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REPRODUCTIVE TRAITS OF TWO HAPLOTYPES OF THE EUROPEAN HARE (*LEPUS EUROPAEUS* PALLAS, 1778)

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ABSTRACT - Four hundred and two pairs of hares belonging to the mountain and brown haplotypes of the European hare *Lepus europaeus* Pallas, 1778 were raised in a farm located in central Italy over 4 years (from 2003 to 2006).
The birth date, total number of young born, and number of surviving and weaned leverets were recorded for each pair . The start of reproduction, birth-interval, length of the reproductive season, number of birth per pair per year, number of leverets per pair, number of weaned leverets per pair and number of weaned leverets per birth were analysed in relation to the different haplotypes and years; the incidence of superfetation and pseudogestation was also considered.
Results showed that the brown hare produced young at the beginning of February, whilst the mountain hare started reproduction significantly later. Brown hares showed a longer reproductive period than mountain hares (192 days *vs* 156 days) and a higher productivity. The most frequent gestation length was 37-41 days. The distribution of delivery intervals did not differ between the two haplotypes.

Key words: *Lepus europaeus*, brown hare, mountain origin, rearing, reproductive performances

Riassunto – ***Caratteristiche riproduttive di due aplotipi della lepre (*Lepus europaeus *Pallas 1778)***. Lepri (*Lepus europaeus* Pallas, 1788) appartenenti all'aplotipo di montagna e a quello bruno sono state monitorate per 4 anni (dal 2003 al 2006) in uno stesso allevamento situato in una zona dell'Italia centrale.
Per ciascuna coppia di riproduttori allevata (N = 402) sono stati raccolti i dati relativi a: data del parto, numero totale di nati, numero totale di nati vivi e di leprotti svezzati. L'inizio del periodo riproduttivo, l'intervallo interparto, la durata della gestazione, la durata della stagione riproduttiva, il numero di parti per coppia per anno, il numero di nati per coppia, il numero di svezzati per coppia, il numero di svezzati per parto sono stati analizzati in relazione ai differenti aplotipi e agli anni di osservazione; è stata calcolata inoltre l'incidenza della superfetazione e della pseudogestazione.
I risultati mostrano che nelle lepri appartenenti all'aplotipo bruno il primo parto si verifica agli inizi di febbraio mentre nelle lepri appartenenti all'aplotipo di montagna avviene significativamente più tardi. Le lepri brune mostrano un periodo riproduttivo più lungo delle le-

pri di montagna (192 gg *vs* 156 gg) e una produttività più elevata. La durata della gestazione è simile nei due aplotipi con valori più frequenti compresi tra 37 e 41 giorni.

Parole chiave: *Lepus europaeus*, aplotipo, allevamento, successo riproduttivo

INTRODUCTION

The distribution, evolution and origin of wild hares in Italy and abroad have been investigated by the analysis of mitochondrial DNA (Pierpaoli *et al*., 1999; Mamuris *et al*., 2002; Alves *et al*., 2003; Suchentrunk *et al*., 2003; Thulin *et al*., 2003; Alves *et al*., 2004; Fredsted *et al*., 2006). *L. corsicanus* is widespread in Sicily, southern and central Italy, *L. c. mediterraneus* is present only in Sardinia, *L. timidus* is characteristic of Alpine areas, whilst *L. europaeus* shows the widest range, being distributed in the northern, central and southern Italian regions. Within this last species, different haplotypes have been discriminated, particularly the mountain haplotype (Pierpaoli *et al*., 1999) recorded in hares from the Apennines, from the Gigante and Orecchiella Natural Park in the north, to the Abruzzo National Park in the centre and the Pollino National Park in southern Italy.

Some information about the reproductive characteristics of captive and wild *L. europaeus* and *L. timidus* has been reported by several authors (Toschi *et al*., 1971; Spagnesi, 1974; Frylestam, 1980; Spagnesi and Trocchi, 1980; Iason, 1990; Mantovani *et al*., 1993, Castiglione *et al*., 1996; Santilli *et al*., 2004), but no study has compared the productivity of the two haplotypes - the brown haplotype and the mountain haplotype - recently characterized by genetic analysis within *L. europaeus* (Pierpaoli *et al*., 1999), when reared in the same conditions. Actually we do not know if the genetic differences found by the mitochondrial DNA sequencing correspond to different reproductive performance. We examined this aspect comparing captive hares of the brown and mountain haplotypes.

METHODS

The study was carried out in the experimental farm of the Lucca Territorial Office for biodiversity, Corpo Forestale dello Stato (10° 26'.48 19" long, 44° 7'.55 72'' Lat). Data were collected from 402 genetically checked, captive-reared pairs of *L. europaeus*, of which 139 belonged to the mountain haplotype and 263 belonged to the brown haplotype. The hares, reared in wooden cages for fixed pairs (Rivatelli *et al*., 1997), were monitored from 2003 to 2006. Adult hares were fed *ad libitum* with a commercial pelleted diet (chemical composition as-fed basis: crude protein 16%, ether extract 2.7%, crude fibre 19%, ash 9.6%).

New pairs were used for replacing the unproductive pairs and the oldest ones at the beginning of every reproductive season. Leverets were usually weaned at the age of 21 days.

Birth date and the total born, living and weaned leverets were collected. The following parameters were then calculated: the start of reproduction, birth-interval, length of reproductive season, number of births per pair per year, number of leverets per pair, number of weaned leverets per pair and number of weaned leverets per birth. The reproductive period was determined from the date of first mating (normal

gestation time: 42 days), to the last delivery of each productive year. Delivery intervals ranging from 40 to 50 days were considered as normal gestation, longer than 50 days as pseudogestation, shorter than 40 days as superfetation (Castiglione *et al.*, 1996).
Birth dates were converted into their serial number before the analysis. Data were analysed by ANOVA, considering haplotype, year and their interaction (haplotype x year) as independent categorical variables. Means were compared by Tukey-Kramer's HSD (Honestly Significant Difference) test. The occurrence of pseudogestation and superfetation was analysed by crosstabs chi-square tests (SAS, 2002).

RESULTS

Data on the hares' reproductive performances and the analysis of variance in relationship to the variables haplotype and year are reported in Tables 1 and 2 (their interaction was found to be not significant). On average, the brown hare produced offspring at the beginning of February (7th February), whilst the mountain hare started reproduction later (15th February). In 2003 the hares' reproduction started earlier than in the following years, whilst in 2005 it was postponed.
Brown hares showed a longer reproductive period than mountain hares (192 days *vs* 156 days); during the study period its length tended to increase progressively. Consequently brown hares showed a higher number of deliveries of born and of weaned per couple per year than mountain hares (respectively n=4.4, n=10.2, n=7.9 *vs* n=3.4, n=7.0, n=5.7). Considering the year of study, during 2006 the pairs showed a higher number of deliveries and born young per pair than in the other years (n=4.5, n=10.1 *vs* an average of n=3.7, n=8.0).
Hares showed the most frequent delivery interval at 37-41 days (Fig. 1). The incidence of superfetation and pseudogestation did not differ between haplotypes or years.

DISCUSSION

Rearing methods are known to affect the reproductive performance of hares (Mori *et al.*, 1983; Castiglione *et al.*, 1996; Tocchini *et al.*, 2000), several factors being involved, such as management, nutrition, genetic characteristics and climatic conditions. In our study the animals were reared in the same place, so that the different reproductive performances can be mainly explained by genetic differences. Both the haplotypes showed a shorter reproductive season than those observed by other authors for reared hares (240-270 days Mori *et al.*, 1983; 247±16 days, Castiglione *et a*l., 1996). Since domestication and captive breeding selection increase the length of the reproductive period (Araki *et al.*, 2007), both lineages seem to retain a certain degree of wildness and are not yet completely fit for captive breeding, as observed in other studies (Bagliacca *et al.*, 1992; Mantovani *et al.*, 1993; Castiglione *et al.,* 1996, Fronte *et al.*, 2005). Considering both their actual distribution and the climate, mountain hares showed a significant delay in the commencement of reproduction, which could be more suited than brown hares for hilly and mountain habitats, where spring is generally delayed. Hares are commonly managed through the spring release of captive reared leverets or the winter

Table 1 - Reproductive performance of hares in relationship to haplotype and year (means ± S.E.); means within the same row with different letters are significantly different (Tukey-Kramer's HSD test, P<0.01); M =mountain; B = brown; NS = not significant.

	Haplotypes		Years			
	M. hares	B. hares	2003	2004	2005	2006
N. of hare pairs	139	263	90	97	107	108
Reproduction start	15-FebA (±3)	7-FebB (±2)	7-FebB (±4)	11-FebAB (±4)	22-FebA (±4)	16-FebAB (±4)
Length in days of the reproductive season	156B (± 7)	192A (±5)	159B (±9)	170B (±9)	173AB (±8)	194A (±8)
N. of births/pair/year	3.4B (± 0.18)	4.4A (±0.13)	3.5B (±0.23)	3.7B (±0.23)	3.9B (±0.22)	4.5A (±0.22)
N. of lever-ets/pair/year	7.0B (± 0.48)	10.2A (±0.35)	7.6B (±0.61)	8.1B (±0.60)	8.4B (±0.58)	10.1A (±0.58)
N. of weaned lever-ets/pair/year	5.7B (±0.44)	7.9A (±0.32)	6.5 (±0.56)	6.7 (±0.55)	6.5 (±0.53)	7.6 (±0.53)
N. of weaned lever-ets/birth	0.7B (±0.04)	1.0A (±0.03)	0.8 (±0.05)	0.8 (±0.05)	0.8 (±0.04)	0.9 (±0.04)
Delivery interval in days	43.5 (±0.7)	43 (±0.44)	42.5 (±0.90)	44 (±0.8)	43.5 (±0.82)	42.9 (±0.72)
Total number of de-liveries	361	933	257	294	348	393
Super-fetation (%)	58.9	63.6	60.5	61.2	62.4	64.1
χ^2	1.74 NS		0.78 NS			
Pseudo-gestation (%)	16.7	14.0	13.8	14.3	14.9	15.7
χ^2	1.07 NS		0.41 NS			

Table 2 - Analysis of variance, with haplotype and year as independent variables.

	Sum of squares	DF	Means of squares	F Ratio	P
Reproduction start					
Haplotypes	6134.97	1	6134.97	6.12	0.0138
Year	21362.98	4	5340.75	5.324275	0.0003
Interaction	9212.79	4	2303.20	2.296095	0.0586
Error	405249.8	404	1003.09		
Length in days of the reproductive season					
Haplotypes	115479.2	1	115479.19	17.76	<0.0001
Year	58727.34	3	19575.78	3.01	0.0301
Interaction	15300.69	3	5100.23	0.78	0.5032
Error	2562286	394	6503.3		
N. of births/pair/year					
Haplotypes	104.65	1	104.66	23.08	<0.0001
Year	53.13	3	17.72	3.91	0.0091
Interaction	18.46	3	6.16	1.357	0.2555
Error	1786.81	394	4.535		
N. of leverets/pair/year					
Haplotypes	979.43	1	979.43	31.20	<0.0001
Year	327.22	3	109.07	3.47	0.0162
Interaction	65.78	3	21.93	0.70	0.5534
Error	12369.27	394	31.39		
N. of weaned leverets/pair/year					
Haplotypes	459.28	1	459.28	17.30	<0.0001
Year	75.54	3	25.19	0.95	0.417
Interaction	39.74	3	13.25	0.50	0.6832
Error	10457.67	394	26.54		
N. of weaned leverets/ birth					
Haplotypes	57.41	1	57.41	39.92	<0.0001
Year	9.44	3	3.15	2.19	0.0873
Interaction	4.97	3	1.656	1.15	0.327
Error	4613.08	3208	1.44		
Delivery interval in days					
Haplotypes	72.37	1	72.37	0.42	0.5168
Year	288.17	3	96.06	0.56	0.6427
Interaction	293.59	3	97.86	0.57	0.6357
Error	222015.7	1290	172.10		

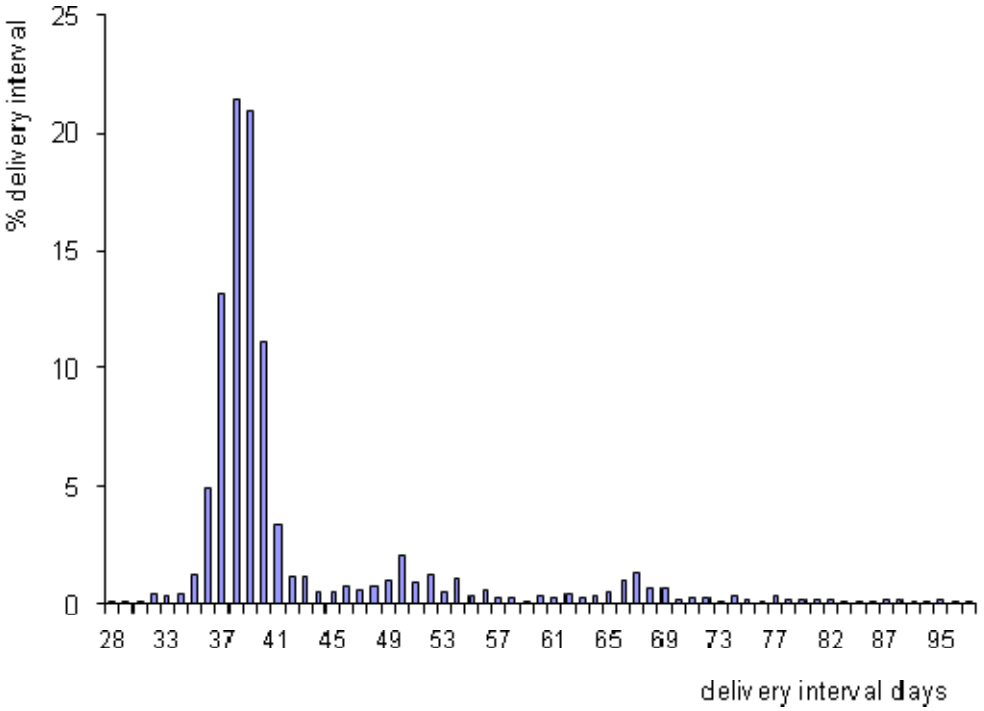

Figure 1 - Delivery intervals distribution.

translocation of wild hares from protected areas for wildlife reproduction. These operations can be carried out only after the end of the hunting season (January), to preserve the translocated animals from shooting, when several hares are already pregnant (Paci *et al.*, 2007). Moreover, the Italian hunting period (from the 3rd Sunday of September to the 8th of December) partially overlaps the reproductive season of the hares, the last deliveries occurring in September.

Consequently, in the current Italian game system, a wider use for restocking of the mountain haplotype would be advisable and would represent a reasonable compromise with the current incorrect hunting management.

Nonetheless brown hares in captivity were more productive than mountain hares, due to the longer reproductive life and the higher productivity.

The general increase in the hares' productive performances with the passing of years could depend on farm management, the best reproductive pairs being commonly kept in production for several years and the less productive and unproductive pairs being discarded (Mantovani *et al.*, 1993). The consequence of this is that there are always more offspring chosen as reproducers coming from the most productive pairs,

which perhaps are the most fitted for captive-rearing. Since the increasing reproductive performances could be associated to a lower fitness in the wild (Araki *et al*., 2007), the possibility of using as reproducers a percentage of captured wild hares or less productive captive-reared animals (which probably are less adapted to captivity) should be considered.

The distribution of the delivery interval, showing that 77.5% of gestation time was shorter than the normal, suggests the necessity of studying more deeply captive-rearing techniques, since intensive breeding could entail sanitary problems.

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