Breeding biology of the Northern Pintail *Anas acuta* at the edge of its southwestern Palearctic range

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Abstract

One of the most southern breeding sites of the Northern Pintail *Anas acuta* in the SW Palearctic is in the Guadalquivir marshes (southwest Spain), part of which includes Doñana National Park. Breeding was recorded in 45.7% out of 46 years and was more frequent in those seasons in which the preceding autumn/winter was rainy, suggesting that the species behaved as an opportunistic breeder. Egg-laying started in late March–early April, earlier than in more northern sites. Clutch size and nesting success were similar to those of other populations in Europe and North America. There was a tendency for brood desertion of older ducklings by females. As breeding statistics are similar to those at other sites, the breeding population in the Guadalquivir marshes should not be considered as a peripheral population from an ecological point of view. The size of the breeding population in the Guadalquivir marshes decreased throughout the 20th century. Because the Pintail depends on high water levels to breed in the Guadalquivir marshes, and overexploitation of water resources is increasing in the Doñana area, breeding of this species at this site may be compromised over the next decades.

Key words: brood desertion, clutch size, Doñana, nesting phenology, opportunistic breeder.

The breeding range of the Northern Pintail *Anas acuta* (hereafter Pintail) extends throughout the northern Holarctic (Clark *et al.* 2020). In its Palearctic breeding range, the Pintail has an almost continuous distribution from eastern Siberia to Scandinavia, with scattered populations in Iceland, the British Isles and central Europe (Cramp & Simmons 1977). The southernmost Palearctic site where the species has been recorded breeding was Iriki Lake in southeastern Morocco (Cramp & Simmons 1977), but the lake dried out after the construction of the Mansour Eddahbi dam in 1971, and the Pintail has not bred there since (Karmaoui *et al.* 2015). Although ocassionally breding in Tunisia (Isenmann *et al*. 2005), nowadays the southernmost Palearctic site where the Pintail regularly breeds is in the Guadalquivir marshes (southwest Spain), where it has been traditionally recorded nesting, albeit usually in low numbers (Noble 1902; Valverde 1960; Amat 1982; García *et al.* 2000). Although it has been suggested that the Pintail breeds in these marshes when water levels are high (Chapman & Buck 1910; Valverde 1960; García *et al.* 2000; Martínez et al. 2021), this has not been demonstrated. If this is truly the case, the propensity of Pintails to breed in the Guadalquivir marshes, which include Doñana National Park, could be adversely affected in the future, given that ground water has been overexploited for agricultural purposes in recent decades and this has negatively affected the flooding of wetlands in the Doñana's area (de Felipe *et al.* 2023).

Because nesting does not occur every year in the marshes of the Guadalquivir (García *et al.* 2000), breeding in relation to hydrological conditions was analysed here to ascertain whether water levels triggered breeding of the species, as it has been suggested in the past (Noble 1902; Chapman & Buck 1910; Valverde 1960). In addition, information on the breeding biology of the Pintail in the Guadalquivir marshes is presented to compare with that from other studies, in both Europe and North America. The aim was to show whether basic breeding statistics from a population at the limit of its breeding range are different from those of populations in the core area of the species. All this information may be required in conservation planning of a breeding population at the limit of its breeding range, which may be affected by environmental stressors.

Methods

Data were obtained from the Guadalquivir marshes in SW Spain (36°59' N, 6°23' W), described in Valverde (1960) and Amat (1982). The climate of the area is Mediterranean, with mild and rainy winters, and hot and dry summers. There are several habitat types within the natural marsh areas, mostly within Doñana National Park, which depend on the winter flooding (local names in parentheses). The lagoons ("*lucios*") and channels ("*caños*") are the deepest zones (water depth usually < 1 m), remaining flooded until early or mid-summer. Here the main emergent plants are Bulrush *Schoenoplectus litoralis* and Sea Clubrush *Bolboschenus maritimus*. Shrubby marsh ("*almajares*"), covered with extensive Glaucous Glasswort *Arthrocnemun macrostachyum* stands, remaining flooded very few weeks after heavy rain. Levées ("*paciles*"), which do not flood and are covered mainly with *A. macrostachyum* and Perennial Glasswort *Sarcocornia perennis*. Among these areas, the islets ("*vetas*") are slightly elevated ground that do not flood and are covered with *A. macrostachyum*, *S. perennis*, Shrubby Sea-blite *Suaeda vera* and herbaceous vegetation. Parts of the former marshes has been transformed to agricultural fields and a fish farm.

Censuses of waterbirds were conducted every month by the Equipo de Seguimiento de Procesos Naturales (from ICTS-RBD) of the Estación Biológica de Doñana (CSIC). Aerial censuses are conducted monthly from September 1979. The censuses are made in the morning, following a pre-established itinerary that covers the wetlands in Doñana Natural Space (natural marshes within the national park, Veta la Palma fish farm, and the saltpans of Bonanza), as well as the rice fields (described in detail in Garrido *et al.* 2014). These censuses were complemented with ground counts on days before or after the aerial censuses. We used the censuses of Pintail in April (1980–2022) as an indication of the presence of the species in the area during the breeding season. Although some of the birds recorded in April could have been late migrants (Máñez & Arroyo 2014), the main passage of spring migrants in southern Iberia is conspicuously recorded in late February, with a steep decline in March (Amat 1981; Finlayson 1992; Parejo 2020). Many of the birds recorded in April during ground surveys were solitary pairs, suggesting that they were breeders, as Pintail flocks diminish in size once laying starts (Smith 1968) and pairs tend to avoid conspecifics during laying (Clark *et al.* 2020).

The same habitats were visited each year at the same times to obtain information on nests and broods. Records of nests (n = 63) and broods (n = 52) were obtained from the ICTS-RBD monitoring database, from 1969 to 2022. When a nest was found, date, habitat type, nesting cover and clutch size were recorded. Because all these variables were not recorded for all nests, sample sizes may differ between analyses. To estimate the laying dates, we only considered the nests found during the laying stage and assumed that an egg was laid daily (Cramp & Simmons 1977; Bellrose 1980). A clutch was considered complete when incubation had started. Twelve nests were revisited every 7–14 days and their success determined using the Mayfield's method (Johnson 1979), assuming an incubation period of 23 days (Cramp & Simmons 1977; Clark *et al.* 2020). In the case of successful nests, the number of unhatched eggs was recorded on some occasions.

When a brood was observed, the habitat type was noted. The age of ducklings was allocated to one of three categories relative to adult size: smaller than half-grown, half-grown or larger than half-grown (Hildén 1964; Amat & Rendón 2022). Emergent vegetation precluded in many cases an accurate determination of brood size, so that this variable was not considered. When explicitly indicated in the database, it was noted whether a brood was or was not accompanied by an adult female.

Statistical tests were conducted using jamovi 2.3.13 (The jamovi project 2022). We present basic statistics (mean ± s.d., or median with confidence intervals) for population size, rainfall patterns, laying dates and clutch sizes. Values for the annual rainfall that occurred in September–March preceding the Pintail breeding season for years when the species bred or did not breed in the Guadalquivir marshes were compared with a Mann-Whitney U test. Logistic regression was used to check for a relationship between precipitation during September–March prior to egg-laying initiation and breeding, as the amount of rainfall is a good proxy of water levels during spring in the Guadalquivir marshes

(Amat 1981). Rainfall measurements were obtained from the ICTS-RBD database.

Results

Population size and breeding propensity

Pintail were recorded in the Guadalquivir marshes during all breeding seasons (1980–2022) in which censuses were conducted (mean = 42.1 ± 61.9 individuals, range 1–272, n = 35 years; Fig. 1), although the species did not breed every year. The Pintail were recorded breeding in the Guadalquivir marshes in 21 (45.7%) out of 46 years (1977–2022). The autumns and winters (September–March, 1979/1980–2021/2022) preceding the laying season received significantly more rain in years in which the Pintail nested (median = 460.7 mm, n = 19) than in years in which there was no nesting (median = 364.8 mm, n = 24) (Mann-Whitney U test: U = 141.0, P = 0.033; Fig. 2). Although the Pintail bred during three of the driest years (< 300 mm, Fig. 2), it did so within the fish farm on the site, where water levels were artificially maintained. There was a significant relationship between the probability of nesting and the amount of rainfall (logistic regression: Z = 2.11, P = 0.035), although breeding was not invariably recorded after all very wet autumns/winters (Fig. 3).

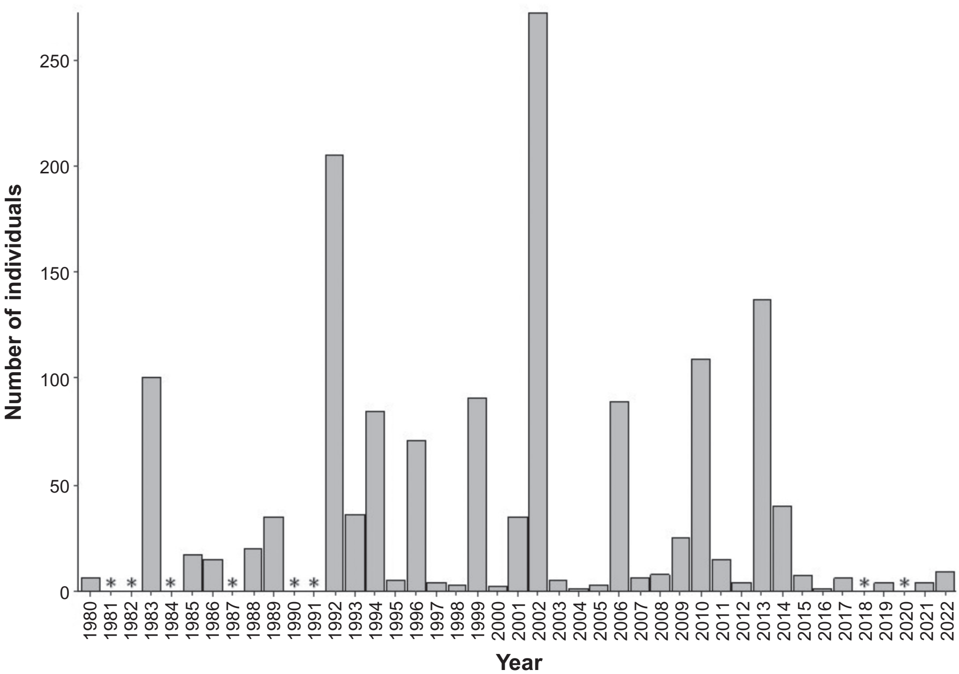

Figure 1. Number of Pintail recorded in the Guadalquivir marshes during April 1980–2022 (data missing in eight years shown with asterisks).

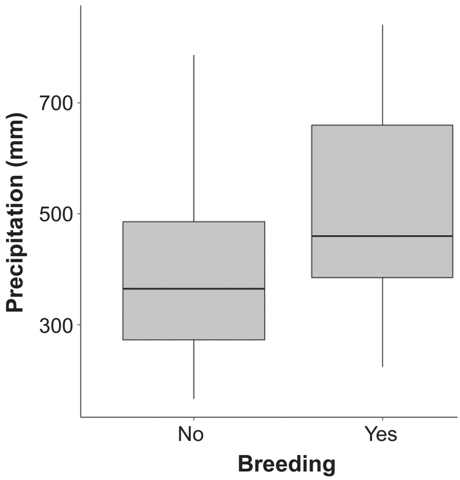

Figure 2. Boxplots for precipitation in the marshes of the Guadalquivir during 1980/1981–2021/2022. The boxes represent the interquartile ranges (IQR: 25th and 75th percentiles), and the lines within the boxes are the medians. Whiskers extend 1.5 × IQR from the 75th and 25th percentiles.

Nests and clutches

Almost all nests (*n* = 63) were in natural areas and only two nests were in the fish farm. In the Guadalquivir marshes the Pintail mainly bred on the islets (57.4%, *n* = 61) and levées (32.8%), and less frequently in the shrubby marsh (9.8%). A female was also observed moving her newly hatched brood overland from a cultivated field to a lagoon. No nests were found in flooded areas. The main cover plant associated with nest sites was *A. macrostachyum* (72.2%, *n* = 18), while 27.8% of nests were devoid of cover. Mean (± s.d.) laying date in nests found during the laying stage was 19.5 ± 9.23 (based on 1 = 1 April, range = 2 April–4 May, *n* = 12). Laying could have started in late March in some nests that were found with completed clutches in April. A female was found incubating on 6 July, so laying may extend up to mid-June. Mean clutch size was 8.7 ± 1.46 eggs (range = 6–12, *n* = 42). The hatching success, determined in 12 nests that were visited every 7–14 days, was 45.1%. Two nests suffered partial predation, likely by Common Raven *Corvus corax*, but the remaining eggs in those nests hatched. A female and her nest were predated by Red Fox *Vulpes vulpes*, and another nest was predated by Wild Boar *Sus scrofa*, while the predators of four nests could not be identified. One nest was trampled by cattle. In eight successful nests, 6.1% of eggs (*n* = 66) did not hatch, but the cause (*e.g.* infertility or embryo death) was not determined.

Broods

The habitats in which the broods were recorded were the lagoons and channels (80.8%, *n* = 52), and the fish farm (19.2%). All broods with smaller than half-grown (*n* = 9) and half-grown ducklings (*n* = 7) were accompanied by females, but only two of six broods with larger than half-grown ducklings were accompanied by females.

Discussion

Breeding population

The Pintail was present in the Guadalquivir marshes during all springs in which waterbird censuses were conducted. The number of Pintail breeding in the Guadalquivir marshes during the first quarter of the 21st century seems to be smaller than 100–130 years ago (Noble 1902; Chapman & Buck 1910;

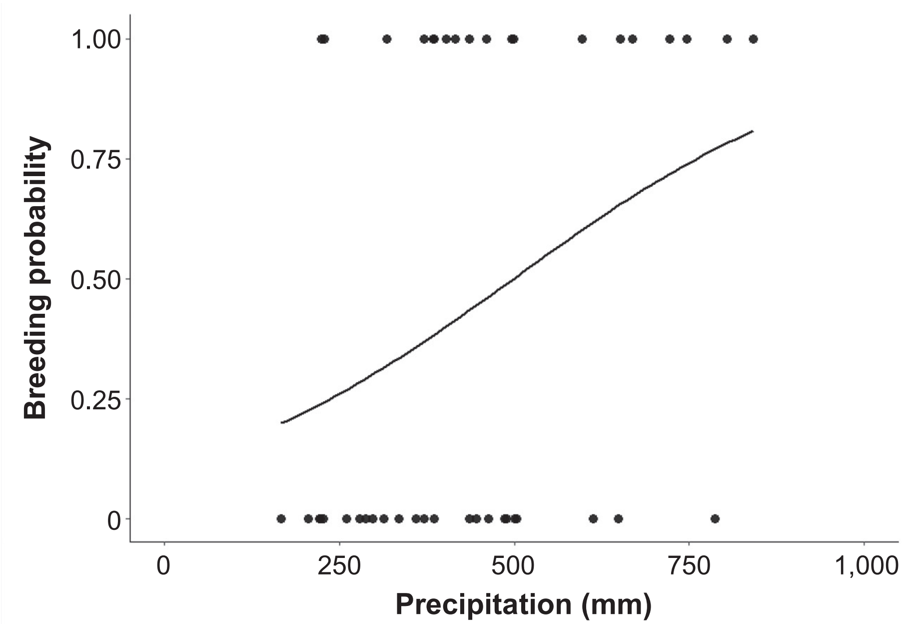

Figure 3. Seasons in which breeding Pintail were recorded (n = 19) or not recorded (n = 24) in the Guadalquivir marshes according to rainfall in September–March preceding each breeding season (1979/1980–2021/2022). The fitted logistic regression curve shows the probability of breeding according to precipitation.

Valverde 1960). For instance, Chapman & Buck (1910) stated that in 1908, a very wet spring, as many Pintails bred in the Guadalquivir marshes as Mallards *Anas platyrhynchos*, which have an estimated breeding population of 5,000–6,000 pairs (Amat 1982), or higher in very favourable years (García *et al.* 2000). Later, Amat (1982) indicated that up to 20 Pintail pairs nested in the late 1970s, and García *et al.* (2000) estimated that up to 45 pairs attempted breeding in very favourable years at the end of the 20th century. The water levels in the Doñana wetlands during the late 20th and early 21st centuries have decreased due to overexploitation of aquifers for agricultural purposes (de Felipe *et al.* 2023). Given that Pintail rely upon high water levels for breeding in the Guadalquivir marshes, the decreasing trend in the number of breeding Pintail at this site during recent decades could have been affected by the lower water levels due to overexploitation for agricultural purposes, and if this trend persists, breeding of this species at this site might be compromised over the next decades (Arroyo *et al.* 2022). In addition, Spain is considered one of the most vulnerable countries to climate change in Europe, as models place it as a region where a decrease in precipitation is expected (Vargas-Amelin & Pindado 2014), which may exacerbate existing reductions in water levels in the Guadalquivir marshes.

Breeding biology

Dabbling ducks are among the birds that respond quickly to variations in water levels (Weller 1999), and of all dabbling ducks in the Holarctic, the Pintail is perhaps the species best adapted to cope with the unpredictability of ephemeral wetlands. Indeed, in North America this species has been reported to move from its usual nesting areas in the prairie region to more northern sites in the parklands area and arctic biomes, and even into Siberia, when water levels in the prairie region are low (Smith 1970; Henny 1973; Hestbeck 1995). The propensity of the Pintail to breed in the Guadalquivir marshes when water levels are high had been previously stated (Chapman & Buck 1910; Valverde 1960; García *et al.* 2000; Martínez *et al.* 2021), and here we have demonstrated the persistence of this, suggesting that Pintail encounter better nesting conditions when there are increases in local wetland area, likely because nesting success improves under such conditions (Devries *et al.* 2023). However, breeding was not recorded in some years in which water levels were high (Fig. 3). Although breeding could have been overlooked in some years, the sampling effort in years in which breeding was not recorded when water levels were high was similar to that of other years in which water levels were also high. This indicates that, in addition to water levels, breeding by Pintail in the Guadalquivir marshes could have been affected by other unknown factors.

The Pintail nests more often than other duck species in sites with low or sparse vegetation, and even on bare ground (Kalmbach 1937; Dementiev & Gladkov 1952; Keith 1961; Hildén 1964; Hudec & Toušková 1969; Stoudt 1971; Bellrose 1980), confirmed by our observations here. Pintail females are vulnerable to mammalian predators (Sargeant *et al.* 1984) and it may be that they use little or no nesting cover to detect approaching predators, a strategy used by other ground-nesting birds (Amat & Masero 2004).

Pintail in the Guadalquivir marshes started laying later than Mallards (Amat 1982). In this site the earliest laying dates of the Pintail were similar to those of Gadwall *Mareca strepera* and Red-crested Pochard *Netta rufina* (Amat 1982), and earlier than those of Marbled Teal *Marmaronetta angustirostris* (Green 1998) and Common Pochard *Aythya ferina* (Amat 1982). In other sites, Pintails initiates laying earlier than other duck species (Väisänen 1974; Raquel *et al.* 2016).

Laying dates of Pintail in the Guadalquivir marshes were similar to those in the former Czechoslovakia, but earlier than in northern sites as Finland, Saskatchewan, Alberta and Alaska (Table 1). Clutch size in the Guadalquivir marshes was larger than in Alberta and Alaska, but similar to that in the former Czechoslovakia, Finland, California and Saskatchewan (Table 1). Although nesting success is not comparable between studies because some report Mayfield's estimates and others provide raw estimates, the data in Table 1 suggest that nesting success of Pintail in the Guadalquivir marshes is within the range in other studies. The causes of egg hatching failure in successful Pintail nests were not determined in this study. Assuming that half of the failures were due to infertility

Table 1. Comparison of laying dates, clutch sizes and nesting success of Pintail across several sites in North America and Europe.

Breeding parameter Site	**Mean**[1]	**Source**
Laying date		
Alaska	4 June	Flint & Grand (1996)
Alberta	27 April	Duncan (1987)
Czechoslovakia	24 April	Hudec & Toušková (1969)
Finland	21 May	Väisänen (1974)
Saskatchewan	28 April	Raquel *et al.* (2016)
Spain	19 April	This study
Clutch size		
Alaska	7.6 ± 1.6	Flint & Grand (1996)
Alberta	6.7 ± 1.4	Keith (1961)
Alberta	6.9 ± 1.5	Duncan (1967)
California	8.2	Rienecker & Anderson (1960)
Czechoslovakia	8.9 ± 0.9	Hudec & Toušková (1969)
Finland	8.3 ± 1.3	Hildén (1964)
Saskatchewan	8.0	Stoudt (1961)
Spain	8.7 ± 1.5	This study
Nesting success (%)[2]		
Alaska	23.9*	Flint & Grand (1996)
California	91.1	Rienecker & Anderson (1960)
Finland	76.0	Hildén (1964)
North Dakota	65.3	Kalmbach (1937)
Saskatchewan	40.4	Stoudt (1961)
Spain	45.1*	This study

[1]S.d. for clutch size is shown if reported.
[2]Studies that used the Mayfield's method to estimate success are marked with asterisk.

(Bellrose 1980), and although the sample size is small, the percentage of estimated infertile eggs in the Guadalquivir marshes (3.1%) is similar to the percentage of infertile eggs (3.3%) of the species in other sites (Amat 1987).

Grand & Flint (1996) suspected that some Pintail females abandoned older broods, but to our knowledge, brood desertion has not been reported in this species. Here it is shown a propensity of females to abandon older ducklings more frequently than younger ones, as in other duck species (Afton & Paulus 1992; Amat & Rendón 2022).

Conclusions and conservation prospects

Information on breeding statistics is valuable for contributing to conservation plans and the results of this study indicate that such breeding parameters for the Pintail in the Guadalquivir marshes are not particularly different from those found in other studies elsewhere within the geographical range of the species. Therefore, although the Pintail breeding in the Guadalquivir marshes would appear to constitute a peripheral group from a geographical point of view, away from its core range, features of its breeding biology there do not seem radically different from those recorded elsewhere.

García *et al.* (2000) indicated that the species did not breed every year in the Guadalquivir marshes, and here it is shown that this is related to water levels. In central European sites, Tunisia and other sites in Spain where there are small populations of Pintail, breeding is also sporadic (Hudec & Toušková 1969; Cramp & Simmons 1977; Isenmann *et al.* 2005; Parejo 2020), suggesting that the species is rather opportunistic in responding rapidly to favourable nesting conditions. In species showing such spatial opportunism, the localities where individuals breed may change from year to year as a result of unpredictable favourable conditions, and it is the flexibility of the transition from migration to settlement what distinguishes spatial opportunists from site-faithful migrants (Hahn *et al.* 1995). The Pintail seems to exhibit such a flexibility (Smith 1970; Henny 1973; Hestbeck 1995).

The Pintail may make long non-stop flights during migration (750–1,650 km, Parejo *et al.* 2015). For Pintails that spend the winter in the Sahel, the use of stopover sites after crossing the Sahara during northward migration, as in the case of the Doñana wetlands, could facilitate the migration process (Amat *et al.* 2005), as well as the settlement in such wetlands of some migrants to attempt breeding if they encounter favourable conditions. Although waterbirds are adapted to track spatio-temporal variations in the flooding conditions of wetlands, the continuous loss of wetlands may disrupt the connectivity between them, affecting biological processes such as migration or breeding (Amat & Green 2010). For this reason, we need to ensure the conservation of the ecological processes that facilitate the nesting of the Pintail in the Guadalquivir marshes. Conservation efforts relating to duck species at regional scale are usually focused on regular (but relatively scarce) breeding species, such as the Marbled Teal or the White-headed Duck *Oxyura leucocephala* in Spain, but no specific plans consider the conservation of opportunistic breeders like the Pintail in Spain. Spatially explicit models of breeding duck populations in the Prairie Pothole Region (USA/Canada) showed that when spatial and temporal variation for highly mobile species, such as the Pintail, are incorporated into conservation planning, the habitat area required to support defined population goals should be increased (Doherty *et al.* 2015). This suggests that an international conservation strategy should be adopted for the declining Pintail in the Palearctic.

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