Zoodiversity, 59(2): 173–190, 2025

DOI 10.15407/zoo2025.02.173
UDC 598.294(1-18:65)

FEEDING BEHAVIOUR OF HYBRID SPARROWS AND THEIR NESTLINGS (AVES, PASSERIDAE) IN AGRICULTURAL AREA IN NORTHERN ALGERIA

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Feeding Behaviour of Hybrid Sparrows and Their Nestlings (Aves, Passeridae) in Agricultural Area in Nothern Algeria. Khoudja S., Aitbelkacem, A., Marniche, F. — Our study explores the origins and impacts of consistent individual behavior in omnivorous passerines, focusing on how personality traits influence population dynamics. We analyzed the feeding behaviors of hybrid sparrows in an agricultural environment using conventional dietary analysis methods. Stomach contents from 71 adult sparrows across different months and 49 chicks of various age groups were examined. Our findings reveal that adult hybrid sparrows predominantly consume seeds and plant fragments (83.53%), preferring them over animal prey (16.47%). Conversely, chicks exhibit a strong preference for animal prey, which comprises 77.86% of their diet, compared to 22.14% from plants. Among adults, the plant diversity (H') index is highest in June (2.20 bits) and January (1.86 bits). For juveniles, the animal diversity index peaks in the youngest age groups, reaching 2.61 bits. The replenishment index (Ir) fluctuates throughout the annual cycle in adults, while in chicks, it reaches its highest values in the first few days of life before gradually declining. This study highlights dietary differences between adult and juvenile hybrid sparrows, which are closely linked to habitat diversity, food availability, digestive flexibility, individual plasticity, and species phenology. Our observations in northern Algeria align with previous research, illustrating the species' ecological adaptability.

Key words: birds, passerines, trophic behaviour, ecosystem functioning, population dynamics.

Introduction

Many species depend on human-modified landscapes, particularly agricultural ones (Bennett et al., 2006). Agricultural intensification has reduced semi-natural habitats and diversity, affecting species differently based on their ecology (Garnier et al., 2007). Birds, as opportunists, adapt their diet to local conditions and seasons. Though a fraction of biodiversity, their role at the top of food chains makes them key indicators of ecosystem health (Dorst, 1999). They also provide crucial ecosystem services, whose loss impacts ecological functions (Anderson et al., 2011). Factors like reduced competition, predation, or pathogens, localized food, or social facilitation influence species-habitat relationships (Ricklefs, 2013). These interactions affect demographic processes (Jennions & Petrie, 1997), population exchanges (Bowler & Benton, 2005), and resource exploitation (Riotte-Lambert et al., 2017). Thus, habitat selection is partly shaped by biotic interactions within food webs (Hagen et al., 2012).

In *Passer domesticus* (Linnaeus, 1758), reduced reproductive success may result from chick starvation due to decreased invertebrate availability, leading to poor condition (Mitschke et al., 1999; Vincent, 2005). The lack of suitable food for young birds could contribute to the significant decline of *P. domesticus* populations observed in many European countries over recent decades (Pan-European Common Bird Monitoring, 2010). Factors driving this decline include agricultural intensification, atmospheric pollution, and habitat modifications (Summers-Smith, 1999; Hole et al., 2002; Peach et al., 2008). In contrast, sparrow populations in North Africa, particularly Algeria, exhibit a mosaic distribution of *P. domesticus* and *P. hispaniolensis*, with over 50 occurrences of intermediate phenotypes (Ait Belkacem et al., 2016; Päckert et al., 2019). This pattern is influenced by agricultural intensification, urbanization, and land expansion, promoting hybrid sparrow spread even in extreme arid zones (Guezoul et al., 2013).

Numerous studies worldwide are investigating sparrow bioecology across various habitats. In Europe, researchers have extensively examined sparrow feeding behaviors (Encke, 1965; Anderson, 1984; Caviedes-Vidal & Karasov, 2001; Marques et al., 2003; Anderson, 2006; Perkins et al., 2007; Brzęk et al., 2010; Klvaňová et al., 2011). Similarly, in Algeria, several studies have focused on the diet of *(P. domesticus x P. hispaniolensis)* and related species (Metzmacher, 1981, 1983; Ait Belkacem, 2000; Akrouf et al., 2002; Guezoul, 2011; Ould Rabah et al., 2014).

In this work, we explore the bio-ecology of these species by analyzing their behavior and foraging strategies. Knowledge of feeding habits is one of the fundamental elements for defining ecological niches and understanding the spatio-temporal use of nutrient resources This study attempts to explain the considerable spread of hybrid sparrows in Algeria.

Material and Methods

Study area. The study was conducted in Bouira, northern Algeria (36°17'20"N, 3°55'8" E) (Fig. 1) at the Oued El Berdi site, a 10-hectare semi-open landscape of foothill plains dominated by cereal crops, horticulture, and arboriculture. A stream runs through the site, where remnants of the former El Benian dam remain with a

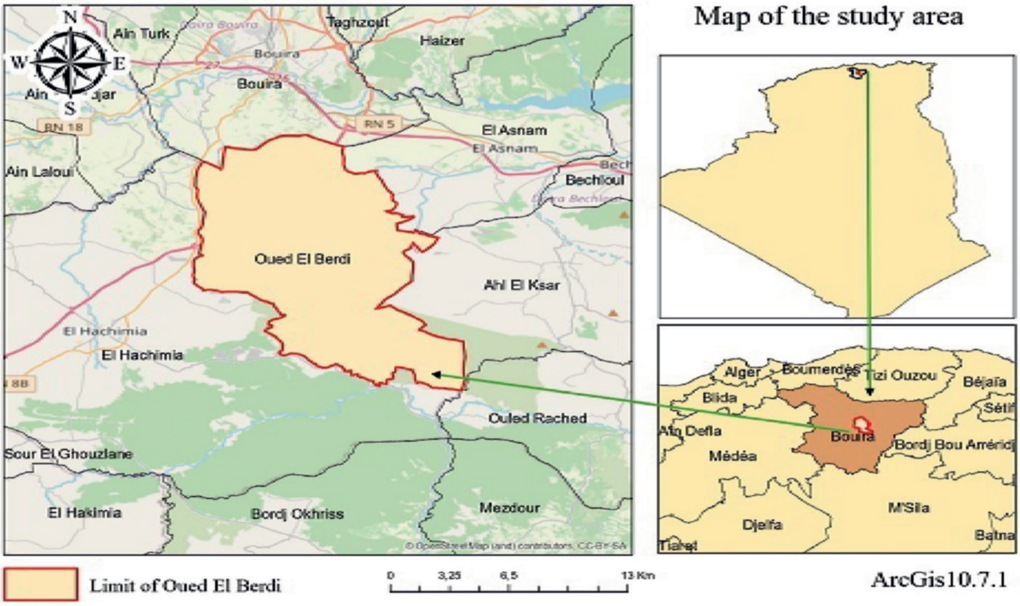

Fig.1. Geographical location of the Study area : Oued El Berdi in Bouira (Algeria)

crest length of 17 m, a height of 5 m, and a base width of 5 m. The region has a temperate semi-arid climate. In 2022, average temperatures ranged from 8.4 °C to 11.8 °C between December and February, and from 26.8 °C to 29.6 °C between June and August, with an annual precipitation of 471.9 mm. The terrain is flat to slightly undulating, with clayey, slightly alkaline, highly calcareous soil. Industrial and anthropogenic activities, including cattle breeding, straw harvesting, storage, and beekeeping, coexist with natural vegetation along the site and the Oued banks.

Sample collection. In this study, adult sparrows were captured with ornithological nets, while juveniles were taken from nests during the breeding season. A total of 71 adults were captured throughout the year: 11 in January, 11 in February, 10 in March, 7 in April, 9 in May, 11 in June, and 12 in November. Additionally, 49 chicks were collected: 9 (1–3 days old), 10 (4–7 days), 14 (7–9 days), and 16 (10–12 days).

After collection, specimens were banded with location and date tag. The contents of the digestive systems were preserved in dilute alcohol for analysis. Ingested parts were sorted under a binocular magnifying glass using forceps and entomological pins. Plant parts were identified by comparison with a reference epidermis (Prat, 1935) and a seed collection from the Institut National Agronomique (INA). Animal prey were identified using dichotomous insect keys (Perrier & Delphy, 1932; Perrier et al., 1935; Chopard, 1943; Antoine, 1955; Du Chatenet, 1986) and an insect fragment collection from the INA's Zoology Department. Identification was performed at the highest taxonomic level, including order, family, genus, and sometimes species.

Data analysis. To describe the diet we used:

Centesimal Frequency (CF, %) or Relative Abundance (RA, %), i. e. the ratio of the number of individuals of a given species to the total number of individuals of all species combined. It provides information on the relative importance of taxa in the diet.

Consistency or Frequency of Occurrence (FO): this is the percentage of stomachs containing the species in relation to the total number of non-empty stomachs. It gives an idea of the interest of a predator species in a particular prey item (Hyslop, 1980).

The Shannon-Weaver index H' is a commonly used measure of species diversity and refers to the relative abundance of different species in the sample. It is obtained by the formula: $H' = -\Sigma\ qi\ \log 2\ qi$. It provides information about the structure of the population from which the sample was taken and the way in which individuals are distributed between the different species (Daget, 1979).

Equitability index (E): This is the ratio between the actual diversity index (H') and the theoretical maximum diversity of the stand ($H'\ max = \log 2\ S$).

Emptiness coefficient (CV): corresponds to the percentage of empty stomachs (EV) in relation to the total number (N) of stomachs analysed**.**

Replenishment index (Ir): This is the ratio of the weight of the stomach contents (p.j) to the body weight of the bird in question (P.c).

In addition, the $\chi 2$ test: theoretical distribution (Snedecor & Cochran, 1971) was used to compare the frequency distributions of trophic elements ingested by adult and juvenile sparrows at the nests.

Results

The results obtained show a diversity in the diet of adult and juvenile sparrows in the nests, with variations in the elements ingested between seeds, fruits, plant fragments and animal prey. Two fractions were therefore identified : the animal fraction and the plant fraction. Adult sparrows ingested 421 plants, accounting for 83.53%, while juveniles consumed only 31, representing 22.14%. In terms of animal prey, the adults consumed 16.47%, with 83 prey items recorded, and the juveniles 77.86%, with 109 prey items (Table 1).

Adult trophic composition. The analysis of trophic elements in the diet of adult sparrows identified 12 families and 18 plant species. The most consumed seeds belonged mainly to Amaranthaceae (*Amaranthus angustifolius)* and (*Amaranthus hybridus*) with 34.92%, Polygonaceae (*Polygonum aviculare*) with 19.24% and Poaceae with 14.25%. The other identified plants accounted for 30% of the plant fraction, mainly Chenopodiaceae, Rutaceae, Solonaceae, Moraceae, Brassiceae, Anacardiaceae, Lamiaceae, Plantaginaceae and Oleaceae (Table 2).

Regarding the animal fraction, 9 orders comprising 25 species were recorded in the diet of adult sparrows. Hymenoptera (*Messor* sp. and *Tapinoma* sp.) dominated with a percentage of 57.83%, followed by Coleoptera (*Cetonia* sp. and *Oxythera* sp.) with 20.5%, while the other taxa (Orthoptera, Stylommatophora, Diptera, Thysanoptera, Blattodea, Squamata and Amphibia) represented less than 24% of the animal fraction (Table 3).

Trophic composition of nestlings. In young nestling sparrows, 11 taxa comprising 40 species were recorded. The most common prey species were Coleoptera, accounting for 33.03%, followed by Orthoptera at 22.93%, and Hymenoptera at 11.93%. The most common genera are Calliptamus, Lixus and Tapinoma. The other taxa, including Hemiptera, Dermaptera, Geophilomorpha, Stylommatophora, Ara-

Table 1. **Percentages of different fractions consumed by adults and young hybrid sparrows**

Parameters	Adults (males & females)		Young Sparrows in nests	
	Ni	%	Ni	%
Plant fraction	421	83.53	31	22.14
Animal fraction	83	16.47	109	77.86
Totals	504	100	140	100

Table 2. **Centesimal frequencies (C.F., %) of plants consumed by adult hybrid sparrows in 2022**

Families	Species	Ni	C.F., %
1 Amarantacae	*Amaranthus angustifolius* (Linnaeus, 1753)	97	34.92
	Amaranthus hybridus (Linnaeus, 1753)	50	
2 Polygonacae	*Polygonum aviculare* (Linnaeus, 1753)	81	19.24
3 Chénopodiacae	*Atriplex patula* (Linnaeus, 1753)	16	8.08
	Chénopodium sp.	10	
	Beta vulgaris (Linnaeus, 1753)	8	
4 Poacae	*Phalaris* sp.	9	14.25
	Hordeum sp.	3	
	Triticum durum (Desfontaines, 1798)	15	
	Oryzopsis sp.	28	
	Poacae sp.und.	5	
5 Rutacae	*Rue fétide* (Linnaeus, 1753)	29	6.89
6 Moracae	*Ficus carica* (Linnaeus, 1753)	20	4.75
7 Anacardiacae	*Schinus molle* (Linnaeus, 1753)	10	2.37
8 Lamiacae	*Marrubium vulgare* (Linnaeus, 1753)	3	0.71
9 Plantaginacae	*Plantago lagobus* (Linnaeus, 1753)	1	0.24
10 Solanacae	*Solanum tuberosum* (Linnaeus, 1753)	20	4.75
11 Brassicacae	*Sinapis alba* (Linnaeus, 1753)	15	3.56
12 Oleacae	*Olea europea* (Linnaeus, 1753)	1	0.24
Totals	12 families and 18 species	421	100

nea, Diptera, Isopoda, and Blattodea, showed consumption rates ranging between 0.92 and 8.26% (Table 4).

For the Plant component of the chicks' diet, 07 families and 07 species were identified. Poaceae (*Triticum durum*) accounted for 35.48% of the plant intake, followed by Anacardiaceae (*Schinus molle*) with 22.58% and Brassicaceae (*Sinapis alba*) with 16.12%. The proportions of other plants varied between 3.23 and 9.68%, mainly Solanaceae, Asteraceae, Lamiaceae and Apiaceae (Table 5).

Monthly diet of passerines. The analysis of the adult sparrows' trophic diet shows significant monthly variations for both fractions. Several plant categories were identified, with spontaneous plants like Amaranthaceae dominating in February, March, and April, with consumption ranging from 66.66 to 82.67%. In May, Chenopodiaceae predominated at 66.66%, while Polygonaceae were most consumed in June at 49.68% and Brassicaceae in November at 30%. Cultivated plants, such as Poaceae and Solanaceae, were consumed year-round, with peak values of 66% and 35.71%, respectively.

Table 3. **Relative abundance (A.R., %) of prey consumed by hybrid sparrow adults**

Orders	Species	Ni	A.R., %
1 Orthoptera	Acrididae sp. und.	2	2.41
2 Coleoptera	*Anotylus* sp.	1	20.5
	Cetonia sp.	6	
	Oxythéra sp.	5	
	Cassida sp.	1	
	Curculionidae sp. und.	1	
	Curculionidae sp. 1 und.	1	
	Buprestidae sp. und.	1	
	Coccinellidae sp. und.	1	
3 Hymenoptera	*Tapinoma magnome* (Forel, 1895)	4	57.83
	Tapinoma sp.	13	
	Messor sp.	18	
	Messor barbara (Linnaeus, 1767)	2	
	Tetramorium sp.	5	
	Cataghliphis sp.	5	
	Crematogaster Scuteullaris (Olivier, 1792)	1	
4 Stylommatophora	Sphincterochilidae sp. und.	3	6.02
	Hélicella itala (Linnaeus, 1758)	2	
5 Diptera	Sarphagidae sp. und.	2	6.02
	Hydrotaea sp.	1	
	Chrysomya sp.	2	
6 Thysanoptera	*Frankliniella intonsa* (Trybom, 1895)	1	1.20
7 Blattodea	Hodotermidae sp. und.	2	2.41
8 Squamata	Lacertidae sp. und.	2	2.41
9 Anura	Anura sp. und.	1	1.20
Totals	9 orders et 25 species	83	100

Table 4. **Relative abundance (A.R., %) of animal prey ingested by young hybrid sparrows**

Orders	Species	Ni	A.R. %
1 Orthoptera	*Pezotettix* sp.	5	22.93
	Gryllus gryllotalpa (Linnaeus, 1758)	2	
	Rhacocleis sp.	1	
	Ensifera sp. und.	1	
	Pamphagus sp.	3	
	Caelifera sp. und.	1	
	Calliptamus sp.	9	
	Acrididea sp.und.	3	
2 Coleoptera	*Lixus* sp.	7	33.03
	Scarabaeidae sp. und.	2	
	Agapanthia sp.	5	
	Buprestidae sp. und.	4	
	Baris sp.	3	
	Staphylinus sp.	1	

The End of the Table 4.

Orders	Species	Ni	A.R. %
	Cetoniidae sp. und.	3	
	Barinus sp. *Larinus* sp. Carabidae sp. und. Carabidae sp. 1 und. Curculionidae sp. und. Tenobrionidae sp. und. *Hypera* sp.	1 3 1 1 1 1 3	
3 Hemiptera	*Delphax* sp. *Aelia* sp. Pentatomidae sp. und.	2 5 2	8.26
4 Dermaptera	*Forficula auricularia* (Linnaeus, 1758) *Anisolabis* sp.	3 2	4.6
5 Hymenoptera	*Messor* sp. *Cataglyphis* sp. *Tapinoma* sp. *Tapinoma nigerrimum* (Nylander, 1856)	4 2 5 2	11.93
6 Geophilomorpha 7 Stylommatophora 8 Aranea	Geophilomorpha sp. und. Helicidae sp. und. Sphincterochilidae sp. und. Aranea sp. und.	2 5 1 3	1.83 5.50 2.75
9 Diptera	*Drosophila* sp. *Anthomyia* sp. Syrphidae sp. und.	3 3 1	6.42
10 Isopoda	Isopoda sp. und.	2	1.83
11 Blattodea	Ectobiidae sp. und.	1	0.92
Totals	11 orders et 40 species	109	100

Table 5. **Centesimal frequencies (C.F., %) of plants eaten by young hybrid sparrows at nests**

Families	Species	Ni	C.F. %
1 Brassicacae	*Sinapis alba*	5	16.12
2 Apiacae	*Férule communis* (Linnaeus, 1753)	1	3.23
3 Lamiacae	*Marrubium vulgare*	1	3.23
4 Asteracae	*Silybum marianum* (Gaertner, 1791)	3	9.68
5 Anacardiacae	*Schinus molle*	7	22.58
6 Solanacae	*Solanum tuberosum*	3	9.68
7 Poacae	*Triticum durum*	11	35.48
Totals	7 families et 7 species	31	100

Annual plants like Anacardiaceae and Rutaceae were consumed less frequently, ranging from 2.43 to 16.35%. Occasional plants from Lamiaceae, Moraceae, and Oleaceae were consumed at rates not exceeding 12.57%. The results show high consumption in March and June for all plants, with a preference for Poaceae in April and May, with occurrence frequencies ranging from 50 to 57.14% (Fig. 2).

The dietary habits of hybrid sparrows show high consumption of Hymenoptera throughout the study period, with frequencies ranging from 36.36 to 83.83%. Coleoptera are the second most abundant order, with consumption ranging from 14.28 to 50%, peaking in March, April, and May, while not consumed in February and June. Other taxa recorded include Diptera in January and June, Stylommatophora in May and June, Squamata in February and April, Blattodea in January, and Amphibia and Orthoptera in June, with consumption rates ranging from 3.70 to 21.42% (Fig. 3). In terms of frequency of occurrence, Hymenoptera was most frequent in April at 57.14%, followed by Coleoptera at 50% in May.

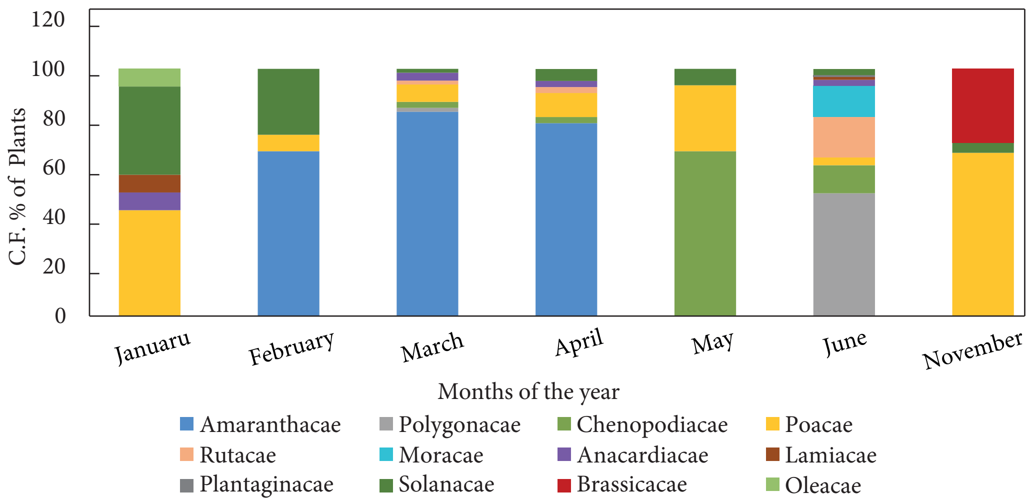

Fig. 2. Centesimal frequencies of plants consumed by adult hybrid sparrows in 2022

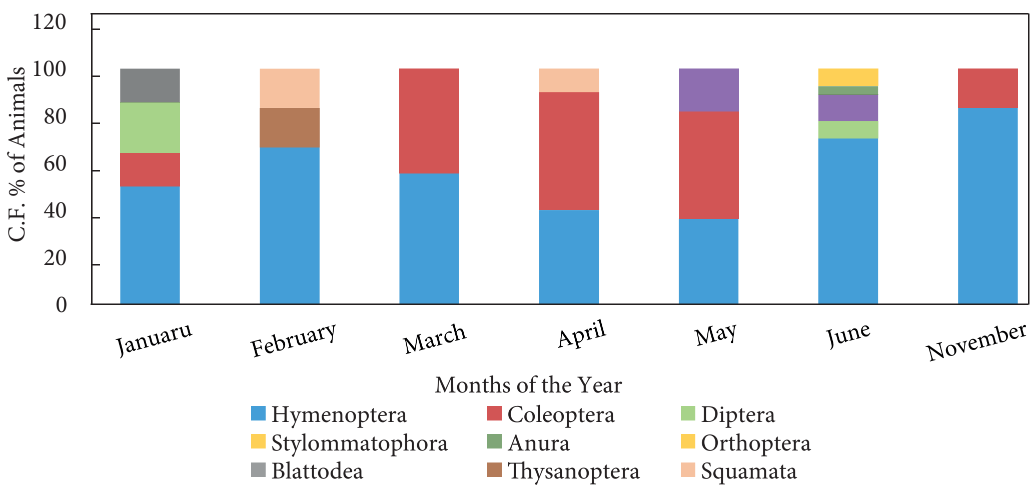

Fig. 3. Relative abundance of animal prey consumed by adult hybrid sparrows in 2022

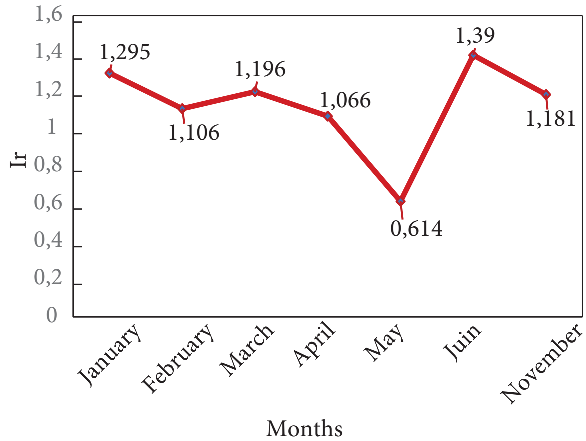

Fig. 4. Evolution of the repletion index in the hybrid sparrow adults in 2022

The diversity index (H') for ingested plants shows peak values of 2.20 bits in June and 1.86 bits in January, with 1 bit for the other months. In terms of distribution, equilibrium is observed in January with E = 0.80, while March and April show E values of 0.37 and 0.46, respectively. The maximum diversity of animal prey is recorded in January at 1.77 bits, with the Shannon index for other months ranging from 0.65 to 1.49 bits. As for equitability, a balance between taxa is noted in January and March, with E values of 0.88 and 0.99. However, an imbalance is observed in February, April, and May, with E approaching 0 (Table 6).

Significant variations were observed in the replenishment index (Ir) by month, with the highest values in June (Ir = 1.39) and January (Ir = 1.29), and the lowest in May (Ir = 0.61) (Fig. 4). The CV value recorded was 2.81%. Of the 71 samples analyzed, only 2 gizzards were completely empty in April and May. The Chi2 test revealed significant differences between the dietary elements ingested by adult sparrows, with (Pearson Chi^2 = 72.94, dl = 48, P = 0.011) for the animal fraction and (Pearson Chi^2 = 794.06, dl = 66, p = 0.000) for the plant fraction.

Diet of young passerines by age category. The diet of young sparrows in the nest shows significant variation with age. In the first age group, Orthoptera (29.41%) and Coleoptera (26.47%) were the most common. In the second age group, Hymenoptera dominated at 23.80%, followed by Coleoptera and Orthoptera at 21.42% each. In the third and fourth age groups, Coleoptera were the most consumed, at 51.85 and 66.66%, followed by Orthoptera (22.22%) for young sparrows aged 7–9 days, and Dermaptera (33.33%) for those 10 days and older. Hemiptera varied from 5.88 to 11.90% across the age groups. Dermaptera appeared in the first (7.14%) and fourth (33.33%) age groups, while Diptera ranged from 4.76 to 14.70%. Hymenoptera and Stylommatophora were consumed at rates from 7.40 to 23.80%. The least frequent prey, such as Geophilomorpha, Aranea, Isopoda, and Blattodea, occurred in the first age group at rates from 2.94 to 8.82% (Fig. 5). In terms of frequency of occurrence, Coleoptera (44.44% to 66.66%) and Orthoptera (30 to 62.5%) were the most sought-after prey.

Table 6. **Specific diversity (H') and equitability (E) of the food fractions ingested by the hybrid sparrow in 2022**

Ecological Index		Month						
		January	February	March	April	May	June	November
Animal fraction	H'	1.778	1.251	0.991	1.361	1.495	1.441	0.650
	E	0.889	0.237	0.991	0.258	0.283	0.620	0.650
Plant fraction	H'	1.866	1.158	1.063	1.210	1.158	2.208	1.102
	E	0.805	0.731	0.378	0.468	0.730	0.696	0.695

For the plant fraction, the chicks in the first age group mainly fed on Apiaceae, Asteraceae, and Anacardiaceae, with Asteraceae dominating at 60%. The second age group primarily consumed Brassicaceae (66%), followed by Anacardiaceae, Solanaceae, and Poaceae. In the third group, Anacardiaceae, Lamiaceae, and Poaceae were most common. The fourth group mainly ate Solanaceae and Poaceae. In the last age groups, Poaceae dominated, ranging from 60 to 75% (Fig. 6).

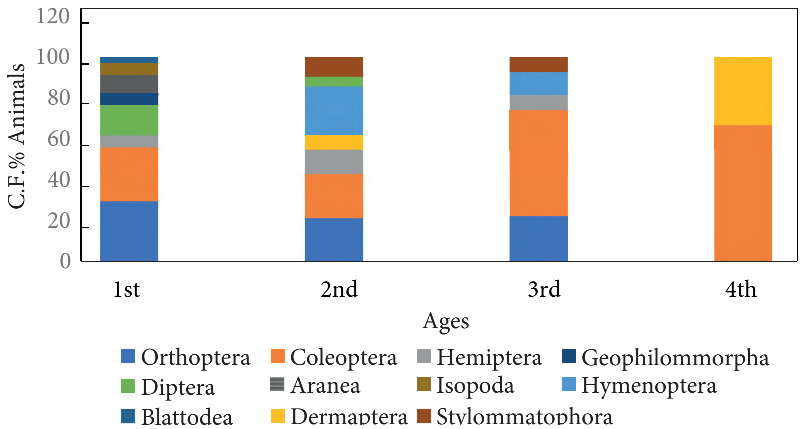

Fig. 5. Relative abundance of animal prey consumed by young hybrid sparrows at the nests

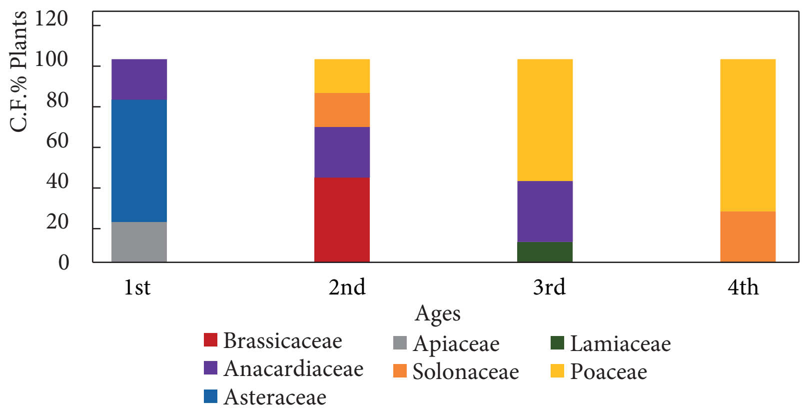

Fig. 6. Centesimal frequencies of plants consumed by young hybrid sparrows at nests

Table 7. **Specific Diversity (H') and Equitability (E) of Food fractions ingested by Young hybrid sparrows according to Age**

Ecological index		Ages			
		1st	2 nd	3 rd	4 th
Animal fraction	H' E	2.613 0.871	2.614 0.931	1.88 0.810	0.918 0.918
Plant fraction	H' E	1.371 0.865	1.887 0.943	1.295 0.817	0.811 0.811

The animal diversity index is highest for younger chicks, with H' = 2.61 bits, and lowest for older chicks. The distribution exponent (E) ranges from 0.8 to 0.9 across age groups. For plant diversity, the highest index (H') was found in the second age group with 1.88 bits, followed by the first and third groups. An equilibrium in plant consumption was observed across age groups, with E approaching 1 (Table 7).

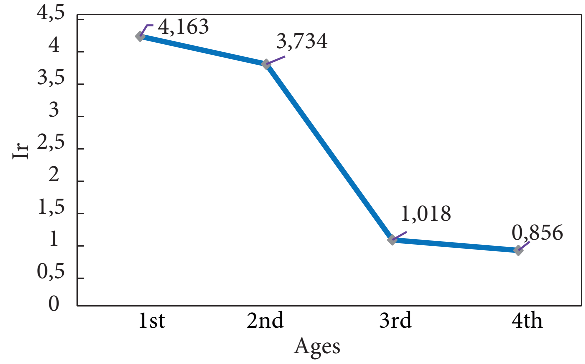

Fig. 7. Variation of the repletion index in young hybrid sparrows accordinng to age

The replenishment index shows significant variations during chick development. The highest indices were recorded for chicks aged 1–3 days (Ir = 4.16) and 4–7 days (Ir = 3.73), while the lowest values were observed for chicks aged 7–9 days and 10–12 days, with Ir ranging from 0.85 to 1.01 (Fig. 7). The coefficient of emptiness (CV) was 38.77%. Empty gizzards were found in chicks from the first (n = 2), third (n = 4), and pre-fledging age groups (n = 13). The Chi^2 test revealed significant differences in the proportions of animal and plant fractions fed to the young sparrows, with (Pearson Chi^2 = 61.73, dl = 30, p = 0.000) and (Pearson Chi^2 = 41.46, dl = 18, p = 0.001), respectively.

Discussion

Adults. The study of hybrid sparrows' diet in northern Algeria reveals a high plant consumption (83.53%) compared to animal prey (16.47%), with Amaranthaceae, Polygonaceae, and Poaceae being the most targeted families. Ait Belkacem (2000) similarly found that adults primarily consume spontaneous plants (73.5%). However, Guezoul (2011) reported that in the northern Sahara, adult hybrid sparrows consume more animal prey, with plants playing a minor role. Ould Rabah et al. (2014) found that Spanish sparrows favor animal prey (79.9%) over plants (20.1%), whereas Metzmacher (1981) in Oran observed a 98% plant-based diet, mainly cereals and spontaneous plants. In Tunisia, Bachkiroff (1953) and Bortoli (1969) noted that, sparrows prefer cultivated cereals but also seek spontaneous plant seeds. In the UK, Perkins et al. (2007) found that house sparrows' diet consisted of 70% seeds from cereals, grasses, and herbaceous plants.

Adult sparrows primarily consumed seeds, notably *Amaranthus angustifolius* (97 seeds), *Amaranthus hybridus* (50 seeds), and *Polygonum aviculare* (81 seeds). Bachkiroff (1953) noted that sparrows can eat 200–400 small seeds daily. However, El Kharrim et al. (1998) observed low seed consumption in Morocco, with *Amaranthus blitoides* (16.09%) and *Polygonum* sp. (9.58%), as their small size fails to meet sparrows' energy needs. Caviedes-Vidal & Karasov (2001) and Brzęk et al. (2010) reported that house sparrows' digestive flexibility decreases with age, making adults almost entirely granivorous.

For the animal fraction, hybrid sparrows showed a strong preference for Hymenoptera (57.83%), followed by Coleoptera (20.5%). Guezoul (2011) found that adult hybrid sparrows primarily consumed Coleoptera and Lepidoptera. Similarly, Ould Rabah et al. (2014) reported a diet mainly composed of Hymenoptera (54.8%) and Coleoptera (20.9%) in adult Spanish sparrows. In Morocco, El Kharrim et al. (1998) observed that P. domesticus fed on Coleoptera and Homoptera at rates of 7.66 and 15.22%, respectively. The prominence of Hymenoptera may result from the ease of capturing social species. Other taxa, including Orthoptera, Thysanoptera, Blattodea, Squamata, and Anura, were scarce, likely due to their limited dispersal, rarity, or the difficulty sparrows face in capturing them.

The monthly analysis of the hybrid sparrow's diet showed high plant consumption, with 5 to 9 recorded families. The highest H' index values appeared in January and June. For the animal fraction, a maximum of 5 taxa was recorded, with the highest diversity in January. These variations likely reflect seasonal changes in resource availability and species phenology. According to El Kharrim et al. (1998) and Millon et al. (2009), foraging behavior shifts with seasons and resources. Metzmacher (1981) also noted that during the breeding season, the Spanish sparrow's diet is 92% plant-based.

This study observed low foraging activity in April and May, coinciding with the breeding period, with gizzards empty of trophic elements. These findings align with El Kharrim et al. (1998). However, dietary preferences for Poaceae (*Triticum durum*) were noted, though only plant fragments were found, not seeds. According to Ait Belkacem et al. (2002), high individual activity occurred around agricultural plots during the wheat's milk stage. Kale et al. (2014) highlight that sparrows continue foraging in wheat fields until depletion. A significant consumption of Hymenoptera (57.14%) and Coleoptera (50%) was observed during these months. The number of Coleoptera consumed fluctuated, peaking in March, April, and May, but declining in November and January, with none recorded in February and June. Chenchouni et al. (2015) suggest that species distribution undergoes extinction and recolonization phases due to environmental changes. Notably, Coleoptera were present on-site in June, indicating they were not consumed solely based on abundance or nutritional value. Some authors state that adult Spanish sparrows are mainly insectivorous during the breeding season to feed their young (Marques et al., 2003).

The highest evenness index values were recorded in January and March for the animal fraction and in February and May for the plant fraction, while lower values appeared in February, April, and May for animal prey and in March and April for plants. A high index indicates balanced taxa distribution, whereas a value near 0 reflects the dominance of one prey type. However, no clear trend emerges between the two fractions. Poikilothermic insects, highly diverse in nature, depend on environmental temperature for body heat, staying active in warm seasons and hibernating in colder ones (Tougeron, 2016). Conversely, vegetation impacts trophic groups of entomofauna through flora composition, function, and plant cover density (Koricheva et al., 2000). Plant phenology is climate-dependent, influenced by species, genetic diversity, and sensitivity to climatic factors (Lebourgois et al., 2008). Moreover, soil insect communities respond to biotic and abiotic factors, either independently or combined (Vidal-Abarca et al., 2004). These dietary shifts across the annual cycle impact bird physiology, explaining the variation in the repletion index (IR) observed in this study, reflecting individual plasticity and dietary adaptation. According to Piersma & Drent (2003), internal organ size and mass fluctuate throughout the year.

Oisillons. The study on juvenile sparrow diet found that 77.86% of their prey was animal-based, with 22.14% from plants. Coleoptera made up 33.03%, followed by Orthoptera at 22.93% and Hymenoptera at 11.93%. These results align with Ait Belkacem (2000), who found that animal prey was more significant than plants in hybrid sparrow diets, with weed seeds comprising 28.6% of the plant component. Similarly, El Kharrim et al. (1998) observed that animal prey accounted for 98.18% of house sparrow chicks' diets in Morocco, with Coleoptera and Orthoptera being the most common. Studies in Europe also highlighted the predominance of insects in juvenile sparrow diets (Marques et al., 2003; Anderson, 2006; Klvaňová et al., 2011), as insects are rich in fat and highly nutritious (Bachkiroff, 1953; El Kharrim et al., 1998).

Trophic composition by age, show Coleoptera and Orthoptera were the most consumed orders by chicks aged 1 to 3 days (29.41 and 26.47%, respectively). For chicks aged 4 to 7 days, Hymenoptera dominated at 23.80%, followed by Coleoptera and Orthoptera (21.42% each). In older chicks, Coleoptera made up 51.85% of the diet for 7–9 days old and 66.66% for 10–12 days old. These findings contrast with Akrouf et al. (2002), who found Homoptera to be most consumed in all age categories of hybrid sparrows, and with Guezoul (2011), who reported caterpillars (Lepidoptera) as the main prey for younger hybrid sparrow chicks. Our results align with Ould Rabah et al. (2014), who observed Orthoptera dominance in Spanish sparrow chicks aged 3 to 6 days and Coleoptera dominance at 9 and 12 days. Bortoli (1969) reported Orthoptera dominance in Tunisian sparrow chicks aged 5 to 6 and 13 to 15 days. According to Marques et al. (2003) and Vincent (2005), these dietary variations reflect generalist feeding habits, with parents offering the most abundant prey to their chicks.

Other prey identified in this study included Hemiptera, Dermaptera, Geophilomorpha, Stylommatophora, Aranea, Diptera, Isopoda, and Blattodea, with frequencies ranging from 0.92% to 8.26%. Bortoli (1969) found that spiders, Hymenoptera, Heteroptera, and mollusks made up a small portion of chicks' diets. Anderson (2006) reported that beetles, grasshoppers, crickets, caterpillars, flies, aphids, and ants dominated the sparrow diet, with spiders in smaller amounts. The diet composition varies geographically and seasonally, depending on prey availability (Encke, 1965; Metzmacher, 1983; Anderson, 1984).

The plant component of the young sparrow diet included seven botanical families, mostly in the form of plant fragments. Chicks in the 1st age category primarily consumed Asteraceae (60%), while those in the 2nd category mainly ate Brassicaceae (41.66%). In older age categories, Poaceae dominated, with frequencies between 60% and 75%. Akrouf et al. (2002) found that Poaceae was the most significant plant fraction, comprising 87.36% of the diet for chicks aged 1–3 days and 68.42% for those aged 10–13 days. For chicks aged 4–6 and 7–9 days, Solanaceae (85.5%) and Moraceae (55.69%) were the most consumed families. Klvaňová et al. (2011) noted that in chicks older than nine days, about 90% of the plants were Poaceae, including seeds, stem fragments, and millet and wheat spikes, with the remaining 10% consisting of seeds from Papaveraceae, Brassicaceae, Urticaceae, and Fabaceae. The diet composition depends on the trophic availability in the environment (Bortoli, 1969).

The low proportion of plants in the gizzards of young sparrows suggests they may be administered for therapeutic purposes. For example, *Schinus molle* (Anacardiaceae) produces antibacterial essential oils from its leaves and fruits (De Mendonça Rocha et al., 2012). *Silybum marianum* (Asteraceae) contains silymarin, known for its hepatoprotective properties (Debuigne & Couplan, 2016). *Sinapis alba* (Brassicaceae) is recognized for its antiparasitic, bactericidal, and fungicidal properties due to glucosinolates (Sotelo et al., 2015).

Second-age chicks had the highest Shannon index (H') for plant diversity, followed by first and third-age chicks, with a fairly balanced distribution of botanical families. Klvaňová et al. (2011) noted that parents increase plant food to meet the growing needs of older chicks, but our results showed a decrease in plant intake with age. The animal component was highly diverse in early ages, with high Shannon index values, while older age groups had lower diversity. Guezoul (2011) found high animal proportions in newly hatched chicks, and Metzmacher (1983) highlighted that sparrows are omnivorous, preferring animal food early in growth, with more plant consumption towards the end of rearing.

The distribution of animal taxa showed balance across age groups, similar to Bachkiroff (1953), who found insects present in young Spanish sparrow stomachs, though their proportion decreased with age. Summers-Smith (1963) noted that nestling sparrows' diet is entirely invertebrates during the first three days, with the animal component gradually decreasing as the diet becomes almost entirely vegetarian (Mueller, 1986). This transition is likely due to the nutritional needs of young sparrows, as animal proteins provide essential amino acids for development (Arnold et al., 2007).

In our study, the proportion of Orthoptera decreased as chicks grew, while Coleoptera intake increased. This aligns with Ould Rabah et al. (2014), who found that sparrows feed younger chicks hard prey like Orthoptera. Marques et al. (2003) noted that Orthoptera biomass increases as chicks develop. The highest index values (Ir) were recorded in chicks aged 1–3 days and 4–7 days, while lower values were seen in chicks aged 7–9 days and 10–12 days. The vacuity coefficient (CV) showed a high rate of empty gizzards in young sparrows before fledging, indicating a decreasing correlation between food intake and nestling development. Possible, in the early stages, parents prioritize animal and plant proteins, along with essential nutrients, to support muscle growth, feather formation, and energy reserves. After these stages, they reduce food intake, providing limited energy from a few plants and insects to prepare the young for flight and promote independence.

Conclusion

This study revealed a remarkable diversity of feeding behaviors in hybrid sparrows, adapted to meet both their own nutritional needs and those of their offspring. These behaviors are shaped by individual traits and influenced by environmental heterogeneity, prey availability, and species phenology. The results suggest that dietary selection and the observed variations between adult and juvenile sparrows stem from a complex interplay of intrinsic factors, such as dietary preferences and digestive flexibility, and extrinsic factors, including the nutritional quality of trophic resources and predation pressures. Supported by individual plasticity, this behavioral diversity contributes to the adaptability of hybrid sparrows to ecological challenges and partly explains their expansion in Algeria.

Acknowledgements. My sincere thanks go to Boualem Khoudja, for his support, his help in the field and all the efforts he has made to carry out this work.

Authors' Contributions. Conceptualisation and Methodology: S. Khoudja, A. Ait Belkacem, F. Marniche; Data collection and insect identification: S. Khoudja, F. Marniche; Validation, Data processing, Writing preparation of the original version: S. Khoudja, A. Ait Belkacem.

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Received 20 February 2024
Accepted 23 April 2025