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Long-term population dynamics of the European Rabbit *Oryctolagus cunniculus* in SW Poland during the years 1980-2020

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Long-term population dynamics of the European Rabbit *Oryctolagus cunniculus* in SW Poland during the years 1980-2020. – *Acta Mus. Siles. Sci. Natur.* 73: 224–236, 2024.

Abstract: Using the hunting bags data, spatial and temporal changes in population densities of the European Rabbit during the years 1981–2020 in SW Poland (29 358 km^2, including 8411 km^2 forests) have been analyzed. During the years 1999-2003, a rapid increase in the numbers of the rabbit took place, reaching a maximum of c. 900 individuals in 2003-2004. However, in the two consecutive years (2005-2006), the numbers rapidly decreased to c. 600, and then levelled off at around 600-700 individuals until 2020. In 1981-1990, rabbits occurred mostly in Sudety foothills. Larger concentrations were recorded in SE Legnica hunting region (HR), SW Wrocław HR, SW Opole HR. The main reason for the decline over the last three decades is the rabbit haemorrhagic disease.

Key words: wildlife ecology, population dynamics, introductions

Introduction

The European rabbit *Oryctolagus cunniculus* (here after referred as the rabbit) is one of the most successful invasive mammal species in the world. It is native to the Western Mediterranean Region and was introduced to all continents, (except for Antarctica) and to over 800 islands. It was transferred to west European countries already in Roman times, in 1859 – to Australia, and in 1936 – to Chile. In the second half of 20th century it became abundant and widespread in most of Australia and New Zealand and most west European countries. However, the alien (Brazilian) *Myxoma* virus and rabbit calicivirus spreading since the 1950's, became very vicious pathogens causing myxomotosis and rabbit haemorrhagic diseases throughout the world, and in consequence, a drastic decline in many part of its range (Lee & Bell 2008).

The rabbit is regarded as a paradoxical species by nature conservationists. In its native range in the western Mediterranean region it is often a key but threatened species, whereas in most areas of its introduction it is successful, but harmful. In the Iberian Peninsula, over 40 vertebrate species depend on the rabbit as a source of food. Two of them the Imperial Eagle *Aquila aldabertii* and the Iberian lynx *Lynx pardinus* are highly endangered rabbit specialists. Through foraging the rabbit affects composition of plant communities, and through the faecal pellets it enhances soil structure, its fertility and seed dispersal.

Rabbit disappearance or decline has caused a cascade reaction in some areas of its introduction. Some species which were heavy dependent on rabbits as a source of food have disappeared, some declined, but others (e.g. *Bubo bubo* in western Europe; *Bubo virginianus, Geranoaetus melanoleucus* and *Galictis cuja* in Chile or *Aquila addax* in Australia) have managed to persist by switching to other prey. The cascade reaction (domino effect) was especially evident in some islands, such as San Juan, Canary or Kerguelen (Lee & Bell 2008).

It is important to point out that in some places of its introduction, the rabbit become a species rather beneficial than destructive to the environment. The best example (most intensively studied) of such places are British Isles. The rabbit was introduced there in Norman

times in 12th century although it has developed viable population as late as in mid-18th century. By mid-1990's the population had grown to c. 37 million (Covan & Hartley 2008). It became beneficial to the environment of British Isles, as it maintains habitats that were previously maintained by species that become functionally extinct (Lee & Bell 2008).

However, in many places of its introduction, the rabbit can be destructive to the environment and often assumes the status of a pest in agriculture. It is listed a priority species for management in the Post-2020 Global Biodiversity Framework for the conservation on Biological Diversity (CBD 2021), and on the IUCN list of 100 worst invasive species (Bondjelas et al. 2000). For example in Australia it is a major ecological pest impacting negatively more than 260 plant species and 44 animals species (Jansen et al. 2023). Managing such invasive species is a challenging task, especially in open landscape where it is difficult to contain.

Despite the staggering long-term ecological and economic impacts of the rabbit, maps of its distribution are usually in a generalized form. However, detailed knowledge on its distribution and abundance is crucial to efficiently manage its population.

In this study, a reliable, high-resolution maps of rabbit spatial and temporal distribution in SW Poland are generated and population dynamics of this species is traced year-by-year over the period 1981-2020. An attempt is also made to look at the population changes before 1980, back to the mid-19th century, when it was first introduced.

Study area

The study area comprised two provinces (actual voivodships) in south-western Poland, i.e. Opole Province (województwo opolskie) and Lower Silesia Province (województwo dolnośląskie). These include the following hunting regions (former voivodships in the years 1975–1999): Opole, Wrocław, Legnica, Wałbrzych and Jelenia Góra (Fig. 1). Nowadays, the Opole hunting region is entirely located within Opole Province, while the four other hunting regions are located within the Lower Silesia Province. Opole, Wrocław and Legnica hunting regions are basically lowlands, while there are mountains in the southern parts of the Wałbrzych and Jelenia Góra hunting regions.

The total surface of such defined study area is 29 358 km^2, which constitutes 9.4% of the Poland's surface area. The land is located almost entirely within the Odra drainage system. Forests occupy 8411 km^2, i.e. 28.6% of the study area (Fig. 2). There are 42 districts, 240 counties (gminas), 127 towns and 3406 villages. The number of people living in this area was 3.87 mln in 2020.

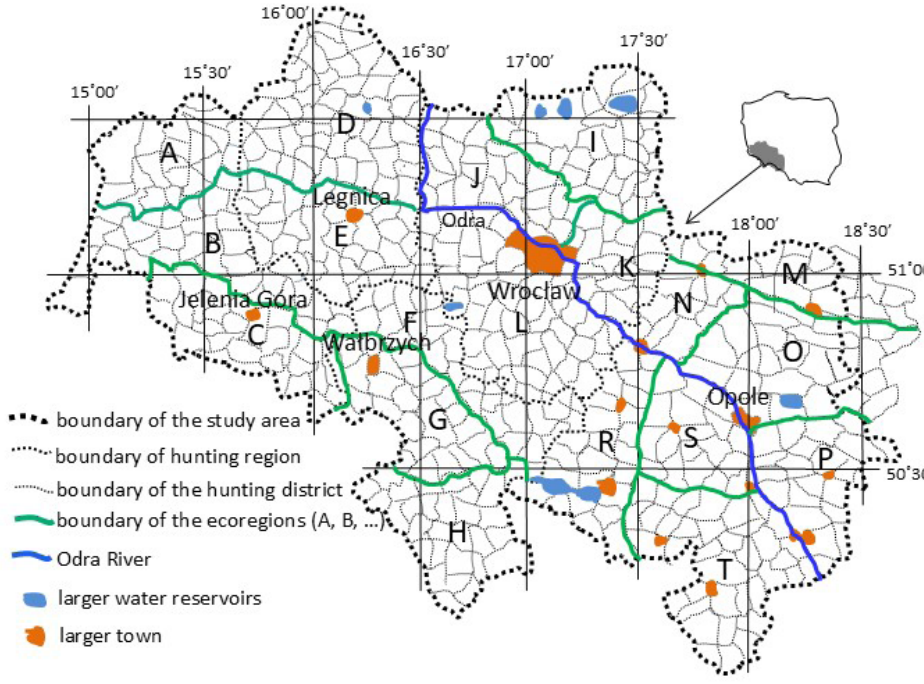


Fig. 1: The study area, SW Poland, divided into hunting districts, 5 hunting regions and 19 ecoregions.

Each hunting region is covered with a net of hunting districts (Fig. 1). Although all hunting districts include both forested and arable grounds, the proportion between them is varied. There are also meadows and pastures, human settlements (towns and villages), rivers and water bodies, waste and industry areas in each hunting district.

The average annual air temperature in the lowlands in SW Poland is 10.6˚C, for Sudeten Mts 9.0˚C (the average for Poland is 9.9˚C). This average has increased form 7.6˚C in 1981–1990 to 9.3˚C in 2020 (0.29˚C per 10 years) (IMiGW PIB 2021). The long-term (1901–2000) average precipitation for Wrocław is 583 mm per annum (in Sudeten Mts. the average is doubled). The amount of rainfall may greatly vary from year to year (318–892 mm) (Dubicka et al., 2002). In the first half of the 20th century, in most decades (except for 1901–1910) the rainfall was above the long-term average; while in the second half of 20th century, in most decades (except for the years 1971–1980) the rainfall was below the long-term average (583 mm) (Dubicka et al., 2002). In SW Poland, snow cover lasts for 30–40 days per year in lowlands, 40-50 days in uplands, and 70 – 80 days in mountains. During the years 1981–2020, the most snowy winters were in 2005–2006 and 2009–2010, whereas the least snowy winters were in two successive winters between 1988–1990 and 2006–2008 (Czarnecka, 2012; Kopij & Panek, 2016; Kopij, 2022).

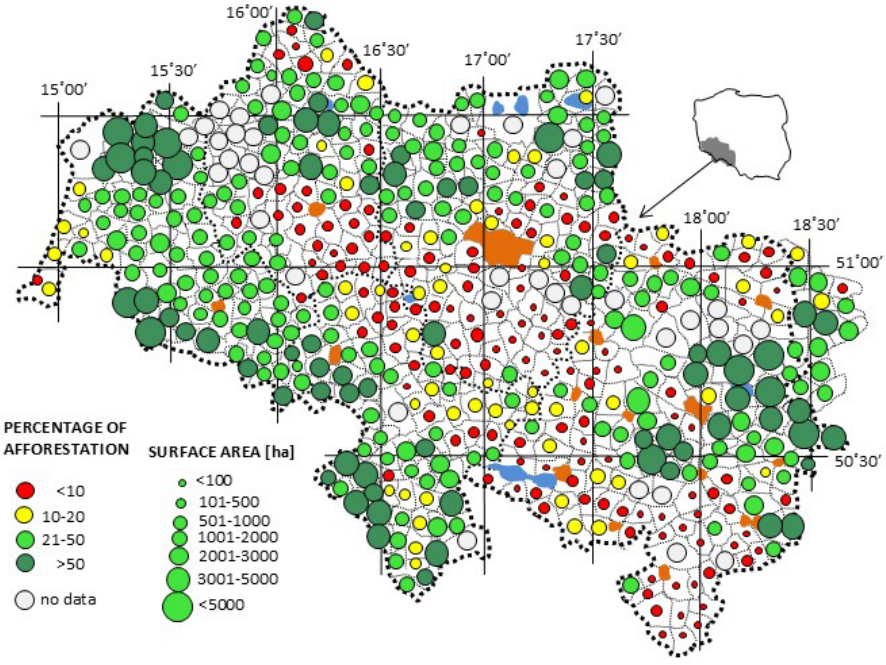


Fig. 2: Afforestation in particular hunting district in SW Poland in 2020.

Material and methods

This study is based on records from the years 1981–2020 kept by the Polish Hunting Association Research Station in Czempiń near Poznań. Records refer to the number of rabbits harvested (hunting bags) and the number of these estimated (quotas) for each hunting district (hunting ground, management area) located in SW Poland, i.e. in five hunting regions (HR): Opole, Wrocław, Wałbrzych, Legnica and Jelenia Góra.

The following methods may be employed to assess rabbit numbers: faecal pellet count, warren survey, spotlight counts, hunting bag statistics (Rogers 1981).

In the entire period 1980–2020, estimations were based on the same rules as applied to other game mammals in SW Poland (Kopij 2022, 2023; Kopij et al. 2015; Kopij & Panek 2016). At the beginning of spring of each year, members of a hunting club of a given hunting district and staff of forest districts located within this hunting district attempted to estimate numbers of rabbits in their respective hunting district. This estimation was based on direct field observations conducted throughout the year in a given hunting district, as well as on the subjective opinions of experts.

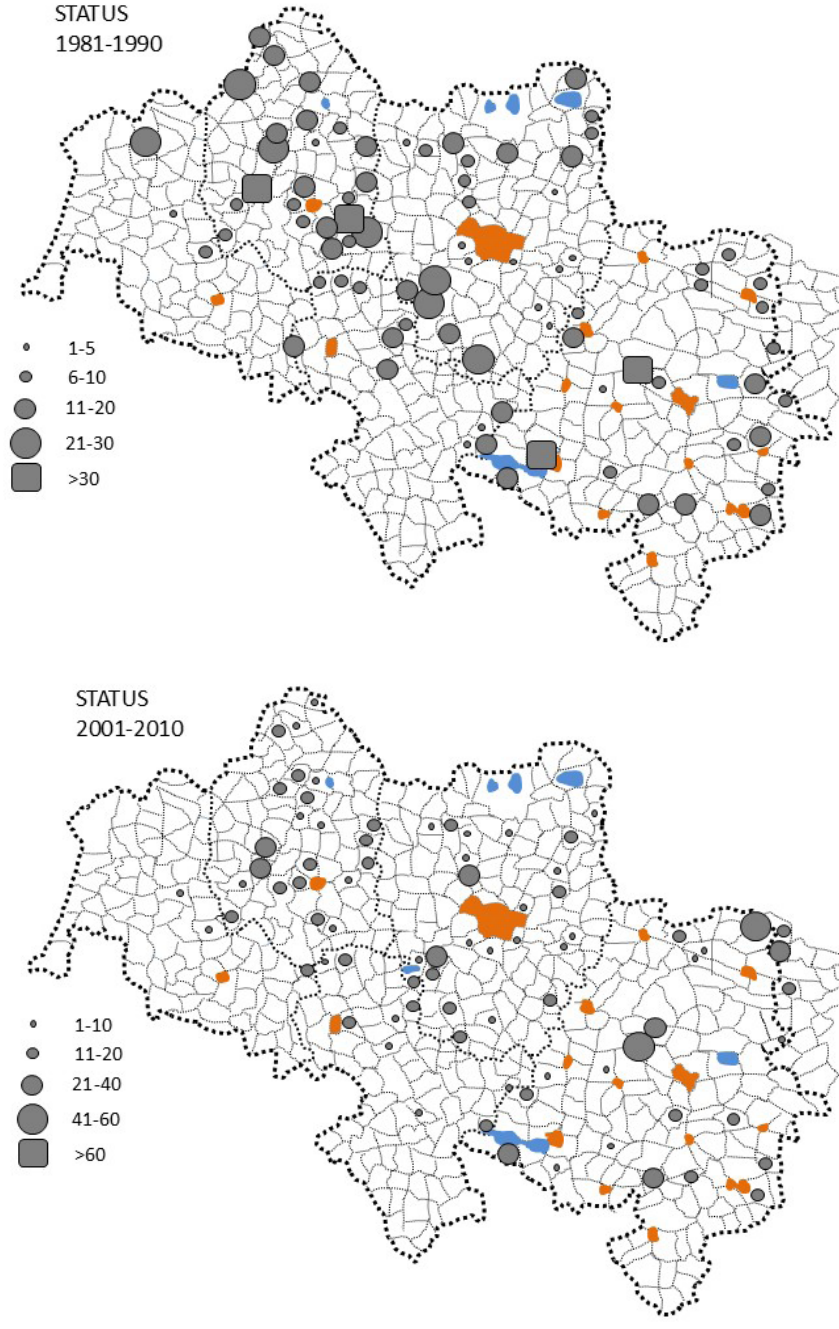
According to Polish Hunting Code, rabbits can be hunted from 1 November to the end of January, and trapped till 15 January (Dz. U. 2020.1683). For each hunting district the following parameters were calculated: the total surface area (including towns, villages, roads), the percentage of arable ground coverage and the percentage of forest coverage. These calculations were made by the Polish Hunting Associations and were continually updated if any changes in the land use structure took place.

Harvested numbers are expressed as the total number of rabbits shot in a given hunting district in a given 10 years period. Each hunting season begins on 1st of April and ends on 31st of March of the next year.

Results

In 1981–1990, most rabbits occurred in Sudety foothills. Larger concentrations were recorded in SE Legnica HR, W Legnica HR, SW Wrocław HR, SW Opole HR. In 2001–2010, at least 20 rabbits were recorded in ten hunting regions (including six in Opole HR), while there were nine such hunting districts (including three in Opole HR) in 2011–2020. The rabbit was virtually absent in the southern part of Opole HR and in Jelenia Góra HR. Larger concentrations were

found near Wołczyn, Żmigród, Strzegom, and SW part of Legnica HR. Smaller concentrations were recorded near Bierutów, Środa Śląska and Polkowice (Fig. 3, 5).



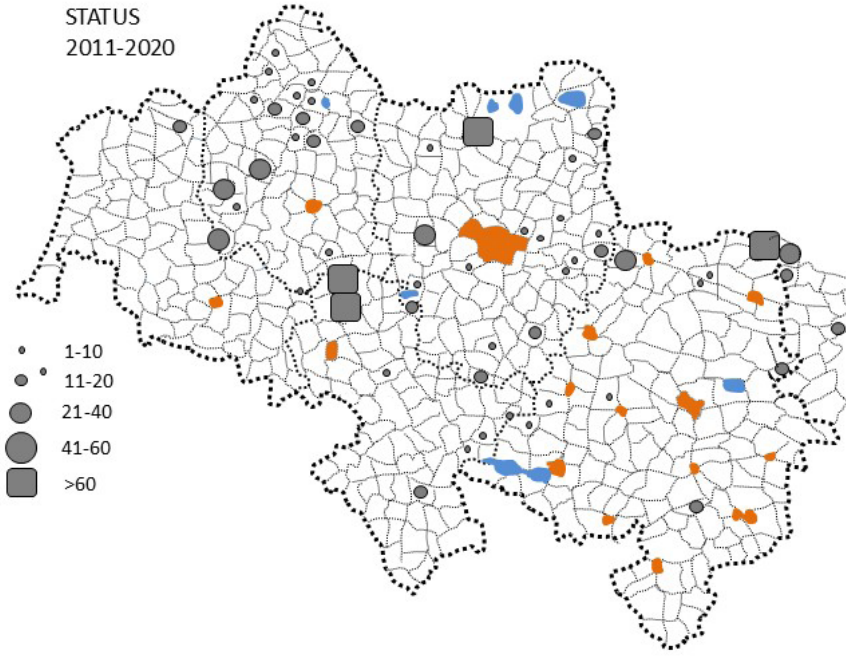
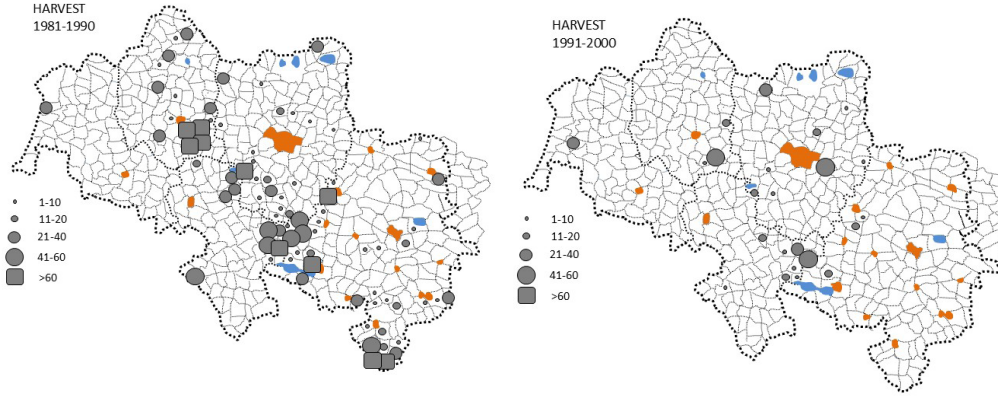


Fig. 3: Estimated mean numbers of the rabbit in particular hunting districts in SW Poland during the years 1981–2000, 2001–2010 and 2011–2020.

In 1981–1990, the rabbit was harvested in larger numbers (>100 individuals) mainly in Sudety foothills, i.e. in SE Głubczyce Plateau, Strzelińskie-Niemczańskie Hills and Strzegomskie Hills. In 1991-2000, there were only 3 areas, with 41-60 individuals harvested: Strzelińsko-Nieczańskie Hills, Strzegomskie Hills, and Odra Valley between Wrocław and Oława. In 2001–2020, only few rabbits were harvested in only 5 hunting districts in Legnica HR (Fig. 4, 5).



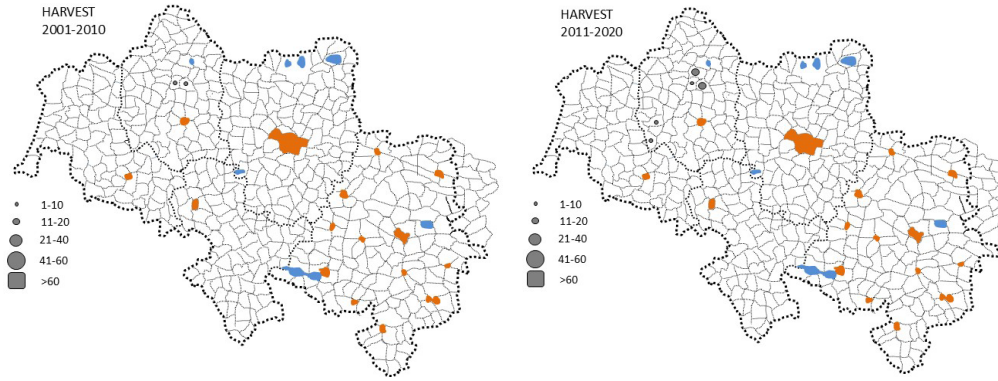
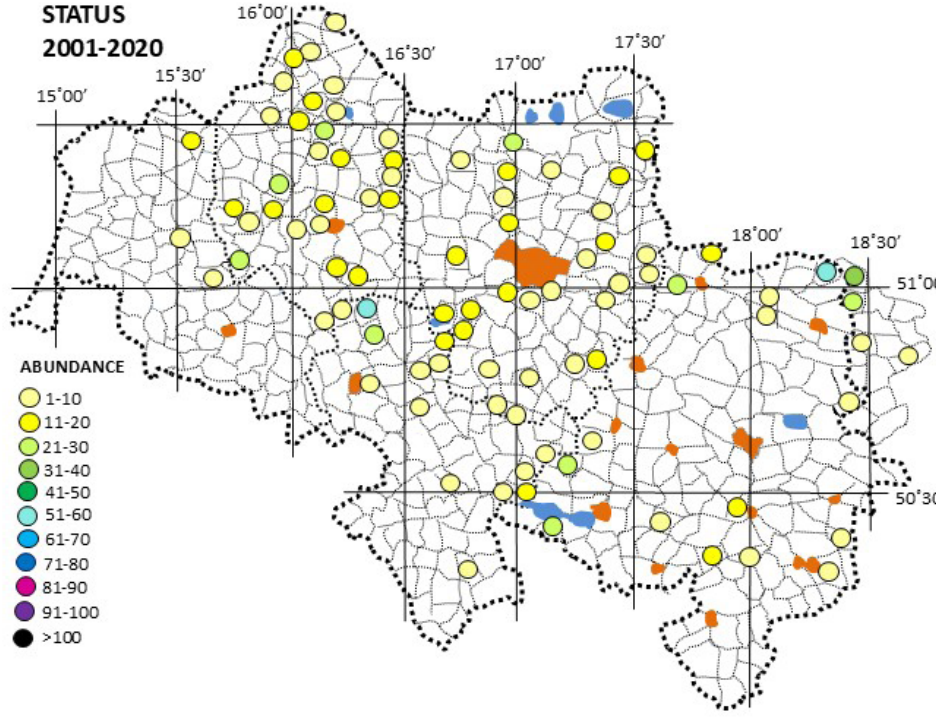


Fig. 4: The number of harvested rabbit in particular hunting districts in SW Poland during the years 1981–2000, 2001–2010 and 2011–2020.



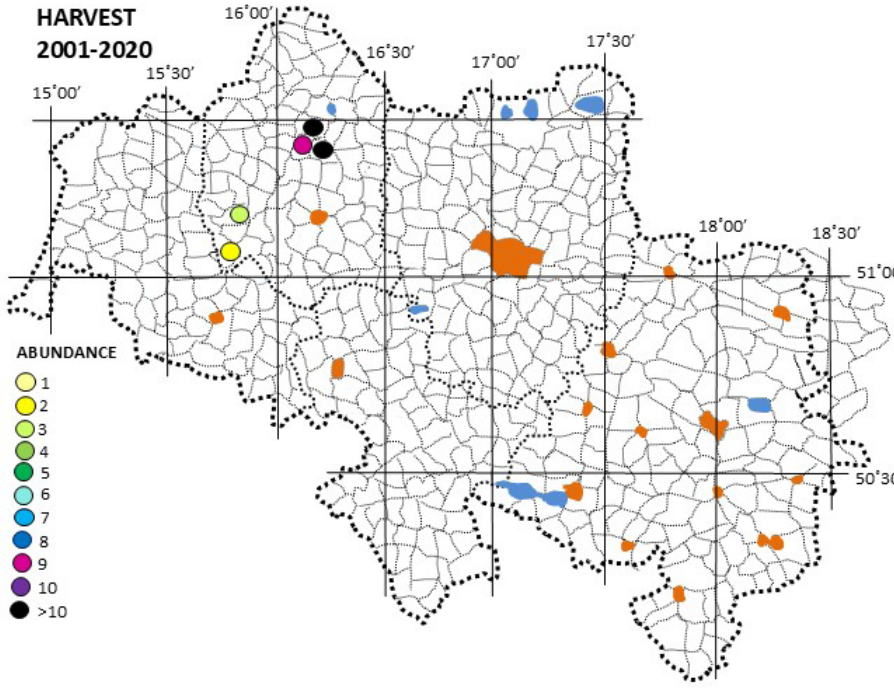
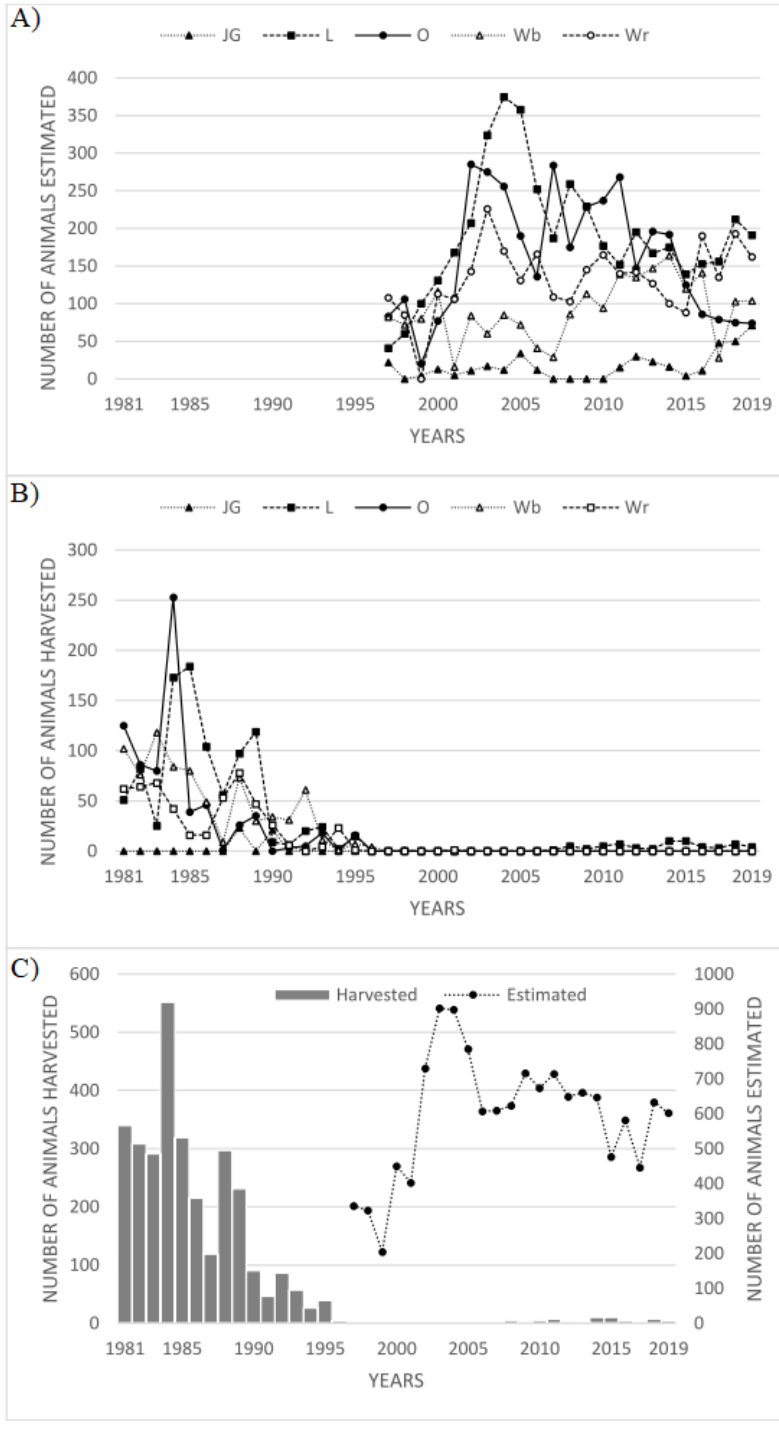


Fig. 5: An overall abundance, population trends and number of harvested the rabbit in particular hunting districts in SW Poland during the years 2001–2020.

During the years 1999–2003, a rapid increase in the numbers of the rabbit took place in SW Poland, reaching a maximum of c. 900 individuals in 2003–2004. However, in the two consecutive years (2005–2006), the numbers rapidly decreased to c. 600, and then levelled off at around 600–700 individuals until 2020. In Opole HR, the harvesting continued to decline between 2007 and 2020, while in Wałbrzych HR it is in an increase since 2015 onwards (Graph 1).

Discussion



Graph 1: Changes in the number of estimated (A) and harvested (B) rabbit in particular hunting regions (JG – Jelenia Góra, L – Legnica, Wb – Wałbrzych, Wr – Wrocław) and in the whole SW Poland (C) during the years 1981–2020.

The rabbit was kept in Poland as a domestic animal since 12th century (Nowak 1968). Although it had escaped into wild on many occasions, it could not develop a viable population under Polish climatic conditions (Nowak 1968). In SW Poland it was absent in the wild up to about 1860 (Schwenkfeld 1603, Börner 1781, Kaluza 1815, Gloger 1833, Pax 1925), but as a result of introductions it soon became locally a common species at the end of the 19th century; 102 608 individuals (255 ind./100 km^2) were harvested in 1885/1886 hunting season in this region (Pax 1925). In Opole HR it was first recorded in 1911–1920, while in Wałbrzych HR – in 1941–1950. In 1925/1926 it was still absent in the Sudety Mts., Silesian Hills and in the central, E and NE Opole Silesia (Nowak 1968). The number of harvested rabbits in whole Silesia was 127 060 (392 individuals/100 km^2) in 1935/1936, 263 472 (746) in 1936/1937, 260 084 (737) in 1937/1938, 183 598 (521) in 1938/1939, and 132 337 (375) in 1939/1940 (Nowak 1968).

In 1963, in Opole province, the rabbit did not occur in southern, central, eastern and NE parts, but it was common in NW and in the vicinity of Opole, Lewin Brzeski, Nysa and Strzelce Opolskie (Nowak 1968). Only 225 rabbits (2.6 individuals/100 km^2) were harvested in this province in 1965-1969 (Kopij 1996). In Dolnośląskie province, the rabbit was common around Wrocław, Środa Śląska, Oława and Zgorzelec, and absent in Sudety Mts. (Nowak 1968). In the 1950's numerous cases of myxomatosis were reported from Opole HR. In Namysłów, Zdzieszowice, Dobra, and Gręboszyce forest inspectorates the myxomatosis cases were reported as being common. However, in those years myxomatosis was not recorded at all in Dolnośląskie province (Nowak 1968).

A similar population development took place in the neighbouring Czech Republic. The rabbit was introduced there also in the second half of 19th century, and in the mid-1920's, it already became a widespread and common species. Its numbers, however, markedly decreased soon after due to the outbreak of myxomatosis. The negative trend continued up to 2005, being especially acute after 1990 (Andera & Červeny 2008). So, while in 1880 11 824 rabbits were harvested, in 1910 as many as 112 132, and in 1928 – 70 385, in 1974 – c. 80 000, in 1992 – c. 5 000, and after 2000 the annual bags were less than 150. Also atlasing conducted in the Czech Republic in three different periods shows the same declining trend: 1973–1975: it was recorded in 512 (81.5% of all grids) atlas grids, in 1991–1992 – 443 (70.5%), and 189 (31.0%) in 2005–2006. In the Ukraine, the rabbit was introduced in 1882. After exponential growth during the 1960's and 1970's (reaching a maximum of c. 25 000 in Crimea and c. 17 000 individuals in the other parts of the country), they have rapidly declined in the 1980's and 1990's, and finally were extirpated by the year 2000 from most of the country, except for the Odessa vicinity (Zagorodniuk 2023). Also in the Netherlands and Germany, the rabbit numbers continuously decreased during the years 1980–2000, but began to slowly recover after this period (Rödel & Dekker 2012).

The main reason for the decline over the last three decades is the rabbit haemorrhagic disease (RHD) introduced with domestic rabbits in Europe in 1984. It is a highly contiguous, very fast spreading and vicious diseases (Abrantes et al. 2012). Other factors playing a role in this regard are habitat deterioration, high rainfall, severe winters (e.g. after 1928/1929 and 1939/1940 severe winters the population sharply decreased in Silesia and other parts of Poland), diseases, predators, and competitors.

The rabbit prefers sandy and dry open places in a close proximity to forest (especially young pine plantations), hedgerows, wood piles. There is substantial site-to-site and year-to-year variations in habitat preferences. Several factors influence these variations, such as soil

structure, dryness and patchiness of soil, ground water level; rainfall in late winter, altitude, woodland/open land edge length, predators removal policy, myxomatosis, and number of rainy days (Trout et al. 2000). The number of European rabbits shot is lower in years with high precipitation in spring of the respective year (on the other hand, the number of European hares shot was lower in years with higher amounts of precipitation during late summer/autumn). Rabbit numbers are also limited by low temperatures of the prior winter season, but only when precipitation was high during spring of the previous year (Rödel & Dekker 2012). Population modelling aimed to control efficiently rabbit population requires measuring of all these factors.

Hares and rabbits have very similar diet and there is a high habitat and food overlap. Both species feed mostly (50-100% of their diet) on grass, with special preferences to wheat. However the rabbit is resident and living in colonies (clumped distribution), the hare is a nomad with a sparse distribution. Apparently the competition between these two species is low (Chapuin 1990, Katone et al. 2004, Santilli et al. 2015). They exploit different microhabitats within the same habitat; while the rabbit prefers open places such as uncultivated fields and permanent crops, in a close proximity to hedges, or woods; the hare lives in arable fields (crops), often far from permanent vegetation cover (Santilli et al. 2015). In Hungary, after the disappearance of the rabbit, the hare did not recover (Katona et al. 2004), which indicates no competition between these species.

In the case of predators (in SW Poland, mainly fox *Vulpes vulpes*, occasionally polecat *Mustela putorius* and birds of prey), the cause and the effect cannot be often disentangled. In such situation, it is unclear whether higher rabbit numbers lead to more predation, or the removal of predators leads to higher number of rabbits.

Introductions of rabbits far away from their native range of the Western Mediterranean area are in most cases detrimental to the environment. Rabbits may facilitate meso-predators release and hyper-predation, overgrazing, and food competition with native mammals. On another hand, introductions to countries close to the rabbit's native range may not only cause any damage to the ecosystem, but may improve its functioning, disturbed by habitat degradation, pollution and fragmentation. Introductions to such ecosystems, should be however carefully planned and monitored. A good example of such situation conducive to environment are the British Islands. Considering Poland and other countries in Central and SE Europe, animals from British Islands should be released if introductions are planned, as being resistant to myxomatosis and better adapted to temperate climate. Numbers of introduced animals should be closely monitored and population densities kept on a level not detrimental to ecosystem functioning.

About 1500 rabbits are introduced each year in various parts of Poland (Krajewski & Sadowski 2013). Most of them originate from two breeding centres, viz. Czempiń and Czelin. In SW Poland, only one hunting club (Kluczbork Forest Inspectorate) is known to breed rabbits for the introduction (Brachmański 2013). Unfortunately, these introductions are inefficient in most cases, as rabbits are released directly into field. After such release, without prior acclimatization / habituation they suffer high mortality. It is recommended, therefore, to keep rabbits (male and 4-5 females) in small cages (c. 40 m^2) with artificial dens, food, salt, water and anticoccidial drugs (e.g. lasalocid Avatec, maduramycin Cygro, or robenidine Cycostat). Cages should be constructed amidst habitat suitable for the species (sandy open fields bordering with low shrubs and trees, abundant of food and with low density of predators) and in such a way that they can slowly deliver themselves by digging underground tunnels (Krajewski & Sadowski 2013).

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