First systematic nesting record of the Blue-winged Teal (*Spatula discors*) in a high-Andean wetland of the Bogotá Highland Plateau

Primer registro sistemático de anidación de la Cerceta aliazul (*Spatula discors*) en un humedal altoandino de la Sabana de Bogotá

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Abstract

Spatula discors is a migratory waterfowl whose breeding has historically been restricted to temperate regions of North America and that has traditionally been considered a non-breeding species in South America. However, observations in the Bogotá Highland Plateau have shown reproductive behavior in high-Andean wetlands, suggesting a recent expansion of its breeding range. This study presents the first systematic record of *S. discors* nesting in Colombia, aiming to characterize its reproductive ecology in a high-Andean wetland undergoing ecological restoration at an elevation of 2,570 m. Between 2018 and 2021, periodic monitoring was carried out to search for nests and conduct monthly population censuses. These observations allowed the description of the ecological context of nesting sites, the dominant vegetation, and the differential use of aquatic habitats throughout the year. The results reaffirm the permanent presence of *S. discors* in the Bogotá Highland Plateau and demonstrate a sustained process of reproductive establishment, in which the species uses habitats characterized by dense vegetation and open water bodies. This information contributes to understanding how an originally migratory species has adapted to high-Andean conditions, possibly favored by the availability of restored habitats and the reduction of competition with other wetland duck species. This record provides key information on the ecological plasticity and adaptive capacity of *S. discors* in high-Andean environments.

Key words: Anatidae, embryonic mortality, high-Andean wetland, nesting habitat, reproductive phenology

Resumen

Spatula discors es un anátido migratorio cuya reproducción se ha restringido históricamente a regiones templadas de América del Norte y que en Sudamérica ha sido considerada tradicionalmente una especie no reproductiva. No obstante, observaciones en la Sabana de Bogotá han mostrado comportamientos reproductivos en humedales altoandinos, lo que sugiere una expansión reciente de su rango reproductivo. Este estudio presenta el primer registro sistemático de anidación de *S. discors* en Colombia, con el propósito de caracterizar su ecología reproductiva en un humedal altoandino en proceso de restauración, a 2.570 m de elevación. Entre 2018 y 2021 se desarrollaron monitoreos periódicos orientados a la búsqueda de nidos y censos poblacionales mensuales. Las observaciones permitieron describir el contexto ecológico de los sitios de anidación, la vegetación dominante y el uso diferencial de hábitats acuáticos a lo largo del año. Los resultados reafirman la presencia permanente de *S. discors* en la Sabana de Bogotá y evidencian un proceso de establecimiento reproductivo sostenido, en el que la especie utiliza hábitats caracterizados por la presencia de vegetación densa y cuerpos de agua abiertos. Con esta información se busca comprender cómo una especie originalmente migratoria ha logrado adaptarse a condiciones altoandinas, posiblemente favorecida por la disponibilidad de hábitats restaurados y la reducción de la competencia con otras especies de patos de humedal. Este registro aporta información clave sobre la plasticidad ecológica y la capacidad adaptativa de *S. discors* en ambientes altoandinos.

Palabras clave: Anatidae, éxito de eclosión, hábitat de anidación, humedal altoandino, mortalidad embrionaria

The Blue-winged Teal (*Spatula discors*) is a migratory waterfowl widely distributed across the American continent, breeding from Alaska and northern Canada south to the central prairies of the United States. In these regions, the species nests near shallow wetlands with emergent vegetation (Baldassarre 2014, Rohwer *et al.* 2020). After the breeding season in North America, the population migrates south to winter in warmer areas, especially in coastal areas and lowland wetlands of Mexico, the Caribbean, and Central America. Movements to northern South America, including Colombia, have also been reported (Hilty & Brown 2001, Rohwer *et al.* 2020).

Due to its limited tolerance to extreme temperatures, *S. discors* begins its fall migration early and returns late in the spring (Baldassarre 2014). In the South American context, it has been considered a non-breeding winter visitor. In Colombia, its presence is recorded between September and April, associated with the use of wetlands as resting and feeding sites (Restall *et al.* 2006). Although there are occasional records further south, in countries such as Bolivia, Uruguay, Argentina, and Chile, it is considered as a rare to occasional visitor (Hilty & Brown 2001, Rohwer *et al.* 2020, Herzog *et al.* 2021).

During the last three decades, observations have shown the continuous presence of the species throughout the year in high-Andean wetlands in Colombia, particularly in the Bogotá Highland Plateau, at elevations of 2,550 to 2,600 m (ABO 2000, Chaparro-Herrera & Ochoa 2015). Since the first report of reproduction in 1993, nesting events have been recorded in at least seven additional wetlands in this region (Stiles *et al.* 2021). This reproductive expansion into montane ecosystems, outside its historical nesting range, raises questions about the mechanisms of ecological plasticity and phenotypic adaptation that allow certain populations to take advantage of non-traditional or ecologically challenging environments (McCracken *et al.* 2009, Graham *et al.* 2024).

The reproduction of waterbirds in high-Andean ecosystems is of ecological interest, given the extreme and seasonally variable conditions that characterize these environments, such as low nocturnal temperatures, high solar radiation, and fluctuating water availability (Rosselli & Stiles 2012). In the Bogotá Highland Plateau, more than 90% of wetlands have been degraded or transformed by urban and agricultural activities, which has drastically reduced the availability of functional habitats for aquatic birdlife (van der Hammen *et al.* 2008). This loss of vegetation cover and water bodies restricts the availability of nesting sites, foraging areas, and refuge habitat for both resident and migratory species. However, some of the latter have shown a surprising ability to establish themselves and reproduce in these transformed environments, evidencing recolonization processes (Castro-Vargas *et al.* 2021).

In this scenario, the case of *S. discors* takes on special relevance as an example of reproductive colonization of high-Andean wetlands undergoing ecological restoration, raising questions about the mechanisms that allow migratory birds to establish themselves in ecologically challenging contexts. Although previous anecdotal records have documented nesting activity of *S. discors* in the Bogotá Highland Plateau, until now there was no systematic evidence or detailed descriptions of the nesting process of this species in Colombia. Therefore, the objective of the present study is to present the first formal and systematic report of *S. discors* reproduction in a high-Andean wetland undergoing restoration in the Bogotá Highland Plateau. Over four consecutive years of monitoring, morphometric characteristics of nests and eggs, hatching rates, microhabitat selection patterns, and population dynamics were documented. These findings allow us to discuss the role of *S. discors* as a reproductive colonizer of montane ecosystems and contribute to a better understanding of ecological adaptation processes in scenarios of environmental change.

Methods

Study area.- This study was conducted in the Ecoparque Sabana Nature Reserve of the Fundación Parque Jaime Duque, located in the municipality of Tocancipá, Cundinamarca, Colombia (4°56.6'N, 73° 57.7'W), at an elevation of 2,570 m. The area has a

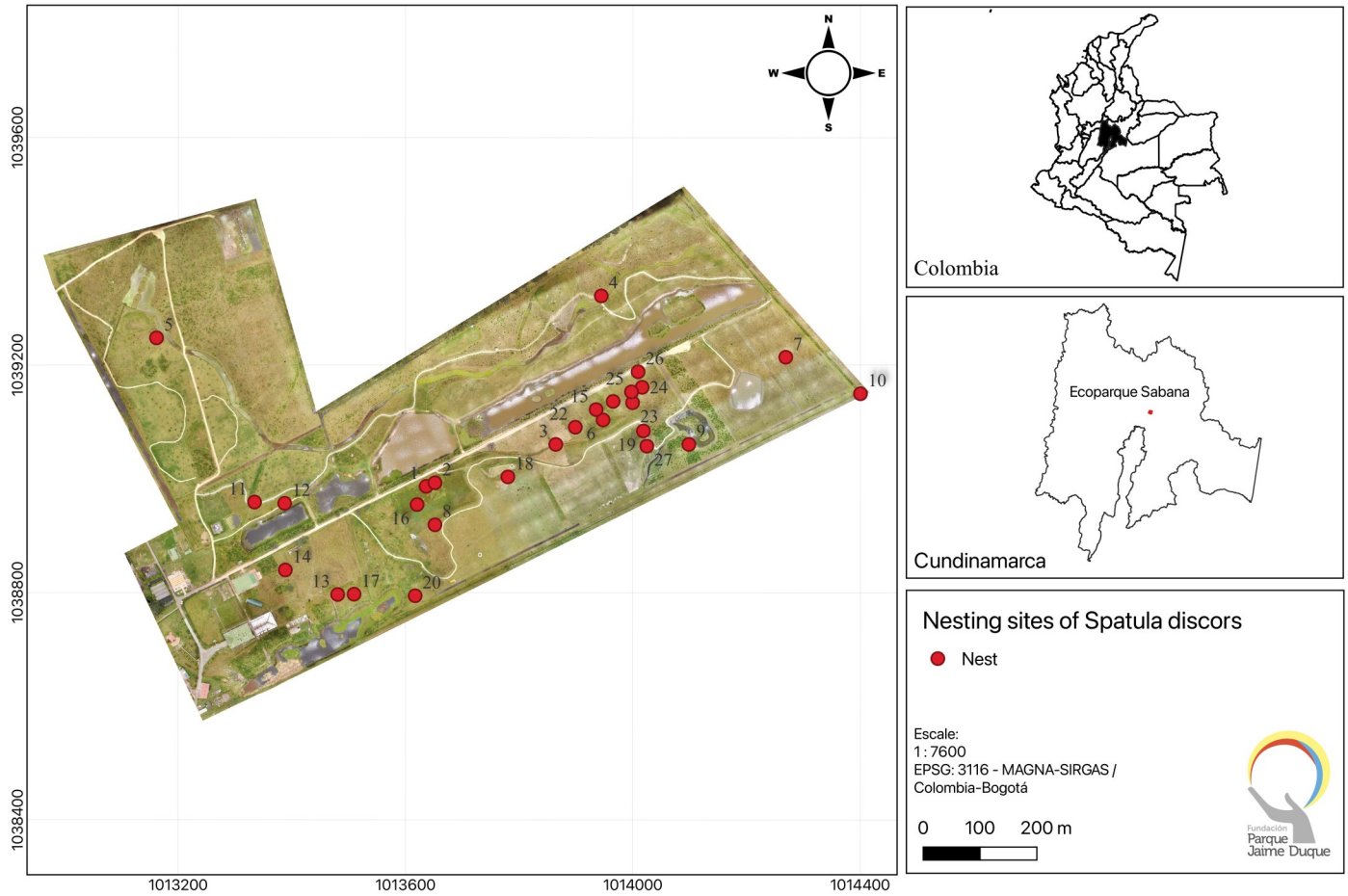

Figure 1. Map of the Ecoparque Sabana Nature Reserve of Fundación Parque Jaime Duque. The historical distribution of *Spatula discors* nests between 2018 and 2021 is displayed.

temperate mountain climate with a bimodal rainfall regime and marked interannual variability between 2018 and 2021 (CAR 2019, 2020, 2021, 2022). Average annual precipitation ranged between 750 and 1,100 mm, with the lowest value recorded in 2019 (761 mm) and the highest in 2021 under La Niña conditions. Rainfall peaks typically occur in April–May and October–November, while drier periods extend from December to March and from June to August. Mean annual temperature varies between 7 and 19°C, with occasional lows near 2°C.

The reserve covers approximately 70 ha, of which about 6 ha correspond to wetlands in different stages of ecological recovery (Fig. 1). The site is undergoing active restoration following the cessation of livestock activities in 2015. The landscape is characterized by a mosaic of Kikuyu grass (*Cenchrus clandestinus*) meadows, formerly used as cattle pastures, and patches of regenerating forest that began as isolated "islands" within the grasslands and have progressively expanded in cover, density, and height. These successional areas are interspersed with open wetlands, reedbeds, and small forest fragments, connected by internal trails and adjacent to the main access road linking the park facilities. In some sectors, the height of the Kikuyu grass reaches 40–50 cm, providing abundant terrestrial vegetation for nest concealment.

Search and characterization of nests.- Between 2018 and 2021, systematic searches for nests were carried out in the Ecoparque Sabana Nature Reserve through weekly surveys during the breeding season (March to September). An average of 4 km per day was covered, exploring grassland areas using a zigzag pattern. To facilitate the detection of nests hidden in the vegetation, 2 m long sticks were held horizontally by observers while walking and used to slightly move the vegetation cover.

Nests were detected when females suddenly flushed in response to the movement of the surrounding vegetation caused by the observer's pole, which revealed the location of the nest. Once detected, geographical coordinates and the number of eggs present were recorded, and morphometric measurements of each egg (length and width) were taken using a digital caliper with 0.01 mm precision. Fresh weight was obtained using a precision scale accurate to 0.1 g. In addition, candling was carried out in situ using a portable LED flashlight, to visualize embryo development and vascularization. Each egg was temporarily marked with a non-toxic pencil to maintain individual identity and avoid duplicate measurements. This procedure enabled us to classify the eggs into one of three incubation stages based on the degree of embryo vascularization observed during candling, thus estimating the relative age of the embryo at the time of discovery (Ernst *et al*. 2004).

Structural variables of the nest were recorded, including depth, width, and length (internal and external), and thickness of the widest edge with a 1 mm precision ruler. Measurements were taken after two-thirds of the incubation period had elapsed to ensure that the nest structure was fully formed and included the characteristic down. The height of the vegetation concealing the nest was also measured. In cases where the nest was incomplete, weekly monitoring was carried out until the completion of the clutch was confirmed. During 2018, the number of eggs hatched per nest was also recorded. Although the incubation period length could not be obtained due to the timing of nest detection, partial estimates were derived from candling stages. No evidence of nest predation was obtained. After hatching, females with broods were observed in open water, although it was not possible to link them to a specific nest.

Population censuses.- Between 2018 and 2021, monthly censuses of the *S. discors* population were carried out using 10 linear transects of 150 m each, separated by 100 m. Observations were made between 6:00 and 9:00., using 10 × 42 binoculars. During each census, the total abundance of individuals was recorded, as well as their classification by sex (male, female, undetermined), age (adult, immature, chick), and type of habitat used at the time of observation.

Data analysis.- For the morphometric variables of eggs and nests, the mean, standard deviation, and standard error (SE) were calculated. One-sample Student's t-test and Mann-Whitney U test were used to compare the morphometric values obtained in this study against published reference means for North American populations, treating published values as population parameters. Egg volume was estimated using Hoyt's formula (1979): $V = k \times L \times W^2$, where L and W correspond to the length and width of the egg, and k is a shape constant. This value was calculated using the mean fresh weight per nest (nest as the unit of analysis) for nests in which eggs were in the first third of incubation according to candling, and a theoretical density of 1.06 g/cm^3 was used (Paganelli *et al.* 1974). Apparent nest success and Mayfield nest success were calculated for nests monitored in 2018. Nest-exposure days were estimated from the incubation stage at discovery, assuming a total incubation period of 24 days: nests found in the first third received 20 exposure days, those in the second third 12 days, and those in the third 5 days. The daily nest failure rate was calculated as the number of failed nests divided by total exposure days, and Mayfield nest success as (1 – daily failure rate)^24. All analyses were conducted in RStudio version 4.0 using the Stats package.

A principal component analysis (PCA) was performed with the FactoMineR package to explore the joint variation in the characteristics of the eggs, nests, and their environment. The analysis included morphometric variables of the egg (length, width, volume, clutch size), along with structural measures of the nest and habitat (vegetation height and distance to water). Pearson correlations were calculated to identify associations between reproductive and environmental variables, and p-values were obtained to assess their statistical significance.

For population census data, the monthly mean was calculated. A classification was also made by habitat type: open water, wetland margins, floating or emergent vegetation, grasslands dominated by *C.*

clandestinus, and *Typha* sp. patches. A seasonality analysis using Student's t-test was also applied to compare abundance between the rainy season (April, May, October, and November) and the dry season (December to March and June to September), according to the region's climate regime. ChatGPT-4 was used exclusively for grammatical and style correction of the text. It was not used to generate ideas, interpret results, or construct reference lists.

Results

Morphometry of eggs and nests.- During the four years of the study, a total of 27 active *S. discors* nests was recorded, temporally distributed as follows: 11 in 2018, 5 in 2019, 9 in 2020, and 2 in 2021. The highest detection frequency (pooled across all years) was concentrated in April (n = 12) and May (n = 6), followed by July (n = 4), June (n = 3), and August (n = 2). The nests had average external dimensions of 20.4 ± 3.33 × 14.7 ± 3.78 cm (SE = 0.20 and 0.23) and internal dimensions of 19.0 ± 3.63 × 13.5 ± 3.69 cm (SE = 0.22 and 0.22). The depth was 8.57 ± 1.74 cm (SE = 0.10), the thickness of the highest edge was 5.28 ± 2.13 cm (SE = 0.13), and the height of the surrounding vegetation was 44.3 ± 15.0 cm (SE = 0.91). The average distance between the nest and the nearest wetland was 30.6 ± 16.8 m (SE = 1.01).

The nests were mainly built with *C. clandestinus* and hidden among this same vegetation. At the beginning of egg laying, the nests consisted solely of a grass structure with no visible down, while in more advanced stages of incubation, a greater accumulation of down was observed. In addition, it was evident that the nests remained covered with down in the absence of the female (Fig. 2).

A total of 274 eggs was recorded. These were subelliptical, creamy white in color (Fig. 2A), with a length of 44.8 ± 1.55 mm (SE = 0.09) and a width of 32.9 ± 1.06 mm (SE = 0.06), corresponding to an estimated volume of 25.7 ± 2.01 cm^3 (SE = 0.12). The average clutch size was 10.4 ± 1.4 eggs per nest (SE = 0.09). To validate Hoyt's formula (1979), nest mean fresh weight was used as the unit of analysis, including 18 nests (180 eggs) whose eggs were in the first third of incubation according to candling (Ernst *et al.* 2004), with a mean nest fresh weight of 25.7 ± 2.21 g. The loss of mass was less than 5%, yielding a value of k = 0.532 ± 0.027, consistent with the theoretical value of 0.51 proposed for Anatidae (Paganelli *et al.* 1974).

Figure 2. Egg and nests of *Spatula discors* found in the Ecoparque Sabana nature reserve of the Fundación Parque Jaime Duque **(A)** An egg close-up **(B)** Nest structure and early laying **(C)** Nest covered with down in the absence of the female **(D)** Nest and eggs in an advanced stage of incubation.

During 2018, 96 hatchings and 21 unhatched eggs were recorded across 11 monitored nests, corresponding to an apparent egg hatching rate of 82.1%. All monitored nests produced at least one hatched egg, yielding an apparent nest success of 100% and a Mayfield nest success of 100% (0 nest failures over 166 estimated nest-exposure days, based on incubation stage at discovery; incubation period = 24 days (Farnsworth *et al.* 2000). These results should be interpreted as egg-level and nest-level success metrics respectively, which are complementary but distinct measures of reproductive performance. Among the eggs that did not hatch, embryonic death was identified at different stages of development by candling, which revealed embryo size: seven in the first third (33.3%), ten in the second third (47.6%), and four in the last third of incubation (19.0%). These data suggest that the highest proportion of deaths was concentrated in the intermediate stages of embryonic development.

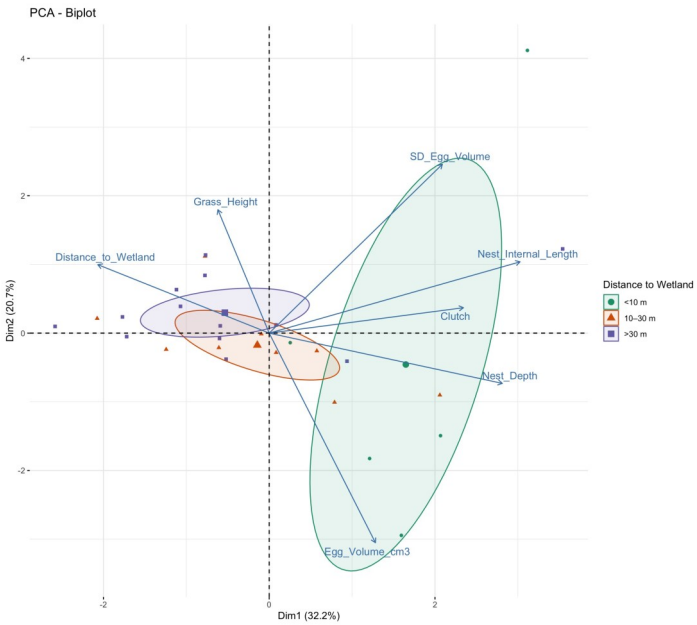

Figure 3. PCA biplot for *Spatula discors*. Shows the joint variation in characteristics of eggs, nests, and environment. Nests are grouped according to distance from water (<10 m, 10–30 m, >30 m). The first two components explain 52.9% of the variability. Nests close to water are associated with larger eggs and deeper nests, while nests further away are associated with greater heterogeneity in egg volume and taller vegetation.

Association between reproductive and habitat variables.- PCA allowed for the exploration of joint patterns of variation between the morphometric characteristics of the eggs, the structure of the nests, and the immediate environment. The first two components explained 52.9% of the total variance (PC1 = 32.2%, PC2 = 20.7%) (Fig. 3).

The PC1 axis reflected a transition from larger nests (in dimension) with larger clutch sizes (more eggs per nest; positive values) to nests with greater variability in egg volume and taller grass (negative values). This suggests that more heterogeneous clutches tend to occur in sites with taller vegetation and smaller nests. In addition, a positive correlation was observed between clutch size and variability in egg volume (r = 0.32), indicating that larger clutches tend to have greater heterogeneity in egg size, a pattern likely driven by conspecific egg dumping from multiple females (Rohwer & Freeman 1989), although this could not be confirmed in the present study. The PC2 axis, on the other hand, reflected a change in egg size, with negative values associated with larger eggs (greater length, width, and volume) and shorter distances to bodies of water. In other words, nests closer to water tended to contain larger eggs.

Pearson's correlation supported these patterns, highlighting negative relationships between distance to the wetland and clutch size (r = –0.27, p= 0.172), as well as between distance to the wetland and egg volume (r = –0.16 p= 0.429). A negative correlation was also observed between egg volume variability and internal nest length (r = –0.48 p= 0.011), suggesting that smaller nests have more heterogeneous clutches. Taken together, these results indicate that nests located farther from water tend to have fewer and smaller eggs.

Population dynamics and habitat use.- Monthly censuses between 2018 and 2021 confirmed the year-round presence of *S. discors* in the study area, consistent with previous reports for wetlands of the Bogotá Highland Plateau (Chaparro-Herrera & Ochoa 2015, Stiles *et al.* 2021). Total abundance showed a progressive decline between April and August, coinciding with the breeding season. In contrast, higher values were recorded during the dry months, with peaks in December (58.5 ± 40.3 individuals) and March (50.8 ± 21.9 individuals), coinciding with the migration season (Fig. 4). However, no significant differences in abundance were found between the dry and wet seasons (t=1.27, p=0.231), suggesting a relatively constant presence throughout the year.

During the censuses, adults were the most frequent category, with a monthly average of 21.9 ± 14.5 individuals. Peaks were observed between May and July, in line with the period of maximum reproductive activity. Juveniles were recorded continuously between April and September, reaching a peak in June (4.6 ± 3.6 individuals), indicating that most hatchings occur between April and May. Chicks, on the other hand, were only observed between May and July, also peaking in June (2.0 ± 2.2 individuals), reinforcing the pattern of synchronous reproduction with the onset of the rainy season.

Regarding sex, males were observed more frequently than females during most months. The average ratio

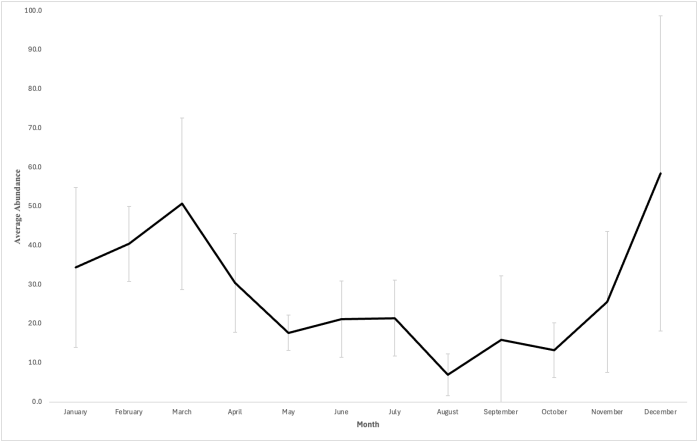

Figure 4. Average monthly abundance of *Spatula discors* recorded between 2018 and 2021 in the Ecoparque Sabana Nature Reserve – Fundación Parque Jaime Duque (Tocancipá, Colombia). The line represents the monthly average, and the vertical bars indicate the standard error.

was 1.5:1, with peaks in April (3.4:1) and May (2.7:1), possibly due to reproductive behavior and the lower degree of exposure of females during incubation.

In terms of habitat use, open water accounted for 73.7% of records, followed by the margins of wetland (15.9%) and areas with floating or emergent vegetation (8.9%). The least used habitats were grasslands dominated by *C. clandestinus* (2.5%) and areas with *Typha* sp. (0.2%). During the breeding season, females with young were observed in open water and areas with floating vegetation, indicating a clear preference for exposed water bodies that are functional for breeding (Fig. 5).

Discussion

The findings of this study provide the first quantitative evidence of reproductive establishment of *S. discors* in Colombia, confirming that the species has expanded its breeding range into high-Andean wetlands. This colonization at elevations above 2,550 m indicates a remarkable degree of ecological plasticity and adaptation to montane conditions. In North America, *S. discors* breeds predominantly in the temperate prairies of central Canada and the United States at elevations generally below 600 m (Rohwer *et al.* 2020). Breeding populations also occur at near sea level in coastal Louisiana (Johnson & Rohwer 2007) and coastal Texas (Rohwer *et al.* 2020), while the highest documented breeding elevations in North America correspond to playa wetlands in the Southern High Plains of Texas, ranging between 1,000 and 1,067 m (Johnson *et al.* 2010). The nesting elevation documented in this study (>2,550 m) thus represents an increase of at least 1,500 m above the maximum previously reported breeding elevation for the species, underscoring the exceptional nature of this high-Andean population. Previous anecdotal observations and local records (ABO 2000, Wilson *et al.* 2011, Chaparro-Herrera & Ochoa 2015, Castro-Vargas *et al.* 2020, Stiles *et al.* 2025) had already documented breeding activity in the Bogotá Highland Plateau; this study documents for the first time the characteristics of the nest and clutch, as well as the success of these nesting events. The evidence documented here demonstrates not only the reproductive capacity of *S. discors* at an atypical elevation, but also its establishment as a resident breeding species in high-Andean wetlands, which has important ecological and biogeographical implications.

The *S. discors* nests recorded were similar in size to those in the north of the continent and were preferentially located in areas with dense but not compact vegetation of *C. clandestinus*, mostly less than 50 m from wetlands. This pattern is consistent with studies conducted in North America, where it has been documented that the species selects humid and shaded microhabitats near bodies of water that offer favorable microclimatic conditions for incubation, such as higher relative humidity and lower thermal variability (Miller 1976, Dyson *et al.* 2019). The average distance to water (30.6 ± 16.8 m) was less than that reported by Miller (1976) in Iowa (55 m). However, it coincides with observations in more open environments, where the species has shown a high tolerance to lower and more scattered vegetation cover (Fritzell 1975). The height of the vegetation (44.3 ± 15.0 cm) covering the nests suggests a selection oriented toward concealment and thermal regulation, as has been described in other breeding populations (Mulhern *et al.* 1985, Hoekman *et al.* 2002). Recent habitat suitability models have confirmed the importance of structural variables such as vertical cover and proximity to water in the selection of breeding sites by *S. discors* (Stratmoen & Hood 2021).

Figure 5. Individuals of *Spatula discors* recorded during the population censuses at Ecoparque Sabana between 2018 and 2021 **(A)** Mixed group of males and females in open water with emergent vegetation **(B)** Female accompanied by chicks at an early stage of development **(C)** Chicks.

Together, these findings support the idea that, even in a high-Andean environment, the species maintains a pattern in the structural selection of nesting sites.

The eggs recorded in the Bogotá Highland Plateau were subelliptical in shape and had average dimensions consistent with those reported for *S. discors* in North American populations (Rohwer 1986), suggesting that, despite the atypical altitudinal and geographical context, the structural characteristics of the egg remain unchanged. However, statistical analyses revealed significant differences from the dimensions reported in populations in the northern United States. The length of the eggs was significantly shorter than the mean values reported for Iowa (47.1 mm, n = 142; t = 24.49, p < 0.001; Glover 1956 in Rohwer *et al*. 2020) and North Dakota (46.4 mm, n = 1,124; t = 17.03, p < 0.001; Rohwer *et al*. 2020). Similarly, width differed significantly from the mean reported for Iowa (33.9 mm; U = 1427, p < 0.001) and North Dakota (33.3 mm; U = 9007, p < 0.001); these differences could reflect population variation or local adaptations (Rohwer *et al.* 2020).

The estimated average volume was validated using nest means of fresh-weighed eggs as the unit of analysis, and the shape constant value remained within the expected range for Anatidae, indicating that the theoretical value of 0.51 proposed by Hoyt (1979) provides a reasonable approximation for field studies with fresh eggs in this species. This methodological consistency reinforces the applicability of the volume model in tropical contexts (Paganelli *et al.* 1974). The average clutch size (10.4 eggs) is also comparable to that of northern populations, where averages of between 10 and 12 eggs have been reported in initial clutches (Dane 1966, Krapu *et al.* 2004).

Likewise, the recorded apparent egg hatching rate (82.1%) and a Mayfield nest success of 100% indicate favorable environmental conditions for embryonic development in an ecological restoration context (Weller 1979). The egg hatching rate is comparable to that reported by Rohwer (1985), who found rates

above 93% in a controlled experiment in which nests were protected from predation by fences, reflecting maximum hatching under ideal conditions. In contrast, in disturbed environments such as those subjected to agricultural burning, Fritzell (1975) documented considerably lower hatching rates (38.5% in burned areas and 15% in unburned areas), highlighting the influence of landscape structure on the reproductive success of the species. The Mayfield method remains valid when nests are discovered at different stages of the nesting cycle, provided that survival rates are homogeneous across stages (Farnsworth *et al.* 2000). The highest proportion of embryonic mortality was concentrated in the second third of development, which could be related to critical thermal fluctuations, alterations in gas exchange, or metabolic failures during sensitive stages of organogenesis (Swanson & Meyer 1977, DuRant *et al.* 2013, Carter *et al.* 2014, Clauser & McRae 2017). Taken together, these results demonstrate efficient reproductive investment by females and successful embryonic performance under high-Andean conditions atypical for the species.

The patterns of association between reproductive traits and microhabitat characteristics reveal a non-random selection of nesting sites by *S. discors* in the Bogotá Highland Plateau. PCA showed that nests closer to wetland contained larger eggs with less variability, while nests further away were associated with smaller structures, taller vegetation, and greater heterogeneity in egg size. These results are consistent with those reported by Miller (1976), who found that nests in humid sites near wetlands offered more stable microclimatic conditions, favoring efficient incubation. Similarly, studies in boreal environments have shown that vegetation structure affects nest thermal regulation and oviposition site selection (Hoekman *et al*. 2002, Dyson *et al.* 2019, Stratmoen & Hood 2021).

The negative correlation between distance to water and clutch size supports the findings of Swanson & Meyer (1977), who highlighted the influence of water and food availability on female body condition and reproductive investment. The negative relationship between egg volume heterogeneity and nest length further suggests that structural constraints at the nesting site may limit clutch uniformity. Conspecific egg dumping is a likely driver of this heterogeneity (Rohwer & Freeman 1989), although it could not be confirmed here. Re-nesting may also contribute independently to the observed variation in clutch size, as females in subsequent nesting attempts typically produce fewer eggs (Dane 1966); individual female tracking was not feasible in this study, so its influence on the patterns reported here cannot be excluded. Together, these findings reflect microhabitat selection shaped by fine structural variables and resource access, consistent with previously described patterns of reproductive plasticity in the species (Mulhern *et al*. 1985, Krapu 2000, Krapu *et al.* 2004).

The continuous presence of *S. discors* throughout all months of the year confirms its establishment as a resident breeding species in the Bogotá Highland Plateau, coinciding with previous records documenting its dual status as a boreal migrant and resident, with evidence of sustained population growth in the region (Stiles *et al.* 2021). Although no statistically significant differences in abundance were detected between the dry and wet seasons, the seasonal patterns observed in total abundance and age composition suggest reproductive synchrony with the onset of the rainy season, like that reported in populations that adjust their phenology to favorable water conditions (Krapu 2000). The high proportion of males during the breeding months could be related to the cryptic behavior of females, which remain hidden while incubating or caring for their chicks, as has been documented in other populations of Anatidae (Forbes *et al.* 1994).

In terms of habitat use, the marked preference for open water and margins with floating vegetation supports the hypothesis that *S. discors* selects sites that offer a balance between visibility, access to food resources, and reduced exposure to predators (Mulhern *et al.* 1985, Dyson *et al*. 2019). The low frequency of records in areas dominated by dense vegetation such as *Typha* sp. coincides with a lower affinity for high lateral cover and a preference for microhabitats with intermediate vertical cover that allow for both concealment and surveillance of the environment (Stratmoen & Hood 2021). It should be noted, however, that detectability of adults and

broods varies among habitat types, and individuals in dense or emergent vegetation are less likely to be detected than those in open water; this may have resulted in an underestimation of habitat use in flooded grasses and areas with emergent vegetation, as broods of *S. discors* in North America commonly use and may actively select flooded grasslands (Rohwer *et al.* 2020). Habitat use patterns reported here should therefore be interpreted with this caveat in mind. This selection pattern, which is consistent even in high-Andean wetlands, reinforces the idea of high ecological plasticity in the species, typical of pioneer birds capable of colonizing marginal or newly available environments (Toay *et al.* 2019). Taken together, these results suggest that *S. discors* has successfully exploited open, low-competition habitats, such as those that may have become available after the local extinction of *Spatula cyanoptera borreroi* in the Bogotá Highland Plateau (Stiles *et al.* 2021).

In this context, the reproductive establishment of *S. discors* in the Bogotá Highland Plateau represents a clear example of adaptive expansion in response to new ecological opportunities. Its ability to occupy open, low-competition habitats with low predation pressure suggests a successful response to the transformation of high-Andean wetlands. Continuous reproduction, high hatching rates, and structured microhabitat selection reinforce the species' pioneering nature and its potential to establish itself as a stable breeder in the region. These observations underscore the importance of conserving functional habitat mosaics in disturbed Andean landscapes, which not only favor the persistence of species with high ecological plasticity but also contribute to the comprehensive conservation of local aquatic communities.

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