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# A REVIEW OF THE METHODS FOR MONITORING ROE DEER EUROPEAN POPULATIONS WITH PARTICULAR REFERENCE TO ITALY

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ABSTRACT - Throughout the last century, deer populations have shown a remarkable increase both in North America and Europe. As a consequence, the estimate of roe deer density has become a matter of interest. We reviewed the available literature on the methods used for monitoring roe deer populations in Europe from 1950 to 2004, with the aim of detecting the trend of papers and distribution of census techniques by years, countries and habitat types. Particular attention was paid to the census and monitoring methods adopted in Italy and in Tuscany, which is the region where the roe deer is more carefully managed. Published papers showed an increasing trend, as did the number of methods used and their complexity. France, Italy, UK, and Spain were the countries with the richest literature and the largest variety of methods applied. Eleven census methods have been applied in woods - particularly line transects, pellet group counts, CMR and IKA - with only 6 in open country, mainly pellet group counts. In Europe vantage points are more commonly used for planning culling programs, whilst in Italy, and particularly in Tuscany, the drive census and spotlight counts are mainly used. Unfortunately, in Europe, harvesting programs are still too much based on hunter knowledge and traditions. However the countries where the management of roe deer hunting is of more recent tradition make an exception to this rule. In Italy and in Tuscany the methods of monitoring roe deer populations should be improved towards less expensive and more accurate methods.

*Key words*: *Capreolus capreolus*, monitoring methods, culling, management, Europe, Italy

RIASSUNTO – ***Revisione dei metodi di monitoraggio delle popolazioni di capriolo in Europa con particolare riferimento all'Italia.*** Le popolazioni di Cervidi hanno avuto nell'ultimo secolo un notevole incremento sia in America settentrionale, sia in Europa. Di conseguenza la densità delle popolazioni di capriolo è diventata oggetto di interessi diversi e la sua stima suscita grande attenzione. Con lo scopo di evidenziare l'andamento delle pubblicazioni e la distribuzione dei metodi di censimento per anno, Paese e tipo di habitat, abbiamo analizzato la letteratura europea sui metodi di monitoraggio delle popolazioni di capriolo dal 1950 al 2004. Particolare attenzione è stata data ai metodi normalmente adottati in Italia e in Toscana, che è la regione dove la gestione del capriolo si può considerare più avanzata. I lavori pubblicati hanno avuto una tendenza all'aumento così come il numero di metodi utilizzati e la loro complessità. La Francia, l'Italia, il Regno Unito e la Spagna sono

risultati i Paesi con la letteratura più ricca su questo argomento e anche quelli dove è stato sperimentato il maggior numero di metodi. Undici metodi di censimento - soprattutto transetti lineari, conteggi di pallottole fecali, cattura-marcatura-ricattura e indice chilometrico d'abbondanza -, sono stati usati negli ambienti boscati e solamente 6 nelle aree aperte, in particolare il conteggio delle pallottole fecali. In Europa il metodo più usato per pianificare il prelievo con la caccia di selezione è risultato quello dei punti dominanti, mentre in Italia e particolarmente in Toscana sono principalmente usati le battute su aree campione e i conteggi notturni. Sfortunatamente in Europa i piani di prelievo sono ancora troppo basati sulle conoscenze e sulla tradizione dei cacciatori. Tuttavia, fanno eccezione a questa regola i Paesi dove la gestione venatoria del capriolo è iniziata di recente. In Italia e in Toscana i metodi di monitoraggio delle popolazioni di capriolo dovrebbero essere migliorati, adottando tecniche meno dispendiose e più accurate.

*Parole chiave*: *Capreolus capreolus*, metodi di monitoraggio, piani di prelievo, gestione, Europa, Italia

## INTRODUCTION

Throughout the last century, deer populations have remarkably increased both in North America and Europe (Gill, 1990), probably as a consequence of the general improvement of habitat quality and availability together with that of game management (Gill *et al.*, 1996; Cederlund *et al.*, 1998). The European roe deer (*Capreolus capreolus*) derived much benefit from the widespread decrease of intensive stockbreeding and the abandonment of agriculture on the hills and mountains, followed by an increase of woodland. Moreover, in the last forty years, the game management of roe deer populations has improved, providing shorter hunting seasons and limited quotas, food supply and habitat improvement, reintroductions and restocking. On the other hand, if the consequent growth in density and distribution of roe deer populations has brought benefits to hunters, the increasing damage to forestry and agriculture has enlarged the social component interested in the proper management of this species (Staines and Ratcliffe, 1987; Cederlund *et al.*, 1998; Duncan, 1998; Radeloff *et al.*, 1999).

Roe deer density has become the object of different interests: hunters, naturalists and tourists that want higher densities, and, on the other hand, stakeholders, farmers and foresters that would prefer low or even zero densities. Nevertheless the roe deer, as all the other ungulate species, must be also considered as an important prey for threatened and protected carnivores such as the wolf (*Canis lupus*) and lynx (*Lynx lynx*) (Mattioli *et al*., 1995; Okarma, 1995; Meriggi and Lovari, 1996; Meriggi *et al.*, 1996; Aenes *et al.*, 1998; Mattioli *et al.*, 2004; Gazzola *et al.*, 2005; Meriggi *et al.*, in press).

Considering all these aspects, roe deer management should gain a sort of balance between harvesting and conservation of habitats and species without affecting human activities. In other words, different strategies should be adopted to adjust population density according to different habitats and ecosystems.

Several examples of different harvest

plans are reported in the available scientific and technical literature; most of them are focused on a single objective, such as maximising harvest quotas or trophy hunting. Harvest plans can be qualitative, when based on criteria such as the distribution of age or sex classes and trophy size (Von Raesfeld, 1985; Kurt, 1991), or quantitative, when based on the estimate of fecundity and productivity (Ellenberg, 1975; Blant, 1991).

The adoption of one approach or the other may depend on the main management objective - e.g. population control *vs*. the rational exploitation of the population -, the information needed varying drastically in relation to the different circumstances (Cederlund *et al.*, 1998). In the case of a small harvest quota, compared to the population abundance (e.g. trophy hunting), it is sufficient to evaluate by direct counts the minimum number of adult males. If the management objective is to reduce deer damage to forests or crops, it is necessary to estimate the whole population size, particularly the proportion of adult females (Ratcliffe, 1987; Lubow *et al.*, 1996). Finally, if the objective was to achieve the maximum sustainable exploitation, the population recruitment should be known, as also the intrinsic and external factors that influence it. In any case, especially for the last target, a sound knowledge of the main parameters of population dynamics represents the first step for a correct management of roe deer populations.

Hunting techniques have changed over the years as a consequence of increased public awareness promoted by the acquisition of scientific knowledge of roe deer populations. This process has been different across Europe. In the Mediterranean area, for example, roe deer were, and somewhere still are, hunted by drives with hunting dogs without any selective and sustainable harvesting criterion. Otherwise, in central Europe roe deer are traditionally hunted for their trophies, so only adult males and individuals of poor quality (i.e. old, sick or injured ones) were culled, often ignoring young and females.

Progressively, harvest plans and techniques have evolved everywhere towards culling plans that respect the sex and age class proportions, according to the consciousness that each population has its own characteristics and parameters. As a result, the census of deer populations has become a priority to formulate culling plans, following the idea that the more accurate the census the higher the probability of avoiding the degeneration of the population towards either overabundance or scarcity.

In this review we collected the available information on roe deer monitoring methods that have been applied in Europe and Italy, in particular in Tuscany, where the species is widespread and more carefully managed. Data were obtained from the international and national scientific literature as well as from technical reports and congress proceedings.

## MATERIALS AND METHODS

To investigate the census methods usually adopted for roe deer populations in Europe, we analysed the bibliography available for the period 1950 - 2004. From 1990 onwards, the scientific indexed papers were searched for using the CILEA digital library, by means of ISI Web of Science and Current Contents Connect (CCC). The

Wildlife Service software was used to search for and consult the abstracts of all the literature published before 1990; above all, this database yielded a list of references for non indexed journals, congress and workshop proceedings. Moreover, we consulted books and reports on the conservation and management of ungulates, particularly the roe deer, in Europe and Italy.
The following journals were consulted: *Journal of Animal Ecology* (1968-2004), *Journal of Applied Ecology* (1968-2004), *Acta Theriologica* (1979-2004), *Revue D'Ecologie* (*Terre e Vie)* (1979-2004), *The Journal of Wildlife Management* (1981-2004), *Gibier Faune Sauvage* (1984-1998), *Ethology Ecology & Evolution* (1989-2004), *Ecography* (1994-2004), *Oikos* (1994-2004), *Wildlife Biology* (1995-2004).
The references of each paper of some interest were searched for and consulted, and the same was done for the two most important books about the roe deer (Danilkin and Hewison, 1996; Andersen *et al.*, 1998). Then all papers were ordered and listed per year of publication, country, study period, census techniques, census season and habitat. All these data were fully available only for some papers.
The analyses were conducted in order to obtain: a) the 1950-2004 trend of papers dealing with fully explained census techniques, b) the distribution of papers per country and the frequency distribution of census techniques c) per year, d) country, e) habitat and f) season.
Moreover, the census techniques adopted by the major European wildlife services and research institutions have been investigated to define the main methods used to note down culling plans. In particular, for Italy, all the Regional and Provincial regulations on the management of ungulates were collected, in order to find out the official rules on this matter. Finally, a more intensive investigation was conducted in Tuscany by direct inquiries with gamekeepers and wildlife managers, to define the census techniques adopted in each game management unit.

## RESULTS

### 1. Evolution of roe deer census methods

The first census methods adopted for management and scientific purposes - the drive census and direct observations - derived from hunting practices (De Crombrugge, 1969; Boisaubert and Stoquert, 1975; Boisaubert *et al.*, 1979; Von Berg, 1979; Cederlund *et al*., 1984; Denis, 1985; Blant, 1987). These techniques have been largely used, even if some authors pointed out the risk of underestimating the actual roe deer density (Cederlund *et al.*, 1998; Van Laere *et al.*, 1998), whilst others authors asserted their accuracy (Boscardin, 1999). Particularly, with the drive census technique it is very difficult to apply an adequate sampling strategy and a sufficient number of replicates (Van Laere *et al*., 1998). The impossibility of replicating the census in the same conditions prevents the calculation of confidence intervals and standard errors (Cederlund *et al.*, 1998), which are necessary to obtain comparable data (Fattorini and Pisani, 1999; Fattorini, 2000).
Successively less laborious techniques - spotlight road counts, sector census, vantage points census, line transects and pellet-group counts -, have been adopted, with the main aim of reducing the number of people involved, and sample size. All these methods have been scarcely used in the past, due to environmental constraints and the lack of scientific tests on roe deer populations (Cederlund *et al*., 1998), even if

sometimes their potential and applicability has been shown (Mitchell *et al*. 1985; Staines and Ratcliffe, 1987; Ratcliffe and Mayle, 1992; Boscardin, 1999; Crépin *et al.*, 1999; Mayle *et al.*, 2000).

Among them, line transects are becoming more and more used in the monitoring of wildlife populations (Burnham *et al*., 1980, 1981; Seber, 1992; Buckland *et al*., 1993). This method is based on the count of animals observed on both sides of a standardised transect of known length; for each individual or group of individuals detected the perpendicular distance from the transect must be measured. In order to obtain reliable population estimates and confidence intervals some assumptions should be fulfilled: a) all the individuals on the transect must be observed, b) the individuals are observed in their initial position, c) the observations are independent events. This technique is still poorly adopted for roe deer, even if some encouraging results have been derived from its application in various habitats (Zejda, 1984, 1985; Alvarez Jimenez, 1988; Fandos *et al*., 1990; Gaillard *et al*., 1993). Particularly, roe deer are easily detectable at night, so this method has been adopted with good results using night-vision and thermal-imaging equipment; however the costs of this equipment still represent a limiting factor (Gill *et al*., 1997). Line transects methods are increasingly used by researchers, whilst managers are still reluctant because not all the assumptions can be verified and sometime few observations are recorded.

Since the first time that roe deer census estimates have been checked, their inaccuracy has been clear. Andersen (1953) exterminated a roe deer population that demonstrated a three times more abundant estimate than had previously been recorded by direct observations and drive counts. Successively, Strandgaard (1972), Pielowski (1984) and Ratcliffe (1987) reported similar cases, the solitary and secretive behaviour of roe deer, particularly in forested habitat, enhancing the probability of population underestimates (Gaillard *et al*., 1993).

One of the first methods adopted to evaluate the accuracy of the different census techniques and for research purposes was the Petersen-Lincoln method (Petersen, 1896; Lincoln, 1930), also called the Capture-Mark-Recapture (CMR) method (Andersen, 1962; Strandgaard, 1967, 1972; Gaillard *et al*., 1986; Gill *et al*., 1996; Andersen *et al*., 1995).

This method is hardly suitable for management, being time-expensive. Nevertheless, population estimates and confidence intervals are generally reliable if the following assumptions are fulfilled (Strandgaard, 1972; Caughley, 1977; Seber, 1982): a) the population is closed, b) both marked and unmarked individuals have the same probability of being recaptured or re-sighted, c) the number of marked animals in the population is known at any time, d) the proportion of marked individuals is around 60%. Recently several software packages have been released that yield precise calculations, even when not all these assumptions are fulfilled (Pollock *et al*., 1990).

The CMR method is considered the reference one when other methods are to be tested. Obviously this means that suitable experimental areas with a lot

of marked animal have to be available. On the other hand, nowadays the need for methods that fit the various levels of management strategies and population density is declared.

Recently, during the VI European Roe Deer Congress that took place the 23-26th April 2003 in Portugal, it emerged that the more popular and widespread census methods (drive counts, line transects, pellet-group counts, etc.) show limitations in some situations and a solution for all density levels and habitats is still far from achieved. A flexible and well-studied approach is necessary. Especially in France, a set of indicators is being developed for roe deer populations and their habitats (Ballon *et al*., 1991; Van Laere *et al*., 1998). All these indexes are based upon biological parameters that were selected for being easily measurable and closely correlated with population density and resource availability (Milner-Gulland and Akcakaya, 2001). The most widely used are the kilometric index of abundance (IKA, Vincent *et al*., 1991), body mass (Maillard *et al*., 1989; Gaillard *et al.*, 1996; Van Laere *et al*. 1998), ovulation rate (Liberg *et al*., 1991; Gaillard *et al*., 1992), fawn production (Boutin *et al*., 1987; Liberg *et al*., 1991; Vincent *et al*., 1995), jaw or hind foot length (Hewison *et al.*, 1996; Van Laere *et al*., 1998) and browsing index (Mabille and Neet, 1994; Ballon, 1994; Guibert, 1997). Unfortunately, none of them give information about the population structure, limiting their application for an accurate culling plan.

Finally, a new tendency in roe deer management is to apply, by the Geographical Information System (GIS), habitat suitability models that incorporate even small habitat changes and population dynamics. The adoption of a Graphical User Interface (GUI) makes them adaptable to any local situation, in order to enhance the accuracy of the estimates of roe deer density through the computation of annual habitat changes and the culling effort of previous years (Radeloff *et al*., 1999).

## 2. Trend and distribution of census methods

Sixty-one papers on roe deer census methods in Europe were found. The published papers were unevenly distributed among years, only 4 before 1975 and a remarkable increase starting from the late 1970s until 1985, when the number of published papers stabilized around a mean of 3 papers per year, with a peak of 7 papers in 2001 (Fig. 1). Paper distribution among European countries was overbalanced towards France (47.5%), Italy (14.8%), the United Kingdom (9.8%) and Spain (8.2%), while in the rest of Europe papers were lacking or absent (Fig. 2).

The most common methods were line transect or distance sampling (22.8%), pellet group counts (17.5%), the CMR (often involving re-sighting instead of recapture; 14.0%) and the kilometric index of abundance (IKA; 12.3%). The other methods were less used even if all the pooled ecological and biological indexes reached 10.7% (Fig. 3). Considering the frequency of use of the different methods, a tendency to diversification and experimentation clearly appeared through the years, with the progressive abandonment of expensive and time consuming methods such as the

drive census and CMR in favour of population indexes (Fig. 4).
France was the country where the largest number of methods has been applied (8), followed by UK, Spain (7 each) and Italy (4). In the other European countries only one or two methods have been used (Fig. 5).
Only for 35 out of 61 papers it was possible to define the habitat where the

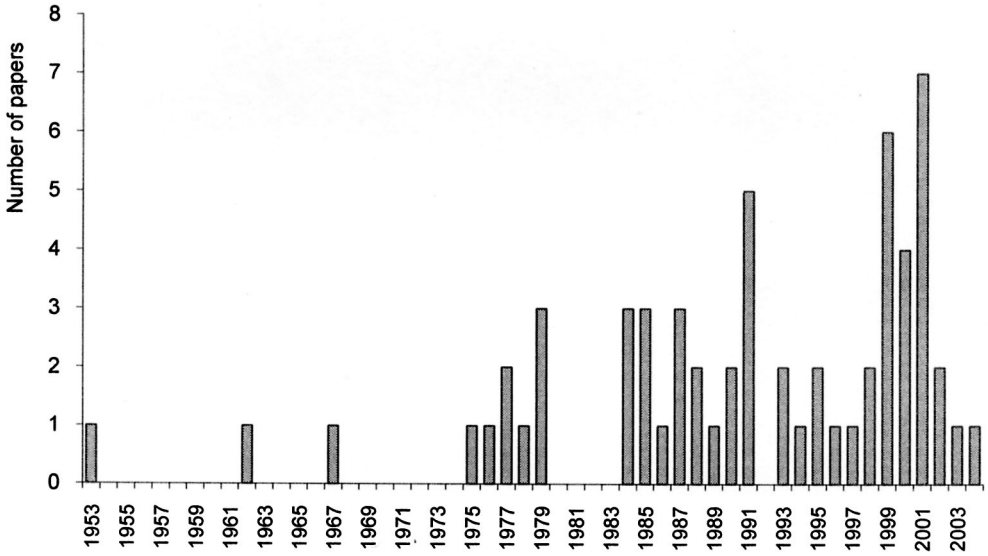


Figure 1 - Trend of the papers on monitoring methods of roe deer populations in Europe.

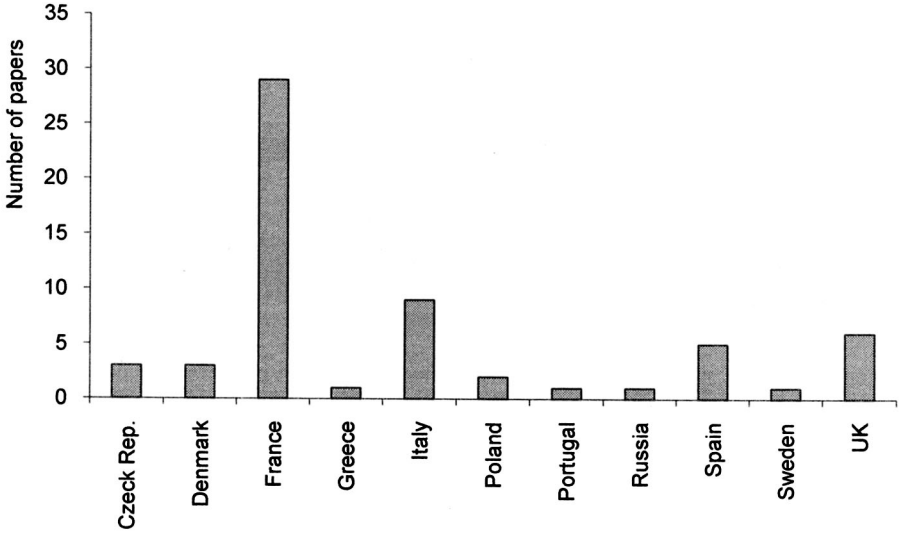


Figure 2 - Distribution of papers on roe deer monitoring methods in the main European countries.

census methods were applied. The different habitat types were grouped into two macro-habitats: open country (crops, pastures, grassland, etc.) and woods. Eleven methods were applied in woods, whilst only 6 in open country; in particular, line transects, pellet group counts, CMR and IKA were the most used methods in the former, whereas in the latter pellet group counts prevailed (Fig. 6).

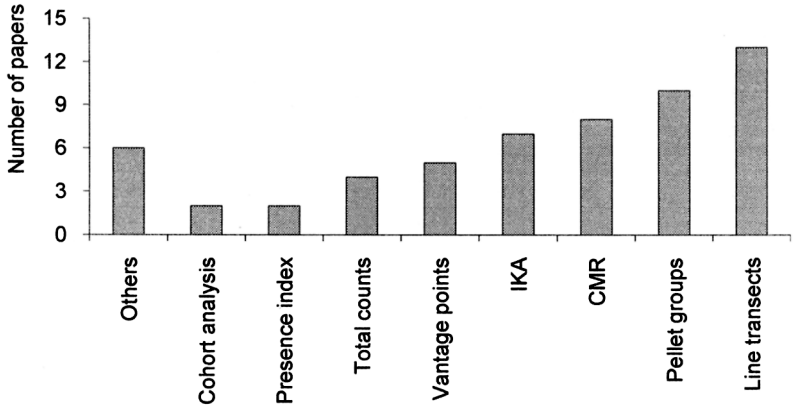


Figure 3 - Frequency distribution of the main roe deer monitoring methods.

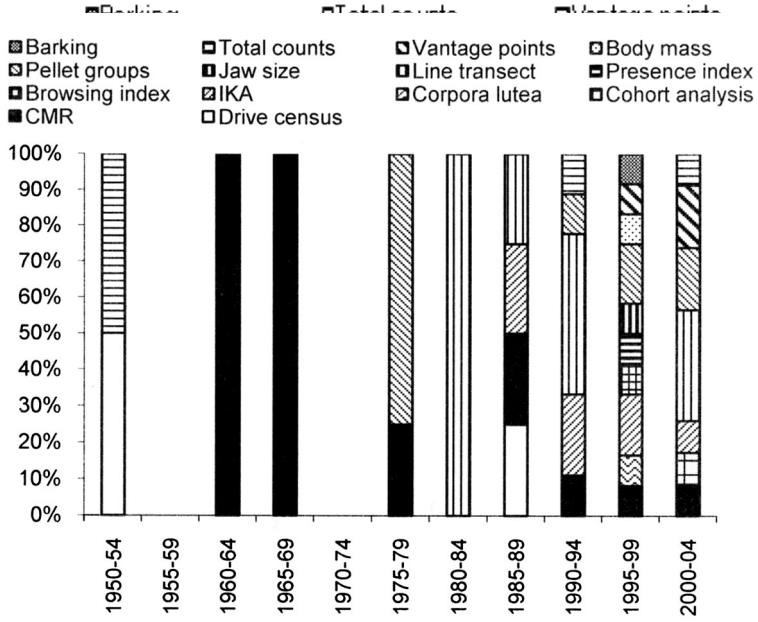


Figure 4 - Percentage of occurrence of the different roe deer monitoring methods from 1950 to 2004.

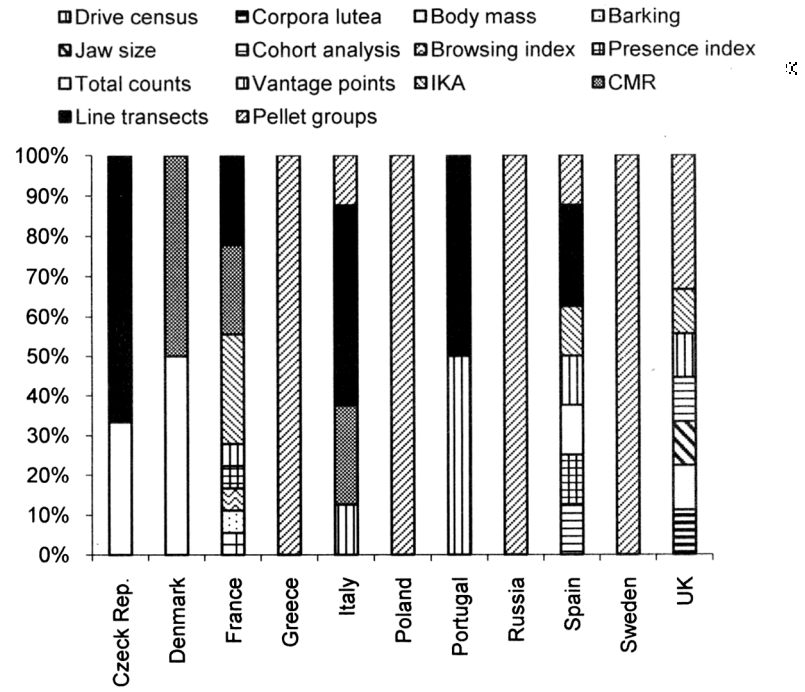


Figure 5 - Percentage of occurrence of the different roe deer monitoring methods in some European countries.

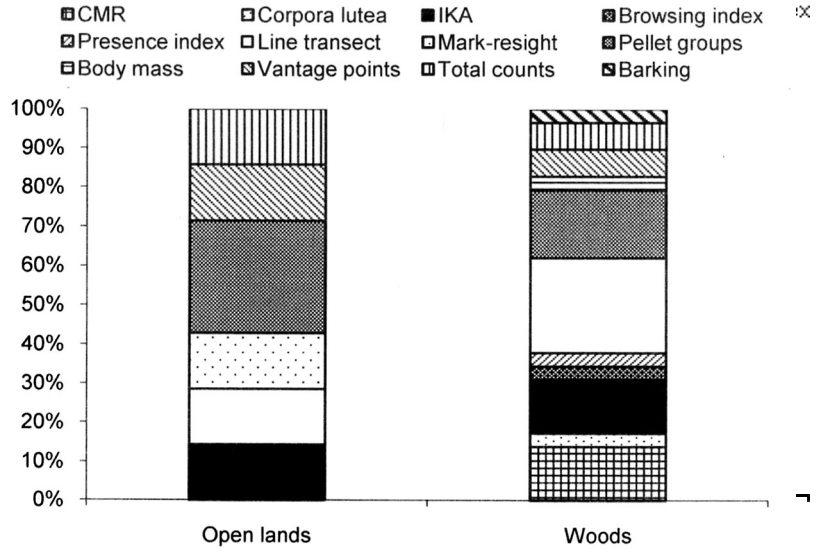


Figure 6 - Percentage of occurrence of the different roe deer monitoring methods in open and wooded habitats

## 3. Roe deer census methods in Europe

The abundance of roe deer populations that are regularly culled has been estimated by various methods: in some European countries no census has ever been applied, while in other countries sophisticated methodologies have been used, even for research purposes. The most used methods in planning deer culling were the measure of body weight and jaw length and age estimation by tooth eruption and consumption. The census methods more commonly applied were vantage points counts, either complete in open areas or according to a sampling design in wooded areas (Tab. 1).

## 4. Roe deer census methods in Italy

In Italy the roe deer is present in 67 out of 103 provinces (65.0%) and hunting is allowed in 38 (36.9%), usually by selective criteria except for some north-eastern provinces (Pordenone, Udine, Treviso, Vicenza, Belluno) were the species is also hunted by drives with dogs (Pedrotti *et al*., 2001, Apollonio, 2004). Roe deer censuses are conducted in 34 provinces, that is 50.7% of the provinces where the species is present and 89.5% of those where the species is hunted (Apollonio, 2004).
Considering both regional and provincial regulations, only in five provinces belonging to two regions (Piedmont and

Table 1 - Monitoring methods of roe deer populations applied in some European countries.

| Country | Census methods |
|---|---|
| Finland | snow-tracking |
| Sweden | snow-tracking, pellet groups |
| Norway | sanitary surveillance on culled animals |
| Denmark | drive census, line transect |
| United Kingdom | drive census, vantage points, pellet groups |
| France | vantage points, sector counts, populations indexes |
| Germany | vantage points |
| Austria | browsing index, direct counts, culling statistics, pellet groups, snow-tracking |
| Poland | drive census, snow-tracking, direct observations. |
| Czech Republic | sector counts in spring |
| Hungary | vantage points, IKA, culling statistics |
| Bulgaria | no census |
| Romania | no census |
| Serbia | vantage points, IKA |
| Croatia | vantage points, IKA. |
| Slovenia | vantage points |
| Spain | no census |

Tuscany) were the periods and methods for roe deer census provided. Usually, the normative simply refers to technical report of the wildlife services or to agreement documents with the INFS (National Institute for Wildlife).
Vantage point counts was the most used census method in all the provinces where roe deer culling is allowed. The drive census was mostly applied in Liguria and Tuscany, whilst sector counts and spotlight night counts prevailed in alpine areas, where counts are conducted using the roads in the valley bottom or those above the tree-line. In central Italy these techniques are commonly used in hunting estates. In some scientific researches line transects, pellet group counts and capture-mark-resight have been used (Focardi *et al*., 2002 a, b, c; Fattorini *et al*., 2004).

5. Roe deer census methods in Tuscany

In Tuscany roe deer harvesting is conducted by means of quantitative and qualitative shooting plans. The shooting plans, as reported in the regional regulation, must be based on census data and all hunters must take part in the census activities, under the control of the wildlife services of the provinces. Only qualified hunters can take part in culling and all culled individuals must be recorded. Nevertheless, only in some provinces are harvesting data analysed to obtain proper information on population structure and dynamics. Despite these inconsistencies, population monitoring appears to be excellent in Tuscany compared to the rest of Italy. The drive census is the most adopted method in forest habitats (except for the province of Prato). It is performed by hunters form March to May and planned by the technicians of the Hunting Districts. The sampling area usually ranges from 4 to 7% of the total wooded area of the Hunting District.
Vantage point censuses are performed wherever the wood percentage is lower than 50%, whilst in areas where the previous two census techniques are not suitable (e.g. Siena, Pisa and Grosseto provinces) the IKA and population structure are assessed by observations from transects (Tab. 2).
Roe deer are hunted also in private estates; in this case shooting plans are decided by the owner under the supervision of the wildlife services of the provinces. Censuses are performed by the technicians of either the estate or the province, and usually the vantage points technique or night counts are adopted. In the province of Pisa, private estates adopt the IKA technique and, once every three years, the drive census.

DISCUSSION

In Europe, the scientific and technical literature on roe deer census methods and population monitoring has not been abundant in the past fifty-four years, even if some papers may have been neglected by mistake from this review, especially the technical reports, and PhD and degree theses that are not always easy to locate.
In the last fifty years, roe deer census techniques have taken two opposite paths, as often happens when species are the object of interest by hunters, managers and researchers. Even if researchers have improved the accuracy and precision of census techniques,

managers have often ignored the update, preferring to keep the obsolete techniques that well fitted the purposes of management.

Table 2 - Census methods of roe deer adopted by the province Administrations in Tuscany region.

| Province | Type of hunting area | Census method | Period |
|---|---|---|---|
| Arezzo | Hunting districts | Drive census | March-May |
| | | Vantage points | March-May |
| Firenze | Hunting districts | Drive census | - |
| | | Vantage points | Late spring |
| | Private estates | Vantage points | Late spring |
| | | Spotlight census | - |
| Pisa | Hunting districts | Drive census | April |
| | | Vantage points | April |
| | Private estates | Drive census | April-June |
| | | Vantage points | March-April |
| | | Spotlight census | February |
| | | Line transects | April |
| Livorno | Hunting districts | Drive census | March-April |
| | | Vantage points | March-April |
| Pistoia | Hunting districts | Drive census | - |
| Massa-Carrara | Hunting districts | Drive census | - |
| | | Vantage points | - |
| Lucca | Hunting districts | Drive census | - |
| | | Vantage points | - |
| Siena | Hunting districts | Drive census | April |
| | | Vantage points | April |
| | Private estates | Drive census | April-June |
| | | Vantage points | March-April |
| | | Spotlight census | February |
| | | Line transects | April |
| Grosseto | Hunting districts | Drive census | March-April |
| | | Vantage points | April |
| | | Line transects | April |
| | Private estates | Drive census | March-April |
| | | Vantage points | April |
| | | Spotlight census | February-March |
| Prato | Hunting districts | Vantage points | - |

After the pioneering papers from the Danish school in the fifties, which highlighted the high risk of underestimating deer populations by the most frequently used census methods, a period of stasis lasted until the second half of the 1980s. Then the frequency of publications increased and became considerable in the first years of the 1990s. At the same time, the census methods adopted and verified increased in number, and biological indicators have been developed for monitoring roe deer populations.

This trend could be explained by a combination of different factors: a) the increase of the European deer populations and the consequent rise of management and economic interest, b) the increase of knowledge on roe deer biology and of the concern about their proper management, c) the increasing consciousness about the unreliability of traditional census methods for hunting management, d) the necessity of harvest programs for reducing deer damage and browsing pressure and e) the need of less expensive and more accurate census methods.

In the last ten years, managers have discovered that every harvest program that does not respect the natural structure, in terms of age and sex classes, of each population can have huge effects on population dynamics and recruitment (McIntosh *et al*., 1995). Recently, population genetics have shown that a high percentage of individuals are not involved in reproduction, only few adults playing an important role in annual recruitment (Clutton-Brock, 1988).

Moreover, adult males, as happens in all polyginic species, are under a strong selective pressure and suffer high mortality rates; as a matter of fact the sex-ratio is strongly shifted towards females in many natural population, even if local variability is high (Clutton-Brock, 1991). Therefore reliable census data are fundamental to prevent selective hunting from altering the structure and life-history traits of natural populations (Gadgil and Bossert, 1970; Dhondt, 1991).

In some countries scientific research has been greater compared with the European mean. In particular, 80% of papers were published in only four countries - France, Italy, the United Kingdom and Spain. These countries are those where selective hunting is of recent tradition and deer populations have showed a marked increase, probably stimulating the research.

Notwithstanding the increasing knowledge of roe deer biology and the experimentation of improved monitoring methods, it seems that in management practices innovations have been rarely adopted and accepted throughout Europe (e.g. France and United Kingdom). Unfortunately, harvesting programs are still too much based on hunters' knowledge and traditions and referred to low-scale geographical units, without adopting objective census methods (Pollock *et al*., 2000).

In Italy, in spite of the lack of proper regulations, it seems that roe deer management has reached an acceptable level, all shooting plans being based on census data. Unfortunately, no census is performed where roe deer hunting is forbidden. Among all regions, Tuscany is top ranking in the organization and diffusion of roe deer censuses, even if there is high local variability. A large

difference is evident comparing the provinces where selective hunting started first (e.g. Siena and Arezzo) with the others. In the former, a larger portion of territory is sampled, many hunters participate in the census activities, biometrics and fecundity data of culled animals are collected, while in the provinces where selective hunting started in recent years census operations should be improved and biometrics data are not collected.

The census methods adopted appear to be effective for management purposes, even if sometimes they may be difficult to organize and apply. This is particularly true for the drive census that is time-expensive and scarcely efficient in terms of the area covered.

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