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Population structure variations of wild boar *Sus scrofa* in central Italy

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Keywords: Wild boar, *Sus scrofa*, productivity, hunting effect, population fluctuations

1. Introduction

From the 1960s, as a consequence of huge environmental changes, desertion of the countryside, artificial restocking, a decrement in the number of direct predators and consequent profound modification in breeding techniques, wild boar populations have been increasing throughout Europe (e.g. Saez-Royuela & Telleria 1986; Csanyi 1995; Fruzinski 1995; Herrero et al. 1995; Nores et al. 1995; Massei & Genov 2000; Wilson 2003), as well as Italy (e.g. Debernardi et al. 1995; Massei & Genov 2000; Monaco et al. 2003; Brangi & Meriggi 2003).

The Italian wild boar population has been roughly estimated at more than 300,000–500,000 individuals (Monaco et al. 2003). Data from hunting bags, although incomplete, reported a minimum harvest of 30,000 individuals per year. This number was probably underestimated since, less recently, Pedone et al. (1995) reported an annual harvest of 20,000–30,000 for the Tuscany region alone. As consistent estimates of wild boar populations are intrinsically difficult (Boitani et al. 1995a,b), every attempt to give a large-scale estimate is hazardous. In Tuscany, wild boar hunting is deeply rooted in the country tradition, and wild boar management is a critical issue in the social life both for its impact on cultivation (e.g. Brangi & Meriggi 2003; Schley & Roper 2003), and for its induced hunting-related economy.

Many studies have been focused on wild boar populations in Tuscany, both on demography and on biology (e.g. Boitani et al. 1994, 1995a,b; Mattioli & Pedone 1995; Mazzoni della Stella 1995; Mazzoni della Stella et al. 1995a,b; Pedone et al. 1995; Russo et al. 1995, 1997; Massei et al. 1996, 1997; Genov et al. 1998; Massei & Genov 2000), and most were based on harvest data (Boitani et al. 1995a,b; Mazzoni della Stella 1995; Mazzoni della Stella et al. 1995a,b; Genov et al. 1998).
Intensively harvested populations often have increased mortality and reduced life expectancy, often with the sex ratio and population structure strongly skewed (Stubbe & Stubbe 1977; Genov et al. 1998; Laurian et al. 2000). In the case of sexually dimorphic big game, hunting exerts a consistent selective pressure in favour of bigger trophy animals (i.e. males), thus skewing the population structure.

We aimed to evaluate, by means of harvest data, the variations of population structure and productivity in a harvested wild boar population, more than the actual patterns of its demography. We assumed that, even though harvest data may somehow be biased, in the case of wild boar (scarce sexual dimorphism) and in the presence of intense hunting pressure and efficiency, this bias does not nullify the information related to trends and productivity variations implicit in harvest data (e.g. Gaillard et al. 1993; Ahmad et al. 1995; Fernández-Llario & Mateos-Quesada 1998; Spitz et al. 1998).

2. Materials and methods

The study has been focused on the harvest bags of six hunting seasons (October to January, 1990–1996) on wild boar Sus scrofa in a hunting area (Monticiano) of the Siena Province (Tuscany, Italy; Figure 1). The area (9672 ha) was partially hunting-free (21.0%), and was mostly covered by woods (84.1%) of deciduous oaks Quercetalia petraeae, Quercetalia robori-petraeae, with a dominance of Castanea sativa, and of Quercetalia ilicis (De Dominicis & Casini 1979).

Wild boar density estimates by drive counts averaged to 12.0 ind./km² (Mazzoni della Stella 1990, 1995). The hunting method was uniform all over the Siena Province: hunts were guided with hounds, and wild boars were pushed towards standing hunters, with a maximum number of 30 hunters per team. Each team had its own hunting area assigned.

Every hunted boar was sexed, weighed (all years but 1993) and aged, and female productivity was investigated through foetus count (all years but 1993). Age was assessed using mixed criteria based first on tooth eruption (1: 0–12 months; 2: 13–24 months; 3: 24–36 months), and then using eight different wear classes. To analyse the trend of the population structure in the six-year period, data were pooled in four classes (1—piglet: 0–12 months; 2—second year: 13–24 months; 3—third year: 24–36 months; 4: >36 months), as suggested by other authors (Boitani et al. 1995b; Mazzoni della Stella et al. 1995a).

A piglet index (PI) was expressed as percentage, and calculated as follows:

$$PI = \frac{N_{Cl_{t+1}}}{\sum_{i=2}^{4} N_{Cl_{i}}} \times 100$$

where

- $N_{Cl_{t+1}}$=total number of individuals in the first age class (i.e. ≤12 months) in the season $t+1$
- $N_{Cl_{i}}$=total number of individuals belonging to age class $i$ in the previous season $t$
- and the summation, from age class 2 on, referred to all the individuals in season $t$ but those in class 1.

Frequencies of both sex and age have been compared by Pearson Chi-square test (Sokal & Rohlf 1995). The probability levels have been computed using a complete randomisation method (permutation or exact test), or by a Monte Carlo simulation (Mehta & Patel 1996; Good 2000) based on 10,000 sampled tables ($P_{Monte Carlo}$) when computation was not possible. The Kruskal–Wallis test was used to compare mean number of foetuses per females among different age classes in each season, and to verify variations in weights of females of different age classes during the study period. Otherwise stated, throughout the text means are reported along with standard deviations (mean ± SD).

The z levels for multiple frequency comparisons by Chi-square tests were corrected using the Dunn–Sidák significance level correction method: $z'=1-(1-z)^{1/k}$, were $k$ is the number of comparisons (Sokal & Rohlf 1995). In our case, comparing the proportions of the seven age classes among the six hunting seasons, the new thresholds were: $z'_{0.05}=0.0073; \quad z'_{0.01}=0.0014; \quad z'_{0.001}=0.0001$. Throughout the text the reported $P$ values were referred to the corrected significance levels.

All the statistical analyses have been performed using the Statistical Package for Social Sciences v. 10.05 (SPSS®).

3. Results

We analysed 2773 individuals (Table I) harvested during six hunting seasons (462.2 ind./season ±205.5): 1505 males, 1262 females and 6 undetermined, with a sex ratio significantly male-biased (1:0.84; $\chi^2=21.340, P_{Monte Carlo}<0.001$).

The analysis of the population structure of pooled data (six years; Figure 2) showed a significantly
Figure 1. Monticiano hunting area in the Siena Province (Italy, inset map). The territory is divided into three Administrative Hunting Districts, and each hunting team is assigned to its own hunting area.

Table I. Total number of wild boars harvested in six hunting seasons (1990–1996) from a population in central Italy (Monticiano district, Siena, Italy). Number of males, females and undetermined are reported along with sex-ratio values. Results of Chi-square analysis ($\chi^2$, d.f. and $P_{Monte Carlo}$) are reported.

<table>
<thead>
<tr>
<th>Season</th>
<th>Undetermined</th>
<th>F</th>
<th>M</th>
<th>MM:FF</th>
<th>$\chi^2$</th>
<th>d.f.</th>
<th>$P_{Monte Carlo}$</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990–1991</td>
<td>0</td>
<td>271</td>
<td>329</td>
<td>1:0.82</td>
<td>5.607</td>
<td>1</td>
<td>&lt;0.05</td>
<td>600</td>
</tr>
<tr>
<td>1991–1992</td>
<td>2</td>
<td>175</td>
<td>236</td>
<td>1:0.74</td>
<td>9.054</td>
<td>1</td>
<td>&lt;0.01</td>
<td>413</td>
</tr>
<tr>
<td>1992–1993</td>
<td>2</td>
<td>353</td>
<td>414</td>
<td>1:0.85</td>
<td>4.851</td>
<td>1</td>
<td>NS</td>
<td>769</td>
</tr>
<tr>
<td>1993–1994</td>
<td>0</td>
<td>213</td>
<td>259</td>
<td>1:0.82</td>
<td>4.483</td>
<td>1</td>
<td>&lt;0.05</td>
<td>472</td>
</tr>
<tr>
<td>1994–1995</td>
<td>2</td>
<td>170</td>
<td>169</td>
<td>1:1.01</td>
<td>0.003</td>
<td>1</td>
<td>NS</td>
<td>341</td>
</tr>
<tr>
<td>1995–1996</td>
<td>0</td>
<td>80</td>
<td>98</td>
<td>1:0.82</td>
<td>1.820</td>
<td>1</td>
<td>NS</td>
<td>178</td>
</tr>
<tr>
<td>Table total</td>
<td>6</td>
<td>1262</td>
<td>1505</td>
<td>1:0.84</td>
<td>21.340</td>
<td>1</td>
<td>&lt;0.001</td>
<td>2773</td>
</tr>
</tbody>
</table>
Our data highlighted significant differences in the population structures (both on 7 or 4 age classification) of males and females, with an anomalous abundance of second-year males. This should be due, assuming a not-selective harvest, to the hunting destructuring process, or conversely (if the assumption was not met), to selection by hunters. We believe, in agreement with other authors (Boitani et al. 1995a), that, in our study area, given the high harvest rate during the whole hunting season, hunters did not select between sex and age classes.

Surprisingly, no more than the 46% of the total sample was younger than 24 months, quite different from the percentages (70–80%) reported by Boitani et al. (1995a,b) for the same population, by Moretti (1995) in Switzerland, or by Durio et al. (1995) in the Italian Alps.

The relative abundance fluctuations of males and females of different age, recorded in the six-year period with evident peaks of piglets in alternate years (1990, 1992, 1994), were probably due to an alternation of food abundance. The influence of environmental and climatic conditions on reproductive success in wild boar has already been reported in other Mediterranean areas (Massei et al. 1996, 1997; Fernández-Llario & Mateos-Quesada 1998;...
Figure 3. Trend of structure of a wild boar population in central Italy (Monticiano district, Siena, Italy) from hunting bags of six hunting seasons. Different classes of age (Piglets M and F: dotted thick line; others: decreasing thickness for increasing age class) and sex (M: broken line; F: continuous line) for Results of Chi-square analysis are reported: **$<\chi^2_{0.01}=0.001$; ***$<\chi^2_{0.001}=0.0001$.

Figure 4. Productivity (represented by the PI; grey bars) trend in a wild boar population in central Italy (Monticiano district, Siena, Italy) and its variation (expressed as the difference between successive PI values; lines) during the study period (1990–1996).
Fernández-Llario & Carranza 2000), and in our area it was possibly caused by years of high productivity of oak woods, alternated with years of normal/low productivity. Moreover, clear opposite trends were observed between piglets and second-year males and females, with significant variations of relative abundance during the study period. Even though male fluctuations were probably due to the preceding piglet abundance or scarcity, second-year female fluctuations may have been both a consequence and a cause of piglet abundance variations in the preceding and following years. None the less, the peaks in second-year male abundance may have contributed to an increment of the overall productivity of population. In fact, young males may have substituted older males in the breeding pool after a year of intensive harvest, causing an incremented occurrence of fecundated females. This hypothesis is neither refutable nor trivial, since we noted an alternative trend in occurrence of fecundated females, in phase with peaks of second-year males, but out of phase with piglets.

Mortality, possibly induced by critical trophic conditions, may have played a critical role in determining these fluctuations, although we did not highlight any difference in mean weights of females in different hunting seasons. Furthermore, the presence of protected areas may have induced a reservoir effect, but this was likely to be less pronounced in years of poor oak productivity, as food paucity could have forced young individual outside of protected areas (Mazzoni della Stella et al. 1995a,b), exposing these age classes to incremental mortality that brought, in the following years, a productivity loss. This reservoir hypothesis is based on the assumption that hunting exerted de facto a differential selection from year to year, and this seemed not to be the case. Several consequences of selective hunting (Laurian et al. 2000), as unbiased sex ratio and strongly skewed structure, were not detectable in our study population, possibly for the difficult to distinguish young males from females, that reduces the feasibility of an active selection by hunters. Moreover, the selection by hunters was possibly limited by the wild boar social behaviour, that usually aggregates in large groups of females and young males, while older males wander alone (Massei & Genov 2000).

Another explanation for fluctuations in piglet abundance is that they were related to variations of female reproduction success more than to mortality. As a matter of fact, population structure variations might have been caused by trophic availability in late autumn, which can induce considerable effects on

Figure 5. Mean number (and SD) of foetuses per female (grey bars), and percentage of foetuses (line) for each age class of harvested wild boars in central Italy (Monticiano district, Siena, Italy) from 1990 to 1995 (1993 excluded).
female condition, weight, and hence on their fertility (e.g. Massei et al. 1996; Jedrzejewska et al. 1997; Festa-Bianchet 1998; Fernández-Llario & Carranza 2000), or through variations of mortality of piglets or of second-year females the year before (Saez-Royuela & Telleria 1986; Gaillard et al. 1993; Pedone et al. 1995; Massei et al. 1997). Second-year females, along with third-year females, are known to play an important role in the overall population productivity, but, in this case, the latter did not appear to have any clear relation with the productivity trend in the overall period. According to several authors (Gaillard 1987; Boitani et al. 1995a), a partial destructuring of the population induced by harvest should bring second-year females to overcome third-year females as the reproductive pool; in our study area, this seemed not to be the case, for no unstructured female population was observed.

More likely, a contribution to piglets, and hence productivity fluctuations, may have been exerted by second-year female more through their abundance than by an increment in individual productivity, since their mean contribution to the reproductive pool was not higher than that of the older females. On the contrary, older females were individually more prolific than second-year ones.

Interestingly, as already mentioned, despite weight analysis results, a significant alternation of years with high occurrence of females in the breeding pool with low occurrence years was detected, suggesting that females participating in the breeding pool did produce similar numbers of foetuses both in good and poor years, but a smaller number of females reproduced. These clear variations in the breeding pool were, in our opinion, consistent with the productivity peaks in the following years and hence are the correct explanation of this phenomenon.

Notwithstanding the consistency of our results, to correctly plan harvest and wild boar management, we stress the need of long-term studies that focus both on population dynamics and ecological variations, with particular concern to wood productivity and to female fecundity.

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