FIELD EXPERIMENTS ON EGG PREDATION BY HOODED CROW *CORVUS CORONE CORNIX*

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ABSTRACT. The predation by Hooded Crow on white, cryptic and blotched hen's eggs was observed in experimental situations at three study zones. The time interval between appearence of the Crows and predation decreased with training of the birds. This is not due to the association of the experimenter's presence with the availability of a certain food, as shown by experiments with both eggs and other food. The formation of a "search image", documented by earlier studies, is thus confirmed also for the Carrion Crow. The predatory behaviour during the second and third years of experiments indicate that the specific search image may be retained by the Crows for over 8 months without reinforcement.
KEY WORDS: *Corvus corone cornix* / Behaviour / Predation / Learning / Memory/ Search image.

Foraging behaviour, particularly in birds, has received since time immemorial much attention by the layman as well as the zoologist.Recently however, a full methodological approach and a good deal of theoretical thinking to simple observation and descriptive recording has been added, monstly by ethologists. This has led to a "bursting" of research both in the laboratory and the field opening new pathways to the solution of some problems, but often entangling the student of bird behaviour into the orbweb of circular reasoning concerning for example the efficiency by which bird species exploit food sources in their environment. Terms such as "specialists" and "generalists" are now of much wider occurrence, among zoologist and ecologists than before; the conceptual meaning of "guild", at least so it seems, is mainly referred to the exploitation of particular parts of an habitat for feeding purposes etc.

It must be recognized that through the work of ecologists–ornithologists, such as Cody and Mac Arthur to cite only two workers which come immediately to our mind, much progress has been achieved in understanding some of the "basics" which rule bird-distribution, ecological competition within and between species and the significance of habitat exploitation. Zoogeography has received "new blood" and many studies are now appearing which try to explain (sometimes quite successfully) past and present distribution of birds also in terms of their feeding requirements, both physiological and ethological. Evolution of predator-prey relationships are also being investigated in terms of costs/benefits rate from both the point of view of the predator and ist preys. Feeding strategies are beginning to appear finely tuned to the characteristics of the habitat, the distributional pattern of food items and the energy expenditure that these parameters demand on the part of the "feeding individual" (f.e. Krebs 1971, 1973; Goss-Custard 1977).

It is unquestionable that in several fields of scientific research optimality theory has become "a valuable tool in the quantitative study of adaption" (Krebs *et al.* 1981). According to this theory but according also to more trivial reasoning a foraging animal is faced with several problems whose solution requires decision-making. In fact the animal (eg. a crow) must decide where to forage, when to forage, which food items it is going to include in its diet, when it is time to abandon the research of a particular item or when it is more convenient to give up a particular feeding patch... The study of how animals make decision of this kind and which rules they use for decision making has become one of the most promising, though most intriguing, fields of research among ethologists, ecologists and non-committed zoologists as well.

By optimality theory it is assumed that the complex of decisions taken by an animal not only should tend but actually tends to maximize the results, i. e. in the case of foraging strategies to maximize foraging efficiency. No attempt will be made here to summarize the very numerous papers dealing with this problem. The reader is referred to the proceedings edited by Kamil & Sargent (1981) where the contributions by several authors both support and criticize the optimalization approach to the study of foraging behaviour in animals.

Although the present research did not originate as a test for the application of the optimality theory to the feeding behaviour of birds, our findings fatally encroached upon problems of optimalization. We shall discuss this in our concluding remarks.

During some years of investigation on the learning abilities, "handling capacities" and general feeding strategies of our commonest lowland corvids (Hooded Crow *Corvus corone cornix*, Magpie *Pica pica*, and Jay *Garrulus glandarius*), the senior author (S.F.) was repeatedly confronted with puzzling aspects of corvids behaviour which seemed amenable to more detailed analysis, both in laboratory and the field. With the substantial help of the three junior authors it has been possible to carry on a preliminary study on some problems involved in the feeding behaviour of the Hooded Crows in their natural habitats. Stimulated also by earlier works conducted by Croze (1970) on the same species (the Carrion Crow *Corvus corone corone* is considered conspecific with the Hooded Crow) and Montevecchi (1976) on closely related species, we tried to find out wether at least in some experimental situation in the field a "search image" was used also by wild Hooded Crows. Moreover we wanted to test how long this "search image" lasted after remouving the sign stimulus upon which the image was based. Further research is needed on the importance and evolution of discriminatory abilities and capacities of memorization in the feeding behaviour of birds.

INITIAL TESTS

MATERIALS and METHODS

After a preliminary survey in the field, two experimental areas (each about 1500 m^2) in the countriside near Fidenza (Northern Italy) were selected: one (A) located in the lowland on the gravel banks of the Stirone stream and the other (B) on the hills of the pre-Appenines. The two areas were chosen because of the constant presence of Hooded Crows both during the breeding season and in winter, when the number of Crows varied between 5 and 8 individuals which we believe were relatives. Observation of Crows were mostly made from a car and with 10 x 50 and 7 x 50 binoculars to avoid undue disturbance to the birds.

As "prey" white and/or "painted" (cryptic) chicken eggs were used. The eggs were of normal average size (54 x 39,5 mm) as this was shown to be the preferred size in earlier experiments accried out by Montevecchi (1976) in New Jersey with the Common Crow (*Corvus brachyrhynchus*), the North American ecological counterpart of the Eurasian Carrion-Hooded Crow complex. During April, May, June, July and August 1979 and 1980 (training period) batches of eggs were set out in "artificial" nests in the two experimental areas to "stimulate" predation resident Hood Crows.

Zone A) Two batches, each 3-5 eggs, simulating a natural nest were repeatedly (two-three times each month) set out on the gravel bank of the stream. One contained cryptic (i.e. homocromic with the substrate), the other white (non cryptic) eggs. The batches were 8-10 m apart. This allowed the Crows an easy finding of the prey.

Zone B) The procedure was the same as in A but in this case only white eggs were used in the artificial nests on the pasture.

From a "hide" (usually one of authors' cars), at a safe distance, the following elements of the preying Crows behaviour were recorded:

- Latency to predation (LP) i.e. time interval between Crows appearance on the zone and their first landing with approach to the "nest" followed by actual predation of the eggs.
- Behaviour before and during predation.
- Behaviour interactions among indiduals involved in actual predation.
- Predation patterns.

RESULTS

The results are summarized on Fig. 1 and 2. If one compares the LP (latency to predation) over the whole training period, in the two zones during the first year, the rapid decline in time spent to find and recognize the eggs is quite clear. Moreover, in this respect, no difference is evident between the two "populations" of Hooded Crows. It must be remembered in fact that the individual Crows involved in the field-tests were certainly not the same in the two areas which were sufficiently apart from each other to be "owned" by different pairs at least throughout 1981. Thus in both zones initial LP was around 3-4 hours, while in the successive trials LP seldom exceeded 15 minutes. One more point needs to be stressed: in 1980, at the beginning of the second year of training and well after 8 months during which no test of any kind was carried out, again in both areas, LP resulted

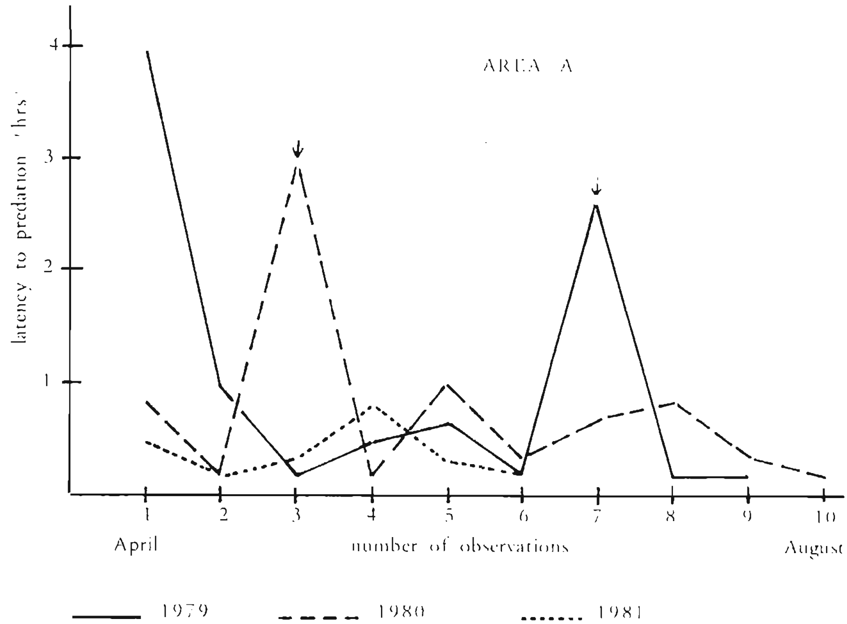

FIGURA 1. Area A. Latency to predation of chicken eggs by Hooded Crows.

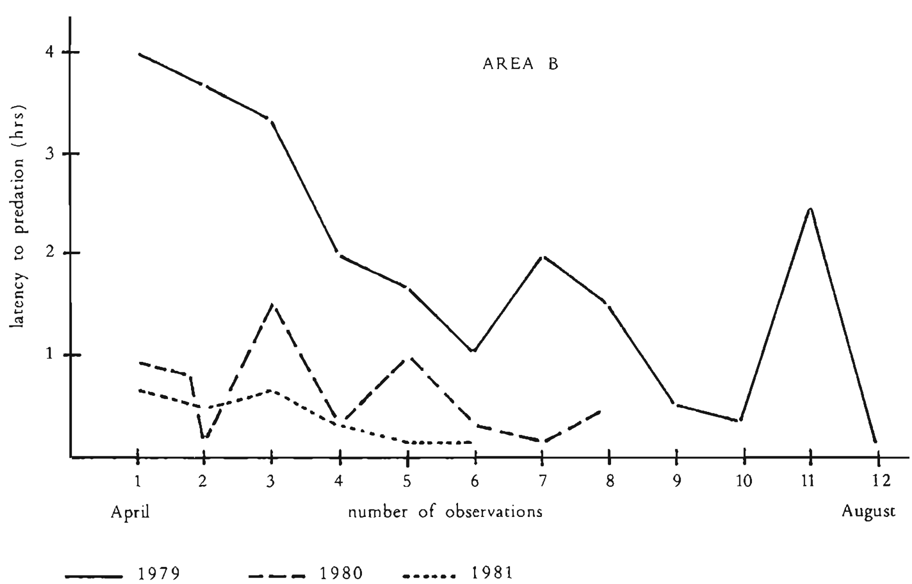

FIGURA 2. Area B. Latency to predation of chicken eggs by Hooded Crows.

shorter than in the previous year, being less than 1 hour. These findings are well in accordance with similar studies on closely related species (Montevecchi, 1976, on *C.brachyrhynchus*) or different subspecies (Croze, 1970 on *C. corone corone)* and confirm the ability of Hooded Crows to achieve a rapid and persistent memorization of experience, in this case at least the environmental situation in which a food item is possibly found. Concerning the behaviour preceeding actual predation in almost every istance the Crows performed "typical" exploratory flight (EF) over the zones. EFs were obviously more prolonged at the beginning of the training period probably because the birds had to learn the characteristics of their prey. EFs over the experimental areas covered roughly between 500 and 800 m^2 and were performed in zig-zags typical of many species of Crows even when "walking" to find food (Frugis pers. obs.). Once the prey was spotted, a circular flight "overhead" ensued, until eventually the Crow(s) alighted close to the nest. After the first "session" EFs very rapidly decreased in both length and time thus showing that EF was the main factor contributing to LP duration. During the breeding season only one pair Hooded Crows was present in each zone. Afterwards, more than two adult birds happened, on occasions, to be actively engaged in egg predation, in which case fighting was observed. More usually, however, the resident pair was undisturbed. In these istance while the presumed mate stealed the eggs, the other standed by in alert position. The eggs were either eaten on the spot, in the vicinity of the discovered nest, or carried away in the bill, the Crow flying to the nearby wooded resorts, possibly to their own nest. It is likely that in this last case the eggs were "cached" as the Crows flew back-andforth rapidly until the last egg was removed. This caching behaviour has also been reported by Montevecchi (1976) for *C.brachyrhybcus*. Sometimes competition aroused with Magpies which also tried to steal the eggs. In every instance however Hooded Crows succeeded in driving the Magpies away though fighting and chasing time influenced the LP (or start of egg oredation). Two such occurrences are indicated in Fig. 1 (downpointing arrows).

FINAL EXPERIMENTAL TEST

The results of the training period show an istance of good conditioned learning in Hooded Crows. In fact the birds quickly associated the experimenter's manoeuvers in the field with the availabilty of a certain food-item. From data collected during the training periods it is impossible to ascertain whether Crows had the capacity to acquire an image of the food and subsequently to search actively for a definite kind of prey they have learned to eat after a series of successful encounters during which the bird stored in the brain the visual cues of its prey (L. Tinbergen's "searching image concept", 1960). According to this hypothesis birds that use a "searching image strategy" would tend to overlook unusual prey on the area where they have learned to find and recognize a certain type of prey. Consequently our Final Test was designed to verify the presence of a searching image in Hooded Crows.

METHODS and PROCEDURE

In order to "eliminate" the above mentioned associative learnig (experimenters presence = prey (eggs) availability in the zone) we chosed a new zone (C) of pastureland (with some scattered trees) on the hills about 15 km from area B. Here during Febraury through June 1981 residents Hooded Crows were trained to prey on meat pellets (commercial canned cat-food) set out in batches and in "artificial" nests (Fig. 3) as was done with eggs in the other zones and in previous years. Now the Crows had the opportunity to associate the presence of the experimenters with a food item unknown to them and completely different in color and shape from chicken eggs, as in A and B. Of course, during the same period Crows in the A and B zones were again trained as previosuly. In the second half of June a Final Test was carried out as follows; in all three zones (A, B and C) ten artificial nests with batches of four eggs each were set out, five nest with white eggs; four nests with painted (cryptic) eggs and one nest with blotched eggs (distruptive coloration). It must be noted that cryptic eggs were painted "grey" on the gravel bank (zone A) and "green" on the pasture (zone B). The nests were placed at the periphery of a circle of about 35-400 sq. meters, well spaced. In the three zones the experiment started at 07.30 a.m. and we fixed maximum experimental time at 5 hours, thus ending our scheduled observations at 12.30. Weather conditions, temperature and humidity were almost identical at the three zones, on experimental days. We again recorded the following parmeters:

- LP (latency period to predation as previously defined).
- Behaviour before and during predation.
- Interactions between pair members (mates?).
- Patterns of predations.
- Number and type of eggs taken every hour.
- Total predation time at the end of the five hours.

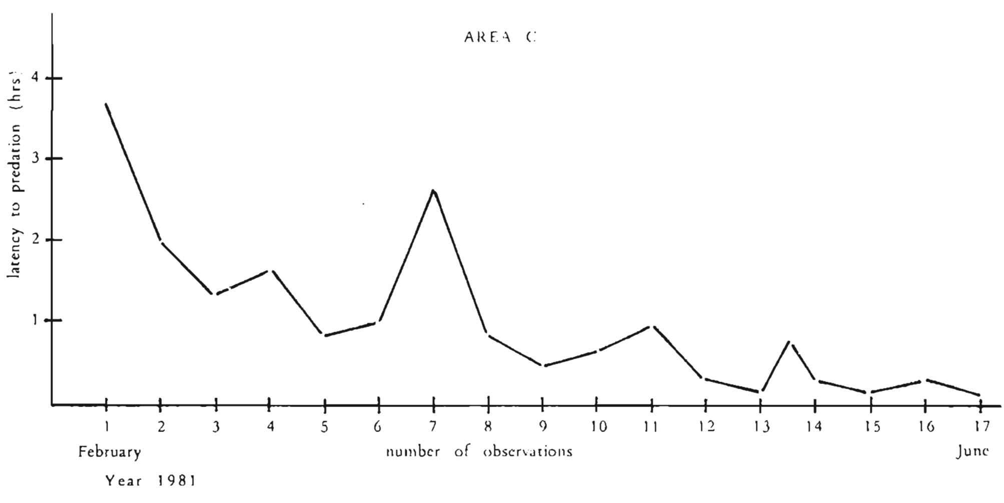

FIGURA 3. Area C. Latency to predation of meat pellets by Hooded Crows, during the initial period of the final test.

RESULTS

The results are summarized in Tab. I. In zones A and B, the LP was very short and Crows started predation almost on arrival. In C the birds started their exploratory flights (EF) on arrival but it took 4 hours to find their first eggs. This time-lapse is the same as the registered initial LP in the three zones during the training sessions. In C, Hoode Crows started active searching for meat pellets, overlooking the eggs for long. This seems confirmed by Crows behaviour. In A and B, the EFs were very brief and almost immediately followed by "overhead" flight. In C, however, EFs were sustained and performed over a large area. Moreover the birds, from time to time, gave up research altogether to start again later on.

TAB. I — Egg predation in the three experimental zones during the final tests.

ZONES	Egg type and number of nets			Total number of eggs	Type of eggs removed			Total number of eggs removed
	camouflaged	white	blotched		camouflaged	white	blotched	
A	5 (grev)	4	1	40	all	all	all	40 (100%)
B	5 (green)	4	1	40	none	all	all	20 (50%)
C	5 (green)	4	1	40	none	12	all	16

Concerning the number and type of eggs taken, in A, where birds were accustomed to prey upon white and cryptic eggs, both kinds were completely removed within one hour. Once discovered, the eggs were carried away and probably cached before being eaten as the rapid flights to-and-fro seem to indicate. It must be stressed that the egg batches were discovered also by walking from one artificial nest to the next. It is also interesting to consider the spatial and temporal pattern followed by Crows as shown in Fig. 4. Both types of eggs are easily recognized as prey. In B after one hour only white and blotched eggs were removed. Fig. 5 showing the sequence of predation clearly indicates that cryptic (unusual) eggs were "overlooked". In this case too, blotched eggs were removed and afterwards the research was completely abandoned. Once flown away, the birds did not return to the zone. In C only 12 (30%) of the eggs were removed but again all nests with cryptic eggs were left untouched.

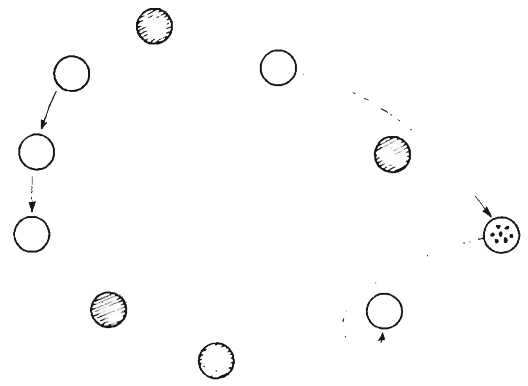

FIGURA 4. Area B. Predation sequence at the final test. Open circles= white eggs, hatched circles= homocromich eggs, stippled circle= blotched eggs.

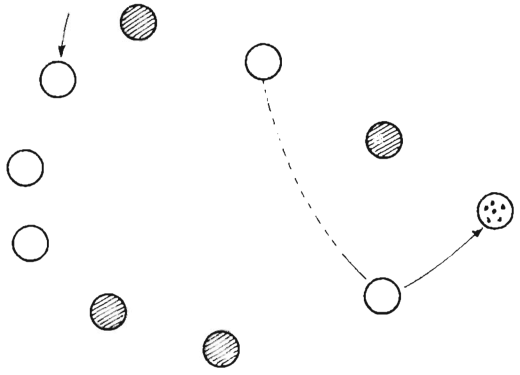

FIGURA 5. Area C. Predations sequence at final test. Symbols as in Fig. 4.

DISCUSSION

Cryptic homochromic eggs (i. e. those matching the background) are an efficient antipredatory device for many ground nesting birds and our work seems to corroborate this assumption. Our results show that also Hooded Crows, after successful encounters with certain types of prey, acquire a mental image or temporarily predisposition to search for particular food-items in familiar locations. In fact this was the case in B and C where homochromic eggs were (deliberately?) overlooked, or the time to adjust predatory behaviour on eggs was as long as that required at the beginning of the training period with meat-pellets. This is in full agreement with Tinbergen's hypothesis of "learning a visual character of preys and the formation of a "searching image". It has been said that this kind of behaviour is typical of unspecialized (opportunistic) predators such as most Corvids seem to be. Learning abilities of Hooded Crows are also demonstrated by two further results of our work. Firstly we recorded a rapid shifting of prey selection, namely from meat pellets to eggs, in C. Quite obviously in A the Crows had acquired searching images for both white and camouflaged eggs. This is no contradiction as it is well known that camouflage looses much of its effectiveness when camouflaged prey becomes too common (Croze 1970). Secondly the very short LP on resuming trials after 8 months interval seems to confirm an efficient long-term memory at least in Hooved Crows but probabily in many other Corvids as well (Shettelworth 1983). However, to our knowledge this is the first time that an 8 months memory for a specific searching image has been documented in literature. Our experiments are admittedly of a crude nature, and to confirm our findings more detailed, precise and controlled tests, both in the field (with marked individuals) and in laboratory are needed. We hope, nontheless, to have contributed to the understanding of the ways by which feeding strategies might have evolved in birds. Surely the formation of and "long -term memory" for searching images in animals must play a fundamental rôle in developing feeding strategies which tend to be the optimal possible among the many (or few?) available.

RIASSUNTO

ESPERIMENTI SULLA PREDAZIONE DI UOVA DA PARTE DELLA CORNACCHIA GRIGIA *CORVUS CORONE CORNIX*

— Negli anni 1979, 1980 e 1981, sono stati condotti alcuni test in natura sulle strategie di scoperta del cibo nella Cornacchia grigia in tre zone della provincia di Parma (zone A, B, C).

— Nelle zone A e B le coppie di Cornacchie residenti sono state abituate a predare uova di gallina disposte in "nidi" simulati sul terreno. Le uova erano bianche, o mimetiche cioè rese artificialmente omocrome col substrato o machiettate con colorazione disruptiva.

— Nella zona C (test del 1981) le Cornacchie sono state abituate solo con un diverso tipo di preda (carne per gatti in bocconi) prima di essere sottoposte alla prova con uova come nelle zone A e B.

— I risultati confermano anche nella Cornacchia grigia la formazione di "immagini di ricerca" (sensu Tinbergen) poiché il tempo impiegato per trovare e predare le uova è diminuito con l'aumentare dell'esperienza (Fig. 1 e 2).

— Inoltre la Cornacchia dimostra di possedere un'ottima memoria a lungo termine, poiché negli anni successivi, a oltre 8 mesi dall'interruzione di esposizione a stimoli-rinforzo, il tempo di ricerca è stato più breve che nell'anno precedente.

FIG. 1 Zona A. — Tempo impiegato dalla Cornacchia grigia per predare le uova (ordinata: tempo in ore, ascissa no. osservazioni).

FIG. 2 Zona B. – Come in Fig. 1.

FIG. 3 Area C. – Tempo impiegato per un diverso tipo di cibo.

FIG. 4 Area B. – Sequenza della predazione nei "nidi". Cerchi vuoti: uova bianche, cerchi a sbarre: uova mimetiche, cerchi a punti: uova macchiettate.

FIG. 5 Area C. – Come in Fig. 4.

TAB. I – Predazione delle uova nelle tre zone. Da sinistra: tipo uova e no. nidi (uova mimetiche, bianche, macchiate); no. totale di uova; tipo di uova predate (mimetiche, bianche, macchiate); no. totale di uova predate).

RESUME'

TESTS SUR LA PREDATION D'OEUFS PAR LA CORNEILLE MANTELEE *CORVUS CORONE CORNIX*

– En 1979, 1980 et 1981 on a effectué des "tests" en nature pour examiner certains aspects de la strategie alimentaire (decouverte et reconnaisance des proies) dans la Corneille mantelée *Corvus corone cornix*. On a choisi trois zones (resp. A, B et C), l'une dans les bancs caileouteux de la rivière Stirone et les autres dans des prés colliniers de l'Appennine aux environs de la ville de Fidenza (Italie du Nord).
– Dans les zones A et B, les Corneilles ont eté dressées a ravager des oeufs de poule disposées dans des "nids" (artificiels) simulés sur les differents terrains des trois zones. Les oeufs etaient soit "blancs", soit tachetèes avec coloration "disruptive", soit mimetiques, homocromes avec le terrain.
– Dans la zone C (test di 1981) les corneilles etaient dressées avec des "proies" differentes (morceaux de viande pour chats) avant d'etre soumises au test de oeufs comme elles etaient en A et B.
– Les résultats confirment la capacité de la Corneille mantelée à former une "image de recherche" (sensu Tinbergen) comme est montré par la diminution du temp employé à trouver les oeufs, au fur et à mesure que l'experience augmente (Fig. 1 et 2).
– En outre la Corneille semble posseder une excellente memoire à long terme, parce que dans les années suivantes, 8 mois après l'interruption des stimulus-renforces, le temp de recherche a été plus court que dans la première année.

FIG. 1 Zone A. – Temp de recherche de la Corneille avant de trouver les oeufs (temp en heures, no. observations).

FIG. 2 Zone B. – Comme Fig. 1.

FIG. 3 Zone C. – Temp de recherche pour la viande.

FIG. 4 Zone B. – Sequence de prédation. Cercles blancs: oeufs blancs, cercles hachurés: oeufs mimétique, cercles pointillés: oeufs pointillés.

FIG. 5 Zone C. – Comme fig. 4.

Tab. I. – Prédation des oeufs dans les trois zones. De gauche: type et no. oeufs et no. de nids (oeufs mimetiques, blanches, tachetées); no. total des oeufs; type des oeufs trouvées (mimetiques, blanches, tachetées); no. total des oeufs trouvées.

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