

## RED-LEGGED PARTRIDGE (*Alectoris rufa*) AGE AND SEX RATIOS IN DECLINING POPULATIONS IN HUESCA (SPAIN) APPLIED TO MANAGEMENT

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### INTRODUCTION

The Lower Cinca Red-legged Partridge populations suffered progressive decline from 1960 to 1989 due to habitat damage, overpredation and absence of game management (Nadal *et al.*, 1990, 1992) as reported by Birkan (1979), Potts (1986), Rands (1986, 1992), and Birkan & Jacob (1988).

The age ratio represents the present population structure and as such is a population production index (Mendel & Peterson, 1980). The age ratio consists of recruitment (natality plus immigration) less disappearance (mortality plus emigration) (Pépin *et al.*, 1985). Age and sex ratio studies of Red-legged Partridge populations have contributed to an understanding of species management (in France : Birkan, 1977 and Treussier & Fouquet, 1978 ; in Portugal : Ruela & Barbosa, 1983 ; and in Spain : Calderón, 1983). Studies have also been carried out in the Mediterranean area of Hérault (France) by Pépin (1981), Pépin *et al.* (1985) and Ricci *et al.* (1987, 1988). Studies previously undertaken in the Ebro Valley include : Castien & Zudaire (1983) in the Northwestern zone (Province of Navarra) ; Lucientes (1983, 1984) in the Central zone (Province of Zaragoza) ; Hernández & Cabrera (1986) and Nadal *et al.* (1987, 1988) in the Southern-central zone (Azuara). Lucio (1989) and Lucio & Llamas (1992) in the North plateau and the Cantabrian Chain (Province of Leon).

No attempt has been made to apply the findings as a whole to management. The aim of this study is to describe age and sex ratios of two Red-legged Partridge populations from Huesca, compare these ratios of declining populations (suffering neglect) as contrasted to stable populations (managed) from previous studies carried out in other areas, and relate these ratios with the factors responsible for Red-legged Partridge populations decline.

### STUDY AREAS

Lower Cinca and the area surrounding the city of Huesca (around Huesca) were selected in previous studies of species density because the Red-legged

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Partridge habitats have been damaged by the impact of human activity. These areas are described elsewhere : Nadal (1988, 1989) and Nadal *et al.* (1990, 1992) (Fig. 1 and 2, Tab. I, II, III, IV, V, VI and VII). The Lower Cinca study area consists of 60,000 ha of agricultural land on Pyrenean foothills. It includes Quaternary planes, erosion slopes and Tertiary valley floors with tabular relief in a semiarid environment, and corresponds to the transition from damaged evergreen oak grove (*Quercetum rotundifoliae*) to Kermes oak bush (*Rhamnetum cocciferae*-coscojar-) (Braun-Blanquet & de Bolós, 1957). The area around Huesca city is situated 60 km west of Lower Cinca, has 282,743 ha of agricultural land, and corresponds to transition from evergreen oak grove to damaged evergreen oak grove (Sarda). Due to its subhumid climate (Pujol, 1974) it has a greater percentage of small evergreen oak (*Quercus rotundifolia*) woods than are found in the Lower Cinca.

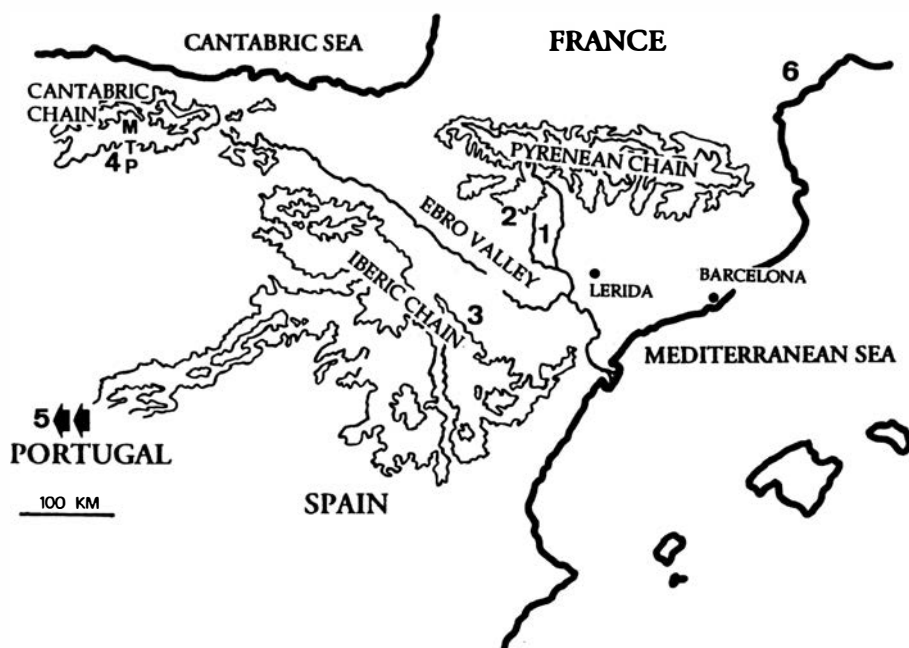


Figure 1. — Study area locations : 1) Lower Cinca, 2) Around Huesca, 3) Azuara, 4) Plain, Transition and Mountain of León, 5) Portugal, 6) Hérault.

## MATERIALS AND METHODS

Statistics of agronomic features are extracted from previous studies (Acin, 1986 ; Ereza, 1986). We studied Red-legged Partridges shot by hunters during the hunting seasons, which generally extends from October 12 to January 31. To inspect samples we contacted hunters directly.

TABLE I

*Soil use in farm land of Huesca.*

Soil use	Before 1975	1985
Cultures	52.63 %	74.20 %
Scrubs	40.10 %	6.14 %
Urban	7.27 %	19.64 %

Culture and urban soil increased, whereas scrub soil decreased.

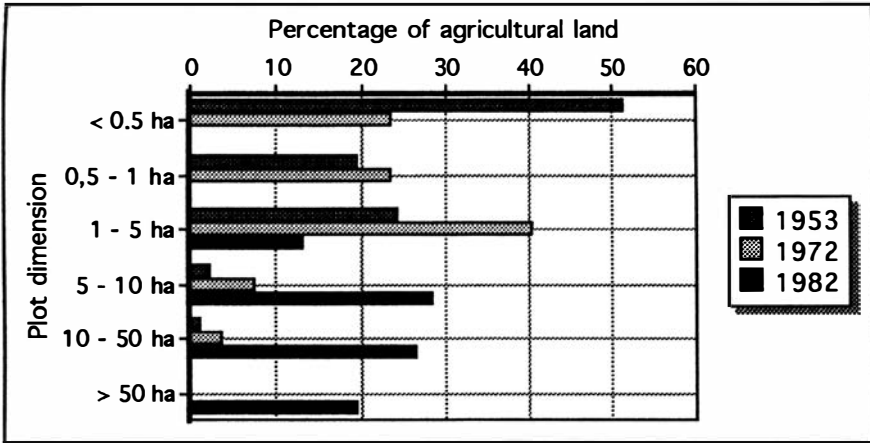


Figure 2. — Percentage of agricultural land with respect to plot dimension. In recent time the increase of plot dimension implicates the hedge destruction.

AGE AND SEX DETERMINATION OF BAGGED RED-LEGGED PARTRIDGE

Birds were classified as adult or juveniles according to the ninth and tenth primary shape and moult sequence (Birkan, 1977a ; Treussier & Fouquet, 1978 ; Pépin & Contant, 1981 ; Calderón, 1983. Subsequently, we measured body mass, total length, wing length, tarsus length, tarsus diameter, eighth, ninth and tenth primary length to determine sex (Svensson, 1975 ; Pépin & Contant, 1981 ; Calderón, 1983 ; and Pépin, 1985). We assigned birds to each sex group with reference to critical values (Pépin & Contant, 1981 ; Calderón, 1983 ; and Pépin, 1985).

As any farm bred Red-legged Partridge found among captures were eliminated from the sample, all samples included in this study were wild partridges. The following criteria were used to discriminate farm bred partridges :

1. Primary feather tips damaged due to living in pens.
2. Differences in colour of plumage, legs and beak.
3. Morphometric measures.
4. Sick animals with a significant loss of weight.
5. Presence of feathers on flanks with double bar or the remains of a double bar (hybridism).

TABLE II

*Species cultivated in farm land of Huesca.*

Species cultivated	Before 1975	1985
Cereal	66.54 %	75.73 %
Lucerne	4.79 %	11.58 %
Vegetables	7.14 %	1.4 %
Industrial cultures	1.6 %	2.1 %
Ligneous cultures	19.93 %	9.15 %

Species in ha	Before 1975	1985
Wheat	80,000	28,000
Barley	225,000	288,000
Oats	3,500	2,370

The increase of lucerne and small cycle cereal (barley) implies nest losses and the decrease of vegetables, oliveyard and vineyard implies habitat quality losses.

## STATISTICAL METHODS

In total 1,193 partridges were studied, 481 shot during the 1985-86 hunting season to the 1987-88 season in Lower Cinca (Lc) and the remainder shot the same years in the area around Huesca (Ah). Age and sex ratios were contrasted with regard to 1:1 hypothesis, in distinct seasons and among different study areas within each zone. The difficulties encountered in obtaining samples led us to work with little data, between 1.1 % and 2.7 % of the spring population in Lower Cinca. Following Zar's (1984) indications, we used the likelihood ratio with Wilks' theorem (test G) and continuity correction. To demonstrate the significance with respect to 1:1 proportion the binomial test was used, being the most powerful for dichotomous data (Siegel, 1976).

Results with critical level  $P \leq 0.10$  are considered significant (Ratti & Rotella, 1989) whenever they can be supported by results with  $P \leq 0.05$  for other similar contrasts. Such strategies have been used to avoid increasing the type II error probability (Still, 1982 ; Luna & Martin, 1984). As contrasted differences are small and it is impossible, due to conditionings, to increase the data to decrease this error. In multiple comparisons when contrasts include more than 250 data items and the contrasted difference is large, we use Bonferroni's sequential technique (BST) to calculate the collective level of significance (Rice, 1988) with  $P \leq 0.10$  (Ray, 1995).

## RESULTS

## FACTORS RESPONSIBLE FOR RED-LEGGED PARTRIDGE POPULATION DECLINE

Factors responsible for Red-legged Partridge decline are : absence of game-keepers and game management, excessive hunting pressure and poaching, absence

of habitat improvements, modern agriculture — increase of plot dimension, hedge destruction (Fig. 2), the adventitious flora extinction (pesticides, tillage, fire, seed selectors and progressively smaller-cycle culture varieties) (Tab. I, II, III and IV), accidents caused by machinery, vehicles (Tab. III) and unavoidable constructions (Tab. I), nest and protection site reduction (destruction of relief supporting natural vegetation, Tab. I), decline of presence time of agricultural resources (Tab. II and III), poisoning and pollution by toxic chemical products (Tab. IV), drying up of water point (Tab. II), overgrazing, sewerage and pollution from intensive breeding (Tab. V), urban and rural centers (Tab. I), overpredation by antropophilous species (*Vulpes vulpes*, *Meles meles*, *Corvus corax*, *Corvus corone*, *Corvus monedula* and *Pica pica*) and by domestic species (*Canis familiaris* and *Felix domesticus*) (Tab. VI).

TABLE III

*Agricultural machinery in Huesca.*

Machinery	Before 1975	1985
Number	4,443	13,424
Horsepower	203,203	817,796

The increment of machinery and its power implies the increase in accidents and habitat losses, as well as time reduction of agricultural resources.

TABLE IV

*Xenobiotics consumed in Huesca.*

Xenobiotics × 10 <sup>9</sup> pta	Before 1975	1983
Total	7.2	25.9
Insecticides	4	11
Herbicides	1.5	7.5

The increase of xenobiotics consumed implies the reduction of quantity and diversity of biotic resources.

AGE RATIOS

In lower Cinca the age ratio (AR) was significantly less than 1 during the 1985 season ; yet in the 1987 season it was greater than 1 with  $P \leq 0.10$ . The AR during the 1987 season was significantly greater than in 1985 ( $n = 337$ ,  $G = 7.29$ ,  $P \leq 0.01$ ). In the area around Huesca AR was significantly less than 1 during 1985 and 1986 (Fig. 3, Tab. VII) ; during the 1987 season AR was significantly greater than in 1985 ( $n = 431$ ,  $G = 4.93$ ,  $P \leq 0.05$ ) and 1986 ( $n = 466$ ,  $G = 4.01$ ,  $P \leq 0.05$ ). The two study areas do not differ in their AR in the studied seasons (1985-6 :  $n = 491$ ,  $G = 0.001$ ,  $P \leq 0.95$  ; 1986-7 :  $n = 425$ ,  $G = 1.12$ ,  $P \leq 0.30$  ; 1987-8 :  $n = 277$ ,  $G \leq 0.59$ ,  $P \leq 0.50$ ).

TABLE V

*Drugs consumed by poultry in Huesca.*

Drugs × 10 <sup>9</sup> pta	Before 1975	1983
Poultry	1.3	7.5

The increase of drugs consumed by poultry implies the increase of sewerage and pollution from intensive breeding.

TABLE VI

*Characteristics of Red-legged Partridge study areas.*

Study areas	Al	Pon	km/km <sup>2</sup>	Cult/NV	S.d.	Pre wc
Lower Cinca	350	459	5.7	76.6/14.2	0.14	5 dn
Around Huesca	400	627	> 5.7	60.1/31.5	0.10	

Habitat quality : Al : altitude, Pon : rainfall, km/km<sup>2</sup> : km of hedge/km<sup>2</sup> of surface, Cult/NV : cultivation land/natural vegetation in percentage. S.d. : spring density in partridges/hectares. Pre wc : predation without predator control, dn : days until artificial nest are predated.

TABLE VII

*Age and sex ratio in the Lower Cinca and around Huesca from 1985 to 1987.*

Lower Cinca	Number of partridges	Age ratio	Juvenile sex ratio	Adult sex ratio
1985-1986	245	0.68**	1.75**	1.35*
1986-1987	144	0.92	1.16	1.67**
1987-1988	92	1.35*	0.89	2.00**
<b>Around Huesca</b>				
1985-1986	246	0.68**	1.17	1.43**
1986-1987	281	0.72**	0.90	1.29*
1987-1988	185	1.08	0.81	1.54**

\*  $P \leq 0.10$ ; \*\*  $P \leq 0.05$ .

Age ratio : young/adults ; juvenile sex ratio : young males/young females ; adult sex ratio : adult males/adult females.

## JUVENILE SEX RATIOS

In Lower Cinca the juvenile sex ratio (JSR) was significantly greater than 1 during the 1985 season due to the drought in the spring and the lack of summer rains (Fig. 4, Tab. VI and VII). 1985 was a very dry year with 293.5 mm of annual rainfall compared with average annual rainfall over 28 years (1940-1967) of

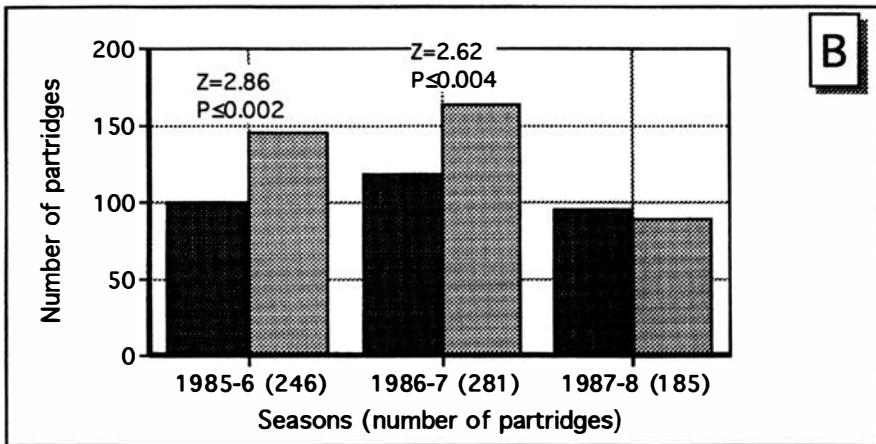
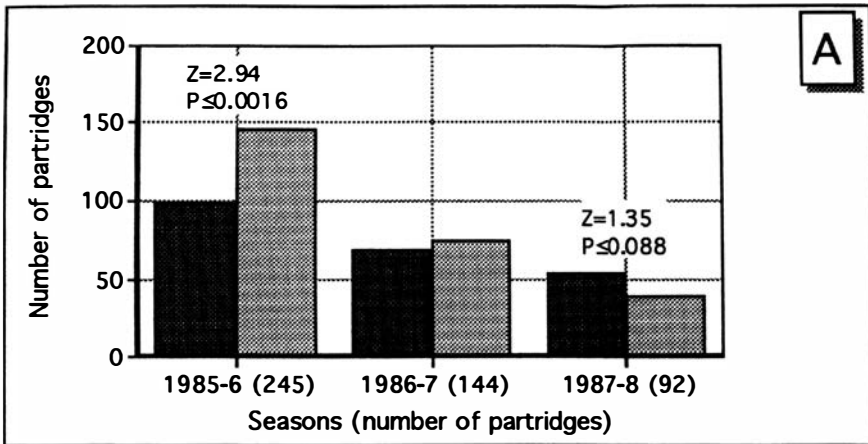


Figure 3. — Adults and young in Lower Cinca (A) and around Huesca (B). Dark bars : young. Pale bars : adults.

458.7 mm. Only 7.1 % of the years exhibit the same or lower rainfall. In contrast, in the area around Huesca JSR did not differ from 1 during any of the analysed seasons (Fig. 4, Tab. VII).

In Lower Cinca, JSR during the 1985 season was significantly greater than 1987 ( $n = 152$ ,  $G = 3.17$ ,  $P \leq 0.10$ ). In the area around Huesca JSR did not show significant differences by season ( $P \leq 0.30$ ). The two study areas did not differ in their juvenile sex ratio in any of the studied seasons (1985-6 :  $n = 199$ ,  $G = 1.53$ ,  $P \leq 0.30$ ; 1986-7 :  $n = 187$ ,  $G = 0.43$ ,  $P \leq 0.60$ ; 1987-8 :  $n = 149$ ,  $G = 0.01$ ,  $P \leq 0.95$ ).

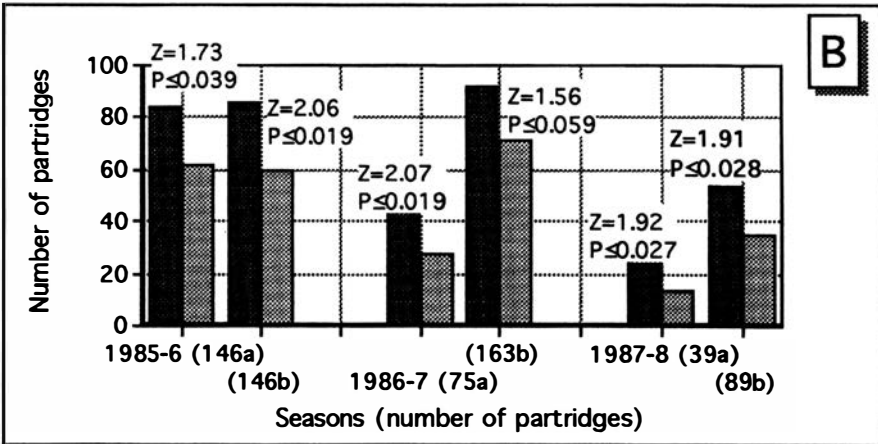
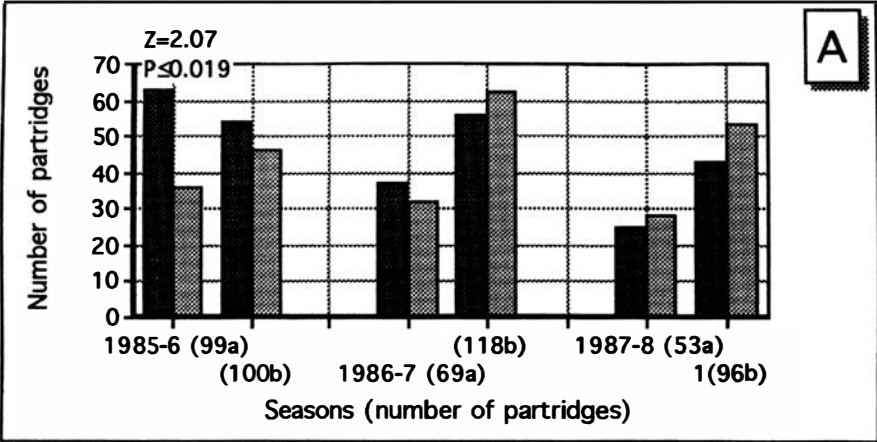


Figure 4. — Juvenile (A) and adult (B) males and females in Lower Cinca (a) and around Huesca (b). Dark bars : males. Pale bars : females.

#### ADULT SEX RATIOS

In Lower Cinca adult sex ratio (ASR) was greater than 1 during the three seasons. In the area around Huesca during the 1985 and 1987 seasons, and with  $P \leq 0.10$  during 1986 (Fig. 4, Tab. VII). The two study areas did not differ in their ASR in any of the studied seasons (1985-6 :  $n = 292$ ,  $G = 0.01$ ,  $P \leq 0.95$ ; 1986-7 :  $n = 238$ ,  $G = 0.58$ ,  $P \leq 0.50$ ; 1987-8 :  $n = 128$ ,  $G = 0.20$ ,  $P \leq 0.70$ ).



## DISCUSSION

### FACTORS RESPONSIBLE FOR RED-LEGGED PARTRIDGE POPULATION DECLINE

Factors responsible for Red-legged Partridge decline are the same as reported by Birkan (1979), Potts (1986), Rands (1986, 1992), and Birkan & Jacob (1988) for Red-legged and Grey Partridges in France and U.K., and the same for other galliforms of the world (see *Perdix VI* symposium).

### AGE RATIOS DURING EACH SEASON WITH REGARD TO 1:1 PROPORTION

The percentage of seasons with  $AR < 1$  in declining populations of Lower Cinca and around Huesca was greater than in the rest of the study areas from previous studies (stable or increasing populations), and even greater than in Blue Grouse tetraonid with half egg lay (Zwickel, 1982). The low individual turn-over was not sufficient for annual renewal of the adult group. To support population density at least  $AR \geq 0.95$  is needed (Potts, 1989). In Lower Cinca the small age ratio confirms the diminishing number of partridges (Caughley, 1974; Roseberry, 1974; Birkan, 1979; Larson & Taber, 1980; Nadal *et al.*, 1990, 1992). The decline was corroborated in Spain by Calderón (1983), in Valladolid by Serrano (1989), and by the Spanish hunting press between 1985 and 1990.

The declining populations in Lower Cinca should not be hunted, apart from when  $AR$  is equal to 1 — stable population — or greater than 1 — increasing population. Only then it produces a surplus that could be exploited in proportion to its abundance (Tab. VIII; Caughley, 1974; Birkan, 1979; Larson & Taber, 1980; Pépin & Blayac, 1990 and Bernard-Laurent, 1991). This decline in population was not only due to the adverse effects of the climate during the year and, consequently, to the lack of birds' resources — as in the 1986 season in the Transition and Plain of Leon (Lucio, 1989), during the 1983 season in Lower Cinca (inedit data) and during 1985 in both areas Lower Cinca and around Huesca —, but it is also explained by habitat damage — increase plot dimension and hedge destruction (Fig. 2), scrub break up (Tab. I), increase barley and lucerne (Tab. II), increase machinery (Tab. III), increase xenobiotics (Tab. IV) and increase pathology (Tab. V) — as in previous studies (Birkan, 1979; Potts, 1986; Rands, 1987; Dowell, 1988; Brennan, 1991 and Rands & Sotherton, 1992), predation (Potts, 1986 and Rands, 1988), overgrazing (Zwickel, 1972 and Severson, 1990) and by the absence of game management (Church & Taylor, 1992; Schulz, 1992; Brennan & Jacobson, 1992; Nadal, 1993; Tab. VIII).

$AR$  changes with season — Hérault (Pépin, 1985), Portugal (Ruela, 1983), Plain of Leon (Lucio, 1989), Azuara (Nadal *et al.*, 1987), area around Huesca and Lower Cinca — therefore bag limit management requires specific determination for each season (Pépin, 1981; Pépin *et al.*, 1985). Similar measures have been proposed for Greek Partridge (Bernard-Laurent, 1991), Grey Partridge (Birkan, 1979 and Potts, 1986) and for Bobwhite (Brennan & Jacobson, 1992).

### JUVENILE SEX RATIO WITH REGARD TO 1:1 PROPORTION

The JSR of declining populations in Lower Cinca during the 1985 season was significantly greater than 1, due to the effect of the differential mortality of the

TABLE VIII

*Lower Cinca Red-legged Partridge population estimates with and without bag management.*

	Autumn bag 1985-86	Spring population 1986	Autumn bag 1988-89	Spring population 1989
Without bag management	4,500	9,000*	2,900	7,800*
With bag management	1,800	12,600	3,500	12,600

Note : With bag management the captures (28 %) diminish (only two seasons considered), although without bag management the spring population (70 %) decreases. \* data estimates from censuses, other data estimates from age ratio and inquiries.

juvenile hens with regard to juvenile males (Pulliainen, 1968 and 1974 and Mendel & Peterson, 1980). The differential birth rate of cocks with regard to hens may be produced by factors that provoke greater mortality in female embryos than in male : stressful conditions during incubation due to absence of quality nest sites (Fig. 2, Tab. I and II ; Rands, 1986 and 1987 and Ricci *et al.*, 1990), extreme climatic conditions (1985 year ; Reitz, 1988 and Lucio, 1990), injuries produced by predators (Tab. VII ; Rands, 1988) and agricultural machinery that disturb incubating hens (in 20 years the number increase 302 %, Tab. III ; Havet, 1982, Potts, 1986 and Birkan & Jacob, 1988), the necessity of females to spend more time out of their nest to eat — due to poor habitat quality (Fig. 2, Tab. II and IV ; Rands, 1987, etc. ; see also Olsen, 1989 ; Zwickel, 1972 and Zwickel & Carveth, 1987 in Blue Grouse ; Pulliainen & Huhtala, 1985 in Black Grouse).

The lack of food availability in the environment requires increasing daily displacement of flocks with chicks to find food — in agricultural land of the province of Huesca due to hedge destruction (Fig. 2), scrubs break up (Tab. I), and the extinction of adventitious flora by machinery (Tab. III), fire and use of xenobiotics (Tab. IV) (Rands, 1985 and Birkan & Jacob, 1988). Displacements are selective since male chicks, due to their greater physiological capacity, can be restrained for longer periods (Lathan, 1947) ; thus they have an advantage in competing for food and defending themselves from predators (Tab. VI). Angelstam (1984) has constructed an annual pattern of sex ratio for Black Grouse based on the differential mortality of both sexes.

In declining populations, differential mortality of juvenile hens conditions the sex structure (Wegge, 1980), this implies the reduction of their potential reproduction. Juvenile hen mortality is associated with population decrease (Potts, 1986 and Brennan, 1991), and reproduction failure (Panek, 1992 and Carroll, 1992).

#### ADULT SEX RATIO WITH REGARD TO 1 : 1 PROPORTION

The frequently greater percentage of males in the adults group — which also occurs in Bobwhite (Lehman, 1984) and in Willow Grouse (Pulliainen, 1975) — is a consequence of the adult hens mortality being higher during the reproduction period. This is a result of the hens reluctance to move during the last days of the

incubation and in the first days of brooding (Zwickel & Caveth, 1978 ; Angelstam, 1984 and Ricci *et al.*, 1990). This behaviour facilitates their capture by predators (Tab. VII) and destruction by agricultural machinery (Tab. III), that is more acute in barely and in years with early harvest (Havet, 1982 ; Berger, 1987 ; Berger *et al.*, 1988 and Rands, 1988).

The lack of adult hens significantly reduces the population production potential, because adult hens rather than juveniles have the greatest laying capacity : due to their greater clutch number, their reposition nests, and their double nests (Zwickel, 1982 and Green, 1984). This shows that the declining populations of Lower Cinca have a greater percentage of seasons  $ASR > 1$  than the stable populations.

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#### SUMMARY

In two areas of the district of Huesca (Spain) the age and sex ratios of declining Red-legged Partridge (*Alectoris rufa*) populations were studied between 1985 and 1987, and were compared with data found in previous studies. Declining Red-legged partridge populations in the Province of Huesca, in contrast to stable ones, are characterized by age ratios  $< 1$  while sex ratio and adult sex ratio  $> 1$  due to poor habitat quality (ecotone absence, low diversity, and great agricultural impact), overabundance of antropophilous predators and excessive hunting pressure, which reduces the survival of hens and chicks. Unfavourable yearly climate variations induce mortality of juvenile and adult hens. Bag limits must consider not only density, but also population structure and habitat quality. Habitat restoration, bag management, and antropophilous predator control are necessary as well as urgent measures to guarantee the viability of Red-legged Partridge populations.

#### RÉSUMÉ

Dans deux régions de la province de Huesca (Espagne) l'âge et le sexe des individus de populations en déclin de la Perdrix rouge ont été étudiés pendant les saisons de chasse de 1985, 1986 et 1987, en vue d'une gestion cynégétique, et ont été comparés aux données de la littérature. Les populations en déclin de Perdrix rouge à Huesca, à la différence des populations stables, se caractérisent par un échec reproducteur constant (ratio d'âge  $< 1$ ) et par la mortalité fluctuante des adultes (sexe ratio d'adultes  $> 1$ ) dus à la mauvaise qualité de l'habitat (absence d'écotone, faible diversité, grand impact agricole), à la surabondance de prédateurs

anthropophiles et à une pression cynégétique excessive, qui font que la survie des poussins et des femelles diminue. Selon les années, les conditions climatiques défavorables accroissent la mortalité des femelles juvéniles et adultes, et en conséquence diminuent la productivité et la densité de la population. Les taux de prélèvement cynégétique ne doivent pas seulement être basés sur la densité, mais doivent aussi tenir compte de la structure de la population et de la qualité de l'habitat. La restauration de l'habitat, la gestion des tableaux de chasse et le contrôle des prédateurs anthropophiles sont des mesures nécessaires et urgentes pour garantir la viabilité des populations de Perdrix rouges.

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