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The Mallard *Anas platyrhynchos* in Slovenia: a review with an estimation of its current population

Mlakarica *Anas platyrhynhos* v Sloveniji: pregled z oceno trenutne populacije

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Although the Mallard is one of the most numerous and best-studied waterbirds in the world, it received almost no attention in Slovenia. It is one of the most frequently observed waterbirds in our country, with frequency often reaching 100%. Sites with lower frequency either freeze in winter or have a low number of individuals to start with. The Mallard is also the most dominant species (17.5% and 89.0%) with higher dominance at sites less suitable for waterbirds due to the lack of available shoals. Mallards reach their maximum numbers during fall migration and winter. Spring migration has no discernible peak and has been significant only for Lake Cerknica. On shallow waters, the maximum is reached in August and September, a month before fall migration begins, indicating local movement to food-rich sites. Females make up only 36.7% of the observed Mallards and reach the maximum proportion (41.5%) in winter and the lowest in April and May (14.7%), when they nest. The breeding season in Slovenia lasts from mid-January to early December, with the majority of females rearing broods from April to July. Average brood size is 6.2 ± 2.66 and declines with season, age of young and altitude. It varies between habitat types and is highest on Treatment and Coastal Wetlands (7.3) and lowest on deep waters such as Reservoirs (5.7) and Lakes (5.6). No really high breeding densities were found in Slovenia and were similar to those in other countries. Breeding densities are higher on smaller Ponds (< 8 ha), on sites with isolated islands and breeding colonies of gulls and terns (e.g. Lake Ptuj). Breeding density also decreases with elevation. Slovenian breeding population is estimated at 1,473–3,763 bp and wintering population averages 22,237 (10,376–32,010) individuals. Data suggest a decline in the wintering population most likely due to warmer winters. The majority of Mallards winter in NE Slovenia, where eight of eleven sites have a maximum of more than 1,000 Mallards. Most Mallards winter on the Drava river with Ptuj and Ormož lakes, where the highest numbers of Mallards were also recorded (Lake Ptuj: 8,330 ind., Lake Ormož: 5,400 ind.). The highest number of individuals during spring migration was recorded on Lake Cerknica (4,581) and during autumn migration on Medvedce reservoir (3,379). Apart from standing waters, the highest density of wintering Mallards is found in urban sections of slow-flowing rivers, probably due to higher safety and food availability.

72,731 Mallards were hunted between 2001 and 2018, mainly in NE Slovenia (28% in the Pomursko hunting management district). The number of Mallards hunted is declining in all hunting areas and has declined by 64% since 2001 and even more since the 1990s. According to hunt data, hunting is by far the most important cause of the Mallard mortality in Slovenia (97.4%), followed by predation (1.1%). The Mallard mortality in Slovenia is largely unstudied and natural mortality is most likely underestimated, not only because it does not include mortality in the pre-fledging period, a period with the lowest survival, but also because the detectability of natural mortality is considerably lower. In contrast to the hunted numbers, there have been only nine recoveries of ringed individuals from abroad in the last 100 years, suggesting that hunters may not be reporting recoveries to the ringing centre. Apart from the 1972–1975 period, when 87% of Mallards were ringed, the intensity of ringing of Mallards in Slovenia is low, resulting in only seven Mallards recovered abroad. The longest distance of a Mallard ringed in Slovenia comes from Ukraine (1,290 km), while the longest distance between ringing and recovery sites is 2,075 km from an individual ringed in Finland. The only colour morphs documented in Slovenia are Mallards with paler feathers, attributed to one of the colour aberrations resulting from lower melanin productivity. Only few hybrids and mixed pairings with other wild duck species were observed.

Keywords: Mallard *Anas platyrhynchos*, Slovenia, population, breeding biology.
Ključne besede: mlakarica *Anas platyrhynchos*, Slovenija, populacija, gnezditvena biologija

1. Introduction

Waterfowl Anatidae are a diverse and often ecologically important group of birds. They contain some of the most important hunting species (Cotter *et al.* 1996, Dalby *et al.* 2013, McDougall & Amundson 2017) and can transmit diseases to domestic animals (Slemons *et al.* 1991). On the other hand, they can be a proxy for the state of a wetland (Kreakie *et al.* 2015) and can be used to test for the presence of toxins in the environment (Lumeij *et al.* 1989, Plessl *et al.* 2017). They are an important vector for the dispersal of seeds of aquatic plants (Kleyheeg *et al.* 2016, Kleyheeg *et al.* 2019) and nutrients (Post *et al.* 1998), making them a relevant part of wetland ecology.

The Mallard *Anas platyrhynchos* is the most widespread and numerous waterfowl species across most of the Northern hemisphere and by far the most numerous species of dabbling duck (Delany & Scott 2006). It is distributed over much of Eurasia and North America with small and isolated populations in northern Africa. It has been introduced to Australia and New Zealand, but also to South Africa and Mauritius (Drilling *et al.* 2020). It is found in almost all wetlands throughout Europe (BirdLife International 2020), but reaches highest breeding densities in the lowlands of Western Europe, especially in the Netherlands (Keller *et al.* 2020).

Owing to its wide distribution, adaptability, and large numbers, it is a good candidate for various environmental studies. Indeed, it is one of the most studied waterbirds with many studies on urban (Figley & van Druff 1982, Engel *et al.* 1988, Avilova 2018) and feeding ecology (Jorde *et al.* 1983), daily (Shin *et al.* 2016, Yetter *et al.* 2018) and migratory movements (Krementz *et al.* 2011,

Kang *et al.* 2014), inter- and intraspecific interactions (Marchowski & Neubauer 2019), toxicology (Friend & Trainer 1974, Plessl *et al.* 2017), virology (Wille *et al.* 2018), endocrinology (Haase 1983), physiology (Gatti 2011, Söderquist *et al.* 2014), phenology (Grishchenko 1997), population dynamics (Janke *et al.* 2017), population regulation (Hill 1984), seed dispersal (Kleyheeg *et al.* 2019), and habitat use (Link *et al.* 2011). Many aspects of breeding have also been studied, such as habitat selection (Fan *et al.* 2017), site fidelity (Clark *et al.* 2005), hybridisation (Sheppard 2018), productivity (Singer *et al.* 2016, Garrick *et al.* 2017), duckling survival (Titman & Lowther 1975, Krapu *et al.* 2006), population recruitment (Kaminski & Gluesing 1987), second (Olsen *et al.* 2003) and replacement broods (Arnold *et al.* 2010), brood size (Zicus *et al.* 2003), adult survival (Boyer *et al.* 2018), brood parasitism (Talent *et al.* 1981) and breeding ecology at the edge of the species' range (Fouzari *et al.* 2018). It has been used as a model species for testing new research methods such as census technics with the use of drones, radiotelemetry and modelling of a disease spread (Stafford & Pearse 2007, Pöysä *et al.* 2018, van Toor *et al.* 2018).

In Slovenia, the Mallard is the most numerous waterbird both during winter (Sovinc 1994) and breeding periods (Mihelič *et al.* 2019). It was present in Slovenia already in the prehistoric times (Janžekovič *et al.* 2004) and was the most numerous waterbird also in the second half of the 19th and early 20th centuries (Reiser 1925). It was especially numerous in winter (Schiavuzzi 1883) when it was hunted (Schulz 1890). In Slovenia, no studies focusing on the Mallard have been conducted so far. It has been only part of broader studies of local or regional avifauna (i.e. Tome *et al.* 2005, Bordjan & Božič 2009, Bordjan 2012, Tome *et al.* 2013). It has also been included in the national January waterbird census, carried out annually since 1997 (Štumberger 1997, Štumberger 1999, Štumberger 2000, Štumberger 2002a, Štumberger 2002b, Božič 2005, Štumberger 2005, Božič 2006, Božič 2007c, Božič 2008c, Božič 2008d, Božič 2008a, Božič 2010, Božič 2011, Božič 2012, Božič 2013, Božič 2014, Božič 2015, Božič 2016, Božič 2017, Božič 2018, Božič 2019, Božič 2020). In the 40 volumes of the Acrocephalus journal (regional ornithological journal) there is not a single paper specifically devoted to this species, except for few short notes on the occurrence of leucistic individual (Kmecl & Rižner 1992), forceful copulation attempts by several males (Bačani 1999), mixed species pairing (Sovinc 2014) and a report on new maximum numbers for a monitored site (Bordjan 2012a). As breeding distribution was recently published (Bordjan 2019), the aim of this paper was to summarize the available knowledge on phenology, dominance, frequency, breeding estimates, densities and trend, brood size and habitat type, colour morphs, hybrids and escapees, causes of mortality and hunting activity, ringing records and non-breeding numbers of the Mallard in Slovenia.

2. Methods

2.1. Data sources

Data from the following available sources were used in the analysis: (1) ongoing and former waterbird monitoring schemes, listed here with the years of monitoring data used: Sečovlje Salina Landscape Park (KPSS) 1983–2019 (Škornik 2012, I. Škornik *pers. comm.*), Škocjanski zatok Nature Reserve (NRŠZ) 2001–2019 (B. Mozetič & D. Stanič *pers. comm.*), Medvedce reservoir 2002–2019 (Bordjan & Božič 2009b, *own. data*), Ormož Basins Nature Reserve 2007–2019, Ptuj and Ormož lakes 2009–2019 (L. Božič *pers. comm.*), Požeg reservoir 2011–2019 (*own. data*), Rački ribniki 2011–2019 (*own. data*), Lake Cerknica 2007–2011 (Bordjan 2012b, M. Cvetko & A. Škoberne *pers. comm.*, o*wn data*), Vrbje fishpond 1993–1998 and 2009–2011 (Vogrin 1996, Vogrin 2004, Gamser & Novak 2013), Gradiško Lake 2012–2013 (*own. data*), Šaleška lakes 2014–2015 (Gregori & Šere 2005, Deberšek & Bordjan 2016); (2) data from January wintering census (IWC) annual reports (Štumberger 1997, Štumberger 1999, Štumberger 2000, Štumberger 2002a, Štumberger 2002b, Božič 2005, Štumberger 2005, Božič 2006, Božič 2007c, Božič 2008c, Božič 2008d, Božič 2010, Božič 2011, Božič 2012, Božič 2013, Božič 2014, Božič 2015, Božič 2016, Božič 2017, Božič 2018, Božič 2019, Božič 2020), as well as data on domestic form of Mallards that is collected during

IWC counts since 2011; (3) all published data on Mallards from journals (Acrocephalus (ISSN 0351-2851, Vol. 1–40), Biota (ISSN 1580-4208, 5–9), Svet ptic (ISSN 1580-3600, 6–26), Scopolia (ISSN 0351-0077, 1–98), Falco (ISSN 1318-5411, 9–13/14), Annales (ISSN 1408-533X, 0353-8281, 1–29), Natura Sloveniae (ISSN 1580-0814, 1–21), Varstvo narave (ISSN 0506-4252, 1–31)), monographs (Polak 2000, Božič 2003, Gregori & Šere 2005, Tome *et al.* 2005, Škornik 2012, Tome *et al.* 2013, Denac & Kmecl 2014) and various reports (Jančar 1997, Tome 2000, Mihelič 2005, Božič 2007a, b, 2008b, Denac & Smole 2008, Figelj & Kmecl 2009, Denac 2010, Denac *et al.* 2011, Kmecl 2017, Tome *et al.* 2011, Kmecl & Figelj 2011, 2012, 2013, 2015, 2016, Kmecl *et al.* 2014, Kmecl & Šumrada 2018, Kmecl 2019, Kmecl *et al.* 2019); (4) data on the Mallard broods from the online database (DOPPS 2022) up to 2019; (5) data on the Mallard broods on the Internet, mainly from the online forum Foto narava (2022). Photos with known location and/or date photographed in Slovenia were selected; (6) data on high numbers, breeding density and observation of broods directly from observers, including data on location, date and size of broods; (7) data on the Mallard mortality in Slovenia from the online database OSLIS of the Slovenian Forestry Institute (GIS 2022), which was developed to present official data on hunting and from 10-year hunting management plans (ZGS 2012a, b, c, d, f, g, h, i, e, j, k, l, m, n, o); (8) data on ringed Mallards and foreign or domestic recoveries either published or available at Slovenian Ringing Centre (SCOP). For local recoveries, this means a period from 2013 to 2018 for which data are accessible and available.

Data on monthly spring temperatures were gathered from the Slovenian Environment Agency (ARSO 2022a).

2.2. Brood age

Each observed brood was classified into one of five groups. All observed clutches in nests were placed in the first group called "Eggs". All ducklings of known approximate age were placed in an appropriate class I, II or III according to Gollop & Marshal (1954). Class I includes all broods with ducklings aged 1–18 days with no sign of feathers. It also includes broods described in data sources as "very small," "less than a week old," or "only a few days old". Class II includes ducklings 19–45 days old with both down and feathers. Class III includes fully feathered ducklings aged 46–60 days just before independence. Descriptive names for these three classes are used throughout the remainder of this text: Downy, Partially feathered and Feathered, respectively. Broods whose ages were not known or could not be classified were referred to as Ducklings. All broods with 14 or more ducklings were not used in calculating average brood size due to the high likelihood of brood parasitism (Cotter *et al.* 1996, Seabrook-Davison 2014, Drilling *et al.* 2020).

2.3. Breeding season calculation

The duration of breeding from nest-building to independence for an individual brood was calculated depending on the observed age class. Mallards take an average of 3 (1–6) days from nest completion to the start of egg laying. They typically lay one egg per day and incubate for an average of 28 (23–30) days (Drilling *et al.* 2020). For all broods observed outside the nest, an average number of 9 eggs (Drilling *et al.* 2020) and an average duration of incubation were assumed. Other classes last as follows: I. 18 days, II. 27 days, III. 15 days (after Gollop & Marshal 1954). Since the exact age of broods was unknown, they were standardized at the centre of the corresponding (observed) period. A more conservative approach was used for broods with the unknown age class. For calculating the onset of breeding, Ducklings were treated as Downy, since feathered ducklings are rarely recognized as ducklings by observers. On the other hand, for the end of breeding Ducklings were treated as Partially feathered. Simplified formulas are used here to calculate the duration of breeding period from nest building to fledging for observed broods:

Eggs
Observation date (Obs. date) – (3 days from nest building to egg laying + Number of eggs + 14 days (half of the average incubation period))

Downy
Obs. date – (3 days + Number of ducklings + 28 days of incubation period + 9 days (half of downy period))

Partially feathered
Obs. date – (3 days + Number of ducklings + 28 days + 18 days +13 days (half of Partially feathered period))

Feathered
Obs. date – (3 days + Number of ducklings + 28 days + 18 days +27 days + 7days (half of feathered period))

Duckling
Obs. date – (3 days + Number of ducklings + 28 days + 9 days (As for Downy))

The end of breeding period was calculated by adding the estimated periods for individual classes as follows:

Eggs
Obs. date + 7 days (one fourth of the incubation period) + 18 days + 27 days +15 days

Downy
Obs. date + 9 days (half of downy period) + 27 days + 15 days

Partially feathered
Obs. date + 14 days (half of Partially feathered period) + 15 days

Feathered
Obs. date + 7 days (half of feathered period)

Duckling
Obs. date +14 days + 15 days (As for Partially feathered)

Breeding periods calculated from individual observations were summed and the proportion of all probable breeding attempts was calculated for each day.

2.4. Frequency and dominance

Frequency is defined as the percentage of specific periods when Mallards were recorded at specific monitored sites. Dominance is the percentage of Mallards compared to the total number of all waterbirds recorded (Bordjan & Božič 2009b). Some studies also include birds of prey (e.g. Bordjan 2012b). For such studies, I calculated dominance to include only waterbirds according to Božič (2020).

2.5. Phenology

For the presentation of annual dynamics of the Mallard individuals, broods and temporal dynamics of females, the year was divided into ten-day periods according to Bordjan & Božič (2009a). Data from sites with multiple-year monitoring were averaged across years for each ten-day period. To compare the phenology between study sites with markedly different numbers of Mallards, a relative abundance was used, i.e., the percentage of the annual Mallard total in a single ten-day period. The more even the yearly distribution of Mallards, the lower the maximum percentage in ten-day periods. Phenological periods were used according to Bordjan & Božič (2009a).

2.6. Wetland types

The Ramsar Classification System for Wetland Types (Ramsar Convention Secretariat 2010) was used as the basis for classifying wetland types in the study. For Human-made wetlands category, the same classification as in Ramsar (Table 1) was used. For Inland wetlands, distinction between rivers with an average annual discharge of more than 50 m^3/s, including the Drava, Mura and Sava river from Radovljica downstream, the Kolpa, Krka and Ljubljanica rivers (ARSO 2022b), and those with lower discharge was made. Permanent freshwater wetlands and Seasonal/intermittent freshwater wetlands were grouped into one category each (Table 1). All wetlands on or in the vicinity of coast, natural or man-made (e.g., Salt exploitation sites), were considered as Marine/Coastal wetlands and were not further divided.

2.7. Breeding population estimate

All available data on breeding densities or population size estimates of the Mallard in Slovenia were gathered. The former was divided into breeding densities and ecological breeding densities, separated by Ramsar wetland types (Table 1). For

larger geographical areas (e.g., Ljubljansko barje), breeding densities from literature were compared with estimated breeding densities calculated using different approaches. (1) Where raw data was available, i.e. the number of Mallards counted in a breeding period (22th Mar – 20th May, Bordjan & Božič 2009b), that number was multiplied by the average proportion of males in that period (from the count). As some females do not breed (e.g., approximately 9% of females in New Zealand Sheppard 2018), 10% was subtracted from the number of pairs calculated. (2) Another approach was to estimate the number of breeding pairs from ecological densities for each wetland type in selected areas (from habitat type). (3). In addition, the breeding population for Goričko was estimated

Table 1: Wetland type classification used in this study. First two columns are from the Ramsar Classification System for Wetland Type (RAMSAR CONVENTION SECRETARIAT 2010).

Tabela 1: Uporabljena klasifikacija tipov mokrišč. Prva dva stolpca sta povzeta po Ramsarskem sistemu klasifikacije tipov mokrišč (RAMSAR CONVENTION SECRETARIAT 2010).

Wetland type / Tip mokrišča	Wetland subtype / Podtip mokrišča	Named in this study / Poimenovano v tem delu
Human-made wetlands / Antropogena mokrišča	Aquaculture ponds / ribogojnice	Aquaculture / ribogojnice
	Canals and drainage channels, ditches / kanali, izsuševalni kanali in jarki	Canals / kanali
	Excavations / gramoznice, glinokopi, rudniški bazeni	Excavations / izkopi
	Ponds (less than 8 ha) / manjši zadrževalniki (< 8 ha)	Ponds / ribniki
	Wastewater treatment areas / sanitarna močvirja, usedalniki ipd.	Treatment / čistilne naprave
	Water storage areas (more than 8 ha) / rezervoarji, akumulacijska jezera	Reservoirs / zadrževalniki
Inland wetlands / Celinska mokrišča	Permanent freshwater marshes/pools / stalna sladkovodna močvirja, jezera, manjša od 8 ha	Lakes (Pools if smaller than 8ha) / jezera (jezerca, če manjša od 8ha)
	Permanent freshwater lakes / stalna sladkovodna jezera (> 8 ha)	
	Permanent rivers/streams/creeks* / stalne reke/potoki	Large river (more than 50 m^3/s) / velike reke (več kot 50 m^3/s)
		Small river (less than 50 m^3/s) male reke (manj kot 50 m^3/s)
	Seasonal/intermittent freshwater lakes / sezonska/občasna sladkovodna jezera	Intermittent / presihajoča jezera
	Seasonal/intermittent freshwater marshes/pools on inorganic soils / sezonska/občasna sladkovodna močvirja/mlake	
Marine/Coastal Wetlands / Obalna morkišča	Salt exploitation sites** / soline	Coast / obala
	Coastal freshwater lagoons / obalne brakične/slane lagune	
	Permanent shallow marine waters / trajno plitve morske vode	
Unknown / Neznano	Unknown / neznano	Unknown / neznano

* Ramsar does not differentiate rivers on the basis of discharge. / Ramsar ne razlikuje rek po njihovem pretoku.
** Ramsar places it as a human-made wetland. / Ramsar jih uvršča med antropogena mokrišča.

from data gathered during the survey of birds in Landscape Park (Denac & Kmecl 2014) and data from the Slovenian Bird Atlas database (estimate).

Two approaches were used to calculate the Slovenian breeding population of the Mallard. (1) All known breeding populations and those estimated in this paper using different approaches were summarized (Appendix 1) and extrapolated to the rest of Slovenia (1,821,350 ha). As there are almost no permanent water sources in many areas in Slovenia (Perko & Oražen Adamič 1998), different geographical regions were divided into three categories according to the percentage of wetland cover: more than 2%, 1–2% and less than 1% of wetland cover (Table 2). (2) Ecological densities for different wetland types were used (Table 1, Appendix 2) and extrapolated to the area size of the corresponding wetland types in Slovenia (areas with known population size were excluded) and summed with known populations. Some wetland types (e.g., torrents, fast-flowing streams...) are unsuitable for breeding Mallards and were assigned a population size of zero breeding pairs. For habitats with lacking corresponding breeding density (canals, mire, etc....), the most similar habitat type was used.

2.8. Non-breeding population

For the IWC, Slovenia is divided into eight count areas, in turn subdivided into count units (whole or large parts of rivers and meaningful geographical units such as Dravsko and Ptujsko polje), which are further divided into river sections and localities (smaller rivers, standing waters and larger areas such as Radensko polje) (Božič 2005). For the calculation of wintering densities, river sections with large dams were considered standing waters and presented in a figure as localities. Number of individuals during a non-breeding period (Appendix 3) is presented based on a maximum for a site if it is greater than 100 individuals.

2.9. Statistics

For statistical analysis, the program R (R Core Team 2017) was used. To estimate trends from IWC data for wintering Mallards in Slovenia, annual and seasonal sum of Mallards at monitoring sites (wintering, summering, spring and autumn migration), breeding population at selected sites and number of Mallards hunted, package rtrim was used, which estimates species

Table 2: Slovenian regions (Perko & Oražen Adamič 1998) sorted by wetland coverage.

Tabela 2: Slovenske regije (Perko & Oražen Adamič 1998) ločene po deležu pokritosti z mokrišči.

More than 2% of region is covered by wetlands / Več kot 2% regije je pokrito z mokrišči	1-2% of region is covered by wetlands / 1-2% regije je pokrito z mokrišči	less than 1% of region is covered by wetlands / Manj kot 1% regije je pokrito z mokrišči
Dravska ravan*, Koprska brda*, Krška ravan*, Murska raven*, Ribniško-Kočevsko podolje, Savinjska ravan, Savska ravan, Velenjsko and Konjiško hribovje, Ljubljansko barje*, Dravinjske gorice	Novomeščanska pokrajina, Julijske Alpe*, Notranjsko podolje, Strojna, Kozjak and Pohorje, Slovenske gorice, Goriška Brda, Ložniško and Hudinjsko gričevje, Voglajnsko and Zgornjesoteljsko gričevje, Krško, Senovsko and Bizeljsko gričevje, Bela krajina, Kambreško and Banjšice, Vipavska dolina, Idrijsko hribovje, Brkini and dolina Reke*, Posavsko hribovje, Srednjesotelsko gričevje*, Haloze	Pivško podolje and Vremščica, Dolenjsko podolje, Velikolaščanska pokrajina, Goričko*, Kamniško-Savinjske Alpe, Cerkljansko, Škofjeloško, Polhograjsko and Rovtarsko, Velika gora, Stojna and Goteniška gora, Zahodne Karavanke, Krimsko hribovje and Menešija, Suha Krajina and Dobrepolje, Bloke, Vzhodne Karavanke, Gorjanci, Raduljsko hribovje, Mala gora, Kočevski rog and Poljanska gora, Trnovski gozd, Nanos and Hrušica, Boč and Macelj, Kras, Javorniki and Snežnik, Lendavske gorice, Podgorski Kras, Čičarija and Podgrajsko podolje

* Regions partly or completely covered by available data on breeding population of Mallards / Regije, ki so delno ali v celoti pokrite z znanimi ocenami populacij mlakarice

populations based on frequent (annual) counts at a varying collection of sites (Bogaart *et al.* 2020). For estimating wintering population trends, the periods 1999–2019 (Drava river) and 2000–2019 (Entire Slovenia) was used. For breeding population trends, monitoring sites with available estimated annual breeding population were used. For figures, the ggplot2 package (Wickham *et al.* 2020) was applied. For visual comparison of average brood size among years, months and wetland types, violin plots were created with a marker for the median of the data and a box indicating the interquartile range, as in a standard boxplot. Violin plots show the kernel probability density of the data at different values. Nonparametric Spearman's correlation (coefficient used in text r_s) was used (1) for analysis of annual trends in wintering Mallards on the Drava river and (2) for correlation between seasons and brood size. Parametric Pearson's correlation (r_p) was used (1) for the analysis of the relationship between monthly average temperatures, the sum of daily average temperatures in February, March and April and the annual onset of nesting, (2) between breeding density and elevation, (3) brood size and elevation. The nonparametric Kruskal-Wallis test (H) in R was used for (1) comparing brood size among different wetland types, (2) age groups and years, and (3) for comparing breeding densities among different wetland types. For spatial analysis and drawing of maps, ArcGis (ESRI 2015) was used.

3. Results

3.1. Dominance, frequency and phenology

The Mallard is a year-round species in Slovenia with frequency exceeding 70% at all monitored sites (Table 3). At eleven sites, the frequency was 100% and only in two cases the frequency was lower than 80%. It is often the most dominant species at a given site, with dominance ranging from 17.5% to 89.0% (Table 3). The average dominance for all sites is 46.4% and Mallard represents more than half of all waterbirds at seven sites.

In Slovenia, Mallards are most numerous in winter and early spring, from late December to early March, when numbers begin to decrease and reach a low point in late April and early May. Numbers increase from May to September and then fluctuate until December (Figure 1). There are large differences in phenology between studied sites (Table 4). In the Ormož Basins Nature Reserve, Mallards are mostly absent in winter. Shallow sites (Medvedce, Rački ribniki, Požeg, Ormož Basins Nature Reserve) reach maximum numbers during autumn migration, while deep reservoirs (Ptuj, Ormož and Gradiško lakes) reach maxima during winter. Mallards reach their maximum at the end of winter in February on Lake Cerknica and in late February and early March on Vrbje fishpond. The number of Mallards fluctuates on the deep lakes in Šaleška valley with a maximum in November and in late

Table 3: Frequency and dominance of Mallards *Anas platyrhynchos* at different sites

Tabela 3: Frekvenca in dominanca mlakarice *Anas platyrhynchos* na posameznih območjih

Location / Lokacija	Frequency [%] / Frekvenca [%]	Dominance [%] / Dominanca [%]	Source / Vir
Lake Bled (June-August)	100.0	89.0	Jančar *et al.* (2007)
Lake Bohinj (June-August)	100.0	88.0	Jančar *et al.* (2007)
Lake Bled (June-August)	100.0	81.0	Jančar *et al.* (2007)
Lake Pernica lower	100.0	84.5	Gregori (1989)
Lake Pernica upper	100.0	74.9	Gregori (1989)
Drava river in Maribor (Apr.-Sept.)	100.0	71.7	Logar & Božič (2014)

Continuation of Table 3 / Nadaljevanje tabele 3

Location / Lokacija	Frequency [%] / Frekvenca [%]	Dominance [%] / Dominanca [%]	Source / Vir
Lake Moste (December-January)	100.0	60.0	Jančar *et al.* (2007)
Lake Bohinj (December-January)	100.0	50.0	Jančar *et al.* (2007)
Drava river in Maribor	100.0	42.9	Logar (2009)
Lake Ormož	100.0	41.4	L. Božič *pers. comm.* / L. Božič *osebno*
Lake Moste (June-August)	100.0	39.0	Jančar *et al.* (2007)
Drava river in Maribor (Oct.-March)	100.0	38.6	Logar & Božič (2014)
Šaleška lakes	100.0	29.6	Deberšek & Bordjan (2016)
Medvedce reservoir 2010–2019	100.0	28.7	*Own data / lastni podatki*
Lake Cerknica	100.0	27.2	Bordjan (2012b)
Lake Ptuj	100.0	19.7	L. Božič *pers. comm.* / L. Božič *osebno*
Sečovlje salina nature park	100.0	4.9*	I. Škornik *pers. comm.* / I. Škornik *osebno*
Vrbje fishpond 2009–11	97.2	17.5	Gamser & Novak (2013)**
Rački ribniki	95.8	34.0	*Own data. / lastni podatki*
Lake Radehova	93.0	49.2	Gregori (1989)
Lake Komarnik	93.0	49.0	Gregori (1989)
Vrbje fishpond 1994–95	93.0	22.2	Vogrin (1996)
Požeg reservoir	92.2	50.2	*Own data. / lastni podatki*
Medvedce reservoir 2002–2009	92.0	31.9	Bordjan & Božič (2009a), *Own data. / lastni podatki*
Fishponds in Pesnica valley	89.0	74.2	Gregori (1989)
Žovnek reservoir	83.3	58.6	Vogrin (2005)
Lake Gradišče	81.0	65.3	Gregori (1989)
Lake Pristava	78.0	77.4	Gregori (1989)
Ormož Basins Nature Reserve 07–10	72.1	26.7	L. Božič *pers. comm.* / L. Božič *osebno*
Lakes Trboje and Zbilje	Present in all months	49.0	Trontelj (1992)
Nature reserve Škocjanski zatok	100.0% in most years		Škornik *et al.* (1990), D. Stanič *pers. comm.* / D. Stanič *osebno*
Ljubljana	Present year round		Tome *et al.* (2013)
Ljubljansko barje	Present year round		Tome *et al.* (2005)

* all bird species / vključuje vse vrste ptic
** source includes birds of prey / vir vključuje tudi ujede

December and early January. At most sites, the maximum percentage of Mallards in a ten-day period compared to the annual total is around 9%. Medvedce and Šaleška lakes have a lower maximum of 6% and 4%, respectively, while Lake Cerknica and Ormož Basins Nature Reserve have higher maximum of 13.8% and 12%, respectively (Table 5).

Females make up 36.7% of the Mallards counted at five monitoring sites (Figure 2). The proportion of females is lowest during the breeding season (14.7%) and highest in winter (43.9%). At the start of the breeding season in March, females make up 41.7% of the observed Mallards. The greatest percentage decline occurs in mid-April, when it drops to 26.1% and continues to decline until early May (Figure 2).

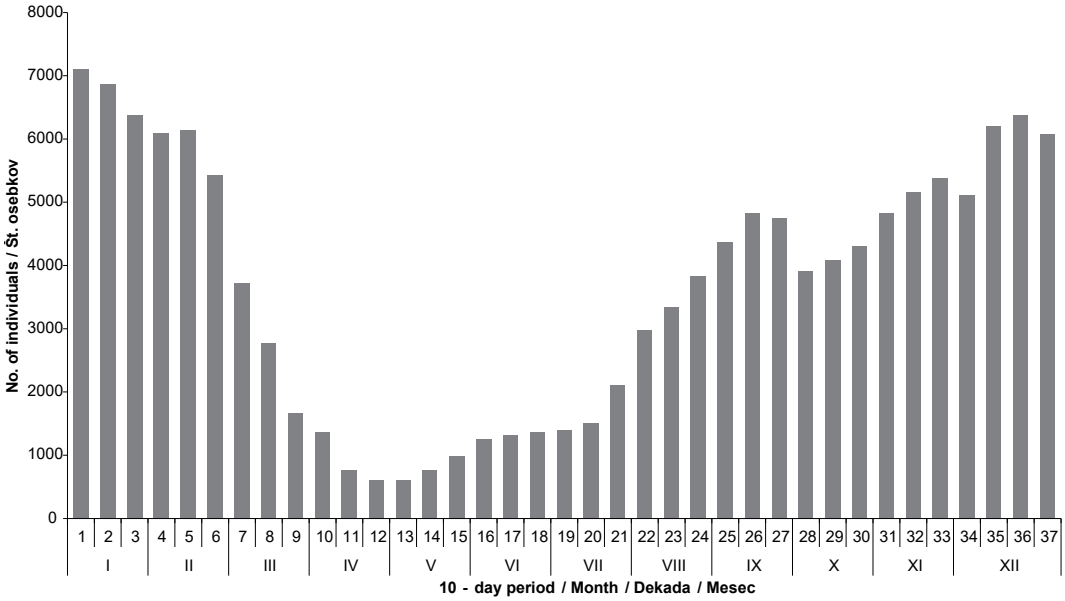


Figure 1: The sum of Mallards *Anas platyrhynchos* in a ten-day period from fifteen monitoring sites in Slovenia (Medvedce reservoir, Cerknica, Bled, Bohinj, Moste, Gradiško, Ptuj and Ormož lakes, Ormož Basins Nature Reserve, Vrbje fishpond, Rački ribniki, Požeg reservoir, Šaleška lakes, Škocjanski zatok Nature Reserve and Sečovlje Salina Lanscape park).

Slika 1: Vsota števil mlakaric *Anas platyrhynchos* v deset dnevnih obdobjih iz petnajstih območij z monitoringom vodnih ptic v Sloveniji (Zadrževalnik Medvedce, Cerkniško, Blejsko, Bohinjsko, Moste, Gradiško, Ptujsko ter Ormoško jezero, Naravni rezervat Ormoške lagune, Ribnik Vrbje, Rački ribniki, Zadrževalnik Požeg, Šaleška jezera, Naravni rezervat Škocjanski zatok in Krajinski park Sečovlje Soline).

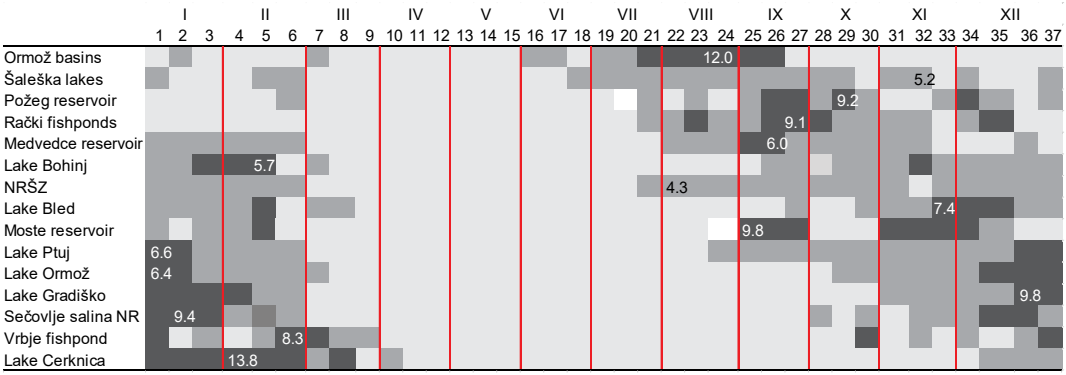
Table 4: Monthly dominance of Mallards *Anas platyrhynchos* from eleven sites (Medvedce reservoir, Cerknica, Bled, Bohinj, Moste, Gradiško, Ptuj and Ormož lakes, Ormož Basins Nature Reserve, Rački ribniki, Požeg reservoir).

Tabela 4: Mesečna dominance mlakarice *Anas platyrhynchos* iz enajstih območij z monitoringom vodnih ptic (Zadrževalnik Medvedce, Cerkniško, Blejsko, Bohinjsko, Moste, Gradiško, Ptujsko ter Ormoško jezero, Naravni rezervat Ormoške lagune, Rački ribniki, Zadrževalnik Požeg).

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Dominance / Dominanca	41.6	38.2	18.6	23.9	36.2	31.1	26.1	33.0	29.9	27.0	25.1	35.5

Table 5: The comparison of percentage of annual Mallard *Anas platyrhynchos* total in separate ten-day periods at fifteen monitored sites. Different colours represent different percentages: light grey: less than 2.7% (average for all ten-day periods); grey: 2.8 – 5.4% (double the average); dark grey: more than 5.4 %. The number presents the highest percentage in a ten-day period for a site.

Table 5: Primerjava deležev letnega seštevka števila mlakaric *Anas platyrhynchos* v posameznih deset dnevnih obdobjih na petnajstih območjih z monitoringom vodnih ptic. Različna barva predstavlja različne deleže: svetlo siva: manj kot 2.7% (povprečje vseh deset dnevnih obdobij); siva: 2.8 – 5.4% (dvakratnik povprečja); temno siva: več kot 5.4 %. Zapisano število predstavlja desetdnevno obdobje z najvišjim deležem za območje.



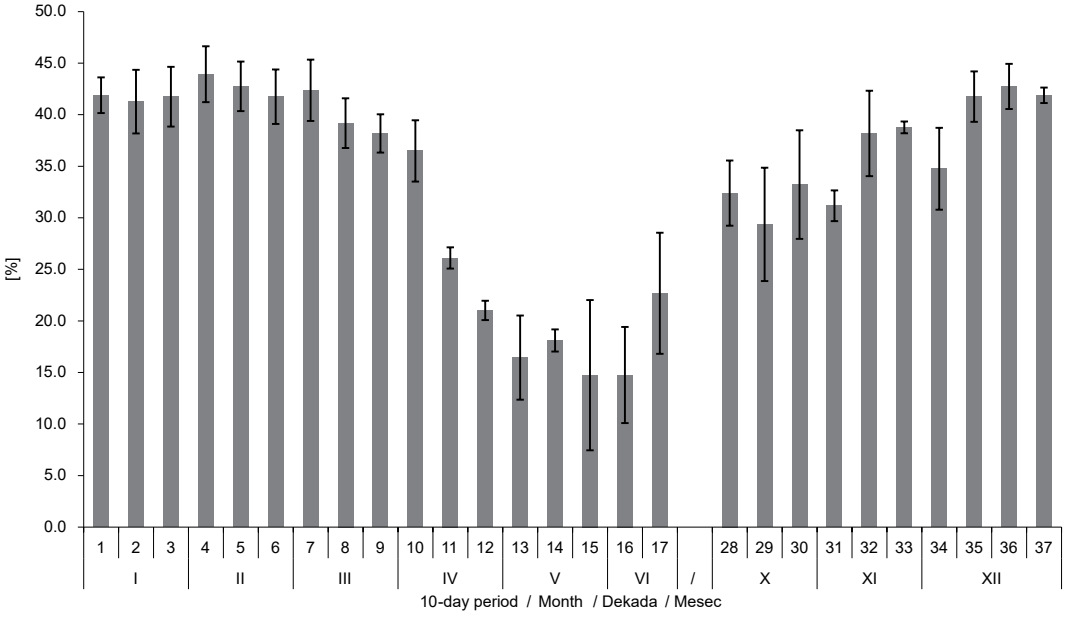


Figure 2: Yearly average percentage (±SD) of female Mallards *Anas platyrhynchos* at five monitoring sites (Medvedce reservoir, Rački ribniki, Požeg reservoir, Gradiško Lake, Drava river in Maribor). Empty space presents a period between the end of June and the end of September when sex is harder to distinguish and data are lacking or unreliable.

Slika 2: Delež (±SD) samic mlakaric *Anas platyrhynchos* na petih območjih z monitoringom vodnih ptic (Zadrževalnik Medvedce, Rački ribniki, Zadrževalnik PožegGradiško jezero, reka Drava v Mariboru). Prazen prostor predstavlja obdobje med koncem junija in koncem septembra, v katerem podatki o spolih manjkajo ali so manj zanesljivi.

3.2. Breeding biology

3.2.1. Brood phenology

1741 data on nests or broods with recorded dates were gathered during 2001–2019. Two Downy broods were sighted in late February on Ptuj (D. Bombek *pers. comm.*) and Ormož (M. Premzl *pers. comm.*) lakes without an exact date or year. Estimated start of breeding in these cases is mid-January. The earliest clutch with an exact date was a nest with eggs found on 28th February. The latest nest was found on 3rd June. The number of observed broods increased through the end of May and remained high through early July, then decreased rapidly (Figure 3). 44.7% of all broods were observed in June, 28.2% in May, 20.5% in July, and substantially fewer in other months (Table 6). Only 25 broods (1.5%) were observed in August, the last with downy young on 25th August. A very late brood with downy young was sighted in the coastal region on 17th October in Sečovlje salina.

The estimated breeding season of the Mallard in Slovenia lasts from mid-January to early December. 75% or more broods were estimated to be present between mid-May and late June, more than half between late April and mid-July, and more than 10% between late March and the second half of August (Figure 3).

Mallards start breeding earlier with warmer mean temperatures in February ($r_p = -0.51$, df = 15, p = 0.0377), but not in March ($r_p = -0.39$, df = 15, p = 0.1189) or April ($r_p = -0.2967$, df = 15, p = 0.2475). The correlation is also present for the sum of daily mean temperatures in February ($r_p = -0.64$, df = 12, p = 0.0130), March ($r_p = -0.54$, df = 12, p = 0.0466), and April ($r_p = -0.62$, df = 12, p = 0.0188).

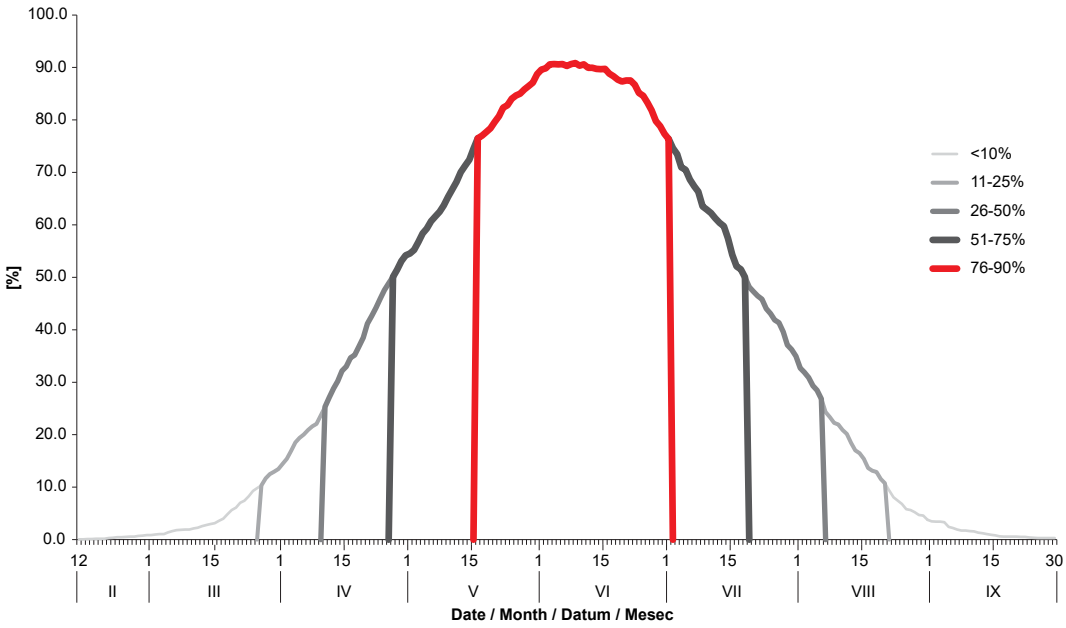


Figure 3: Calculated proportion of active Mallard *Anas platyrhynchos* broods on a given day between February and September in Slovenia, estimated from observed nests and broods. Different lines represent time periods when a certain proportion of Mallard broods were likely present. Red represents a period when more than 76% of all broods were likely to have been present.

Slika 3: Izračunan delež aktivnih zarodov mlakarice *Anas platyrhynchos* za vsak posamezen dan med februarjem in septembrom v Sloveniji. Različne črte predstavljajo časovna obdobja, znotraj katerih so določeni deleži zarodov mlakarice verjetno prisotni. Rdeča barva predstavlja obdobje, ko je bilo verjetno prisotnih več kot 76% vseh zarodov.

Table 6: Number of broods and mean brood size of the Mallard *Anas platyrhynchos* for separate months with standard deviation. Number of broods with known size is given in brackets.

Tabela 6: Število in povprečna velikost zarodov mlakarice *Anas platyrhynchos* prikazana po posameznih mesecih s standardno deviacijo. Število legel je prikazano v oklepajih.

Month / Mesec	No. of broods / Število zarodov	Mean / Povprečje	SD
February / februar	3	/	/
March / marec	4 (1)	6.0	/
April / april	82 (54)	7.9	2.63
May / maj	487 (381)	7.0	2.66
June / junij	772 (654)	6.0	2.56
July / julij	354 (285)	5.6	2.58
August / august	25 (21)	4.7	2.33
October / oktober	2 (1)	2.0	/

3.2.2. Brood size

Altogether, data (including various sources) were gathered on 1,394 of broods with known size. Most had seven young (206). More than 50% had 5–8 young (Figure 4). Eighteen broods had 14 or more young with a maximum of 29. The average brood size was 6.2 ± 2.66. There is a statistically significant difference in the average number of young among the age classes (Figure 5 & Table 7, H = 13.11, df = 4, p = 0.0108). Eggs had the largest clutches (7.2 ± 2.52) and Feathered had the smallest broods (5.2 ± 2.30, H = 79.09, df = 6, p = 5.502e–15). The brood size decreased throughout the season (Figure 6 & 7) from April (7.9 ± 2.7) to August (4.7 ± 2.3, r_s: –0.25, p = 2.2e–16). This applies for both Downy (r_s = –0.28, p = 9.823e–14) and Partially feathered (r_s –0.18, p-value = 0.00197).

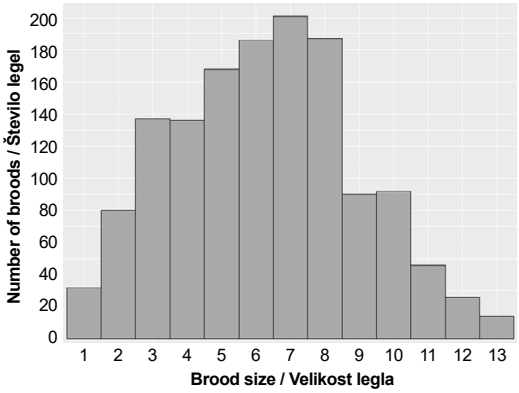


Figure 4: Number of nests and broods with certain brood sizes for Mallards *Anas platyrhynchos* (N=1,395)

Slika 4: Število gnezd in zarodov mlakarice *Anas platyrhynchos* z določeno velikostjo (N=1,395)

Table 7: Number of broods, mean brood size with standard deviation in different brood age classes of the Mallard *Anas platyrhynchos*.

Tabela 7: Število in povprečna velikost zarodov s standardno deviacijo po posameznih starostnih razredih mladičev mlakarice *Anas platyrhynchos*.

Brood age class / Starostni razred	No. of broods / Št. zarodov	Mean / Povprečje	SD
Eggs / jajca	14	7.2	2.52
Downy / puhasti	690	6.4	2.65
Partially feathered / delno operjeni	285	6.3	2.84
Feathered / operjeni	56	5.2	2.30
Ducklings / mladiči	335	6.2	2.59

Figure 5: The Mallard *Anas platyrhynchos* brood sizes for different age classes presented with boxplots, rotated kernel density plots (violin plots) and mean (red dots).

Slika 5: Velikost legel mlakarice *Anas platyrhynchos* v različnih starostnih razredih mladičev predstavljeno z grafikonom kvantilov, violinskim grafikonom in povprečjem (rdeče pike).

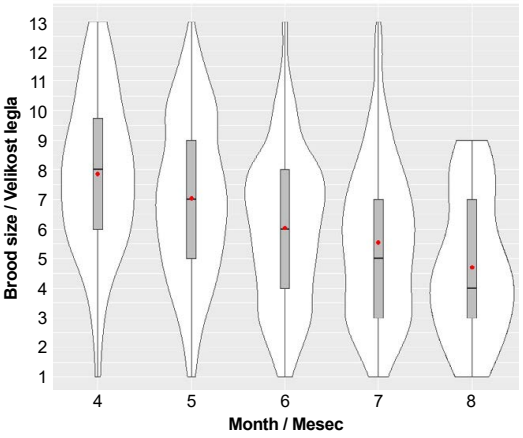


Figure 7: The Mallard *Anas platyrhynchos* monthly brood sizes (N = 1389) in Slovenia presented with boxplots, rotated kernel density plots (violin plots) and mean (red dots).

Slika 7: Velikost zarodov mlakarice *Anas platyrhynchos* v Sloveniji po mesecih (N = 1389) predstavljeno z grafikonom kvantilov, violinskim grafikonom in povprečjem (rdeče pike).

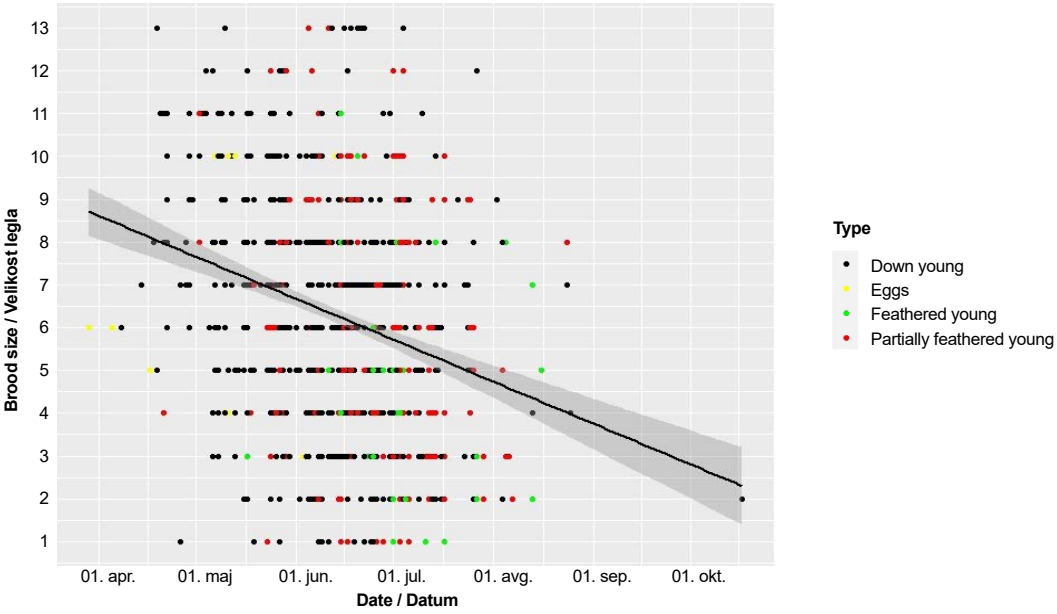


Figure 6: Seasonal distribution of brood sizes of Mallards *Anas platyrhynchos* in Slovenia for different age classes with a linear trend line ($R^2 = 0.001$, $p < 0.001$, $t = -0.09$) for brood size of all observed broods.

Slika 6: Sezonska razporeditev velikosti zarodov mlakaric *Anas platyrhynchos* v Sloveniji za različne starostne razrede mladičev s prikazom linearnega trenda ($R^2 = 0.001$, $p < 0.001$, $t = -0.09$).

3.2.3. Brood size and wetland type

Most broods were observed on Aquaculture (Table 8). Although mean brood size ranges from 5.6 to 7.3, there is no statistically significant difference among wetland types (H = 13.8, df = 10, p = 0.1833). There is also no statistically significant difference between Human-made, Coast and Inland wetlands (H = 3.3, df = 2, p = 0.1953). The largest average brood sizes were observed on wetlands currently or formerly used as treatment facilities (7.3 ± 2.96) and Coastal wetlands (7.2 ± 2.59). The smallest ones were observed at Reservoirs (5.7 ± 2.64) and Lakes (5.6 ± 2.66, Table 8). Broods with 14 or more young were observed at Aquaculture (12), on Large rivers (4), Ponds (1) and Reservoirs (1).

Brood size differs between years (H = 48.83, df = 18, p = 0.0001). Between 2003 and 2018, only one year had an average brood size greater than seven (7.5 in 2010) and five had smaller than six (min. 5.7 in 2007, Figure 8).

3.2.4. Brood size and elevation

Broods were observed from the sea level to 900 m a.s.l., with an average elevation of 242 m a.s.l. and a median of 240 m a.s.l. The majority of broods were observed in the 201–300 m a.s.l. elevation belt (90.5%). There is a statistically significant correlation between brood size and elevation (Figure 9, $r_p = -0.06$, df = 1394, p = 0.0369) with smaller broods at higher elevations (below 200 m: 7.3 ± 2.91 young per brood, above 400 m a.s.l.: 5.8 ± 2.60).

3.2.5. Mallard breeding densities

The average breeding density for different regions (size 4.1–880 km^2) covering about 10.3% of Slovenia is 0.4–0.7 bp/km^2 (Appendix 1), with the highest breeding densities recorded for lowland areas along the Mura river (7.0 bp/km^2) and the lowest for Triglav National Park (0.01–0.03 bp/km^2).

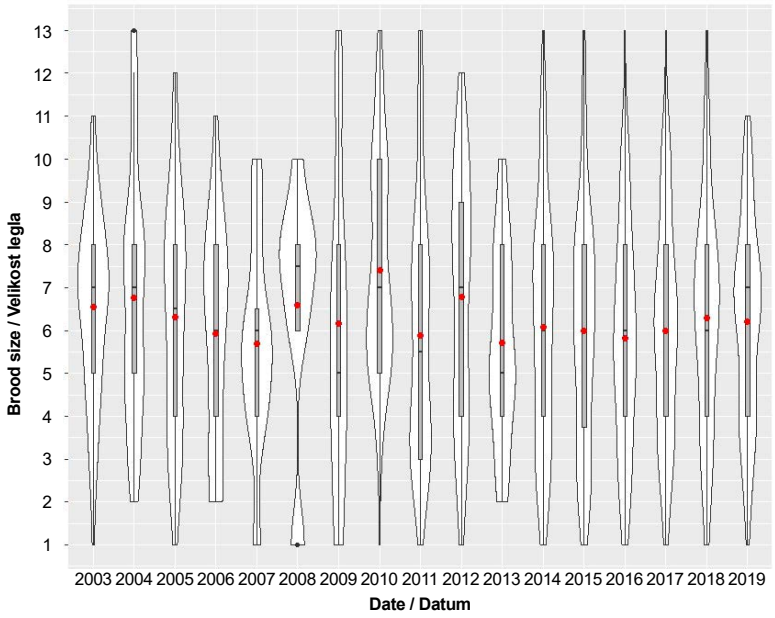


Figure 8: The Mallard *Anas platyrhynchos* brood sizes in different years (N = 1390) in Slovenia presented with boxplots, rotated kernel density plots (violin plots) and mean (red dots).

Slika 8: Velikost zarodov mlakarice *Anas platyrhynchos* v Sloveniji po posameznih letih (N = 1390) predstavljeno z grafikonom kvantilov, violinskim grafikonom in povprečjem (rdeče pike).

Table 8: Number, average size and standard deviation of the Mallard *Anas platyrhynchos* brood size for different wetland types in Slovenia. Coast combines several types of wetland on the sea coast.

Table 8: Število, povprečna večlikost in standardna deviacija velikosti legel mlakarice *Anas platyrhynchos* na različnih tipih mokrišč v Sloveniji. Obala združuje različne tipe mokrišč ob slovenski obali.

Wetland type / Tip mokrišča	No. of broods / Št. zarodov	Mean / Povprečje	SD
Treatment / čistilne naprave	15	7.3	2.9
Coast / obala	87	7.3	2.9
Excavations / izkopi	44	7.0	2.0
Large river / velike reke	97	6.4	2.9
Intermittent / presihajoča jezera	20	6.3	2.8
Small river / male reke	37	6.3	2.6
Canals / kanali	68	6.3	2.5
Aquaculture / ribogonice	1,096	6.2	2.6
Pond / ribniki	73	6.1	2.9
Reservoirs / zadrževalniki	131	5.7	2.5
Lakes / jezera	33	5.6	2.6

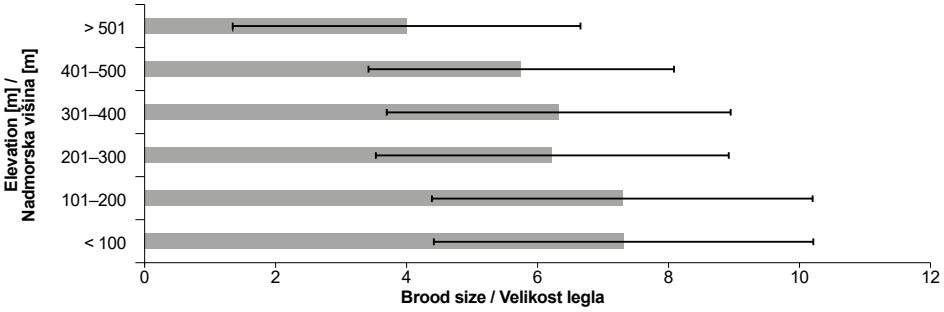


Figure 9: Average brood size (± SD) of Mallards *Anas platyrhynchos* recorded in separate elevational belts (N = 1380) in Slovenia.

Slika 9: Povprečna velikost zaroda (± SD) mlakarice *Anas platyrhynchos* v Sloveniji po posameznih višinskih pasovih (N = 1380).

Average ecological breeding densities calculated from known localities (size 4 ha – 29 km^2) are 5.3–8.4 bp/km^2 (Appendix 2). Densities differed between different wetland types (Figure 10, H = 27.372, df = 6, p = 0.0001). The lowest mean ecological densities were found for Coastal wetlands (2.9 bp/km^2) and Lakes (3.5 bp/km^2). The highest ecological breeding densities at individual sites were found in smaller wetlands (< 8 ha), on Pools (50.4 bp/km^2), and Ponds (38.1 bp/km^2). On wetlands larger than 8 ha, the highest breeding density was recorded on Excavations (24.8 bp/km^2) and Aquaculture (13.5 bp/km^2, Appendix 2). Breeding densities for all wetland types were similar across elevations (r_p = 0.03, df = 55, p = 0.9720), but differed when smaller wetlands (higher density due to smaller size) were excluded (r_p = –2.60, df = 34, p = 0.0140).

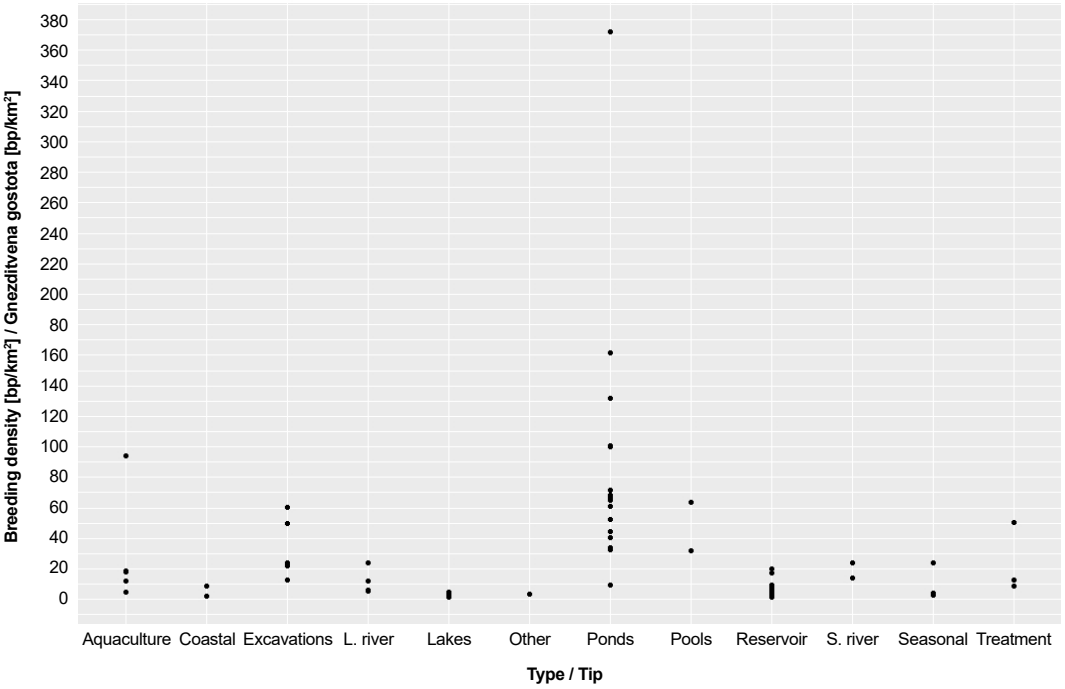


Figure 10: Breeding density of Mallards *Anas platyrhynchos* in different wetland types in Slovenia (N = 57).

Slika 10: Gnezditvena gostota mlakarice *Anas platyrhynchos* na razčnih tipih mokrišč po Sloveniji (N = 57).

3.3. Breeding population estimate

The number of estimated breeding pairs in the regions covering 10.3% of Slovenia is 854–1474 bp. Localities with known breeding populations add another 260–442 bp (Appendix 2). Lower breeding populations than in the literature were estimated for Ljubljana, Ljubljansko barje, Goričko and both sections of the Sava river (Table 9). For Ljubljana, the low estimate is similar to the estimate from the count. For Ljubljansko barje, the estimates from the count and wetland types are similar. The estimates from the wetland types are usually the lowest estimate for a region. For the Drava river, RP Kozjansko and NP Triglav the new estimates are lower but similar between methods. The number of breeding pairs using the corrected estimates for areas with known breeding population is 690–918 bp. The estimated breeding population for Slovenia using the first method is 2,736–3,763 bp, and the estimated breeding population using the second method is 1,473–2,168 bp. The combined estimated population for Slovenia is 1,473–3,763 bp.

3.3.1. Breeding population trend

Long-term monitoring of the breeding population was conducted at several sites, but data were available for only five (Table 10). Although the breeding population fluctuates from year to year, a moderate increase in the breeding population is evident at all sites combined (TRIM, multiplicative overall slope ± SE): 1.0667 ± 0.0276).

3.3.2. Non-breeding population

More than 1,000 individuals were counted at least once at eleven sites (Appendix 3), with the highest numbers at Ptuj (8,330 individuals), Ormož (5,400) and Cerknica (4,581) lakes. Six sites had more than 1,000 Mallards counted in more than one season. Ten out of eleven sites had this during winter, five

Table 9: Locations with estimated breeding populations of the Mallard *Anas platyrhynchos* acquired from literature and compared using different methods described in chapter 2.7. Estimates used for a new national population estimate are in bold.

Tabela 9: Območja z ocenjenimi velikostmi gnezdeče populacije mlakarice *Anas platyrhynchos* iz literature in primerjava z ocenami pridobljenimi na podalagi različnih metod opisanih v poglavju 2.7. Ocene uporabljane za izračunu slovenske populacije so odebeljene.

	Breeding population size estimate / Ocena velikosti gnezdeče populacije			Calculated density [bp/km²] / Izračunana gnezditvena gostota [gp/km²]		
Location / Lokacija	Min	Max	Area [km²] / površina [km²]	Min	Max	Source / Vir
Ljubljana	142	426	211	0.67	2.02	(Tome *et al.* 2013)
	145	**145**		**0.97**	**0.97**	**from count / s popisa**
	49	90		0.23	0.43	from habitat type / s habitatnega tipa
Ljubljansko barje	210	258	180	1.17	1.43	(Tome *et al.* 2005)
	161	213		0.89	1.18	without Žabnica pond* / brez ribnika Žabnica*
	110	**126**		**0.59**	**0.67**	**from count / s popisa**
	87	132		0.48	0.73	from habitat type / s habitatnega tipa
Drava river (Maribor–Ptuj)	54	54	76	0.71	0.71	(Bračko 1997)
	68	**78**		**0.89**	**1.03**	**from habitat type / s habitatnega tipa**
Goričko	150	250	448.3	0.33	0.56	(Denac & Kmecl 2014)
	26	40		0.06	0.09	from habitat type / s habitatnega tipa
	36	**69**		**0.08**	**0.15**	**estimate**
Kozjansko	10	20	198	0.05	0.10	(Jančar & Trebušak 2000)
	16	**22**		**0.01**	**0.01**	**from habitat type / s habitatnega tipa**
Triglav National Park	11	30	880	0.01	0.03	(Jančar 1997)
	18	40		0.02	0.05	from habitat type / s habitatnega tipa
Sava river (Litija–Zidani most)	10	20	2.7	3.70	7.41	(Denac 2010)
	7	**11**		**2.59**	**4.07**	**from count / s popisa**
Sava river (Krško–border with Croatia)	54	90	33.3	1.62	2.70	(Denac & Smole 2008)
	41	**71**		**1.23**	**2.13**	**from count / s popisa**

* Žabnica pond is the place where Mallards *Anas platyrhynchos* were released for hunting and formed large breeding population of 50 nesting females in the 1990's (Tome *et al.* 2005), but not anymore. / Ribnik Žabnica je lokacija, kjer je v devetdesetih letih gnezdila velika populacija (50 gnezdečih samic) mlakaric *Anas platyrhynchos*, vzpostavljena iz osebkov spuščenih v naravo za namene lova (Tome *et al.* 2005).

during spring migration and six during autumn migration. The highest number of Mallards during spring migration was counted on Lake Cerknica (4,581) and in autumn on Medvedce reservoir (3,379). Štajerska is the region with the most sites with a maximum of more than 1,000 observed Mallards (6), while Dolenska and Gorenjska regions have none (Appendix 3). The estimated trend in the number of Mallards counted in the phenological periods at the monitoring sites is a moderate to strong increase, with the exception of winter, where the trend is uncertain (Table 11.).

During the 1997–2019 period, IWC counts averaged 22,237 (10,376–32,010) Mallards (Figure 11). Mallard numbers fluctuated with two winters over 30,000 and seven winters with fewer than 20,000 individuals. On average, almost half (41.6% ± 6.40) of all individuals were counted in the Drava count area in NE Slovenia. Two other count areas (the Mura and Upper Sava) averaged more than 10% of Mallards and the top three count areas represented 73.2% of all Mallards counted (Table 12). In all count areas, more than 1,000 individuals were counted in at least three (Kolpa count area) or four (Coastland count area) years. Four count areas had more than 5,000 Mallards, and only the Drava count area had more than 5,000 individuals in all years (Table 12). Twelve IWC units had more than 1,000 Mallards counted in at least one year, and only three had more than 3,000 Mallards in a single count.

Table 10: Breeding population size estimate for the Mallard *Anas platyrhynchos* at five wetlands in Slovenia between 2002 and 2019.

Tabela 10: Ocena velikosti gnezditvene populacije mlakarice *Anas platyrhynchos* na petih mokriščih v Sloveniji med leti 2002 in 2019.

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Medvedce reservoir	17	26	35	16	17	12	8	11	42	23	20	43	46	30	24	39	20	16
Rački ribniki				16	10	1	1	5	7	11	4	10	8	5	6	6	6	11
Požeg reservoir				9	6		1	3	3	5	6	3	2	4	5	5	2	2
Ormož Basins Nature Reserve												20	17	17	14	14	27	22
Lake Ptuj												15	15	10	18	22	22	26

Table 11: Population trends of Mallards *Anas platyrhynchos* at monitoring sites in different phenological periods between 2003 and 2019 in Slovenia.

Table 11: Populacijski trend mlakarice *Anas platyrhynchos* na območjih z monitoringom vodnih ptic v različnih fenoloških obdobjih v obdobju med 2003 in 2019.

Phenological period / Fenološko obdobje	Trend / Trend	Trend* / Trend*
All periods / Vsa obdobja	Moderate increase / zmerni porast	1.1004 ± 0.0263
Spring / Pomlad	Strong increase / močan porast	1.2095 ± 0.0795
Breeding / Gnezdenje	Moderate increase / zmerni porast	1.1129 ± 0.0300
Summer / Poletje	Moderate increase / zmerni porast	1.0766 ± 0.0268
Autumn / Jesen	Moderate increase / zmerni porast	1.0925 ± 0.0294
Winter / Zima	Uncertain / negotov trend	1.2879 ± 0.1823

* multiplicative overall slope ± SE / multiplikativni naklon ± SE

Table 12: Average number of Mallards *Anas platyrhynchos* in separate IWC count areas in Slovenia with number of years with more than 1,000, 3,000 and 5,000 Mallards counted (after Štumberger 1997, Štumberger 1997, Štumberger 1999, Štumberger 2000, Štumberger 2002a, Štumberger 2002b, Božič 2005, Štumberger 2005, Božič 2006, Božič 2007c, Božič 2008c, Božič 2008d, Božič 2010, Božič 2011, Božič 2012, Božič 2013, Božič 2014, Božič 2015, Božič 2016, Božič 2017, Božič 2018, Božič 2019, Božič 2020).

Tabela 12: Povprečno število mlakaric *Anas platyrhynchos* na ločenih števnih območjih v Sloveniji s prikazom števila let, ko je število mlakaric presegalo 1,000, 3,000 in 5,000 osebkov (po Štumberger 1997, Štumberger 1997, Štumberger 1999, Štumberger 2000, Štumberger 2002a, Štumberger 2002b, Božič 2005, Štumberger 2005, Božič 2006, Božič 2007c, Božič 2008c, Božič 2008d, Božič 2010, Božič 2011, Božič 2012, Božič 2013, Božič 2014, Božič 2015, Božič 2016, Božič 2017, Božič 2018, Božič 2019, Božič 2020)

IWC count area / Števno območje IWC	No. of years / Št. let	Average / Povprečje	SD	Min	Max	>1000	>3000	>5000
Mura	22	3,260	1,082	1,004	5,175	22	14	1
Drava	23	8,952	2,321	6,421	14,776	23	23	23
Savinja	22	1,636	485	661	2,564	19	0	0
Upper Sava	22	3,771	964	2,355	5,872	22	16	2
Lower Sava	22	2,085	917	855	5,231	20	2	1
Kolpa	18	626	335	278	1,186	3	0	0
Notranjska & Primorska	23	1,689	770	703	3,311	20	2	0
Coastland	23	834	245	499	1,440	4	0	0
Total	22	22,741	4,082	10,376	32,010			

Remark: Some regions were underrepresented in the first count in 1997 and had substantially lower numbers than in subsequent counts and was thus not considered here. / Opomba: Posamezna območja so bila v prvem šteju leta 1997 glede na kasnejša štetja slabše zastopana, zato tukaj niso vključena.

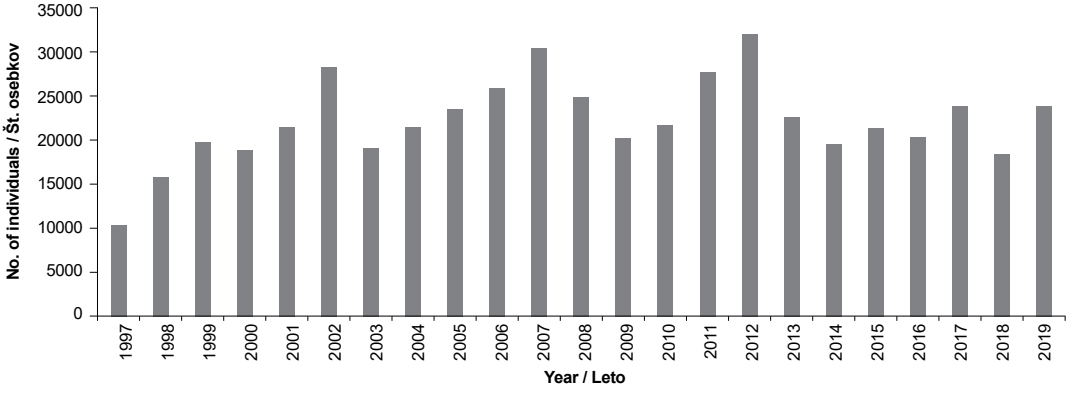


Figure 11: Number of Mallards *Anas platyrhynchos* counted during mid-winter counts between 1997 and 2019 (after Štumberger 1997, Štumberger 1997, Štumberger 1999, Štumberger 2000, Štumberger 2002a, Štumberger 2002b, Božič 2005, Štumberger 2005, Božič 2006, Božič 2007c, Božič 2008c, Božič 2008d, Božič 2010, Božič 2011, Božič 2012, Božič 2013, Božič 2014, Božič 2015, Božič 2016, Božič 2017, Božič 2018, Božič 2019, Božič 2020).

Slika 11: Število preštetih mlakaric *Anas platyrhynchos* med zimskih štetjem vodnih ptic med leti 1997 in 2019 (po Štumberger 1997, Štumberger 1997, Štumberger 1999, Štumberger 2000, Štumberger 2002a, Štumberger 2002b, Božič 2005, Štumberger 2005, Božič 2006, Božič 2007c, Božič 2008c, Božič 2008d, Božič 2010, Božič 2011, Božič 2012, Božič 2013, Božič 2014, Božič 2015, Božič 2016, Božič 2017, Božič 2018, Božič 2019, Božič 2020).

Table 13: Maximal and average number of Mallards *Anas platyrhynchos* counted in separate IWC count units between 2004 and 2019 in Slovenia with number of years with more than 1,000 and 3,000 Mallards (Božič 2005, Štumberger 2005, Božič 2006, Božič 2007c, Božič 2008c, Božič 2008d, Božič 2010, Božič 2011, Božič 2012, Božič 2013, Božič 2014, Božič 2015, Božič 2016, Božič 2017, Božič 2018, Božič 2019, Božič 2020).

Tabela 13: Maksimum in povprečno število mlakaric *Anas platyrhynchos* preštetih na posameznih števnih enotah med štetjem vodnih ptic med letoma 2004 in 2019 v Sloveniji s prikazom števila let, ko je posamezna enota imela več kot 1,000 ali 3,000 osebkov (Božič 2005, Štumberger 2005, Božič 2006, Božič 2007c, Božič 2008c, Božič 2008d, Božič 2010, Božič 2011, Božič 2012, Božič 2013, Božič 2014, Božič 2015, Božič 2016, Božič 2017, Božič 2018, Božič 2019, Božič 2020).

IWC unit / Števna enota	No. Of years / Št. let	Max	Min	Average / Povprečje	SD	% of yearly wintering population / % slovenske prezimujoče populacije	>3,000	>1,000
Drava river	16	9,219	2,822	5,894	1,875	25.0	15	16
Mura other	16	3,112	954	1,781	722	7.6	1	15
Dravsko and Ptujsko polje	16	4,152	628	1,758	991	7.5	2	13
Ljubljanica river	16	2,214	427	1,374	515	5.8	0	12
Middle Sava river	16	1,783	472	1,161	377	4.9	0	12
Krka river	16	1,357	552	1,028	236	4.4	0	9
Notranjska	16	2,566	107	975	789	4.1	0	7
Mura river	16	2,137	215	905	464	3.8	0	5
Savinja river	16	1,531	361	896	328	3.8	0	7
Upper Sava river	16	988	532	717	134	3.0	0	0
Ščavnica river	16	1,128	138	624	328	2.6	0	4
Coastal saltpans	16	964	142	612	224	2.6	0	0
Lower Sava	16	1,068	285	603	207	2.6	0	1
Kolpa river	16	894	205	528	212	2.2	0	0
Pesnica river	16	1,010	27	485	308	2.1	0	1
Savinja other	14	986	2	471	338	2.0	0	0
Ledava river	16	722	282	437	133	1.9	0	0
Dravinja river	16	554	152	347	135	1.5	0	0
Meža and Mislinja rivers	14	478	55	293	123	1.2	0	0
Sotla river	13	712	9	286	221	1.2	0	0
Drava river Alps	16	522	148	270	91	1.1	0	0
Sava plain	13	499	117	269	115	1.1	0	0
Kamniška bistrica river	12	434	53	253	126	1.1	0	0
Ljubljansko barje other	13	839	68	241	209	1.0	0	0

While the Drava river between Maribor and the border has had more than 3,000 Mallards counted in 15 of the last 16 years, the other two have had only one and two years (Table 13). Out of 38 count units (i.e. Božič 2018), 35 had more than 100 Mallards and 20 had more than 500 Mallards in at least one year (Table 13). Between 2004 and 2019, more than 25% of Mallards were counted on the Drava river and more than 5% on the Mura other, Dravsko and Ptujsko polje and on the Ljubljanica river. More than half of all Mallards were counted in the five most important subareas (Table 13).

In seventeen river sections, 51–130 Mallards were counted per river kilometre (Figure 12). Of these, eleven are in urban areas (Maribor, Celje, Ljubljana and Kranj) and only six on more natural river sections. Most sections had at least one individual per river kilometre. Additionally, four locations had more than 500 individuals, six had between 201 and 500 individuals, and 18 had between 101 and 200 individuals (Figure 12).

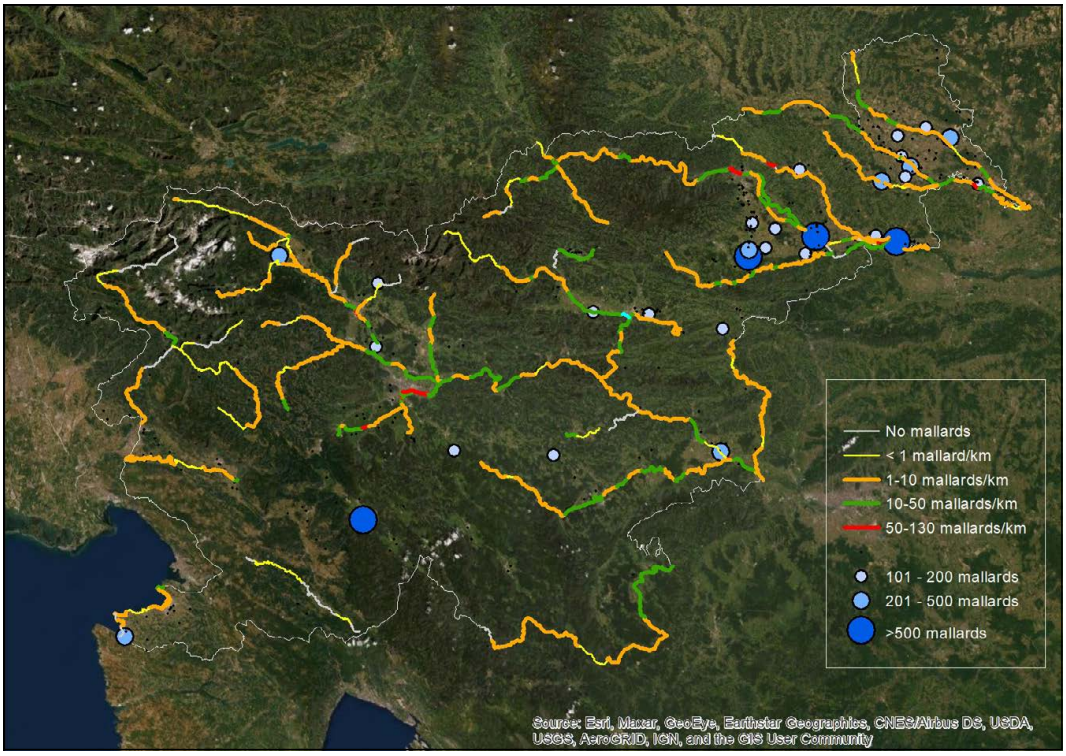
The population of wintering Mallards in Slovenia decreased moderately during 2000–2019, when more complete data were available (TRIM, multiplicative overall slope ± SE: 0.9939 ± 0.0003). Considering only the Drava river, the number of Mallards decreased significantly during 1999–2019 ($r_s = -0.64$, df = 20, p = 0.0022).

3.5. Ringing

Up till 2017, 2,774 Mallards were ringed in Slovenia, 86.9% of them in 1972-1975. Less than 0.5% of our ringed Mallards were recovered abroad (7), most of them (3 each) in the Italian Po valley and in Austria. One mallard was recovered 1,290 km away

Figure 12: Average density (river sections) and number (locations) of Mallards *Anas platyrhynchos* counted during January waterbird census in Slovenia between 1998 and 2019.

Slika 12: Povprečna gostota (rečni odseki) in število (lokacije) mlakaric *Anas platyrhynchos* preštetih med januarskim štetjem vodnih ptic v Sloveniji med leti 1998 in 2019.



in Ukraine and all were recovered within two years of ringing. Nine Mallards were ringed abroad and recovered in Slovenia. Three each were ringed in Finland and the Czech Republic (Figure 13). One in Finland was ringed approximately 2,075 km and two 1,980 km away. Mallards were ringed or recovered in directions NEE–SWW (6 Mallards), NNE–SSW (6) and N–S (4). All recovered Mallards, foreign and domestic, were recovered through hunting.

Eight local recoveries were gathered from the period with available data (Table 14). All were recovered at the locality of ringing, 6 to 1,498 days after ringing. Most were ringed in August and then recovered in September. One individual was confirmed wintering at a site.

3.6. Mortality causes

According to the 10-year hunting management plans for all hunting management areas (ZGS 2012a-o), non-hunting causes of mortality account for only 2.6% of total mortality, with 2.1–4.9% before and 0.5–1.1 after 2005 (Table 15). The majority of non-hunting mortality was caused by predators (41.2%) and traffic (14.2%). A significant percentage of mortality, especially in certain years (e.g. 2002), was due to disease. After 2005, only traffic-related mortality remained similar in number (average 17.4) to pre-2005 (18.8), while other causes showed considerably lower numbers (pre-2005: 50.4, post-2005: 4.5).

Figure 13: Locations of ringing (beginning of arrow) and recoveries (end of arrow) of Mallards *Anas platyrhynchos* ringed (red) and recovered in Slovenia (black).

Slika 13: Lokacije obročkanj (začetek puščice) in najdb (konec puščice) mlakaric *Anas platyrhynchos* občočkanih (rdeče) in najdenih (črna) v Sloveniji.

Table 14: Local recoveries of Mallards *Anas platyrhynchos* in Slovenia between 2013 and 2018 (D. Fekonja *pers. comm.*)

Tabela 14: Lokalne najdbe mlakaric *Anas platyrhynchos* v Sloveniji med letoma 2013 in 2018 (D. Fekonja *osebno*)

	Location of ringing / Mesto obročkanja	Date of ringing / Datum obročkanja	Location of recovery / Mesto najdbe	Date of recovery / Datum najdbe	Days / Št. dni	Sex / Spol	Age / Starost	Ringer / Obročko-valec	Recovery / Najditelj
1	Vrhnika	18. 8. 2013	Vrhnika	4. 9. 2013	17			T.Trilar	T.Trilar
2	Vrhnika	16. 8. 2010	Vrhnika	22. 7. 2014	1436	F	1y	Š. Pavle	Š. Pavle
3	Vrhnika	14. 8. 2011	Vrhnika	20. 9. 2015	1498		AD	Š. Pavle	B. Lapajna
4	Vrhnika	22. 7. 2014	Vrhnika	7. 8. 2017	1112	F	AD	Š. Pavle	T.Trilar
5	Ljubljana	6. 5. 2017	Ljubljana	7. 5. 2018	366	F	AD	D. Fekonja	D. Fekonja
6	Vrhnika	14. 8. 2018	Vrhnika	4. 9. 2018	21	F	AD	B. Lapajna	T.Trilar
7	Lake Bled	12. 9. 2017	Lake Bled	7. 12. 2017, 19. 1. 2018	451	F	AD	A. Mulej, Ž. Pečar	A. Mulej
8	Lake Bled	4. 9. 2018	Lake Bled	10. 9. 2018	6	M	AD	A. Mulej	A. Mulej

Table 15: Recorded Mallard *Anas platyrhynchos* mortality in Slovenia by cause between 2001 and 2020 (ZGS 2012a-o, OSLIS 2021).

Table 15: Zabeležena smtrnost mlakarice *Anas platyrhynchos* v Sloveniji ločena po vzroku med leti 2001 in 2020 (ZGS 2012a-o, OSLIS 2021).

Recorded causes / Zabeleženi vzroki	2001–2005	2006–2010	2011–2015	2016–2020	All / Vsa leta
Hunting / Lov	28,208 (96.2%)	20,115 (99.1%)	16,906 (99.6%)	12,320 (99.3%)	77,549 (98.2%)
Other causes / Drugi vzroki	1,103 (3.8%)	176 (0.9%)	69 (0.4%)	87 (0.7%)	1,435 (1.8%)
Unknown / Neznano	339	34	13	19	405 (0.5%)
Disease / Bolezni	149	4	3	0	156 (0.2%)
Road / Cesta	94	90	47	56	287 (0.4%)
Predation / Plenjenje	488	37	2	7	534 (0.7%)
Dogs / Psi	6	0	0	2	8 (0.0%)
Other / Ostalo	27	11	4	3	45 (0.1%)
All recorded mortality / Vsa zabeležena smtrnost	29,311	20,291	16,975	12,407	78,984

3.6.1. Mallard hunting between 2001 and 2018

Between 2001 and 2018, 72,731 Mallards were hunted in Slovenia. The highest number hunted in one year (2,195) and in all years (20,226) was reported for Pomursko hunting management district (LUO). The lowest number of hunted Mallards was in Triglav LUO (15 in one year, 651 in all years combined). In seven LUOs, more than 3,000 Mallards were hunted in the last 17 years (Figure 14) and only in one (Pomursko LUO) more than 10,000. The four districts with highest

numbers represent more than 60% of all Mallards hunted. The number of Mallards hunted is highest in the eastern part of the country. In the western part, only Notranjsko LUO stands out (Figure 14). The number of hunted Mallards decreased by about 64% between 2001 and 2018 (Figure 15, Appendix 4), and the decrease is significant (TRIM, multiplicative overall slope ± SE: 0.9467 ± 0.0034, moderate decrease $p < 0.01$). The significant decline was observed in all LUOs (Appendix 4). The largest decline in hunted Mallards was observed in Pomursko LUO (82%) and the smallest in Slovensko goriško and Kamniško-Savinjsko LUOs (29%, Figure 16). A decline in the number of hunted Mallards by more than 50% occurred in nine LUOs.

3.7. Colour morphs, hybrids and domestic forms

The only colour morph documented in Slovenia, apart from escapees, are Mallards with paler feathers due to one of the colour aberrations resulting from lower melanin productivity (van Grouw 2013). In the NOAGS database, there are only three entries of individuals with such colour aberrations. Another ten records from Medvedce and Rački ribniki were gathered, referring to at least three separate individuals, one male, one female and one juvenile. All three individuals were extremely pale and therefore had either brown or diluted colour aberration. Probably the same aberration occurred in two records of pale individuals found in the literature. One individual was described as "flavinistic" and occurred in two consecutive years at Lake Cerknica (Kmecl & Rižner 1992). The other individual was referred to as "leucistic" and occurred over a longer period of time on the Drava river in Maribor (Logar 2009). Most records of aberrant individuals are from domestic origin, i.e. 22 records involving at least 61 individuals in NOAGS data base. On average, 15 individuals are counted each year during IWC with a maximum of 28 individuals in 2014. 31 records of 39 individuals at three monitoring sites at Dravsko polje (Požeg

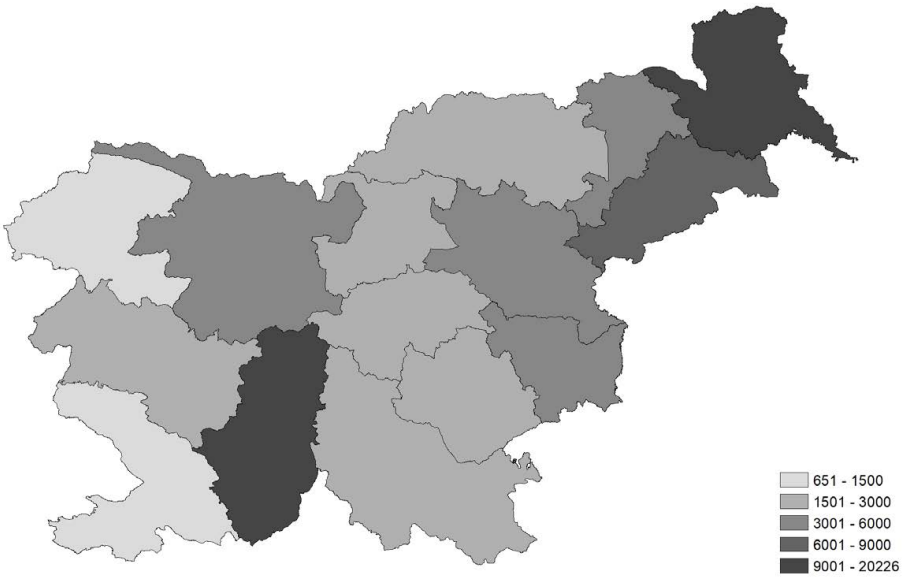


Figure 14: The number of hunted Mallards *Anas platyrhynchos* in Slovenia in separate hunting-management districts between 2001 and 2018.

Slika 14: Število odlovljenih mlakaric *Anas platyrhynchos* v Sloveniji po posameznih lovsko upravljavskih območjih med letoma 2001 in 2018.

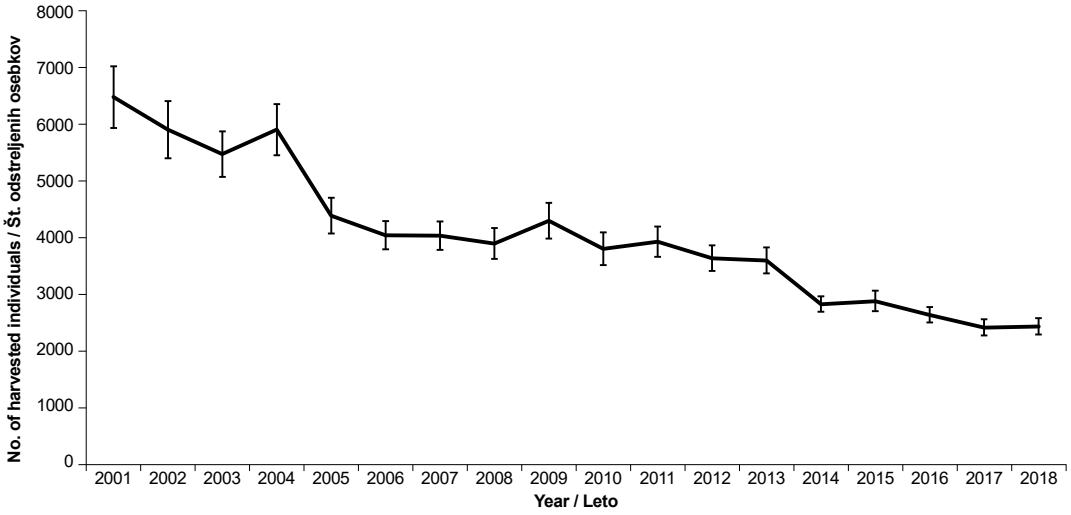


Figure 15: The number (±SD) of hunted Mallards *Anas platyrhynchos* in Slovenia between 2001 and 2018 in all hunting management districts (N= 15).

Slika 15: Število (±SD) odlovljenih mlakaric *Anas platyrhynchos* v Sloveniji med leti 2001 in 2018 za vsa lovsko upravljavska območja skupaj (N= 15).

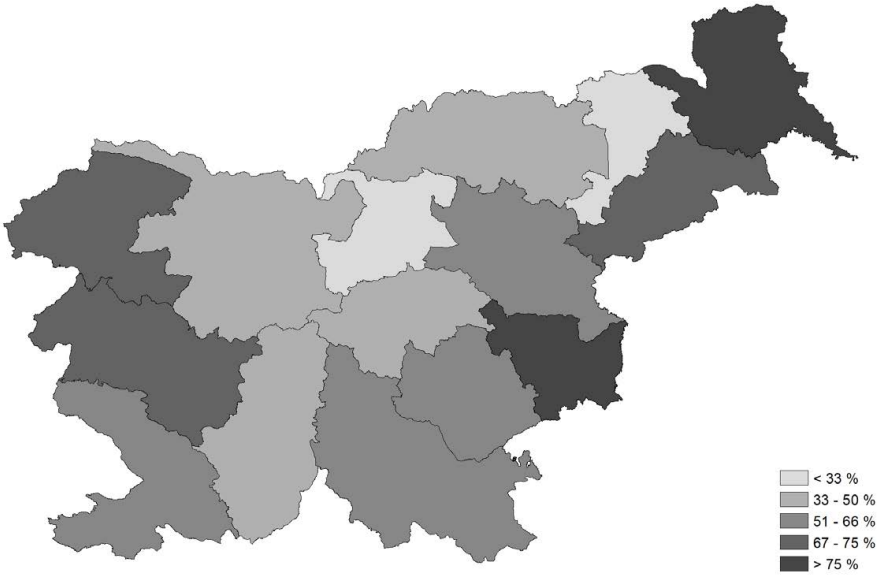


Figure 16: Map of Slovenia with regional difference in the decline in the number of hunted Mallards *Anas platyrhynchos* between 2001 and 2018.

Figure 16: Zemljevid Slovenije s prikazom razlik v upadu odlovljenega števila mlakaric *Anas platyrhynchos* med posameznimi lovsko upravljavskimi območji med leti 2001 in 2018.

and Medvedce reservoirs and Rački ribniki) in 2011–2019 were also gathered. Most were recorded between October and March, with only one record in August. They were mostly present in small numbers, usually only a single individual. 35 out of 76 cases of the Mallard domestic form gathered in the NOAGS database and during IWC are single birds, and only three records are of 10 or more individuals. In some cases, individuals stay for a longer period of time, such as at Medvedce reservoir (almost a year) and on the Drava river in Maribor (Logar 2009).

Apart from possible hybrids between domestic and wild Mallards or with Muscovy Duck *Cairina moschata*, only two wild hybrids in Slovenia were recorded. One was a male that was probably a hybrid with a Shoveler *Spatula clypeata* as parent on fishpond Črnelo near Radomlje (*own data*.). The second was a male hybrid with a Gadwall observed at Lake Ptuj (L. Božič *pers. comm*.). In addition, courtship and copulation were observed between a Mallard and a Common Teal *Anas crecca* (Sovinc 2014) and between a Mallard and a Mandarin Duck *Aix galericulata* (Denac 2004).

4. Discussion

4.1. Dominance and frequency

The Mallard has a high occurrence frequency, often reaching 100%. Frequencies below 100% are usually the result of complete freezing of individual water bodies, such as at Medvedce before 2009 (Bordjan & Božič 2009a) and at Ormož Basins Nature Reserve (L. Božič *pers. comm*.), or due to natural fluctuation of individuals at sites with low Mallard numbers (such as Gradiško lake). It is the eudominant waterbird at all monitored sites and often the most dominant. Interestingly, at some large lakes, such as Lake Constance (Werner *et al*. 2018) and Lakes Ptuj and Ormož (L. Božič *pers. comm*.), the Mallard comes only fourth or fifth among waterbirds in the non-breeding season. In Slovenia, it is most dominant on deeper water bodies (e.g. Bled, Bohinj, Pristava and Gradišče lakes). The absence or small surface area of shallows probably limits the number of other waterbird species (Deberšek & Bordjan 2016, Billerman *et al.* 2020), resulting in high Mallard dominance. Mallards, on the other hand, often feed on land and rest on water (Drilling *et al*. 2020) and may therefore occupy deeper lakes. Lake Ptuj is deep, but has lower dominance due to high numbers of other waterbird species in general, but also due to the recent significant decrease in the wintering Mallard numbers (Božič 2018, L. Božič *pers. comm*.).

4.2 Phenology

The Mallard populations reach a peak during autumn migration or winter at most monitored sites. The latter is characteristic of deep Reservoirs (Lakes Ptuj, Ormož and Gradiško) and Coast. At sites that frequently freeze over during the winter, such as Ormož Basins Nature Reserve and Medvedce reservoir, before 2009, Mallards are mostly absent during this period. The overall phenology of the Mallard in the non-breeding season between September and April is similar to that on Lake Constance (Werner *et al.* 2018). On average, the maximum in numbers at Lake Constance is reached in December (Werner *et al.* 2018), the same as at some sites in Slovenia (e.g. Ptuj, Ormož and Gradiško lakes). On the other hand, the combined Slovenian data of the last 20 years shows the maximum in January.

Already in January (Drilling *et al.* 2020), but more frequently in February (Scott & Rose 1996), spring migration starts and numbers begin to fall. The only site among those monitored with a maximum at the beginning of migration was Lake Cerknica, probably due to flooding at the end of winter at the time of monitoring (Bordjan 2012b). As at Lake Constance (Werner *et al*. 2018), there is no obvious peak during spring migration in the Slovenian data. The low numbers in late April and May can include some late migrants (Drilling *et al.* 2020), but consist mainly of breeding males. From mid-May and early June, moult migration begins (Scott & Rose 1996, Drilling *et al.* 2020), which partly explains the higher numbers in June and July for Slovenian monitoring sites. On the other hand, the majority of broods are also present at this time. In Slovenia, summer movements are more evident from the end of July. Mallards have the most prolonged autumn migration of all duck species (Drilling *et al.* 2020), starting in September (Scott & Rose 1996, Grishchenko 1997), one month later than in Slovenia. One of the

reasons could be a local movement to larger waters, which explains the increase in numbers at Ormož and Ptuj lakes, where the increase in August cannot be explained only by local breeders. Shallow waters such as the Ormož Basins Nature Reserve, NRŠZ, Medvedce reservoir and Rački ribniki also have peak numbers in August and September, indicating a movement to food-rich sites. Autumn migration of northern and eastern populations reach the peak in October and November (Scott & Rose 1996) and ends in early November or, exceptionally, in early December (Grishchenko 1997). In contrast to Lake Constance (Werner *et al.* 2018), in the Slovenian monitoring data there is a small decrease in numbers in October, most likely due to water discharge from Aquacultures in late October (e.g. Medvedce reservoir, Bordjan & Božič 2009).

The earliest documented broods are early compared to Mallards in other parts of Europe and North America (Figley & van Druff 1982, Cramp 1998, Drilling *et al.* 2020). When the influx into breeding grounds starts, usually at the end of February (Balmori 2019, Drilling *et al.* 2020), some exceptional females are already nesting in Slovenia. In early April, more than 15% of breeding females have already started nesting, and more than 50% start before the end of April, earlier than in Bavaria (Germany) and South Russia (Cramp 1998, Drilling *et al.* 2020). Southern populations start nesting earlier than those from Northern and Central Europe (Drilling *et al.* 2020), so an earlier start would be expected in Slovenia. On the other hand, the peak in the number of broods overlaps with the time of fledging in North Germany (Bräger & Ludwichowski 1995). More than half of the females fledge their young by mid-July and more than 90% by the second half of August. As with Mallards in Bavaria and England, the onset of breeding is dependent on February temperatures (Cramp 1998). Thus, due to the climate change, the onset of breeding will probably shift even further forward in the future.

4.3 Sex ratio and non-breeding females

The sex ratio of Slovenian Mallards between December and March is on average lower than in Sweden (44.6%), Finland (46.9%) and the Netherlands (46.5%, Cramp 1998). A lower proportion of females is also observed in other duck species (Bordjan & Božič 2009a, Pöysä *et al.* 2019) and could be attributed to higher mortality of females, as the sex ratio is not skewed at hatching (Donald 2007). The higher mortality of females can be attributed to several factors, such as higher predation pressure on females (Bellrose *et al.* 1961, Donald 2007), higher dispersal tendency (Donald 2007), longer migration to the wintering grounds (Cramp 1998), higher hunting pressure and lead poisoning on wintering grounds of females (Pöysä *et al.* 2019). The lower percentage of females during the breeding season is a consequence of breeding activities, as females do all the brooding (Drilling *et al.* 2020). The percentage of females starts to rebound in late May when most of them emerge with young and even more when the young fledge. Interestingly, the percentage remains low even in October, when breeding has already ended and migration begins (Drilling *et al.* 2020), suggesting that either females in our population migrate at a higher percentage or that the sex of arriving birds is shifted towards males at the beginning of migration.

4.4. Clutch and brood size

The clutch size of Slovenian Mallards is smaller than in North America (Figley & van Druff 1982, Cotter *et al.* 1996, Drilling *et al.* 2020), most of Europe (Cramp 1998) and Algeria (Fouzari *et al.* 2018), which could be due to the small sample size and the inclusion of second and replacement clutches in our sample. The latter are generally smaller (Drilling *et al.* 2020). In addition, our data likely include nests with unfinished clutches. On the other hand, average brood size is similar to other countries in Europe (Cramp 1998).

Most Mallard mortality occurs at duckling age (Hill 1984), mainly as a result of predation (Figley & van Druff 1982, Hill 1984, Singer *et al.* 2016, Fouzari *et al.* 2018). After that the survival probability increases with age (Stafford & Pearse 2007). Since Feathered young are already through the most perilous era, the average size of that age class may be close to the average Mallard productivity in Slovenia. If so, it is close to the average productivity reported elsewhere (0.83–5.4, Hill 1984, Singer *et al.* 2016).

Compared to other studies, Slovenian broods in the Downy age group contain an uncharacteristically high number of broods with fewer than 4 young (25% compared to 0% in Cramp 1998), which may indicate high mortality of young in the early stages of breeding (Krapu *et al.* 2006). As in other countries (Bräger & Ludwichowski 1995, Zicus *et al.* 2003), brood size becomes smaller as the season progresses. This may be a consequence of smaller clutch size and a higher proportion of second and replacement broods later in the season (Cramp 1998).

Brood size of Slovenian Mallards differs by wetland type, confirming the findings of Figley & van Druff (1982). Smaller broods in certain wetland types may be a consequence of poor feeding conditions (e.g. deep Reservoirs, Canals with steep banks, intensive Aquaculture, or nutrient-poor Excavations) or high breeding density (Figley & van Druff 1982, Arcese & Smith 1988, Korpiäkki & Wiehn 1998). The change in brood-size with elevation is not universal in birds (Krementz & Handford 1984, Johnson *et al.* 2006, Bordjan 2013), but it appears to decrease with altitude for Mallard.

4.5. Breeding densities

No really high breeding densities were found in Slovenia. Our breeding densities are similar to those from nearby Austria in general (Feldner *et al.* 2006) and also for fishponds (Albegger *et al.* 2015). Average breeding densities in prairies in several states in the USA and Canada range from 2.3–36 bp/km^2 (Cotter *et al.* 1996, Drilling *et al.* 2020), 49.4 bp/km^2 in urbanised brackish water lagoons in New Jersey, and 13.1 bp/km^2 in urban parks (Figley & van Druff 1982). These densities are similar to breeding densities on Aquaculture ponds, Treatment areas, and Excavations but lower than those on Ponds. Mallards reach the highest densities on wetlands with islands free of mammalian predators (Cotter *et al.* 1996, Berndt & Hill 1997, Drilling *et al.* 2020). Apart from Lake Ptuj, Ormož Basins Nature Reserve and some coastal wetlands, most shallow water bodies in Slovenia do not have isolated islands. Predator-free islands are most likely one of the main difference between the superficially similar lakes Ormož (few pairs) and Ptuj (20 pairs). Another reason for lower breeding densities is the absence of gull or tern breeding colonies on most Slovenian waters. Colonies attract a higher number of species and also allow a higher number of breeding pairs (Bräger & Ludwichowski 1995). This may also be one of the reasons for the high breeding density in the Ormož Basins Nature Reserve and as another difference between Ormož and Ptuj lakes. Mallard is a still and shallow water bird limited to water depths of less than 1 m for foraging (Cramp 1998). This explains the lower breeding densities on lakes, reservoirs and rivers. On the other hand, Aquaculture, although usually smaller and shallower, have lower breeding densities than most Ponds. This could be due to the high fish production, which reduces the food availability for ducks (Musil 2006). Breeding densities are inversely correlated with elevation. Mallards are primarily a lowland species (Cramp 1998) and as such are more abundant at lower elevations (Luder *et al.* 1998, Bordjan 2019), probably due to more severe conditions at higher elevations (Hodkinson 2005).

4.6. Breeding estimates

The estimated breeding population of Mallards on an area representing about 10% of the country represents between 25–48% of the total estimated Slovenian breeding population, indicating that the estimates used in calculation were made on the most suitable areas for Mallard. Indeed, only a few obviously suitable waters are without the estimate (e.g. lower part of the Mura river, Nanoščica, Kolpa and Krka rivers, abandoned excavations in NE Slovenia, waters in the Ljubljana basin and Vipava Valley). As most breeding populations were calculated from the number of Mallards counted (e.g. Denac & Smole 2008, Denac 2010, Tome *et al.* 2011, Denac & Kmecl 2014), some discrepancy between the population estimated in these studies and the present one may result from sex ratio, which is biased in favour of males (Bordjan & Božič 2009a, Logar 2009, *this study*). Additionally, some females (9–13.1%), especially smaller/younger ones, do not breed (Sheppard 2018), further increasing the disparity.

All previous national populations were estimated based on expert opinion, and as these estimates were often extrapolated from local populations from more suitable habitats and did not take into account sex ratios and non-breeding females, this resulted in an overestimated national population. This is reflected in the dynamics of past population estimates. Estimates in the 1990s and early 2000s were 10–20,000 pairs (Geister 1995, BirdLife International 2004). In 2014, the population estimate was reduced to less than half the previous estimate (3,000–9,000 pairs, Denac & Kmecl 2014) and was even smaller in 2019 (1,500–3,500, Bordjan 2019), without any evidence of a decline in the breeding population. The estimate from this study is similar to the last estimate and reflects the more conservative and precise method used.

4.7. Non-breeding population

Overall, 16,000–32,000 Mallards winter in Slovenia, which corresponds to about 0.5% of European wintering population and 1.1–2.3% of the regional Northern Europe/West Mediterranean population (Wetlands International 2019, Wetlands International & BirdLife International 2020). The Slovenian population has been smaller than Sovinc's (1994) estimate (25,000–50,000 ind.) for the 90's. In Central Europe, winter populations in many places have declined to the lowest level since annual surveys began (Werner *et al.* 2018). Although some European populations have increased (Guzzon *et al.* 2005), the decline in Slovenia may at least partly mirror that on the continent scale (Bairlein *et al.* 2014, BirdLife International 2017, Werner *et al.* 2018). The regional population has been increasing from the 1990s, but shows a declining trend in the last decade (Wetlands International 2019), which is also reflected in Slovenian IWC. The major decline probably took place before the year 2000, as many sites in Slovenia report much lower maximum numbers than in the 1990s. Warm winters are becoming more frequent in Europe (IPCC 2018) and in such winters the wintering range of waterbirds tend to shift NE (Pavón-Jordán *et al.* 2019). In Sweden, the number of wintering Mallards more than doubled between 1971 and 2004 due to higher temperatures and lower ice cover (Nilsson 2008), suggesting that more individuals stay closer to their breeding range. Similarly, the number of wintering Mallards in Moscow has been attributed in part to mean winter temperatures (Avilova & Eremkin 2019). This is important because northern populations are mostly migratory, with massive movements during severe winter weather (Scott & Rose 1996). On Lake Constance, Mallards were most numerous in cold winters and least numerous in warm winters (Werner *et al.* 2018). Mallards are especially prone to a north–south shift in wintering range due to winter temperatures, as the shift is more pronounced in shallow-water species (Pavón-Jordán *et al.* 2019). Traditionally, the majority of wintering Mallards in Slovenia were counted on large unfrozen natural and reservoir lakes, and gravel pits (Sovinc 1994). Recently, significant numbers of Mallards are also found on shallow waters such as Medvedce reservoir, where before 2009 the species was present only in small numbers and irregularly during winters (Bordjan & Božič 2009a), but now can hold almost 2,500 individuals at a time (*pers. data*).

The river sections with the highest density of Mallards in winter are located in urban areas (Ljubljana, Maribor, Celje and Kranj). Although the urban sections are generally shorter (1.5 km on average compared to 3.9 km for all sections), density is still high even if sections are pooled. The number of Mallards per kilometre combined for each city is still above average and Maribor and Ljubljana still hold more than 50 mallards per river kilometre (Maribor 58 and Ljubljana 59). This is not surprising, as urban areas are free of hunting and often provide a lot of antropogenic food (Chace & Walsh 2006, Avilova & Eremkin 2019) and have lower predator pressure (Minias 2016). Mallards can become well tolerant of human presence (Scott & Rose 1996) and are often abundant on waters in urban areas (Drilling *et al.* 2020), such as the Drava river in Maribor (Logar & Božič 2014).

4.8. Hybrids and domestic form of Mallards

Releasing captive-bred Mallards for hunting was a common practice in the past (Štumberger 1983a, Ciglič & Trebar 1998, Tome *et al.*

2005, ZGS 2012f) and is still common in many places in Europe (Söderquist *et al.* 2014). Today, the release of Mallards is part of the hunting management plan in Slovenia in only a few LUO's (ZGS 2012a). For example, between 2014 and 2018, 4,615 Mallards were released for hunting in Special purpose state hunting ground LPN Fazan-Beltinci (ZGS 2019). Per year, 620–1,180 Mallards were released, which corresponds to about 170% of the hunted Mallards in this district. In Sweden, such surplus individuals affect morphological traits (Söderquist *et al.* 2014) and reproduction of wild Mallards (Cramp 1998). So far, the effects on Mallards in Slovenia have not been studied. Therefore, efforts should be made to study the survival of released individuals and escapees, the impact and frequency of crossbreeding with wild Mallards using ringing (Gunnarsson *et al.* 2008) or telemetry (Stafford & Pearse 2007).

4.9. Causes of mortality

Hunting accounts for much of the observed Mallard mortality in Slovenia (ZGS 2012h). Similar findings have been made for Finnish and Swedish Mallards, where ringing was used to estimate causes of adult Mallard mortality (Gunnarsson *et al.* 2008). On the other hand, survival in the pre-fledging period is the lowest of all age groups (Hill 1984, Stafford & Pearse 2007) and it is the most influential factor of population growth (Sheppard 2018), so hunting mortality is inferior to natural causes at least in the first 100 days of life (Bergan & Smith 1993). As in other studies (Gunnarsson *et al.* 2008), predation was the most important natural cause of Mallard mortality in Slovenia. Natural causes of mortality are likely to be grossly underestimated, as Mallard mortality in Slovenia is largely unstudied and the detection probability of natural compared to hunting mortality is considerably lower (Naef-Daenzer *et al.* 2017). Moreover, the hunting season starts in September (ZGS 2012a) well after the most vulnerable period for Mallard mortality (Stafford & Pearse 2007). More efforts should be made to study natural Mallard mortality in Slovenia, especially as hunting could be an additive mortality (Burnham & Anderson 1984). In addition to studying the extent and causes of Mallard mortality, other important mortality factors such as water pollution (Choules *et al.* 1978), lead poisoning from ammunition (Pain *et al.* 2019) and climate change (Guillemain *et al.* 2013) should also be studied in Slovenia.

4.10. Hunting

As expected, more Mallards are hunted in areas with higher breeding densities and higher numbers of wintering Mallards (e.g. NE Slovenia). High number of Mallards are also hunted in the Notranjska district, which has a lower overall Mallard density (Bordjan 2019), but with larger Mallard concentrations of on Lake Cerknica and Ljubljansko barje. The lowest hunting numbers are found in districts with extensive forest cover, predominant high mountains and the absence of surface waters.

The decline in hunted Mallards in most parts of Slovenia over the last 13 years is probably a continued trend from a longer period. In the late 1980s and early 1990s, 7,900–12,600 Mallards were hunted per year (Sovinc 1994), almost three times as many as today. The decline may be the result of lower number of wintering Mallards, lower interest in smaller game (ZGS 2012a), higher availability of big game in some parts of Slovenia (Adamič & Jerina 2010), or a consequence of decreasing number of hunters in recent years (more than 2% decrease between 2012 and 2018, (LZS 2014, LZS 2019). One of the suggested reasons is the ban on raising and releasing Mallards for hunting (ZGS 2012f), but this is probably less important as the number of Mallards hunted is also lower in Pomursko LUO, where releases still take place. Moreover, some traditional areas for duck hunting are now covered by nature reserves where hunting is not allowed e.g. Ormož Basins Nature Reserve and Škocjanski zatok Nature Reserve, (Štumberger 1983b, Štumberger 1986, B. Lipej *pers. comm.*).

Hunting has an influence on various aspects of waterbirds life, e.g. movement, energy consumption and displacement from preferred feeding sites (Madsen & Fox 1995). In many places in Slovenia, there is a high proportion of other waterbirds compared to Mallards (Bordjan & Božič 2009b, Bordjan 2012b). Thus, the effect of Mallard hunting also extends to other waterbirds, including those with unfavourable conservation status. The

effects of hunting on waterbirds can be mitigated by the establishment of no-hunting reserves (Evans & Day 2002) as they greatly increase the numbers of Mallards as well as other waterbird species (Guzzon *et al.* 2005). To reduce the negative impacts of Mallard hunting, I propose the expansion of no-hunting zones to all areas important to breeding, migrating, or wintering waterbirds. In addition for sites to be designated as IBAs for waterbirds (Denac *et al.* 2011), criteria for establishing a no-hunting area could include high Mallards populations, i.e., more than 500 regularly present individuals during winter or at least 500 individuals counted during fall migration, and a high proportion of other waterbirds relative to Mallards. According to this study, four sites meet the winter criterion and another eight sites meet the migration criterion. All sites are covered by the Natura 2000 network (Denac *et al.* 2011), and some (e.g. the Škocjanski zatok and Ormoške lagune nature reserves, the Sečoveljske soline Landscape, Park Rački ribniki and Lake Ptuj) are already hunting-free areas. Of the others, the need for establishment of a no-hunting reserve is most critical at Lake Cerknica and Medvedce reservoir. Both host large numbers of Mallards as well as other waterbirds (Bordjan & Božič 2009a, Bordjan 2012b) and duck hunting is present in both areas and is recognised to have a negative impact on waterbirds (Trontelj 1993, Bordjan *et al.* 2013). Lake Cerknica also represents an isolated area of suitable habitat for waterbirds in the wider region and thus is short on places for waterbirds to retreat to from hunting.

4.11. Ringing

A relatively small number of Mallards are ringed annually in Slovenia. As the most numerous waterbird species, it is neglected by ringers in Slovenia and falls far behind other waterbirds such as Mute Swan *Cygnus olor*, White Stork *Ciconia ciconia*, Little Ringed Plover *Charadrius dubius*, Common Sandpiper *Actitis hypoleucos*, Black-headed Gull *Chroicocephalus ridibundus*, Common Tern *Sterna hirundo* and also Water Rail *Rallus aquaticus* (Vrezec & Fekonja 2016, Vrezec & Fekonja 2017, Vrezec & Fekonja 2018). The high effort in the 1970s resulted in all our foreign recoveries. On the other hand, the low number of recoveries (seven in almost 100 years) of birds ringed outside Slovenia is surprising, considering how many Mallards were hunted in Slovenia (almost 100,000 individuals in 20 years). One possibility is that hunters do not report ringed birds. If this is the case, this is a major loss of ringing data and should be addressed in the future by the Slovenian Bird Ringing Centre.

The small number of available foreign recoveries suggests that migratory movements, timing and direction are similar to Mallards in Croatia, most of which belongs to the same flyway (Kralj *et al.* 2013), and to those in Germany, which belongs to two separate flyways (Bairlein *et al.* 2014). All birds were recovered within the Northern Europe/West Mediterranean population boundaries (Scott & Rose 1996, Wetlands International & BirdLife International 2020). Birds ringed within Slovenia move shorter distances than foreign birds recovered in Slovenia. This is similar to Croatia (Kralj *et al.* 2013) and can be explained by shorter migration distances of southern populations compared to more northern ones (Cramp 1998, Drilling *et al.* 2020). Our few local recoveries suggest site fidelity, especially for the non-breeding season. Although the data is limited, it may suggest that at least some individuals are resident (e.g. Mallard ringed in early fall on Lake Bled and recovered in winter).

5. Povzetek

Namen prispevka je zapolniti vrzel v znanju te sicer zelo razširjene in številčne vrste v Sloveniji. Mlakarica je ena najpogosteje opazovanih vrst vodnih ptic pri nas, ki na območju rednih monitoringov pogosto doseže frekvenco pojavljanja 100 %. Mlakarica je tudi najbolj dominantna vrsta vodne ptice pri nas z razponom dominance 17,5–89,0 %. Samice dosegajo samo 36,7 % vseh opazovanih mlakaric z najvišjim deležem (41,5 %) pozimi in najnižjim v začetku gnezdenja (14,7 %), ko so samice na gnezdih. Mlakarica je najštevilčnejša med jesensko selitvijo in pozimi. V Sloveniji zabeležena gnezditvena sezona traja večji del leta, od sredine januarja pa vse do začetka decembra. Glavnina samic spelje svoje v povprečju 6,2 ± 2,66 veliko leglo med aprilom in julijem. Velikost legla upada s časom, starostjo mladičev in nadmorsko

višino in je najvišja na bazenih za odpadne vode ter na obalnih mokriščih (7,3), najnižja pa na globokih zadrževalnikih (5,7) in jezerih (5,6). Zares visokih gostot gnezdečih parov v Sloveniji nismo zabeležili in gostote so bile podobne povprečnim gostotam mlakarice po svetu. V Sloveniji ocenjeno gnezdi 1473–3763 parov in prezimuje v povprečju 22.237 (10.376–32.010) osebkov mlakaric. Velika večina mlakaric prezimuje v SV Sloveniji, največ na reki Dravi na Ptujskem (do 8330 os.) in Ormoškem jezeru (do 5400 os.). Največ mlakaric prezimuje na stoječih vodnih telesih, na rekah pa na urbanih odsekih, kjer se zadržujejo v večjem številu zaradi krmljenja in varnosti. Slovenska zimska populacija mlakarice je v upadu, verjetno zaradi vse toplejših zim. Najvišje število mlakaric na selitvi je bilo zabeleženo spomladi na Cerkniškem jezeru (4581) in jeseni na zadrževalniku Medvedce (3379).

V obdobju med 2001 in 2018 je bilo ustreljenih 72.731 mlakaric, večina v SV Sloveniji (28 % v Pomurskem lovsko-upravljavskem območju). Število letno ustreljenih mlakaric upada v vseh lovsko-upravljavskih območjih in je upadlo za 64 % od leta 2001. V lovskih evidencah je najpomembnejši vzrok smrtnosti mlakaric lov, ki dosega 97,4 % vse zabeležene smrtnosti. Med drugo zabeleženo smrtnostjo je najpomembnejše plenjenje, ki dosega 1,1 % smrtnosti. Ker je pri mlakarici največja zabeležena smrtnost pri mladičih, ki niso zajeti v uradne lovske statistike, ter ker je zaznavnost naravne smrtnosti občutno nižja od lova, je zelo verjetno naravna smrtnost vrste pri nas močno podcenjena.

Kljub dolgi tradiciji obročkanja in velikemu številu ulovljenih mlakaric imamo zelo malo ponovnih najdb obročkanih mlakaric, v zadnjih 100 letih le devet tujih najdb. Slednje nakazuje na možnost, da lovci ne poročajo o najdbah Slovenskemu centru za obročkanje ptic. Z izjemo obdobja 1972–1975, ko je bilo obročkanih 87 % vseh mlakaric, je intenzivnost obročkanja mlakarice pri nas zelo nizka. Rezultat je samo sedem najdb naših mlakaric na tujem. Največja razdalja na tujem najdene mlakarice je iz Ukrajine (1290 km), medtem ko je izvor najdaljše tuje najdbe pri nas je iz Finske (2075 km).

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DODATEK 1 / APPENDIX 1

Regional and linear (2 km transects) breeding densities of the Mallard *Anas platyrhynchos* in Slovenia.
Regionalne in linijske (2 km transekti) gnezditvene gostote mlakarice *Anas platyrhynchos* v Sloveniji.

Breeding density [bp/km²] / regionalana gnezditvena gostota [gp/km²]	Breeding population size estimate / Ocena gnezditvene gostote			Calculated density [bp/km²] / Izračunana gostota [gp/km²]		
Location / Lokacija	Min	Max	Area [km²] / Površina [km²]	Min	Max	Source / Vir
Ljubljana	142	426	211.0	0.67	2.02	Tome *et al.* (2013)
Ljubljansko barje	210	258	180.0	1.17	1.43	Tome *et al.* (2005)
Drava river between Maribor and Ptuj	54	54	76.0	0.71	0.71	Bračko (1997)
Goričko	150	250	448.2	0.33	0.56	Denac & Kmecl (2014)
Landscape park Škocjanske jame	1	2	4.1	0.24	0.48	Figelj & Kmecl (2014)
Kozjansko	10	20	198.0	0.05	0.10	Jančar & Trebušak (2000)
Triglav National Park	11	30	880.0	0.01	0.03	Jančar (1997)
Upper Reka river valley	2	5	17.0	0.12	0.29	Polak (2000)
Dragonja valley between Dragonja and Župančiči	6	7	5.3	1.14	1.33	Sovinc (1998), Gregorič & Sovinc (2016)
Jovsi	5	5	4.6	1.09	1.09	Trontelj & Vogrin (1993)
Sava river between Krško and Croatia	54	90	33.3	1.62	2.70	Denac & Smole (2008)
Tivoli, Rožnik in Šišenski hrib	2	2	4.6	0.44	0.44	Mihelič (2005)
Mura, Šentilj-Veržej	207	325	36.8	5.63	8.83	Božič (2007a)
Average	854	1,474	2,098.9	0.41	0.70	
Linear density [bp/km] / linearna gnezditvrna gostota						
Slovenian Farmland bird indeks				2.06	2.06	Božič (2007b, 2008b), Figelj & Kmecl (2009, 2011, 2012, 2013, 2015, 2016), Kmecl *et al.* (2014), Kmecl (2017, 2019), Kmecl & Šumrada (2018)
Dinaric region				4.45	4.45	
Pannonian region				1.15	1.15	
Mediterranean region				2.29	2.29	
Alpine region				1.76	1.76	
Wet meadows				7.62	7.62	
Mosaic farmland				1.37	1.37	
Mediterranean mosaic				3.34	3.34	
Intensively used farmland				1.51	1.51	
IBA				3.47	3.47	
non-IBA				1.96	1.96	

DODATEK 2 / APPENDIX 2

Ecological breeding densities of the Mallard *Anas platyrhynchos* in Slovenia.

Ekološke gnezditvene gostote mlakrice *Anas platyrhynchos* v Sloveniji.

		Breeding population size estimate / Ocena gnezditvene populacije			Calculated density [bp / km^2] / Izračunana gnezditvena gostota [gp / km^2]		
Wetland type / Tip mokrišča	Location / Lokacija	Min	Max	Area [ha] / Površina [ha]	Min	Max	Source / Vir
Aquaculture ponds / ribogojnice		**19**	**69**	**269**	**7.07**	**25.69**	
	Water reservoir Medvedce	8	46	160	5.00	28.75	Bordjan & Božič (2009a), *Own data*
	Rački fishponds	4	16	36	11.14	44.57	*Own data*
	Fishpond Vrbje 1996	2	3	14	14.81	22.22	(Vogrin 1996)
	Fishpond Vrbje 2013	2	3	55	3.66	5.48	Gamser & Novak (2013)
	Turnovi fishponds	3	6	5	66.67	133.33	*Own data*
Excavation / izkopi		**24**	**37**	**120**	**19.99**	**30.81**	
	Gravel pits along the Lower Sava river	9	15	49	18.33	30.55	Denac & Smole (2008)
	Stavbarjeva gramoznica Hoče	2	2	16	12.58	12.58	Vogrin (1994a)
	Hotinja vas	3	5	6	46.88	78.13	*Own data.*
	Koseški bajer	2	2	4	50.00	50.00	Mihelič (2005)
	Gravel pit Stari grad	2	5	14	13.90	34.75	Denac & Smole (2008)
	Gravel pit Vrbina	6	8	30	19.80	26.40	Denac & Smole (2008)
Coast / obala		**15**	**30**	**730**	**2.05**	**4.11**	
	Sečovlje salina	10	20	650	1.54	3.08	Škornik (2012)
	Brackish lagoon (NRŠZ)	5	10	80	6.23	12.45	B. Mozetič *pers. comm.*
Lakes / jezera		**11**	**52**	**693**	**1.59**	**7.50**	
	Lake Bled	2	12	145	1.38	8.28	Jančar *et al.* (2007)
	Lake Bohinj	1	24	318	0.31	7.55	Jančar *et al.* (2007)
	Šaleška lakes	8	16	230	3.48	6.96	Deberšek & Bordjan (2016)

Nadaljevanje dodatka 2 / Continuation of Appendix 2

		Breeding population size estimate / Ocena gnezditvene populacije			Calculated density [bp / km^2] / Izračunana gnezditvena gostota [gp / km^2]		
Wetland type / Tip mokrišča	Location / Lokacija	Min	Max	Area [ha] / Površina [ha]	Min	Max	Source / Vir
Pools / jezerca		**4**	**7**	**11**	**38.10**	**66.67**	
	Oxbow lake Prilipe	1	2	4	22.73	45.45	Denac & Smole (2008)
	Petišovsko jezero	3	5	6	49.18	81.97	Bračko (1994a)
Ponds / ribniki		**34**	**55**	**65**	**52.47**	**84.87**	
	Hraše fishponds	5	5	3	161.29	161.29	B. Blažič *pers. comm.*
	Hodoško jezero	5	5	5	96.15	96.15	Vrezec (2004)
	Ljutomerski ribniki	3	5	12	25.13	41.88	Bračko (1994b)
	Proseniško fishpond 1	1	2	<1	263.16	526.32	M. Gamser *pers. comm.*
	Proseniško fishpond 2	1	2	2	48.39	96.78	M. Gamser *pers. comm.*
	Proseniško fishpond 3	0	1	<1	0.00	250.13	M. Gamser *pers. comm.*
	Proseniško fishpond 4	1	5	5	18.24	91.21	M. Gamser *pers. comm.*
	Proseniško fishpond 5	1	2	1	71.19	142.38	M. Gamser *pers. comm.*
	Proseniško fishpond 6	5	6	8	65.33	78.39	M. Gamser *pers. comm.*
	Proseniško fishpond 7	1	1	2	60.95	60.95	M. Gamser *pers. comm.*
	Proseniško fishpond 8	1	2	4	23.97	47.95	M. Gamser *pers. comm.*
	Fishpond Črnelo	1	2	2	47.62	95.24	*Own data.*
	Fishponds in Prevoje	1	2	3	31.29	62.58	*Own data.*
	Accumulation on Rača river	1	2	1	71.19	142.38	*Own data.*
	Fishpond Lokve	3	5	6	50.41	84.01	NOAGS
	Fishpond Rogaška slatina	1	3	1	76.28	228.84	NOAGS
	Jezerce (NRŠZ)	3	5	7	40.54	67.57	B. Mozetič *pers. comm.*

Nadaljevanje dodatka 2 / Continuation of Appendix 2

		Breeding population size estimate / Ocena gnezditvene populacije			Calculated density [bp / km^2] / Izračunana gnezditvena gostota [gp / km^2]		
Wetland type / Tip mokrišča	Location / Lokacija	Min	Max	Area [ha] / Površina [ha]	Min	Max	Source / Vir
River / reke		**128**	**185**	**1,546**	**8.28**	**11.97**	
	Sava river between Krško and Croatia	45	75	245	18.36	30.60	Denac & Smole (2008)
	Drava river between Maribor and Ptuj	54	54	454	11.90	11.90	Bračko (1997)
	Drava river in Maribor	9	9	155	5.81	5.81	Logar & Božič (2014)
	Mura river	7	15	384	1.82	3.91	Božič (2007a)
	Sava river between Litija and Zidani most*	10	20	270	3.70	7.41	Figelj & Kmecl (2014)
	Landscape park Škocjan cave	1	2	6	16.95	33.90	Denac (2010)
	Kamniška bistrica river from Kamnik to Domžale	2	10	32	6.18	30.92	*Own data.*
Seasonal/ intermittent freshwater wetlands / presihajoča jezera		**276**	**364**	**5516**	**5.00**	**6.60**	
	Marsh (NRŠZ)	7	10	35	20.00	28.57	B. Mozetič *pers. comm.*
	Volčeke meadows	4	4	91	4.39	4.39	Štumberger (1994)
	Floodplain forest along Mura river (Šentilj-Gornja Radgona)	80	120	450	17.78	26.67	Božič (2007a)
	Mixture Flodplain forest/farmland along Mura river (Šentilj-Gornja Radgona)	5	10	180	2.78	5.56	Božič (2007a)
	Flodplain forest along Mura river (Gornja Radgona-Veržej)	80	110	1340	5.97	8.21	Božič (2007a)
	Mixture Flodplain forest/farmland along Mura river (Gornja Radgona-Veržej)	10	20	520	1.92	3.85	Božič (2007a)
	Cerknica lake	90	90	2,900	3.10	3.10	Bordjan (2012b)

Nadaljevanje dodatka 2 / Continuation of Appendix 2

		Breeding population size estimate / Ocena gnezditvene populacije			Calculated density [bp / km^2] / Izračunana gnezditvena gostota [gp / km^2]		
Wetland type / Tip mokrišča	Location / Lokacija	Min	Max	Area [ha] / Površina [ha]	Min	Max	Source / Vir
Water storage areas / zadrževalniki		**44**	**60**	**829**	**5.31**	**7.24**	
	Lake Zbilje	10	10	57	17.54	17.54	Trontelj (1992)
	Lake Trboje	5	5	65	7.69	7.69	Trontelj (1992)
	Lake Ptuj	10	15	350	2.86	4.29	L. Božič *pers. comm.*
	Lake HE Moste	1	1	56	1.79	1.79	Jančar *et al.* (2007)
	Žovnek reservoir	1	3	49	2.04	6.12	Vogrin (2005)
	Požeg Reservoir	2	6	74	2.70	8.11	*Own data.*
	Lake Slivnica	6	6	62	9.60	9.60	M. Vogrin *pers. comm.*
	Lake Gradišče	4	7	27	15.04	26.32	*Own data.*
	Lake Šmartinsko	5	7	89	5.64	7.90	M. Gamser *pers. comm.*
Other / drugo							
	East Teharsko lake	1	3	20	4.90	14.71	M. Gamser *pers. comm.*
	West Teharsko lake	2	4	23	8.77	17.54	M. Gamser *pers. comm.*
	Ormož Basins Nature Reserve	10	30	35	28.99	86.96	L. Božič *pers. comm.*
	Golf course Ptuj	2	2	55	3.64	3.64	Vogrin & Miklič (2004)
	Farmland along Mura river (Šentilj-Gornja Radgona)	5	10	480	1.04	2.08	Božič (2007a)
	Farmland along Mura river (Gornja Radgona-Veržej)	10	20	560	1.79	3.57	Božič (2007a)
Overall ecological density / Skupna ekološka gostota		**585**	**928**	**10,951**	**5.34**	**8.47**	

DODATEK 3 / APPENDIX 3

Highest recorded numbers of Mallards *Anas platyrhynchos* for separate locations and regions.
Abbreviations: R – random, M – monitoring, C – census.

Najvišja zabeležena števila mlakaric *Anas platyrhynchos* na posameznih lokacijah in območjih.
Okrajšave: R – naključni podatek, M – monitoring, C – popis.

		Max	Spring / Pomlad	Autumn / Jesen	Winter / Zima	Type of data / Tip podatka	Source / Vir
Dolenjska	Rudniško Lake	343	33		343	R	Štumberger (1983b), NOAGS
	Kolpa (Metlika-Rosalnice)	453			453	M	IWC
	Kolpa (Pobrežje-krasinec)	490			490	M	
	HE Krško	562	254	203	562	R	NOAGS
Gorenjska	HE Moste	330	275	330	224	M	Jančar *et al.* (2007), NOAGS
	Lake Bohinj	145	145	139	138	M	Jančar (1994, 1997), Jančar *et al.* (2007)
	Lake Gradiško	125	65	64	125	M	*Own data.*
	Lake Zbilje	220	220	50	70	M	Trontelj (1992), NOAGS
	Lake Bled	687	551	687	641	M	Kozinc (1992), Jančar *et al.* (2007), NOAGS
	Lake Trboje	600		35	600	M	Trontelj (1992)
Notranjska	Pivka lakes	150	35	150	40	C	Tome (2000), NOAGS
	Lake Cerknica	4,581	4,581	2,500	2,500	M	Gregori (1979), Kmecl & Rižner (1993), Bordjan (2012a, 2012b,)
Central Slovenia	Ljubljansko barje	800	100	800	300	C	Tome *et al.* (2005)
	Ljubljanica (Ljubljana, Fužine)	547			547	M	IWC
	Ljubljanica (Ljubljansko barje, from 2 km before railway bridge to the bridge)	561			561	M	IWC
	Ljubljana and surroundings	1,739			1,739	C	Tome *et al.* (2011)
Prekmurje	Mura at Murska šuma	500	500			C	Kolenko (2001)
	Gravel pit Nograd Dobrovnik	1,230			1,230	M	IWC
	Gravel pit Babinci	549			549	M	IWC
	Gravel pit Zgornje Krapje	1,069			1,069	M	IWC
	Gravel pit Murska Sobota	850			850	M	IWC
	Gravel pit Ivanci	588			588	M	IWC
	Lake Ledava	501	77	501	186	R	NOAGS

Nadaljevanje dodatka 3 / Continuation of Appendix 3

		Max	Spring / Pomlad	Autumn / Jesen	Winter / Zima	Type of data / Tip podatka	Source / Vir
Primorska	Škocjanski zatok Nature Reserve	501	345	501	328	M	D.Stanič *pers comm.*
	Most na Soči reservoir	238			238	M	IWC
	Sečovelje salina	2,600	1,500	894	2,600	M	(Vrezec (1999), Polak (2000), Škornik (2012), I. Škornik *pers. Comm.*
Štajerska	Žovnek reservoir	464	250	464	150	M	Koprivšek (1993b, 1994), Kmecl & Rižner (1995), Vogrin (2005), NOAGS
	Lake Ormož	5,400	3,005	1,132	5,400	M	Bibič (1988), Bračko (1992), L. Božič *pers. comm.*
	Lake Gajševci	941			941	M	IWC
	Lake Ptuj	8,330	1,796	2,145	8,330	M	Bibič (1988), Vrezec (1997), L. Božič *pers. comm.*
	Vrbje fishpond	294	151	294	124	M	Koprivšek (1993a), Vogrin (1996), Gamser & Novak (2013)
	Komarnik fishpond	450			450	M	IWC
	Lake Pernica	1,052	300	209	1,052	C	Bibič (1988), Bračko (1994c), NOAGS
	Medvedce reservoir	3,379	2,137	3,379	2,800	M	Bordjan & Božič (2009a), *Own data.*
	Požeg reservoir	3,000	428	1,131	3,000	M	Vogrin (1994b), Bordjan (2003), Own data.
	Rački ribniki	1,696	350	1,696	784	M	Vogrin (1990), Own data
	Lake Vonarje	427	427		239	R	(Podhraški (1997, 2001, 2011)
	Gravel pit Kunguta	323			323	R	NOAGS
	Lake Pristava	137			137	C	Bibič (1988)
	Lake Radehova	150			150	R	NOAGS
	Šaleška lakes	165	137	165	132	M	Deberšek & Bordjan (2016)
	Lake Slivnica	271			271	C	NOAGS
	Ormož Basins Nature Reserve	663	138	663	499	M	L. Božič *pers. comm.*
	Drava river in Maribor	1,303	488	466	780	M	Logar & Božič (2014)

DODATEK 4 / APPENDIX 4

The number of hunted Mallards *Anas platyrhynchos* and trends in separate hunting-management districts (LUO) between 2006 and 2018. All trends are statistically significant.

Število odlovljenih mlakaric *Anas platyrhynchos* in izračunan trend po posameznih lovsko upravljavskih območjih med leti 2006 in 2018. Vsi trendi so statistično značilni.

Name of the LUO / Ime lovsko upravljavskega območja	Min	Year / Leto	Max	Year / Leto	All years / Vsa leta	R	p
Gorenjsko	149	2017	304	2004	4,274	-0.89	<0.001
Kamniško-Savinjsko	50	2017	140	2001	1,647	-0.51	0.032
Kočevsko-Belokranjsko	16	2015	185	2003	2,004	-0.65	0.003
Notranjsko	337	2016	762	2002	9,331	-0.77	<0.001
Novomeško	69	2017	211	2004	2,733	-0.84	<0.001
Pohorsko	72	2018	162	2001	1,801	-0.58	0.012
Pomursko	428	2014	2,195	2001	20,226	-0.92	<0.001
Posavsko	125	2017	577	2004	4,577	-0.84	<0.001
Primorsko	52	2018	131	2003	1,357	-0.76	<0.001
Ptujsko-Ormoško	253	2015	965	2001	8,742	-0.87	<0.001
Savinjsko-Kozjansko	123	2018	375	2004	4,424	-0.93	<0.001
Slovensko goriško	247	2014	428	2001	5,958	-0.76	<0.001
Triglavsko	15	2018	60	2005	651	-0.87	<0.001
Zahodno visoko kraško	70	2017	273	2002	2,600	-0.86	<0.001
Zasavsko	87	2010	201	2003	2,406	-0.82	<0.001
All LUOs / Vsa lovsko upravljavska območja	2,421	2017	6,492	2001	72,731	-0.95	<0.001

DODATEK 5 / APPENDIX 5

The maximum number of Mallards *Anas platyrhynchos* counted in winter on several water bodies in two time periods. Sources for the first period are Sovinc (1994) and Polak (2000), and Božič (2015, 2016, 2017, 2018, 2019) for the second period.

Največje število mlakaric *Anas platyrhynchos* preštetih pozimi na izbranih vodnih telesih v dveh ločenih obdobjih. Viri so za prvo obdobje Sovinc (1994) in Polak (2000), ter Božič (2015, 2016, 2017, 2018, 2019) drugo obdobje.

	In 1980's and 1990's / v 80' in 90' letih	2015–2019
Požeg reservoir	1,300	37
Šaleška lakes	3,000	400
Sečovlje salina	2,600	1,222
Drava river below Maribor	15,000–30,000	7,302
Lake Ptuj	8,150	1,890
Lake Ormož	5,150	1,765
Lake Pernica	2,500	53