largest known roost (Bardenas Reales of Navarra). The recent substitution of livestock carcass sites by holes dug in the ground to bury them (Fernández, 1990) means a menace for the existence of other roosts. During the last decades 68% of the traditional livestock carcass sites have disappeared from the Aragonese Middle Depression of river Ebro, or have been substituted by burial ground holes (Tella, 1995). The need of protecting the areas where communal roosts are placed as well as the food sources which the birds rely upon is therefore more evident. The policy for Egyptian Vulture conservation in western Europe will necessarily include the protection of the estival roosts in northern Spain, where most of the species non-breeding population meets.

The strategy for the protection of communal roosts of Egyptian Vultures should consider the following points:

1) Listing all the communal roosts in the Iberian Peninsula, paying a special attention to those in the Pyrenees, Ebro Basin and those areas with «a priori» good conditions to hold them: Cordillera Ibérica, Sistema Central, North Extremadura, Cádiz province.

2) Elaborating protection and management plans for the main roosts (at least for those holding more than 30 individuals). These plans should be fulfilled in a coordinated way by the involved Autonomous Communities and Departments, since it has been shown that Egyptian Vultures shift roosts often. The process should include:

a) managing and, if needed, curbing of those activities contrary to the roost maintenance (hunting, power lines, urbanizing, road or railroad building). All the activities around the roost in a radius of at least 1000 m should be controlled.

b) maintaining, by legal measures if needed, of the livestock carcass sites and refuse dumps upon which these roosts depend. If food supply stopped

TABLE 1

Characteristics and conservation status of the main communal roosts in northern Spain. *[Características y estado de conservación de los principales dormideros comunales del norte de España].*

ROOST	MAXIMUM N OF EVs	MAIN FOOD RESOURCE	LEGAL PROTECTION OF: FOOD RESOURCE	SUBSTRATUM
NA-1	200	LIVEST. CARCASSES	NO	NO
HU-1 LAS CAÑAS	196	LIVEST. CARCASSES	YES	NO
NA-2	130	LIVEST. CARCASSES	YES	YES/NO
HU-2 ANSO	101	REFUSE DUMP	YES	NO
Z-1 EJEA	60	LIVEST. CARCASSES + REFUSE DUMP	YES	NO
Z-2 PEÑAFLOR	46	LIVEST. CARCASSES	NO	NO
NA-3	33	LIVEST. CARCASSES	YES	NO
Z-3 PEÑALBA	33	LIVEST. CARCASSES	NO	NO

due to the closure of domestic fowl farms and abattoirs, carcasses should be supplied in an artificial way to ensure the roost subsistence.

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