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Density and biology of the rock-partridge (*Alectoris graeca whitakeri*) in Sicily (Italy)

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ABSTRACT

Relative indices (MOT = the average number of birds counted during the trips in the breeding season; ITA = the average number of birds encountered per hour during the trips in the breeding season) were used to monitor the rock-partridge breeding population in four areas of Sicily. Statistical analysis of variance demonstrated that the indices are unbiased estimators of the populations under study. The ANOVA MODEL II results showed that sampling means were obtained by studying populations of different densities in the chosen areas. The reason for this difference is due to the different habitat structure and mainly to the presence-absence of hunting protection. Post-breeding relative indices (MOTpb = the average number of birds encountered during the trips in the post-breeding season; MIB = the average number of birds gathered in coveys) were also useful in population monitoring. Data on breeding biology show a medium productivity rate (ratio juveniles/adults) of the population. Pair-forming starts in February, egg-laying occurs from March to June, while chicks are present from June to September; average clutch size is 12 eggs. The seasonal development of calling activity through different time bands is also reported.

KEY WORDS: Rock-partridge; Relative density sampling; Statistical analysis; Breeding biology.

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INTRODUCTION

Rock-partridge (*Alectoris graeca whitakeri*) is an important game bird whose population is declining in most areas of Sicily (Priolo & Sarà, 1985) through the effects of overhunting and of landscape changes and possibly also as a result of long-term climatic changes (Cramp & Simmons, 1980). The biology of the species was poorly known and the need for basic data to manage rock-partridge populations resulted in the initiation of the present study in 1984. The purposes of this study were: 1. to choose the more simple and suitable method for surveys over large areas; 2. to determine the characteristics of the rock-partridge on a population study basis; 3. to obtain biological data concerning its status.

Both absolute (mapping) and relative abundance sampling were used; the latter seems to be one of the most efficient methods (precision/cost, *sensu* Scherrer, 1985) of monitoring rock-partridge populations over large areas. Population density seems more related to the presence of hunting protection, while breeding success depends on habitat structure. The obtained data on density and biology will be very useful for future planning of conservation and population management.

MATERIAL AND METHODS

Review of methods

Several methods are generally used to census populations of Phasianidae but direct counts in sample areas that can be covered on foot or by car (Lucientes, 1980; Weingand, 1980; Lucio & Purroy, 1985) are the most widely used. Another well-known detection method for species of *Alectoris* is the playback technique, performed during the breeding season and under favourable atmospheric conditions (Pepin, 1983; Bernard Laurent & Bernard Laurent, 1984). Pepin (1983), in a review of density survey methods in populations of the red legged-partridge *Alectoris rufa*, dismissed relative abundance indices as «not interesting» in comparison with absolute methods (mapping, capture-recapture etc.), in that the red legged-partridge high mobility causes index variations. The strip-census method, where four to ten people beat the area walking on parallel routes (Pepin & Birkan, 1981) is only practicable on flat or hilly ground.

A similar method suggested for use on rough land (Petretti, 1985) has several drawbacks: gridding of the sample area is difficult to perform; censuses carried out at short intervals disturb rock-partridges and reduce the number of contacts. Line transect sampling (see Burnham *et al.*, 1980, 1981) presents the same problems as the Pepin & Birkan (1981) method. The required minimum number of individuals (40/transect) reported by Burnham *et al.* (1980) is usually higher than that obtained in a rock-partridge count (maximum 15-20); in addition they expressly state that the method cannot be applied to the chukar-partridge (*Alectoris chukar*).

A better approach is perhaps «inverse sampling», a method based on a set number of contacts to be made on random transect lengths (Rao *et al.*, 1981).

Sampling and data analysis

A relative density survey of *Alectoris graeca whitakeri* was carried out in four different areas (pattern of distribution at the sectorial level, *sensu* Blondel, 1979) in the provinces of Palermo and Trapani. The survey was carried out by a number of people, each

responsible for one or more areas and trained in the species field behaviour. Field trips took place during different months on sample areas of about 1000 ha and following the same routes (stratified random sampling: Scherrer, 1985). A total of 125 field trips were carried out from January 1984 to September 1986; 31% were performed with the help of a bird-call decoy and 10% with the help of pointer dogs. Data on the breeding biology and on the behaviour of the rock-partridge were collected during this survey.

By dividing the results for each area, it is possible to estimate the relative abundance indices (Pepin, 1983):

- MOT = the average number of birds counted during the trips in the breeding season;
- ITA = the average number of birds encountered per hour during the trips in the breeding season;

The following indices were estimated from July to January:

- MOTpb = the average number of bird encountered during the trips in the post-breeding season;
- MIB = the average number of birds gathered in coveys.

To test the validity of relative indices, was conducted an analysis of their variance according to Sokal & Rohlf (1981). This analysis consisted of a square root transformation of data, followed by Bartlett's homogeneity test of variance (see also Legendre & Legendre, 1979).

In addition, confidence limits (lower L_1 and upper L_2) for sampling means were calculated using the parametric means of the populations under study (Colton, 1979; Sokal & Rohlf, 1981). Having proved that sample means are unbiased estimators and that their variance is homogeneous, application of an ANOVA MODEL II (for samples of different size) became feasible. ANOVA MODEL II is used to test whether two or more sample means could have been obtained from populations with the same parametric mean.

The absolute abundance index, which was calculated by the mapping method (I.B.C.C., 1969; CISO, 1976) on some 100 ha plots in sample areas A, B and C, allowed the calculation of both the average home range of a pair and the coefficient of correction for relative indices (Blondel, 1975; Pepin, 1983): C = absolute abundance index/relative abundance index.

STUDY AREAS

AREA A (Madonie - Palermo)

The dominant vegetation of the area is mesophylous grassland growing on rocky (calcareous) ground and is characterized by *Lolium perenne, Plantago cupani, Trifolium repens* and *Vulpia sicula*. An oak wood is also present (the *Quercion-pubescenti-petraeae* and the *Quercion-ilicis* association figures, the second one present on the warmer sides). The maximum altitude is 1979 m above sea level. The sample area ranges from 1500 to 1700 m and is located on the eastern and south-eastern side of the mountain Pizzo Carbonara. Total rainfall averages 697 mm a year from a minimum of 4.2 mm in July to a maximum of 206.6 mm in August. No. of rainy days = 112; No. of snowy days = 38. Daily average temperatures range between 2.4°C in January and 24°C in August. Hunting is not allowed in the area.

AREA B (S. Vito lo Capo - Trapani)

Rocky dry grassland area; the sample area is on the eastern side of the peninsula with *Ampelodesmos mauritanicus* being the dominant species, even in association with scrubs such as *Erica multiflora, Chamaerops humilis* (up to 250 m above sea level), *Quercus ilex, Olea europaea var. sylvestris* and *Pistacia lentiscus*. On the whole, the vegetation in the area (the *Oleo-Ceratonion, Quercion-ilicis, Rosmarino-Ericion* and *Thero Brachypodion* phytosociological associations) was partially degraded. The maximum altitude is 913 m, but the sample area ranges between 300 and 600 m. Total rainfall averages 413.4 mm a year from 0 mm in July to a maximum of 102 mm in January No. of rainy days = 60; No. of snowy days = 0. Daily average temperatures range between 10.4°C in January and 25.7°C in August. Hunting is not allowed in the area.

AREA C (Rocca Busambra - Palermo)

The sample area is in the southern and south-eastern side of this calcareous mountain. Grassland vegetation dominates with therophytes like *Medicago* sp. pl., *Bromus* sp. pl., *Trifolium* sp. pl., *Aegilops ovata*; and spiny compositae like: *Carduncellus caeruleus, Onopordon illyricum, Scolymus* sp. pl. A wooded maquis composed of *Quercus ilex, Pyrus pyraster, Prunus spinosa, Crataegus monogyna*, is present in patches up to 1300 m. The maximum altitude is 1613 m, but the sample area ranges between 1000 and 1400 m. Total rainfall averages 742.2 mm a year with 1.8 mm in July and 303.4 mm in January. No. of rainy days = 80; No. of snowy days = 16. Daily average temperatures range between 4.3°C in January and 26.8°C in August. The area is open to hunting.

AREA D (Monte Gradara - Palermo)

This area is very similar to S. Vito lo Capo: a dry grassland on rocky (calcareous) ground is in fact the dominant vegetation, with *Ampelodesmos mauritanicus* and residues of Mediterranean maquis: *Quercus ilex, Pyrus pyraster, Prunus spinosa, Crataegus monogyna*. The order *Thero-Brachypodetalia* has undergone severe degradation. The maximum altitude is 1188 m and the sample area ranges from 900 to 1100 m on the north-eastern and south-eastern side. Total rainfall averages 621.2 mm a year, with 4.4 mm in June and 193.6 mm in January. No. of rainy days = 82; No. of snowy days = 13. Daily average temperatures range between 6.8°C in January and 26.9°C in August. The area is open to hunting.

RESULTS AND DISCUSSION

Since the Bartlett test did not give significant results, the variance of the resulting indices (MOT and ITA) was considered homogeneous (Appendix 1-a).

The monthly variation (February-May) of the indices based on all the areas was also calculated. The indices seem to be quite constant: Student's *t* test calculated on the pair-wise comparison of index values for different months gave significant results only for the pair March-May (Appendix 1-b). The index monthly variation, during the breeding season, would therefore be due to a normal sampling fluctuation, except for one case. In the same way, dividing the values of the indices obtained for each year (1984, 1985, 1986), the values were similar and not statistically significant; this result also demonstrates the stability of the indices examined over that short period. Contrary to Pepin (1983), statistical analysis proved the stability and the representativeness of the applied indices. This difference is probably due to species-specific behaviour.

Like the red-legged partridges, rock-partridges are very mobile and good pursuers, but in rocky areas they are attached to a number of characteristic resting and feeding areas (i.e. prominent rocks or bushes, grassy patches, small valleys etc.). Therefore, knowledge of their tracks and their territories results in a reliable sampling and the relative indices would have a small variation.

Table I shows the sampling results from different areas and their confidence limits. The results of ANOVA

TABLE I - *Sampling in Sicily of* Alectoris graeca whitakeri *employing relative abundance indices during the breeding season. Confidence limits set the interval covering the true mean with 95% probability. Increasing the sample size* n, *this interval becomes narrower.*

Sample area	Simple random sampling		Confidence limits 95%	
	MOT	ITA	MOT	ITA
A n = 8	11.6 ± 4.7 (5-17)	4.2 ± 2.4 (0.8-7.1)	L_1 = 7.67 L_2 = 15.53	L_1 = 2.19 L_2 = 6.20
B n = 11	8.4 ± 4.8 (3-18)	2.8 ± 1.4 (1.3-4.2)	L_1 = 5.18 L_2 = 11.62	L_1 = 1.86 L_2 = 3.74
C n = 10	4.5 ± 2.5 (0-8)	1.1 ± 0.6 (0-2)	L_1 = 2.71 L_2 = 6.29	L_1 = 0.67 L_2 = 1.53
D n = 16	1.5 ± 1.7 (0-4)	0.7 ± 0.8 (0-2.3)	L_1 = 0.59 L_2 = 2.41	L_1 = 0.27 L_2 = 1.13

MODEL are statistically significant (Appendix 1-c), therefore the null hypothesis of the test, which states that the means have the same variance and assess the same population, is rejected. In other words, the sampling means were obtained by studying populations of different densities in the four chosen areas. This difference can be attributed to the different habitat structure (i.e. vegetational figures, food and water supply, slope etc.) and to the presence-absence of hunting protection (Sarà, 1988).

The limited use of pointer dogs does not allow any inference. Bernard Laurent & Bernard Laurent (1984) found some discrepancies with this method. Petretti (1985), on the other hand, considers it one of the most reliable. With regard to the playback technique, Pepin (1983) used it to detect *Alectoris rufa* and obtained a low frequency of response (about 25% = no. males answering/total males counted × 100). Bernard Laurent & Bernard Laurent (1984) reported a better response (90%) to this technique by *Alectoris graeca saxatilis* cocks in the Maritimes Alps. Zbinden (*in litteris*) working on the same subspecies in the Swiss Alps obtained different patterns of responses (from extreme indifference to extreme reaction). In Sicily the frequency of response was 59% (n = 98); the highest response rate (100%; n = 12) was observed in February. From March to May the cocks showed a lower rate (53%; n = 86) and a pattern of response similar to that found by Zbinden. The use of a bird-call decoy, howewer, affects the number of birds counted (+ 26.8%), the Mann-Whitney U-test is in fact significant (Appendix 1-d).

The mapping method (see Oelke, 1981; Dawson, 1981 for limitations of this technique) was used in three sampling areas, and gave idea of density (× 100 ha) and therefore of a pair mean home range (Table II). This table also shows the correction coefficients for the rock-partridge. These coefficients could be preliminarly used to adjust the relative densities of the rock-partridge in Sicily.

The value of the indices obtained in the post-breeding season are reported in Table III. There is a high and direct linear correlation between these indices and the reproductive MOT (Appendix 1-e). The number of flocking birds is therefore considered a good abundance index (see also Dragoev, 1974; Lüps & Heynen, 1978).

Table IV shows the average size of post-breeding social groups. It refers to the summer-autumn and winter period according to a conventional division of the coveys (Ricci, 1985). The different percentage in the composition of coveys observed over two seasons is due to both natural and hunting mortality. A decrease in the number of medium-large coveys was followed by an increase in the number of small ones. At the same time, the increase in the number of ⩾ 14-bird coveys (maximum 23) shows that different family groups can join together and/or include isolated birds. Obviously, the MIB index values in Table III fall in the most common group (5-8).

NOTES ON BIOLOGY

In Figure 1 some phases of the social behaviour of the rock-partridge in Sicily are summarized and explained on the basis of the frequency of observation. Pair-forming occurs in February, although bad weather can postpone it.

The number of singing males increases from January to March. The presence of flocking birds remained constant at minimum values even during the breeding season. According to Cramp & Simmons (1980), these coveys, formed by yearling birds and/or by older un-

TABLE II - *Mean home range of different subspecies of* Alectoris graeca. *The methods used to assess density (pairs/100 ha) are different. Coefficient of correction for relative indices were calculated in three areas of Sicily. s = variance.*

Sample area	n	Mean home range (ha) $\bar{X}$ ± s.d.	min.-max.	Pairs/100 ha	Correction coefficients MOT	ITA
A	6	22.9 ± 8.5 ;	8.0- 33.0	4.4	0.38	1.05
B	9	25.8 ± 16.6 ;	12.5- 57.0	3.9	0.46	1.40
C	6	61.9 ± 44.9 ;	21.4-150.0	1.6	0.35	1.45
Sicily	21	35.3 ± 30.5 ;	8.0-150.0	3.3 ± 1.5	0.4 ± 0.05 s = 0.003	1.3 ± 0.2 s = 0.05
Apennines (Petretti, 1985)				7.65		
Swiss Alps (Zbinden, 1984)				2.9 ± 0.74		
Swiss Alps (Hess, 1979)				3.6 ± 2.11		
Maritimes Alps (Bernard Laurent & Bernard Laurent, 1984)				1.8 ± 1.1		

TABLE III - *Relative indices of* Alectoris graeca whitakeri *and related subspecies in the post breeding season (July-January).*

No. trips	Sample area	No. flocks	MIB	MOT pb
19	A	40	9.5 ± 6.9 (3-23)	16.1 ± 24.7 (0-110)
6	B	8	6.1 ± 1.9 (4-10)	9.3 ± 4.0 (5-14)
8	C	11	7.4 ± 3.1 (3-12)	9.7 ± 8.5 (0-24)
15	D	16	6.1 ± 3.2 (2-12)	7.1 ± 3.6 (0-12)
80	Sicily	110	6.9 ± 4.0 (2-23)	
28	Year 1984	28	7.0 ± 3.3 (2-14)	
41	Year 1985	70	7.1 ± 4.4 (2-23)	
11	Year 1986	12	6.5 ± 4.0 (5-9)	
	Alps (Lüps & Heynen, 1978)		4.65 ± 1.7	
	Alps (Bocca, 1975)		5.2	
	Apennines (Petretti, 1985)		2.3 ± 0.67 4.4 ± 2.73	

TABLE IV - *Average size of post breeding coveys of* Alectoris graeca *in Sicily and in the Apennines. Reference coveys are formed conventionally in an iterative fashion starting from social groups observed in summer when juveniles can be distinguished from adults, and from average clutch size observed in Sicily ($\bar{X}$ = 12). The probability that one does not detect the whole covey is assumed to be insignificant. Difference in percentage between months could be due to mortality, joining and mixing of birds in winter time; therefore productivity ratio refers only to summer coveys.*

	Reference categories			
	N	M	H	VH
No. individuals	2-4	5-8	9-12	⩾ 14
Productivity ratio	0-1	1.5-3	3.5-5	⩾ 6
Summer flocks (%) July-Semptember (ads + juvs) n = 31	16.1	58.1	22.6	3.2
Winter flocks (%) October-January (ads + subads) n = 79	27.8	45.6	19.0	7.6
Difference % July-January	+11.7	−12.5	−3.6	+4.4
Total % Sicily n = 110	24.5	49.1	20.0	6.4
Total % Apennines n = 53 (Petretti, 1985)	81.1	13.2	0	5.7

N = null productivity; M = medium; H = high; VH = very high.

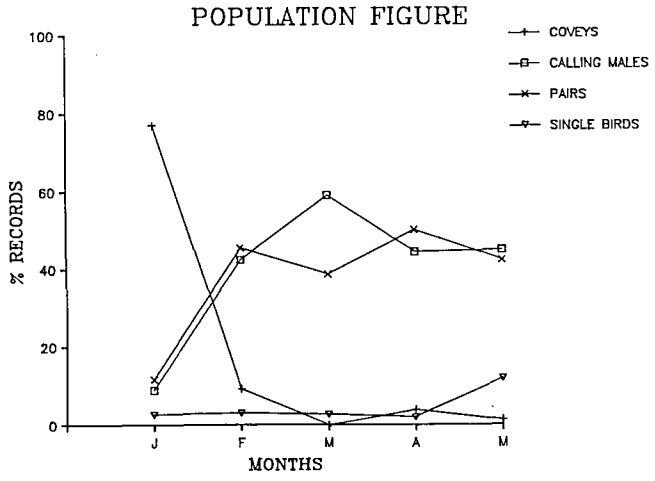

Fig. 1 - Phases of social behaviour of rock-partridge (*Alectoris graeca whitakeri*) in Sicily on the basis of frequency of observation.

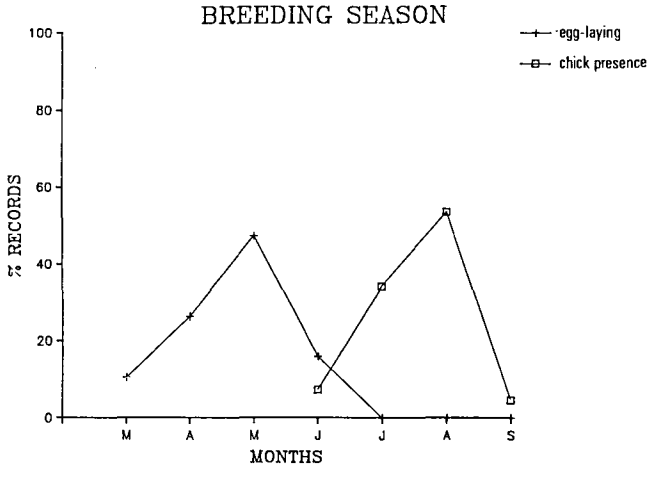

Fig. 2 - Breeding season of rock-partridge (*Alectoris graeca whitakeri*). May is the main month for egg-laying, while August is the main month for chick presence.

paired ones, are evidence of a healthy demographic population. It is possibly not by chance that spring-coveys were sighted only in the areas (A, B) with the highest values of relative indeces. About 3% of the sampled population is probably formed by single birds, which are probably old adults. The increase recorded in May is certainly due to contact with birds that do not breed or leave the nest (anti-predator display). In fact, May is the main month for egg-laying, while August is the main month for chicks presence (Fig. 2). The earliest recorded date for egg-laying is the 25 March (Agrigento), while the latest is 22 June (Palermo). Preliminary data indicate that the breeding season is not strictly related to altitude, despite the range

TABLE V - *Productivity of* Alectoris graeca whitakeri *according to the Christensen (1970) ratio, arranged for two areas, three years and preliminary total in Sicily compared to the species in the Apennines.*

	juv/ads ratio	
	$\bar{X} \pm$ s.d.	Min-Max
Area A 1985 n = 8	2.6 ± 1.0	2.0-3.5
Area D 1985 n = 7	1.3 ± 1.0	0.0-2.5
Year 1984 n = 8	3.6 ± 1.7	1.5-6.5
Year 1985 n = 17	2.2 ± 1.2	0.0-4.0
Year 1986 n = 5	3.1 ± 0.2	3.0-3.5
Sicily n = 31	2.9 ± 1.5	0.0-6.5
Apennines (Petretti, 1985)	0.9	

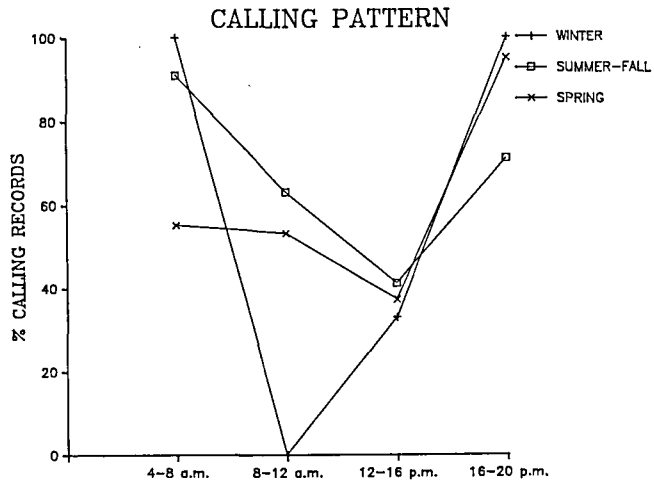

Fig. 3 - Calling records of rock-partridge (*Alectoris graeca whitakeri*) in different time bands throughout the year.

(50-2500 m) for breeding in Sicily. On 21 nests found from 1979 to 1986 the mean clutch size was 11.9 (± 3.1; 5-17); this value agrees with data reported by Harrison (1977) and Cramp & Simmons (1980). The average hatching rate, calculated on a sample of 6 nests, is 64.4% (± 36.6; 0-100), however, further investigation is required to substantiate this finding.

The average egg size is 40.9 mm (± 1.2; 37-43.8) × 30.1 mm (± 0.6; 27.9-31; N = 27); the average weight is 20.4 gr (± 0.8; 19-21; N = 17).

It is well known that population productivity calculated by the juvenile/adult ratio (Christensen, 1970) is quite variable (Petretti, 1985). Preliminary data for Sicily (Tables IV and V) indicate a medium productivity rate.

Figure 3 shows the seasonal development of calling activity throug different time bands. This variability must also be taken into account when carrying out sampling, especially when the playback technique is used (Pepin, 1983; Bernard Laurent & Bernard Laurent, 1984).

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APPENDIX 1

Statistical Inference Tests

a) Bartlett's homogeneity test of variance:

index MOT $\chi^2_{[3]} = 0.49$ ns

index ITA $\chi^2_{[3]} = 4.38$ ns

b) Student's *t* test calculated on the pair-wise comparison of the relative index values for different months:

	MOT	ITA
FEB/MAR	$t_{[30]} = 0.74$; P = ns	$t_{[30]} = 1.28$; P= ns
FEB/APR	$t_{[22]} = 0.13$; P = ns	$t_{[22]} = 0.25$; P = ns
FEB/MAG	$t_{[24]} = 0.96$; P = ns	$t_{[24]} = 0.21$; P = ns
MAR/APR	$t_{[32]} = 0.74$; P = ns	$t_{[32]} = 1.53$; P = ns
MAR/MAG	$t_{[34]} = 1.90$; P = 0.03	$t_{[34]} = 1.89$; P = 0.03
APR/MAG	$t_{[26]} = 1.25$; P = ns	$t_{[26]} = 0.61$; P = ns

c) ANOVA MODEL II results:

index MOT $F_{[3,4]} = 21.87$; $P < 0.001$

index ITA $F_{[3,4]} = 18.14$; $P < 0.001$

d) Mann-Whitney U-test between the mean number of birds counted with or without playback technique:

$U_{[11,15]} = 48.5$; $P > 0.05$

e) Linear correlation between relative indices (breeding and post-breeding):

MOT/MOTpb	N = 4; $r = 0.87$; P = 0.05
MOT/MIB	N = 4; $r = 0.87$; P = 0.05

[n] = degrees of freedom
MOT = The average number of birds counted during the trips in the breeding season
ITA = The average number of birds encountered per hour during the trips in the breeding season
MOTpb = The average number of birds counted during the trips in the postbreeding season
MIB = The average number of birds gathered in coveys