FOREST LAB – NIUS PROJECT

Introduction

Most birds, especially in temperate regions such as Catalonia, adjust their breeding season to match the time when they have to feed the chicks with the moment of maximum abundance of food. The vast majority of species breeds between spring and early summer, when there are more hours of light and food productivity reaches its annual maximum. Before breeding, however, territorial birds must establish and protect their territories, trying to place them in the most suitable places to build the nest and, above all, where they can ensure the greatest availability of food. The nest is the structure that should provide safety and shelter for eggs and chicks. There are species that make their own nests, others use old nests or holes dug by other species and a few lay their eggs in the nests occupied by other species. There are very elaborate nests made of grass, leaves, twigs, others are solid structures made of mud, but in other cases the nest consists of a very simple and poor structure made from a few banks. Nests can be found almost anywhere: on the ground, on cliffs, houses, trees, shrubs, burrows, also in artificial structures such as nest boxes. Many times, it is the female who builds the nest on her own, but sometimes both parents participate or only the male participates. There are birds that can nest in two or three days and others may need weeks. The size of the clutch (number of eggs) varies greatly from one species to another, and also individually and geographically within the same species. In general, larger species with great longevity lay very small clutches (one or two eggs), while smaller, short-lived species lay much larger clutches, which can even exceed 10 eggs. In general, in small birds such as most passerines, incubation begins when the last egg is laid, and the chicks are all born at the same time. Most bird species are altricial, meaning their chicks are born blind, featherless and unable to fend for themselves. In these species, the chicks remain in the nest fed and protected by their parents until they have matured enough to leave the nest. During the first week of life, in addition, parents should continue to warm them up as they are unable to control their own body temperature. In small birds' chicks remain in the nest for about two to three weeks and, when they leave it, are still almost unable to fly. Once they leave the nest, the young usually remain close to their parents for about two weeks.

Nius is an ICO (Institut Català d'Ornitologia) citizen science initiative aimed at monitoring bird nesting. Its main objective is to obtain information about where, when and how birds breed: the location of their nests, their breeding phenology and their reproductive biology. *Nius* is helping to fill important knowledge gaps on the reproduction of bird species that nest in Catalonia and, especially, those that breed closer to us, for example, those that breed in buildings or in parks and gardens or in easily accessible places, such as nest boxes. Bird reproduction is very sensitive to habitat disturbances

and the effects of climate change, *Nius* is specially designed to know how birds respond to these and other factors of change over time.

Materials and methods

During the 2023 breeding season, 176 nest boxes were monitored by ICO (Istitut Català d'Ornitologia) volunteers in three different habitats and at three different altitudes (as reported in the *tables 1* and *2*) in the Montseny natural park, following the calendar shown in *table 3*. Within the Passeriformes order, the target species identified for this "forest lab" project were the Nuthach (*Sitta europaea*) and four species belonging to the tit family: blue tit (*Parus caeruleus*), great tit (*Parus major*), crested tit (*Parus cristatus*), and coal tit (*Parus ater*).

Table 1 Description of the forest types in the Montseny natural park

Code	*Habitat*	*Description*
Ca	caducifolious forest	beech, oaks or chestnut trees
Co	coniferous forest	silver fir, douglas fir, spruce or pine trees
Es	Sclerophyll forest	holly oak or olive trees

Table 2 Description of the different altitudes

Code	*Altitude*	*Description*
Lo	Low	500 m above sea level
Mi	Middle	1000 m above sea level
Hi	High	1500 m above sea level

Table 3 Timetable of nest monitoring activities

Habitat Code	Starting date	Ending date	Last check
ESLO	24/03/2023	02/06/2023	From 21/08/2023
ESMI	11/04/2023	03/07/2023	From 21/08/2023
CAMI – COMI	24/04/2023	03/07/2023	From 21/08/2023
CAHI - COHI	24/05/2023 (only one check)		From 21/08/2023

For each nest box, the status at the time of the inspection was reported, in particular the box was considered: empty, when it presented no evidence of being used; little, few moss or other nest material in the nest box on the bottom of the nest box (*Fig.1A*); bottom, most of the bottom was filled with nest material (*Fig. 1B*); Cup, the nest material showed a cup shape on the top (*Fig. 1C*); and lining, when there was lining material inside, like feathers (*Fig. 1D*). The number of the eggs (*Fig. 2E*) and the beginning of the incubation period (when the eggs became warm), the number of chicks (dead and alive; *Fig. 2F*) and the outcome (fledging, predation or abandonment) of the nest, were also reported.

For each stage, the frequency of nest boxes checks was identified, according to species-specific characteristics, as specified in the protocol in *table 4*.

Table 4 Nest boxes checking protocol

Stage	Next Check
Nest building	
Empty	In 14 days
Little	In 7 days
Bottom	In 4 days
Cup	In 2 days
Lining	every day to find out the date of the first egg
Egg laying	
Number	every day after they have 5 eggs
Incubation	
Incubating	In14 days. After this second check, check it every day until chicks hatched
Chicks	
Num. of chicks	calculate how old they are, ring them from day 6
Fledged	check it two weeks after until the end of breeding season.
Predated	check it two weeks later until the end of breeding season
Abandoned	check it two weeks later until the end of breeding season

Photographs were taken of the chicks belonging to the different species from the hatching of the eggs until the fledging of the chicks, with the aim of identifying differences between species on the days of eye opening, pin breaking of the primary feathers and the presence/absence of a red spot on the head caused by egg breaking. In addition, when the chicks reached 6 days of age, they were ringed by the authorised person according to the appropriate procedures.

About two months after the end of the breeding season, all nest boxes were checked again for out-of-season breeding activity.

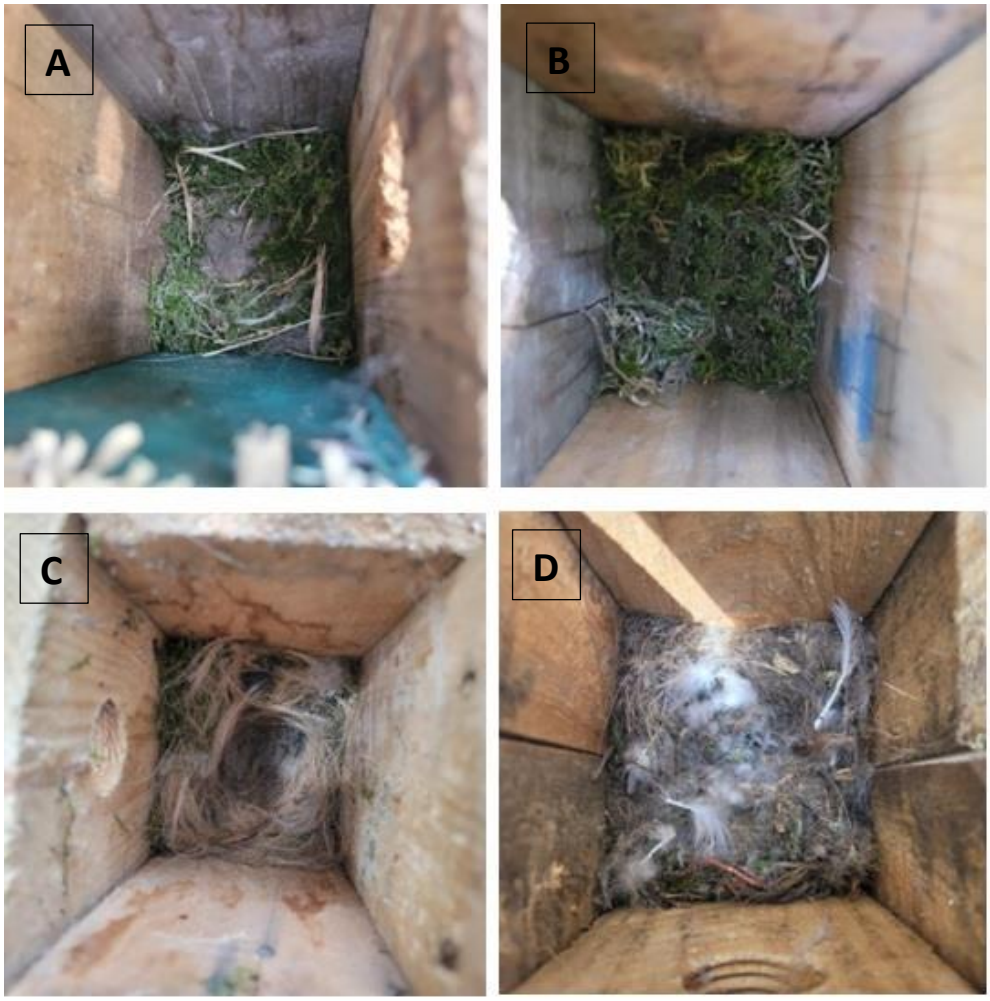

Figure 1 Nest building stages: Little (A); Bottom (B); Cup (C); Lining (D).

Figure 2 Eggs (E); and chicks (F).

Results

During the breeding season, 176 nest boxes were checked at the three different habitats. Of these, only the 30% (52 boxes) was occupied by the species identified, the remaining 70% (124 boxes) remained empty for the entire period. As predicted, the species that used the boxes were: Blue tit, Great tit, Coal tit, Crested tit and Nuthach, as reported in the *Figure 3*. The outcome of them is shown in the *Figure 4*: 48% (28 boxes) of the used boxes were successful and the chicks fledged, the 50% failed: the eggs or chicks were predated or abandoned, and for the remaining 2%, the outcome is unknown.

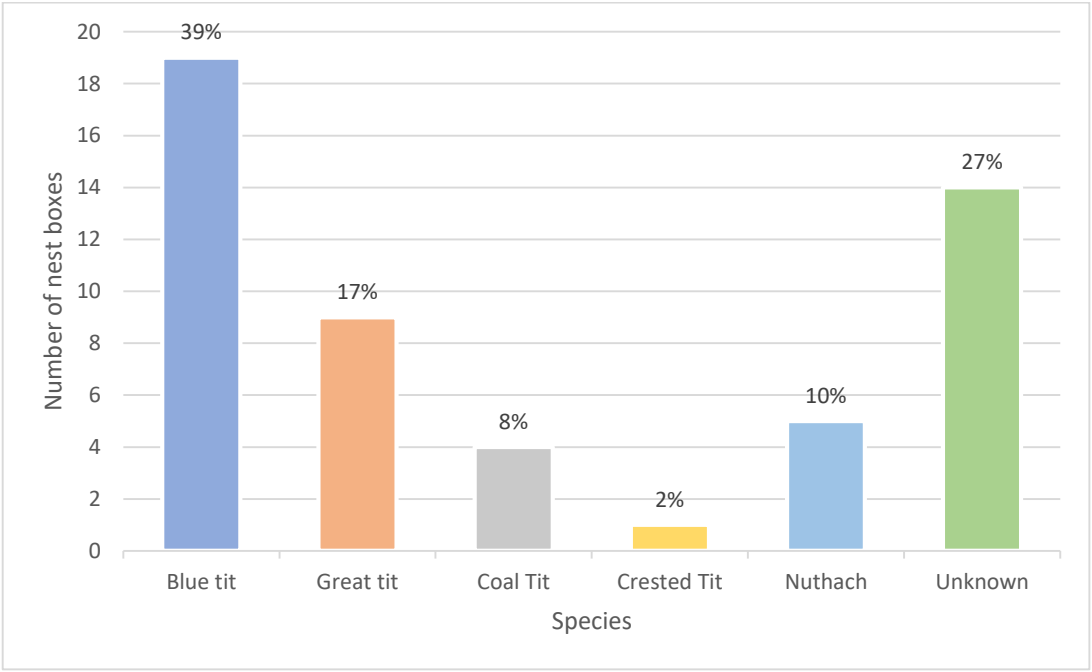

Figure 3 number and percentage of the nest boxes occupied by different species.

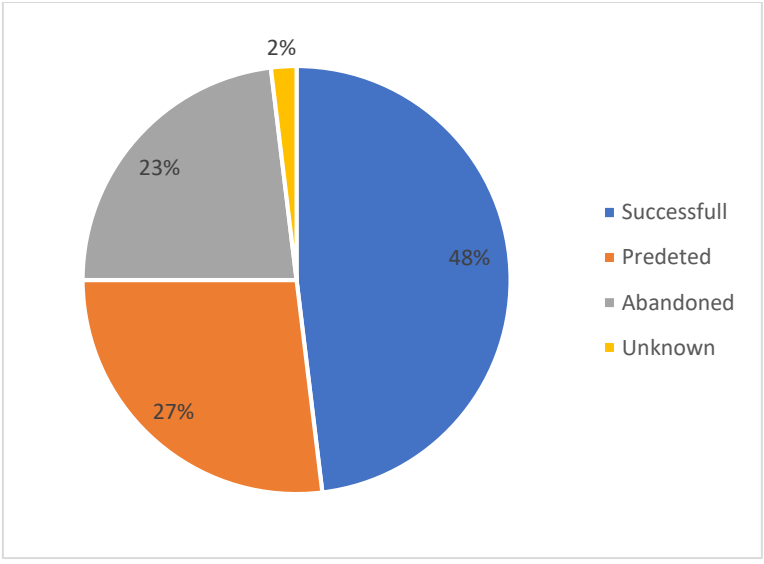

Figure 4 Nest boxes outcome

All habitats were used (*Fig. 5*) except for the high-altitude caducifolious forest (CaHi). The *table 6* shows the number of boxes used and unused in each habitat, and the outcome of those used, where success means when the chicks fledged, and failure means when the nest has been predated or abandoned.

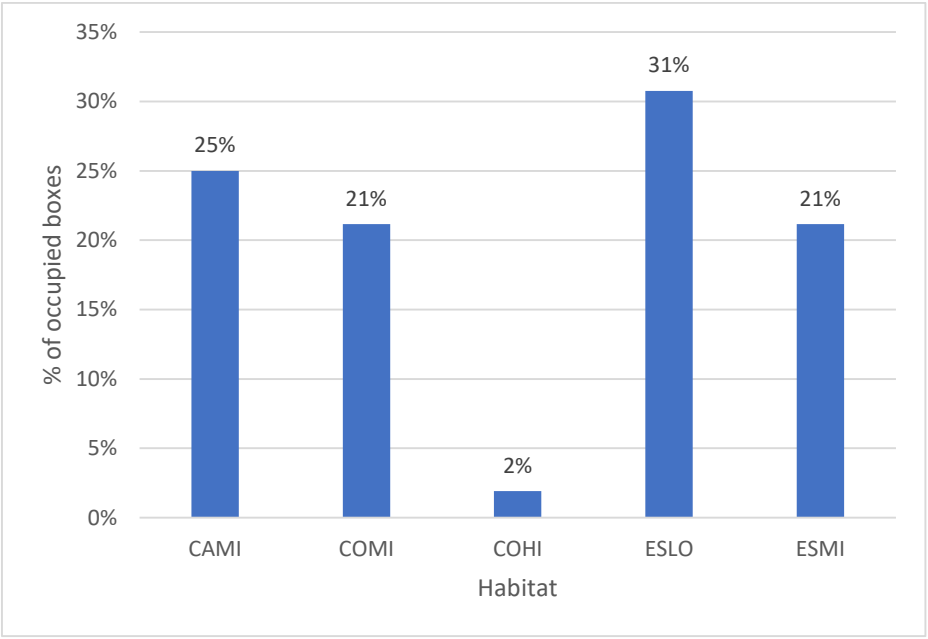

Figure 5 Nest boxes used during the reproductive season in the different habitats.

Table 5 Number of the successful, failed, used and unused nest boxes in the different habitats.

HABITAT	**TOTAL**	**NOT USED**	**USED**	**SUCCESSFUL**	**FAILED**	**OUTCOME UNKNOWN**
CAMI	30	17	13	**6**	7	0
COMI	30	19	11	**3**	7	0
COHI	30	29	1	**1**	0	0
CAHI	30	30	0	0	0	0
ESLO	26	9	17	**8**	8	1
ESMI	30	19	11	**7**	5	0
TOTAL	176	123	53	25	27	1

During the breeding season, a total of 57 chicks were ringed, of these 45 were blue tit species (7 of them did not reach the fledging), 5 were nuthatches and 7 were crested tits.

From the data collected, it was then possible to calculate the average times (in days) of the incubation period, and the period between hatching and fledging in order to make a comparison between the different species. The average number of eggs laid, and the chicks was also compared in the different species of tit: great tit, blue tit, coal tit and crested tit (*Table 6 and Fig,7).*

Table 6 Comparison of the reproductive strategies of birds belonging to the tit family.

species	*incubation*	*Hatching-fledging*	*Eggs*	*Chicks*
Great tit (n 1)	17	14	6	6
Blue tit (n 10)	15	19	6	5
Coal tit (n 4)	16	19	7	6,5
Crested tit (n 1)	13	19	4	4

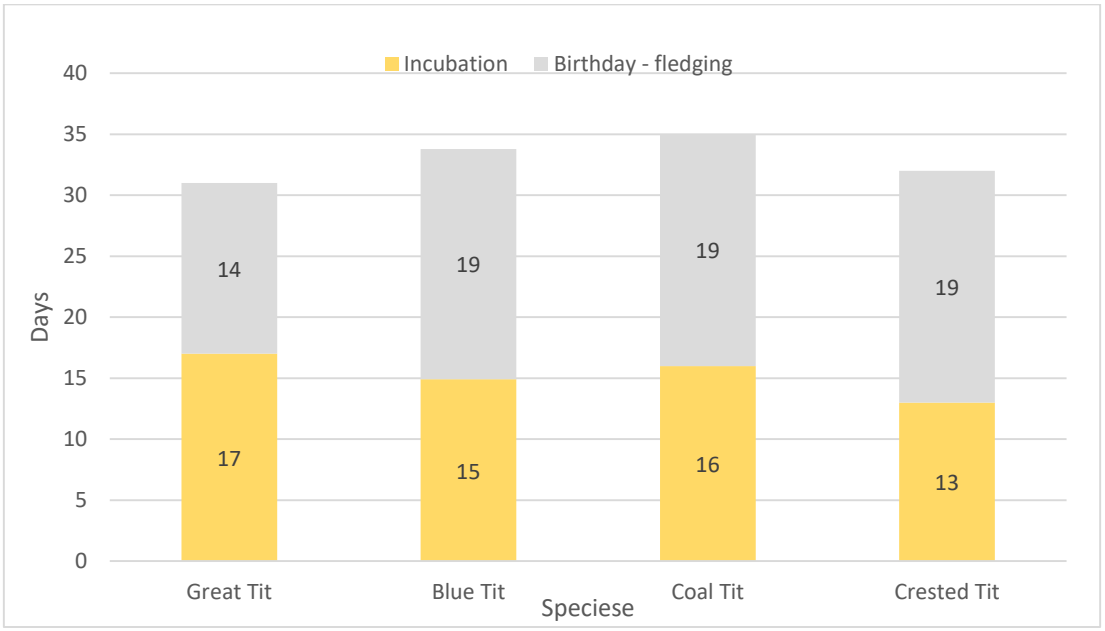

Figure 6 incubation period in the different tit species

The information about the species that occupied the nest, the first day of nest building, the number of eggs laid, number of chicks born and fledged with the exact day they were seen for the first and last time, the outcome of the nest, and the presence of a second brood were entered on *nius.cat.*

A final check of the nest boxes was carried out from 23rd of August until 30th of September: only 10 boxes showed a different outcome compared to the last check made during the breeding season (as reported in *table 6* and *Fig. 7*).

Table 7 Boxes with the breeding season and autumn outcome

Nest box	breeding season	last check
CaHi21	Empty	Nest
CaHi22	Empty	Nest
CoHi01	Empty	Nest
CoHi04	Empty	Nest
CoMi07	Empty	Nest
CoMi10	Empty	Nest materials
CaMi17	Empty	Nest materials
EsLo13	Empty	Nest materials
EsLo17	Empty	Nest materials
EsMi14	Empty	Nest materials

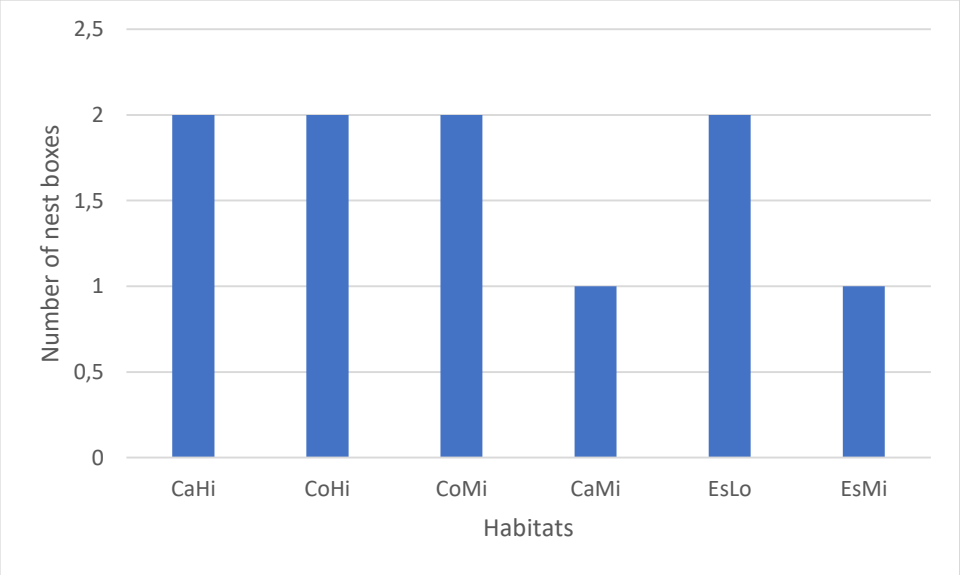

Figure 7 number of the nest boxes with a different outcome at the different habitats

Considering the last check made out of the breeding season, in total 62 boxes (35%) resulted occupied by the species identified, the remaining 114 boxes (65%) remained empty for the entire period.

Out of the 4 tit species, clutches of 3 species were well followed and documented by photos during the breeding season (Figure 9). These were the blue tit, coal tit and crested tit. One great tit nest was followed at the beginning of development (day 1, 4,5 and 6) but later, no pictures were taken about the clutch. Therefore, this species cannot be compared with the other species in this study. Considering the variable number of the pictures taken for each species (*Figure 8*), it's possible to conclude that the eye opening happened around the same time for all species, between the 6th and 9th day after hatching. Although, it is not definitively ascertainable due to gaps in the observation days. Observations are missing for the coal tit from the day 9 and 10, and day 6-8 for the crested tit (*Table 8* and *Fig. 8*).

Table 8 Number of pictures taken for each species from the hatching to the fledging.

Day	Blue tit	Great tit	Coal tit	Crested tit
1	7	7	6	4
2	8	0	0	4
3	4	0	7	4
4	4	7	7	4
5	10	7	8	4
6	10	7	7	0
7	4	0	7	0
8	10	0	7	0
9	8	0	0	4
10	4	0	0	4
11	10	0	7	4
12	4	0	7	4
13	4	0	7	4
14	7	0	7	0
15	3	0	7	0
16	4	0	0	4
17	3	0	0	0
18	6	0	0	2
19	0	0	7	0
20	0	0	0	0
21	0	0	0	0
Total	**110**	**28**	**91**	**46**

The presence of pin feathers better documented for the blue tit, coal tit and crested tit. The earliest growth of pin feathers happened on the blue tits. By the second day, nearly 80% of the clutch had pin feathers. The crested tit chicks started to grow their pin feathers from the third day. The slowest development out of these three species was observed for the coal tit. Their pin feathers were observed only from the 4th day after hatching (*Fig. 9)*.

The presence/absence of a red spot on the head caused by egg breaking was not possible to determine as it was not well visible in the taken photos.

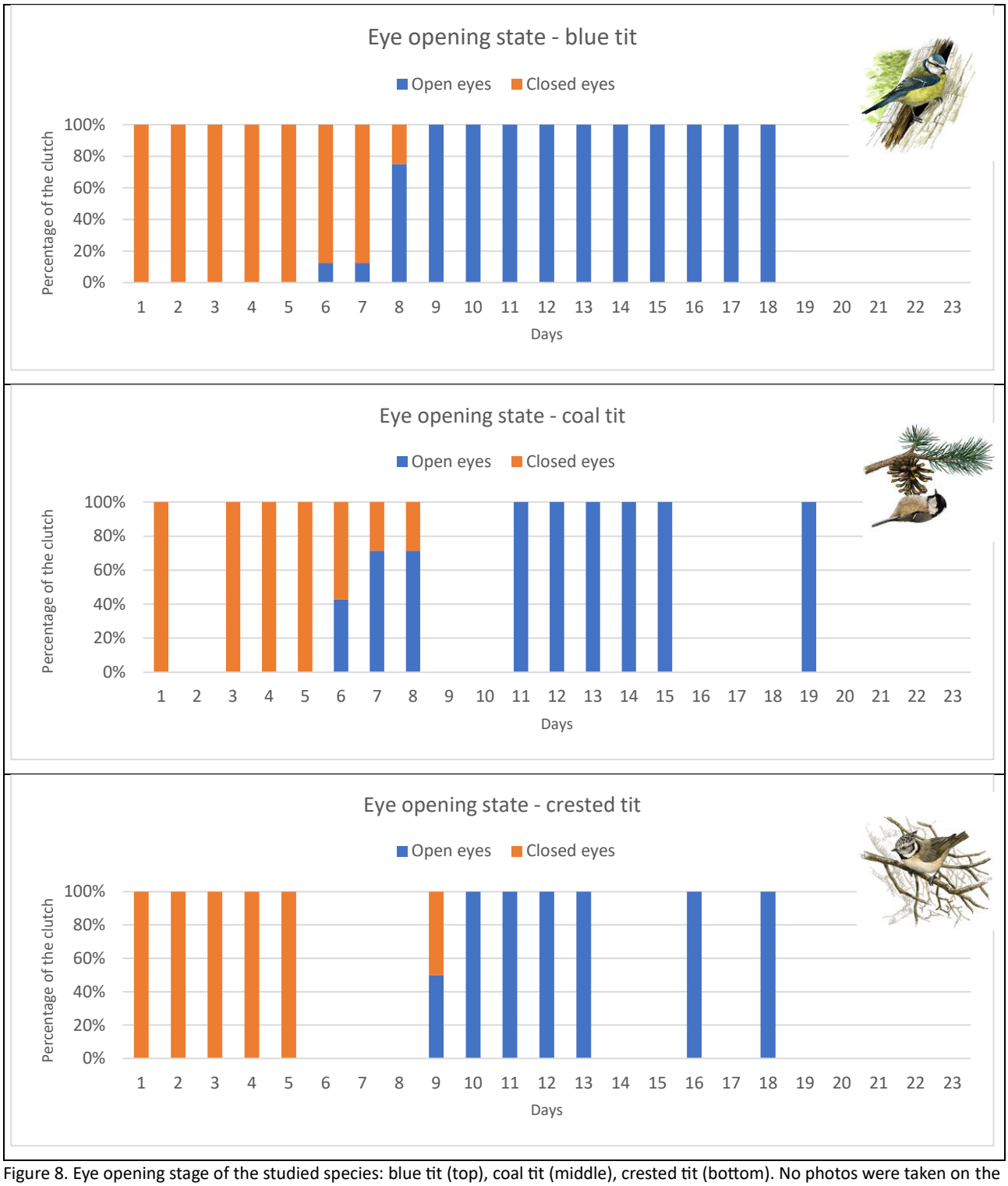

Figure 8. Eye opening stage of the studied species: blue tit (top), coal tit (middle), crested tit (bottom). No photos were taken on the blank days. From these days, we do not know the state of the chicks. No graph was made for the great tit due to the lack of data, especially from the later stage of development.

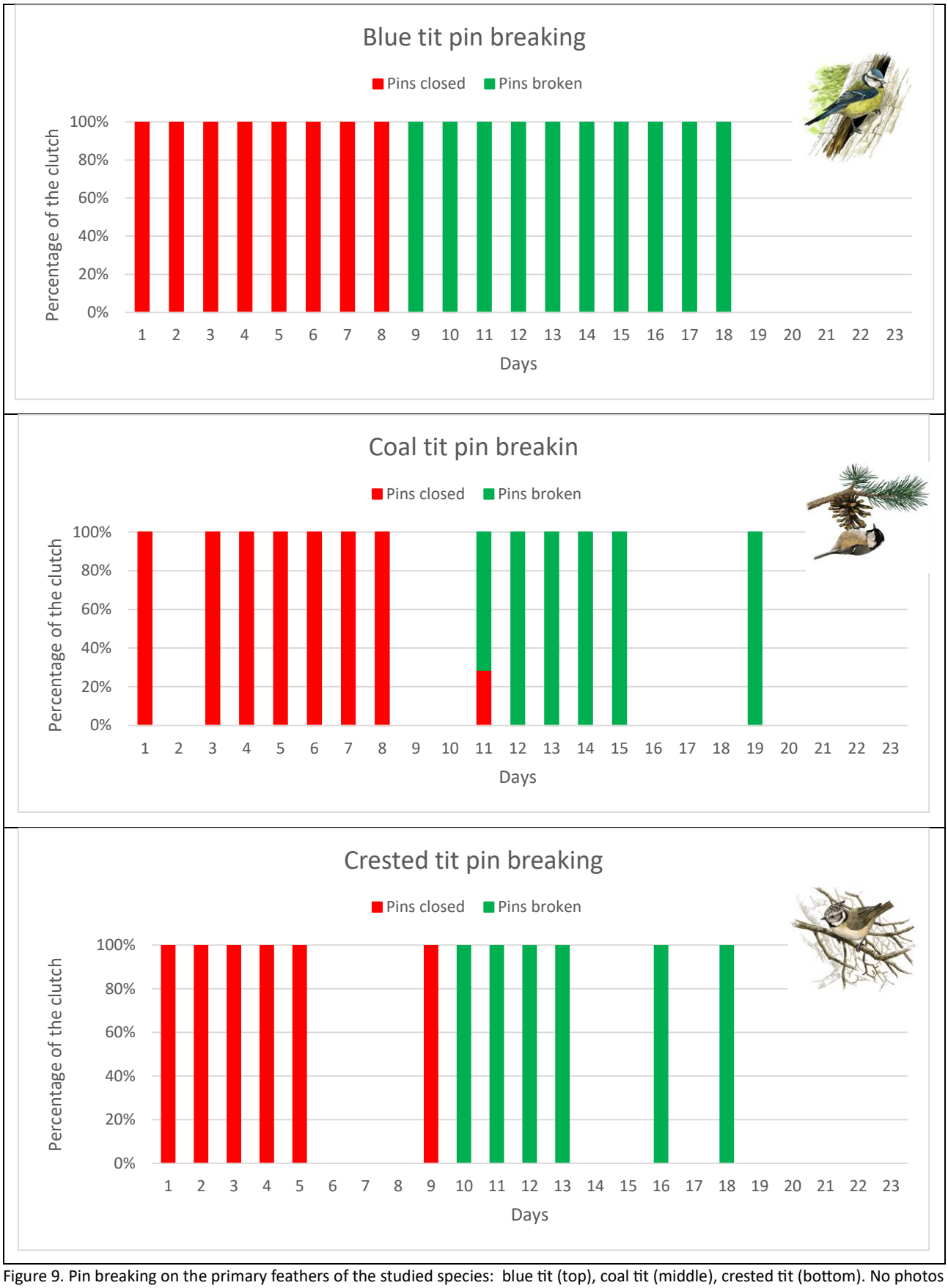

Figure 9. Pin breaking on the primary feathers of the studied species: blue tit (top), coal tit (middle), crested tit (bottom). No photos were taken on the blank days. From these days, we do not know the state of the chicks. No graph was made for the great tit due to the lack of data, especially from the later stage of development.

Conclusions

The 2023 nest boxes monitoring project, which started at the end of March and ended in September, showed that the boxes were indeed suitable for the identified target species: the birds belonging to the tit's family and the nuthatches, although only 62 of the 176 nest boxes were used. Most of the boxes were used by the blue tits, followed by the Great tits and nuthatches. Just over half of the boxes used were successful, the remainder were predated or abandoned.

All habitats were used except for the high-altitude caducifolious forest and only one nest box was occupied in the high-altitude coniferous forest, considering the only one check was carried out on high-altitude nest boxes. However, species showed a slight preference for the Sclerophyll forest at a low altitude, and for the middle-altitude caducifolious forest. The habitats that were most successful in terms of outcome were low-altitude Sclerophyll forest (Eslo) and middle-altitude Sclerophyll forest (EsMi). in the others, more predation and abandonment events occurred.

It was only possible to make the species comparison between the tits, because according to the specific characteristics of the nuthach species, it was not possible to open the boxes (nuthaches build a mud line on the nest and opening the box risked destroying it). So, it wasn't possible to report information on the number of eggs, chicks and the various hatching, incubation and fledging periods. The different species belonging to the tit's family showed small differences in average incubation periods, number of eggs produced and chicks: great tit shows a slightly longer incubation period and a shorter period between hatching and fledging than the other species, while the others only have variation on the incubation period (these average values are derived from a very small sample of birds).

The documentation of the development for the studied species faced with difficulties. During May, many days were rainy and cold which conditions could endanger the health of chicks during manipulation outside the nestboxes. Therefore, the low sample size makes it difficult to compare them and their growth and development rate. Based on the available data, the blue tit nestlings possibly possess a faster development rate than the coal tits and crested tits based on their feather growth but not the time of the eye opening. In order to draw conclusions about the development of the studied species, we need more data.