

BREEDING ECOLOGY OF THE NORTH-AFRICAN BLUE TIT
(*PARUS CAERULEUS ULTRAMARINUS*)
IN TWO SEMI-EVERGREEN OAK FORESTS IN ALGERIA

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INTRODUCTION

The larger the breeding range of a bird species, the greater the chances that varying environmental conditions will trigger different breeding strategies. In the Blue Tit (*Parus caeruleus*), whose breeding area runs from Scandinavia and Finland in the north to Northern Africa and the Canary Islands in the south, there is a clear distinction between the northern populations living in deciduous forests and the southern populations living in evergreen and coniferous forests. The former show a fairly homogeneous pool of populations whose morphology (Martin, 1991a, b ; Martin & Pitochelli, 1991) and life-history traits show clinal variation (Berndt *et al.*, 1983 ; overview in Perrins, 1979 ; Cramp & Perrins, 1993 ; Glutz von Blotzheim & Bauer, 1993). Their breeding effort is particularly remarkable because they are among the passerines with the highest clutch-sizes (means ranging from 10 to 12 eggs). The southern birds show much more variability in their morphology (Martin, *loc. cit.*) and their life-history traits (Isenmann, 1987 ; Gil-Delgado *et al.*, 1992 ; Blondel *et al.*, 1993). These populations are more isolated from one another and their habitats are much more variable. From a morphological and acoustic point of view, the North African (and Canarian) Blue Tits should even be considered as a distinct species (see Martin, 1991b ; Haffer in Glutz von Blotzheim & Bauer, 1993 ; Schottler, 1993). In fact, the Blue Tit populations living in the Mediterranean area show small but variable clutch-sizes and variable breeding times in relation to their respective local habitat quality. In this paper, we present data from North-African Blue Tit (*Parus caeruleus ultramarinus*) populations living in Zeen Oak (*Quercus faginea*) forests and showing life-history traits similar to those developed by Blue Tits in deciduous forests in temperate Europe.

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STUDY SITES AND METHODS

Both study sites are located in northeastern Algeria (Fig. 1). The first is at 500 m a.s.l. on the Djebel Edough (36° 55' N/ 7° 41' E) and the second at 1 000 m a.s.l. on the Djebel Ghorra (36° 32' N/ 8° 20' E). The predominant tree species at both sites is the Zeen Oak, a semi-evergreen species that keeps its leaves more or less alive over winter before renewing them all in the spring. The mean height of the trees is 17-18 m, some reaching 30 m. At both study sites, the climate is Mediterranean with dry and hot summers and wet and mild winters (annual rainfall slightly exceeds 1 000 mm).

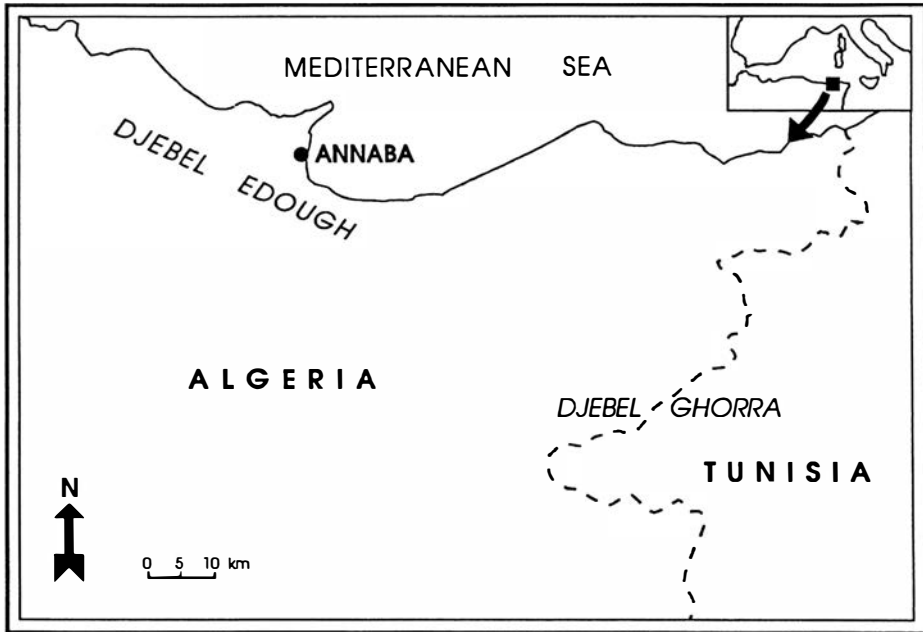


Figure 1. — Map showing the location of the two study sites.

We used 30 wood nestboxes at each study site over a three-year period (1991 to 1993). These were placed at 35 to 40 m intervals and checked every week from mid-March to late June.

The leafing phenology of the Zeen Oaks was followed every week by inspecting 40 randomly selected trees at each study site and by using the 6 scale values proposed by Leclercq (1977) and Du Merle & Mazet (1983).

RESULTS

NESTBOX OCCUPATION RATE (Table I)

The occupation rate (in average about 70 %) may reflect the annual fluctuation of breeding pairs. At the lower altitude study site, the nestbox

occupation rate significantly decreased from 1991 to 1993 ($X^2 = 7.134$, $df = 2$, $p < 0.001$). The nestbox occupation rate at the higher site did not show any significant variation.

Table I

Occupation rate of nestboxes at the two study sites.

	Djebel Edough (500 m)	Djebel Ghorra (1 000 m)
1991	100	77
1992	68	80
1993	54	61
Mean	70	71

THE LAYING PERIOD (Tables II and III)

At the 1 000 m a.s.l. study site, the mean laying date of the first egg occurs on average 18 days later than at 500 m ($t = 2.857$, $df = 102$, $p \leq 0.01$). The interannual variation of the mean laying date was very weak at each altitude, the limits of the mean varied within a range of 6 days. The length of the laying period was always shorter by an average of 8 days at the higher altitude study site than at the lower one. As already shown by previous authors working in southern France (e.g. Leclercq, 1977 ; Cramm, 1982 ; Blondel *et al.*, 1987), the main laying period at both sites corresponds to young leaf appearance in the predominant tree species. For example, in 1993, 80 % of the females at 500 m a.s.l. had begun to lay when the leaves of Zeen Oak were between the scale values of 3 and 4 (very small young leaves) while 90 % of the females at 1 000 m a.s.l. did so when the oak leaves were between the same scale values.

TABLE II

Breeding period at Djebel Edough (500 m).

	Mean \pm SD	Limits	N
1991	10 April \pm 5.39	4 April-20 April	10
1992	16 April \pm 14.72	27 March-18 May	13
1993	14 April \pm 4.79	7 April-27 April	12
Mean	14 April \pm 10.30	27 March-18 May	35

TABLE III

Breeding period at Djebel Ghorra (1 000 m).

	Mean \pm SD	Limits	N
1991	3 May \pm 10.05	29 April-22 May	25
1992	2 May \pm 3.55	26 April-11 May	21
1993	29 April \pm 3.10	19 April-22 May	23
Mean	2 May \pm 7.10	26 April-22 May	69

CLUTCH SIZE (Table IV)

The mean clutch size is higher by nearly 1 egg at the higher study site ($t = 2.75$, $df = 102$, $p \leq 0.01$). At both study sites, there is no any annual variation of the clutch size (at 500 m : $F^{2.60} = 2.80$ and at 1 000 m : $F^{2.60} = 0.25$). At 500 m the clutches never exceeded 9 eggs but at 1 000 m about 12 % of the females produced clutches containing between 10 and 12 eggs.

TABLE IV

Clutch-size at the two study sites.

	Djebel Edough/500 m Mean \pm SD (Limits) N	Djerbel Ghorra/1 000 m Mean \pm SD (Limits) N
1991	6.60 \pm 0.49 (6-7) 10	7.00 \pm 1.83 (4-12) 25
1992	6.15 \pm 1.17 (5-9) 13	7.43 \pm 1.29 (6-11) 21
1993	6.66 \pm 0.62 (6-8) 12	7.78 \pm 1.41 (6-11) 23
Mean	6.46 \pm 0.87 (5-9) 35	7.39 \pm 1.58 (5-12) 69

Furthermore, there is a seasonal decline in the clutch size both at 500 m ($r = -0.587$, $df = 33$, $t = 4.165$, $p \leq 0.001$) and at 1 000 m ($r = -0.639$, $df = 67$, $t = 6.799$, $p \leq 0.001$). This correlation exists each year and is stronger at 1 000 m than at 500 m a.s.l. (Table V).

Moreover, no second clutches have ever been noticed at both study sites.

BREEDING SUCCESS (Table VI)

The mean breeding success was not lower than 70%. It was higher at 1 000 m than at 500 m ($X^2 = 6.946$, $df = 1$, $p \leq 0.01$).

TABLE V

Correlation values of the seasonal decline in the clutch size in the three different years at the two study sites.

	Djebel Edough /500 (r; df; t; p)	Djebel Ghorra /1 000 m (r; df; t; p)
1991	-0.390; 8; 1.19; n.s.	-0.681; 23; 4.45; ≤ 0.001
1992	-0.866; 11; 5.74; ≤ 0.001	-0.483; 19; 2.40; ≤ 0.05
1993	0.193; 10; 0.68; n.s.	-0.542; 21; 2.96; ≤ 0.01

TABLE VI

Breeding success at the two study sites (Young fledged of eggs laid).

	Djebel Edough /500 m (eggs laid)	Djebel Ghorra /1 000 m (eggs laid)
1991	81 % (70)	82 % (175)
1992	59 % (80)	82 % (147)
1993	71 % (80)	73 % (179)
Mean	70 % (230)	79 % (501)

DISCUSSION

The breeding ecology of the different Blue Tit populations in the Mediterranean area has been extensively studied (e.g. Cramm, 1982 ; Blondel *et al.*, 1987 ; Isenmann, 1987 ; Dervieux *et al.*, 1990 ; Potti *et al.* 1988 ; Gil-Delgado *et al.*, 1992 ; Blondel *et al.*, 1993) and the following can be summarized. There is a greater variability in life-history traits of this species in the Mediterranean area than in the rest of its breeding area. In the Mediterranean region, Blue Tits mostly live in evergreen forests where there are fewer available food resources during the breeding period than in the deciduous forests where the species usually lives in temperate Europe further north. This leads to smaller clutch-sizes and consequently to a fewer number of nestlings per brood. Moreover, breeding time is generally late so that Mediterranean populations lay at the same time-period than the more northern populations that live under climatically harsher conditions. The most extreme example is shown by the Corsican population with a particularly late laying time period occurring in May (Blondel & Isenmann, 1979 ; Blondel *et al.*, 1990 ; Lambrechts & Dias, 1993). However, another population living in evergreen Holm Oaks (*Quercus ilex*) in southern Spain shows an early laying period that takes place in March (Isenmann *et al.*, 1990). The late-laying Corsican population with small clutches is known to be well adapted to small surplus feeding resources that appear relatively late in spring (Blondel *et al.*, 1991). The early laying birds in southern Spain might behave this way because they have to

finish their breeding cycle by the time when high temperatures occur there, i.e. in early May (Isenmann *et al.*, 1990). Finally, each population must adapt to very different local environmental constraints. In addition, many of the habitats in the Mediterranean are located in montane areas which further adds to the complexity of the topic.

In northern Africa, where most Blue Tit populations live in montane areas covered with evergreen oaks (*Quercus ilex* and *Q. suber*) and Cedars (*Cedrus atlantica*), data collected in Morocco (Isenmann *et al.*, 1982 ; Baouab *et al.*, 1986) and in Algeria (Moali & Isenmann, 1990 ; Moali *et al.*, 1992) did not greatly differ from those collected in Mediterranean Europe. The present data collected in Zeen Oak forests at 500 m fit the limits already known, but those collected at 1 000 m show some differences. In the latter habitat, the mean clutch size (about 7.4 eggs) is the highest ever found in North Africa, with a small proportion of females laying clutches as high (10-12 eggs) as those laid in high quality habitats in temperate Europe. Furthermore, knowing that clutch size and breeding success generally decrease with altitude (see Glutz von Blotzheim & Bauer, 1993), the Djebel Ghorra (1 000 m a.s.l.) birds show another originality since their mean clutch size and breeding success are significantly higher than those recorded at Djebel Edough (500 m a.s.l.). Montane Zeen Oak forests at the former site probably constitute a high-quality habitat through their high number of caterpillars that are the basic food items for Blue tits allowing the breeding performances of the birds to be slightly similar to those in European deciduous oak woods. We suggest that this high habitat quality comes from the leafing phenology of the Zeen Oak renewing all its leaves in the spring like deciduous oaks do, offering, thus, a large amount of young leaves to a proportional amount of caterpillars for which young leaves are the essential food items. However, shorter spring days in northern Algeria (the reduction is 2 to 3 hours per day) compared to Central Europe probably reduce the effect of habitat quality (see Lack, 1966). Another factor that may hamper breeding performances of these populations is the southern and peripheral position of northern Africa leading to probable lower variation in the seasonality of food resources (see Ricklefs, 1980, Järvinen, 1986). Other constraints related to demographic traits of these North African Blue Tits remain unknown (see Blondel *et al.*, 1992).

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RÉSUMÉ

La reproduction des Mésanges bleues d'Afrique du Nord (*Parus caeruleus ultramarinus*) nichant à 500 m et à 1 000 m d'altitude dans des forêts de Chêne zéen (*Quercus faginea*) dans le nord-est d'Algérie a été étudiée de 1991 à 1993. Si les oiseaux nichant à 500 m d'altitude montrent des paramètres de la reproduction (date et grandeur de ponte, succès de reproduction) classiques en ces latitudes, ceux nichant à 1 000 m montrent quelque originalité en ce sens que leur grandeur de ponte moyenne (7,4) est la plus élevée jamais trouvée en Afrique du

Nord, environ 12 % des femelles pondant 10 à 12 œufs par ponte. Ces valeurs rappellent celles trouvées chez des oiseaux nichant dans des chênaies décidues d'Europe. En effet, le Chêne zéen est un arbre semi-sempervirent qui garde ses feuilles pendant l'hiver mais les renouvelle toutes au printemps comme un chêne décadu, permettant ainsi le développement d'une grande quantité de chenilles dépendantes de feuilles fraîches et qui sont les proies de base des mésanges. Ces populations illustrent l'extrême variabilité des caractéristiques morphologiques et écologiques des populations méditerranéennes de Mésange bleue soumises à des isolements importants et des habitats de qualité variable.

Key words : reproduction, Mésange bleue *Parus caeruleus*, grandeur de ponte, Chêne zéen *Quercus faginea*, Algérie.

SUMMARY

The breeding ecology of North African Blue Tits (*Parus caeruleus ultramarinus*) nesting at 500 m and 1 000 m a.s.l. in Zeen Oaks (*Quercus faginea*) was studied over a three-year period (1991-1993) in northeastern Algeria. The data (laying period, clutch size, breeding success) collected at 500 m fit the limits already known, but those collected at 1 000 m show some differences. In the latter, the mean clutch size (7.4 eggs) is the highest ever found in North Africa, about 12 % of the females lay 10 to 12 eggs per clutch. These clutch sizes are similar to those found in birds breeding in European oak woods. The Zeen Oak is a semi-evergreen tree that keeps its leaves more or less alive over winter before renewing them all in the spring like a deciduous oak whose young leaves allow the development of a great amount of caterpillars, the basic food items for tits. These populations illustrate the high variability in morphology and in life-history traits of Blue Tits living in Mediterranean habitats.

Key words : breeding ecology, Blue tit *Parus caeruleus*, clutch size, Zeen Oak *Quercus faginea*, Algeria.

REFERENCES

- BAOUAB, R.E., THÉVENOT, M., & AGUESSE, P. (1986). — Dynamique des populations de la Mésange bleue (*Parus caeruleus*) en chênaies de Mamora et du Moyen Atlas. *Bull. Institut Scientifique, Rabat*, 10 : 165-183.
- BERNDT, K., WINKEL, W. & ZANG, H. (1983). — Über Legebeginn und Gelegestärke von Kohl- und Blaumeise in Beziehung zur geographischen Lage des Brutortes. *Vogelwarte*, 22 : 93-100.
- BLONDEL, J., CLAMENS, A., CRAMM, P., GAUBERT, H. & ISENMANN, P. (1987). — Population studies on tits in the Mediterranean region. *Ardea*, 75 : 21-34.
- BLONDEL, J., DERVIEUX, A., MAISTRE, M. & PERRET, P. (1991). — Feeding ecology and life history variation of the Blue Tit in Mediterranean deciduous and sclerophyllous habitats. *Oecologia*, 88 : 9-14.
- BLONDEL, J., DIAS, P.C., MAISTRE, M. & PERRET, P. (1993). — Habitat heterogeneity and life-history variation of Mediterranean Blue Tits (*Parus caeruleus*). *Auk*, 110 : 511-520.
- BLONDEL, J. & ISENMANN, P. (1979). — Insularité et démographie des Mésanges du genre *Parus* (Aves). *C. R. Acad. Sc. Paris*, 289 : 161-164.
- BLONDEL, J., PERRET, P. & MAISTRE, M. (1990). — On the genetical basis of the laying-date in an island population of blue tits. *J. evol. Biol.*, 3 : 469-475.

- BLONDEL, J., PRADEL, R. & LEBRETON, J.D. (1992). — Low fecundity insular blue tits do not survive better as adults than high fecundity mainland ones. *J. Animal Ecology*, 61 : 205-213.
- CLAMENS, A. & MARTIN, J.-L. (1991). — Laying date in Mediterranean Blue Tits : effects of habitat type and geographic isolation. *Ornis Scand.*, 22 : 401-403.
- CRAMM, P. (1982). — La reproduction des mésanges dans une chênaie verte du Languedoc. *L'Oiseau et R.F.O.*, 52 : 347-360.
- CRAMP, S. & PERRINS, C.M. (eds) (1993). — *The Birds of the Western Palearctic*. Vol. VII. Oxford University Press, Oxford.
- DERVIEUX, A., ISENMANN, P., CLAMENS, A. & CRAMM, P. (1990). — Breeding time and breeding performance of the Blue Tit (*Parus caeruleus*) in two Mediterranean habitats. pp. 77-87. In : BLONDEL *et al.*, eds, *Population Biology of Passerine Birds. An Integrated Approach*. Springer Verlag, Berlin-Heidelberg.
- DU MERLE, P. & MAZET, R. (1983). — Stades phénologiques et infestations par *Tortrix viridana* L. (*Lep. Tortricidae*) des bourgeons du Chêne pubescent et du Chêne vert. *Acta Oecologica, Oecologica Applicata*, 4 : 47-53.
- GIL-DELGADO, J.A., LOPEZ, G. & BARBA, E. (1992). — Breeding ecology of the Blue Tit (*Parus caeruleus*) in eastern Spain : a comparison with other localities with special reference to Corsica. *Ornis Scand.*, 23 : 444-450.
- GLUTZ VON BLOTZHEIM, U. & BAUER, K. (1993). — *Handbuch der Vögel Mitteleuropas*. Vol. 13. Aula Verlag, Wiesbaden.
- ISENMANN, P. (1987). — Geographical variation in clutch-size : the example of the Blue Tit (*Parus caeruleus*) in the Mediterranean area. *Vogelwarte*, 34 : 93-99.
- ISENMANN, P., ALES, E. & MORENO, O. (1990). — The timing of breeding and clutch size of Blue Tits (*Parus caeruleus*) in an evergreen Holm oak habitat in Southern Spain. *Rev. Ecol. (Terre Vie)*, 45 : 177-181.
- ISENMANN, P., DUBRAY, D., BAOUAB, R. & THÉVENOT, M. (1982). — First results on clutch-size and breeding time of Blue Tit (*Parus caeruleus*) in Morocco. *Vogelwarte*, 31 : 461-463.
- JÄRVINEN, A. (1986). — Clutch size of passerines in harsh environments. *Oikos*, 46 : 365-371.
- LACK, D. (1966). — *Population studies of birds*. Oxford Univ. Press, London.
- LECLERCQ, B. (1977). — Etude phénologique des paramètres liés à la reproduction des mésanges en fûtaie de Chênes. *Terre et Vie*, 31 : 599-619.
- MARTIN, J.L. (1991a). — Patterns and significance of geographical variation in the blue tit (*Parus caeruleus*). *Auk*, 108 : 820-832.
- MARTIN, J.L. (1991b). — The *Parus caeruleus* complex revisited. *Ardea*, 79 : 429-438.
- MARTIN, J.L. & PITOCELLI, J. (1991). — Relation of within-population phenotypic variation with sex, season, and geography in the blue tit. *Auk*, 108 : 833-841.
- MOALI, A., AKIL, M. & ISENMANN, P. (1992). — Modalités de la reproduction de deux populations de Mésange bleue (*Parus caeruleus ultramarinus*) en Algérie. *Rev. Ecol. (Terre Vie)*, 47 : 313-318.
- MOALI, A., & ISENMANN, P. (1990). — The timing of breeding and clutch size of Blue Tits (*Parus caeruleus*) in two montane habitats in Algeria. pp. 117-120. In : J. BLONDEL *et al.*, eds, *Population Biology of Passerine Birds. An Integrated Approach*. Springer Verlag, Berlin-Heidelberg.
- PERRINS, C.M. (1979). — *British Tits*. Collins, London.
- POTTI, J., MONTALVO, S., SANCHEZ-AGUADO, F.J. & BLANCO, D. (1988). — La reproducción del Herrerillo común (*Parus caeruleus*) en un robledal del centro de España. *Ardeola*, 35 : 31-45.
- RICKLEFS, R.E. (1980). — Geographical variation in clutch size among passerine birds : Ashmole's hypothesis. *Auk*, 97 : 38-49.
- SCHOTTLER, B. (1993). — *Die Lautäusserungen der Blaumeisen (Parus caeruleus) der Kanarischen Inseln. Variabilität, geographische Differenzierungen und Besiedlungsgeschichte*. Doctoral Thesis University of Mainz (Germany).