Ammotragus free-ranging population
in the south east of Spain: a necessary first account

Running title: *Ammotragus* free-ranging population in SE Spain

Jorge Cassinello^{1,2}

¹Estación Experimental de Zonas Áridas
C/General Segura 1, 04001 Almería, Spain

and

²Departamento de Ecología Evolutiva
Museo Nacional de Ciencias Naturales
C/José Gutiérrez Abascal 2, 28006 Madrid, Spain

Please send comments and proofs to:

Jorge Cassinello

Departamento de Ecología Evolutiva

Museo Nacional de Ciencias Naturales

C/José Gutiérrez Abascal 2

28006 Madrid, Spain

Telephone: +34 91 4111328 exts 1111-1231

Fax: +34 91 5645078

E-mail: cass@eeza.csic.es

Summary

This is the first attempt to investigate some characteristics of a Spanish population of *Ammotragus lervia* introduced in the wild back in 1970. Aside from a short account of the population history and proceeding up to present, a comparison between population data reported for the American wild populations and the Spanish one is provided. The surveys were conducted during breeding and rutting seasons. The majority of the herds sighted in Sierra Espuña were made up of 1-10 individuals, and adult males were more frequently observed during rutting. The group composition more commonly observed during breeding is that of adult females and subadults, i.e., nursery herds. It was obtained a different habitat use depending on the season and sex-age class. These results are consistent with the dynamics of ungulates and their reproductive phenology. Suggestions for future research and conservation-management concerns in the area are provided.

Keywords: *Ammotragus*, Group dynamics, Habitat selection, Management, Ungulates

Introduction

Ammotragus lervia (arrui, aoudad or Barbary sheep) is a caprid originally distributed in the North of Africa (Brentjes, 1980), but introduced by man in other continents, due to its interest as a game species (see, e.g., Ogren, 1965). Current knowledge of the species has been recently summarised (Cassinello, 1998), standing out works carried out in the field, but in introduced American populations (see, e.g., Simpson, 1980), and in captivity (e.g. my own work). Paradoxically, no published study can be found on its natural African lands, but a few works on its distribution (e.g. Loggers *et al.*, 1992). Habitat selection and group dynamics is thus exclusively reported from introduced American populations (e.g. Johnston, 1980; Gray and Simpson, 1982; 1983).

The species was introduced in Sierra Espuña Natural Park, Spain, in 1970, due to hunting interests (see below); but until now, nor ecological or management study has been conducted on this population, apart from unpublished local reports (Bigalke, unpubl.; ARMAN-Murcia, unpubl.; Eguia and Jiménez, unpubl; DGMN-Murcia, unpubl.). This paper is an attempt to glimpse the basic characteristics of the Spanish introduced population of arruis; thus, an account of the species group composition and habitat preference during the main breeding season (spring) and rutting (autumn) is provided, along with comparisons to the American introduced populations. Finally, conservation perspectives and future research needs are discussed.

Methods

The study area

As the majority of the protected wild areas and parks in Europe, Sierra Espuña Natural Park (Murcia, Spain) was originally a Game Reserve, which preserved it from human exploitation. The park covers 14181 ha and is located in the Iberian Peninsula (37°50'N, 1°35'W); it is part of the Cordillera Sub-Bética, which stretches across south-eastern Spain (see Fig. 1). The

highest summit of this mountain range reaches 1584 m, El Morrón de Espuña, while the plateau lies above 800 m.; it consists of a massif of limestones and dolomites, with a complex and elaborate topography characterised by steep cliffs and deep valleys; there are no permanent watercourses and only a few springs.

The destruction of autochthonous forests initiated in Medieval times, along with grazing and farming, accelerated erosion processes in the area, which eventually led to soil loss. Historic records state the existence of severe floods in the region as a consequence of this soil loss; thus, at the end of last century, the nearby lowlands had experienced more than 70 floods since 1258. In order to prevent these damaging floods, public institutions promoted a reforestation programme, which started in 1891 (see Ortuño and De la Peña, 1979). About two-thirds of Sierra Espuña mountain range is currently characterised by pine forests (*Pinus halepensis*, and *P. nigra* in higher altitudes), particularly abundant in valleys and low areas; oak trees (*Quercus* spp.) can also be found. In higher altitudes, a quarter of the park, short, open brushes rule over (for more details see Ortuño and De la Peña, 1979; Bigalke, unpubl.).

The study animals

Conforming to a regional game policy, 20 arruis (8:12) from the Frankfurt Zoo in Germany, and 16 arruis (8:8) from the Ain Sebad Zoological Park in Casablanca, Morocco, were introduced in Sierra Espuña between 1970 and 1972 (Bigalke, unpubl.). This stock was held in enclosures, after which 9 males and 18 females were released along with 7 (2:5) individuals born in the enclosures, dispersing up to 80 km after released; by 1973 there were 79 arruis, the population increasing at an average annual rate of 30% a year to 1982, when numbers approximately came to 750 (Gray, 1985). Despite the animals started to be hunted in 1977, by 1991 the population number reached

about 2000 individuals, and started to settle in the surrounding mountains, such as Sierra de las Cabras and Sierra del Burete (ARMAN-Murcia, unpubl.).

A mange epidemic drastically reduced the arrui population in 1992 (Eguia and Jiménez, unpubl.), and the most optimistic estimations established that scarcely 200 individuals survived (R. Sánchez, pers. comm.). As a preventive measure, 63 arruis were kept in an enclosure, inside the Natural Park, in 1995 (DGMN-Murcia, unpubl.). Since then on, the population has recovered and it is supposedly expanding once more and reaching nearby mountains (M. A. Sánchez, pers. comm.), even in border provinces, such as Almería (accounts from anonymous forest rangers and local shepherds).

The surveys

During May and October 1991 surveys were carried out in Sierra Espuña Natural Park in order to examine the characteristics of the free-ranging population of arruis which inhabits these mountains. They were mainly performed from four-wheel drive vehicles, and when the activity of the animals is higher, i.e., early in the morning and at dusk (see Johnston, 1980; pers. obs.). Binoculars and a field computer (Psion Organiser II) were used to monitor and register the characteristics of the animals/herds observed, being the following variables registered: time of the day, location, habitat, group composition (according to the age class classification by Cassinello, 1997; see below), and animals activity (see, e.g., Cassinello, 1996), although the lack of variability of the latter (most of the animals were either grazing or moving) precluded to carry out an accurate analysis on animals' behaviour, including factors such as group composition or habitat. The frequency of animals observed during the surveys refers to the number of individuals per herd; also, when comparing results obtained in May and October surveys, spring data were divided by two, as the total observation time was double than in autumn

survey (see Table 1).

The sex and age classes distinguished are the following ones (Cassinello, 1997): J₁ = juveniles up to 4.5 months of age; J₂ = juveniles 4.5-12 months of age; J₃ = juveniles 1-2 years of age; H₁ = females up to 3 years of age; H₂ = females older than 3 years of age; M₁ = males up to 3 years of age; M₂ = males 3-4 years of age; M₃ = males 4-6 years of age; M₄ = males older than 6 years of age.

Three types of habitats were distinguished: (1) open habitats, formed basically by shrubs (e.g., *Quercus coccifera*, *Juniperus* spp., *Berberis vulgaris*, *Pistachio* spp.), and dwarf shrubs (e.g., *Thymus serpylloides*, *Artemisia campestris*); (2) closed habitats, formed by forests of *Pinus* spp. and *Quercus* spp.; and (3) mixed habitats, which consisted of shrubs with scattered trees (see Bigalke, unpubl.).

Statistics

Throughout the study non-parametric tests have been used. χ^2 tests based on contingency tables were applied when analysing absolute numbers, and Mann-Whitney and Kruskal Wallis tests when comparing means, depending on whether the factor variable contained two or more than two levels, respectively; Tukey post hoc tests and its variations were utilized to carry out multiple comparisons whenever a Kruskal Wallis test proved to be significant (see Zar, 1984:199); non-significant p values are indicated in the text by "ns".

Results

Group size and composition

Most of the groups sighted both during breeding (47%) and rutting season (82%) were small (1-10 individuals, see Fig. 2); although the differences between seasons were not significant (Mann-Whitney U=89, U'=120, ns). Some information on the surveys conducted in Sierra Espuña, such as the

observation time, number of herds sighted and their sex-age composition, is shown in Table 1. Adult females and subadults were the sex classes more frequently sighted in spring (Kruskal Wallis $H=22.54$, $df=2$, $p<0.0001$); whereas in autumn or rutting season, either females, males or subadults were equally registered ($H=1.51$, $df=2$, ns). The frequency of animals observed in spring and autumn surveys did not differ statistically ($U=89$, $U'=120$, ns); although males were more frequently encountered during rutting than in spring ($U=43$, $U'=166$, $p=0.002$), in contrast with females ($U=70.5$, $U'=138.5$, ns) and subadults ($U=99.5$, $U'=109.5$, ns), which were equally estimated in both seasons (see Fig. 3).

Four different groups were registered (see also Gray and Simpson, 1982): male or bachelor groups (adult males only), female groups (adult females only), nursery groups (adult females and their calves/juveniles), and mixed groups (adults of both sexes with or without calves/juveniles) (see Table 2). Nursery groups are the most common association during breeding, and mixed groups were registered only in the rutting season; the scarcity of data made not possible to carry out any statistical test.

The age and sex classes sighted are summarised in Fig. 4. Unfortunately, no age class was distinguished for adult males and females during the breeding season, but the whole distribution observed shows a typical pattern in which females and subadults predominate, suggesting a great potentiality for the population to grow (see Discussion).

Habitat preference

The abundance of individuals in the three types of habitats (Fig. 5) shows an evident interaction between sex and habitat. Pooling data from the two seasons, adult males were less frequently sighted in open habitats than in mixed ones ($H=9.68$, $df=2$, $p=0.001$); but neither adult females ($H=4.78$, $df=2$, ns) nor subadult individuals ($H=0.95$, $df=2$, ns) seem to predominate in

any particular habitat. During breeding season (see Fig. 6) no animal was observed in closed forests, and only did adult males differ in their habitat selection, being more frequently sighted in mixed habitats ($U=16.5$, $U'=43.5$, $p=0.03$). During rutting (see Fig. 6), and when pooling data from all the sex classes, arruis were mostly observed in closed than open habitats ($H=5.96$, $df=2$, $p=0.048$).

Keeping constant the type of habitat, and checking whether the animals choose a different habitat according to the season, they were more frequently observed during breeding in open brushes ($U=4$, $U'=41$, $p=0.03$), because adult females actively selected that habitat ($U=4.5$, $U'=40.5$, $p=0.03$), which means larger herds were more commonly sighted in open habitats.

Finally, when considering group composition, nursery groups were more frequently observed in open habitats than in mixed and/or closed ones; although the sample size did not allow to run any statistical test; no differences in habitat preference were appreciated for the other types of groups (see Fig. 7).

Discussion

This is the first attempt to characterize basic ecological factors of the free-ranging population of arruis in Sierra Espuña Natural Park (Murcia, Spain). Due to the small sample size, cautious statements should be thus considered when interpreting the results. Nevertheless, the main results are generally in accordance with previous studies carried out in American free-ranging populations of the species, and in unpublished reports from the study area. The reproductive phenology of this ungulate determines the observed dynamics.

Group size and composition

As in a previous study carried out in Sierra Espuña by Bigalke (unpubl.),

small herds were the trend observed during the surveys; although there was a non-significant prevalence of 6-10 individuals groups in Bigalke's study; likewise, in my survey the majority of groups were formed by less than 11 animals (Fig. 2). There seems to be a high variance from one year to another; thus, Gray and Simpson (1982) found that mean group size of a population of arruis living in Texas was much higher in 1978 than the previous year (approximately 20 vs 5 individuals).

Previous surveys carried out in Texas also showed a great variation in group composition both monthly and yearly (Gray and Simpson, 1982); although mixed groups were mostly found during rutting, and nursery groups during spring and summer, as it should be expected according to the mating system of the species. The results obtained in Sierra Espuña followed this pattern (see also Dickinson and Simpson, 1980; Solbert, 1980). Gray and Simpson (1982) also considered groups made up of subadults exclusively, and solitary adults. During my surveys no subadult groups were seen, and only one solitary adult male was registered; it was included in bachelor male groups data.

Adult females and juveniles were the sex-age classes more commonly observed, which reflected a general tendency from other studies (Barrett, 1980; Gray and Simpson, 1983; Bigalke, unpubl.). This pattern is characteristic when the population is under an expansive or growing phase, so that from these figures we might expect the arrui population in Sierra Espuña to have a high potentiality to expand; however, the mange episode which took place a few months after my surveys could not allow the population to grow as expected. A comparison of free-ranging arruis' population structure both in Spain and USA is provided in Fig. 8. Year fluctuations in the same areas are notable; it is noticeable too the lower percentage of females seen in the Texas population compared to those of Sierra Espuña and California, but precisely because of the great variance appreciated, differences between the three

populations are small, and a general pattern followed: prevalence of adult females, followed by subadults and finally a lower percentage of adult males.

Concerning the present study and the other Sierra Espuña surveys, we might wonder why there is such a low proportion of adult males, compared to previous years. To resolve this question it is important to note that bachelor groups and solitary males are the advance party or first stage in arrui population dispersal and establishment (Barrett, 1980; Dickinson and Simpson, 1980). It should be noted too that the Sierra Espuña arrui population was devoted to a neat dispersal procedure to adjacent areas since its introduction (see Gray, 1985; Bigalke, unpubl.; ARMAN-Murcia, unpubl.); particularly in the early 90's, when sightings outside the park were relatively common (ARMAN-Murcia, unpubl.), in occasions reaching nearby provinces, such as Almería (anonym. comm.). Therefore, the presence of adult males inside the park borders would be reduced when a dispersion pattern, related to colonization of new lands and not to the characteristic home ranges of males, predominates. Also, this dispersion might be promoted by a reduced variability of forage during winter (see Gray and Simpson, 1983). Obviously, from this first approach it is not possible to establish a general pattern; however, the tendencies observed are consistent with other field works carried out in Spain and USA.

Habitat preference

In accordance with a previous work conducted in the central coastal mountains of California (Johnston, 1980), free-ranging arruis tended to prefer open lands during breeding season (May) in Sierra Espuña. However, during rutting Californian arruis were also scarcely seen in closed forests, while in Sierra Espuña they significantly selected closed habitats. Mild autumn temperatures and scarcity of rain falls might explain this result in Sierra Espuña, in contrast to the typically wet-dry climate that characterizes the

central coast of California (Johnston, 1980). Also, Bigalke's (unpubl.) previous study conducted in Sierra Espuña during rutting season showed that only 5 of 38 groups sighted were under pines, being the majority of herds found in open fields.

Management and conservation interests. Effects on native biota.

Arruis are considered as a vulnerable species by IUCN (1996). In their African natural habitat are threatened by permanent poaching, so that the whole population is suffering from a steady decrease, particularly some of the subspecies (Cassinello, 1998). Therefore, studies carried out in introduced arrui populations in other parts of the world may prove substantial value to a better understanding of its dynamics, ecology and behaviour in the wild; particularly when there is a resemblance with their native African habitat, as it is the case of the south east of Spain landscapes. These studies may eventually bring light to the conservation policy on its natural environment. Data acquired from the Sierra Espuña wild arruis should thus convey valuable information on its problematic in both the south east of Spain and its African wildrange.

After nearly 30 years of arrui introduction in Sierra Espuña, no detailed monitoring or management is being conducted neither by the public institution which introduced the species, nor by universities or research organisms. Periodical surveys conducted extensively in the area must be implemented in order to convey an accurate knowledge and tendencies of the species group dynamics. There are a series of ecological components to be studied, some of which have been advanced here: habitat selection, phenology, population density, carrying capacity and interactions to catchment reforestations (see above), reproductive variables, social behaviour and population dynamics, including a detailed mapping of trails and home ranges (see Solbert, 1980). Also, monitoring the welfare state of the

individuals (body condition, parasites and diseases) should be a priority (see Ogren, 1965).

From a purely hunting perspective, the arrui is of great interest (see e.g. Ogren, 1965; Ortuño and De la Peña, 1979; Christian, 1980), but unfortunately the introductions carried out in the past have not taken into account the potential costs for the environment (Barrett and Beasom, 1980; Bigalke, unpubl.). Thus, a careful management and control of the introduced arrui population in Sierra Espuña is needed to prevent any potential risks on autochthonous species, such as a hypothetical competition for resources with the Spanish mountain goat (*Capra pyrenica hispanica*). Although there is no registered instance of direct competition between arruis and other ungulate species, following Simpson *et al.* (1978) a real threat against the desert bighorn (*Ovis canadensis*) might occur in those American sites where both species show close home ranges.

The lack of monitoring commented above allows the raise of episodes, such as the mange epidemic which took place a year after my surveys and nearly caused the whole population to disappear (Eguia and Jiménez, unpubl.). This epidemic might have been caused or facilitated by relatively crowding conditions; it is also suspected that casual contacts with domestic stock might have promoted the infection. So far, unfortunately, no relevant information has been obtained, and the hypotheses contemplated are mostly speculative. This issue should be carefully studied.

From a conservation perspective, the reintroduction or recovery of native fauna is to be implemented, thus, the opportunity for establishing populations of endemic species should have priority over the presence of arruis. In Sierra Espuña Natural Park the only inhabiting ungulates are arruis and wild boars (*Sus scrofa*). Closer main red deer (*Cervus elaphus*) and mountain goat populations are further west and tens of kilometres away. However, from a practical and management view the intense presence of

human activity in the park does determine the species to be introduced, which should tolerate human presence. Arruis stand it so well that, when in great numbers, they may become a threat to farmers, as they shamelessly approach and enter into their properties (accounts from anonymous local farmers and forest rangers).

On the consequences the introduction of this large mammal might have caused on the area, several aspects can be distinguished. Firstly, it is outstanding the importance this introduction is playing not only in the Natural Park, but also in the surrounding areas where arruis are expanding (including provinces of Jaén, Granada and Almería). It is also worth pointing out that this species has not displaced any other herbivore from the area, as in Sierra Espuña Natural Park no Spanish wild goat or deer (potential competitors) were present before the introduction of arruis. Arruis are not selective at all and their diet may comprise shrubs, succulent forbs, forbs, creepers, dwarf shrubs and grasses, depending on season availability; undoubtedly pressure on flora is much stronger now than before this species inhabited the park, but the presence of no plant endemisms and the fact that the carrying capacity of the park has not been reached yet, particularly after the decrease of the population due to the mange epidemic, make the presence of arruis in Sierra Espuña more beneficial than detrimental. On fauna, no direct competition is expected with the other ungulate which inhabits the park, the wild boar, as their habits do not coincide. Finally, the major impact should be on the economy of the region. Benefits are evident from a hunting perspective; game policy is carried out by the public institution which is ruling the park, although unfortunately no scientific monitoring is used yet in game decisions. Costs for the local farmers have increased, as arruis shamelessly approach and enter into their properties, so that expenses in maintaining fences which protect their crops have increased substantially.

Once arruis have become a common ungulate in the area, since its

introduction nearly 30 years ago, and given that there are strong political and economical interests in maintaining the population, ecologists and conservacionists should consider all pros and cons, and undertake studies focused not only on potential impacts on native biota, but also on the characteristics of the population dynamics of this non-native species, as stated above. Under this scenario, this study may work as a basis for future research.

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Figure legends

Fig. 1. Location of Sierra Espuña Natural Park in the Iberian Peninsula (Murcia region, Spain). The range of the Cordillera Sub-Bética is shown by a two-headed arrow.

Fig. 2. Group size (number of individuals) of the 30 arrui herds sighted in Sierra Espuña Natural Park during May and October 1991.

Fig. 3. Frequency of arruis sighted in Sierra Espuña Natural Park during breeding and rutting season 1991, distinguishing adult males, adult females and subadults (calves and juveniles).

Fig. 4. Sex-age class frequency (number of individuals) of the 563 arruis sighted in Sierra Espuña Natural Park during the surveys conducted in 1991. Subadults: J1 (up to 4.5 months), J2 (4.5 - 12 months) and J3 (1 - 2 years); females: H1 (up to 3 years) and H2 (older than 3 years); males: M1 (up to 3 years), M2 (3 - 4 years), M3 (4 - 6 years) and M4 (older than 6 years) (see Cassinello 1997).

Fig. 5. Frequency of arruis sighted in the three types of habitats distinguished in Sierra Espuña Natural Park.

Fig. 6. Frequency of arruis sighted in the three types of habitats distinguished both during breeding (a) and rutting (b) seasons.

Fig. 7. Number of herds encountered in the three types of habitats distinguished in Sierra Espuña Natural Park.

Fig. 8. Free-ranging population structure of *Ammotragus* in Murcia, Spain (Bigalke, unpubl.; this study), California (Barrett 1980) and Texas (Gray and Simpson 1983), USA. The percentage of individuals and sex class is given.

Table 1. Observation time and number of herds and animals sighted in Sierra Espuña Natural Park. Mean ($\pm$ SE) number of individuals per herd is also shown.

Month	Observation time (h)	No. herds sighted	No. arruis sighted	No. males sighted	No. females sighted	No. subadults sighted
May	36	19	497 26.16 ± 7.44	13 0.68 ± 0.48	395 20.79 ± 6.90	89 4.68 ± 1.32
October	18	11	66 6.00 ± 1.16	19 1.73 ± 0.51	28 2.55 ± 0.56	19 1.73 ± 0.56
TOTAL	54	30	563 18.77 ± 5.02	32 1.07 ± 0.36	423 14.10 ± 4.63	108 3.60 ± 0.89

Table 2. Number of the different sex groups sighted in Sierra Espuña Natural Park. The mean ($\pm$ SE) number of individuals is shown in parenthesis.

Month	Male groups	Female groups	Nursery groups	Mixed groups
May	3 (4.33 $\pm$ 2.33)	1 (80)	15 (26.93 $\pm$ 8.32)	0
October	2 (2.00 $\pm$ 1.00)	1 (3)	2 (5.00 $\pm$ 2.00)	6 (8.17 $\pm$ 1.49)
TOTAL	5 (3.40 $\pm$ 1.44)	2 (41.50 $\pm$ 38.50)	17 (24.35 $\pm$ 7.53)	6 (8.17 $\pm$ 1.49)

FIGURE 1 - J. CASSINELLO

FIGURE 2 - J. CASSINELLO

FIGURE 3 - J. CASSINELLO

FIGURE 4 - J. CASSINELLO

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