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NEST-SITE SELECTION BY THE HOBBY (*Falco subbuteo*) IN POPLAR PLANTATIONS IN NORTHERN ITALY

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ABSTRACT.—The hobby (*Falco subbuteo*) nests at a relatively high density (25.8–29 nests/100 km^2 in poplar (*Populus* sp.) plantations bordering the Po River in northern Italy. These intensively managed crops have almost completely replaced the natural riverine forest, which was presumably the hobby's original nesting habitat. Only hooded crow (*Corvus corone*) nests were used by the hobby in poplar plantations. Hobbies selected plots with the largest trees and, when suitable habitat was evenly distributed, their nests were regularly spaced; tree felling did, however, cause local crowding of nests. There were no differences in nest and nest tree features between crow nests used and unused by hobbies within each occupied plot. Breeding success was the same as in other European populations, with 1.9 fledged young per observed pair and 2.2 fledged young per successful pair. Poplar plantations proved to be a suitable nesting habitat for the hobby in northern Italy.

KEY WORDS: *hobby*; Falco subbuteo; *habitat selection*; *nest-site selection*; *breeding success*; *poplar plantations*; *Italy*.

Selección del sitio de nidificación por *Falco subbuteo* en plantaciones de *Populus* sp.

RESUMEN.—Los nidos de *Falco subbuteo* se encuentran en densidades relativamente altas (25.8–29 nidos/100 km^2) en plantaciones de *Populus* sp. que bordean el Río Po en el norte de Italia. Estas plantaciones intensivamente manejadas han reemplazado casi por completo el bosque ribereño original, el que presumiblemente fue el hábitat de nidificación original de *F. subbuteo*. Solamente nidos de *Corvus corone* fueron usados por *F. subbuteo* en las plantaciones de *Populus* sp. Por otro lado, *F. subbuteo* seleccionó sectores de árboles más grandes, y cuando el hábitat era adecuado los nidos se distribuyeron regularmente espaciados; sin embargo, la caída de árboles causó un agrupamiento local de nidos. El éxito reproductivo fué el mismo que en otras poblaciones europeas, con 1.9 volantones por pareja observada y 2.2 volantones por pareja exitosa. Las plantaciones de *Populus* sp. en el norte de Italia parencen ser un hábitat adecuado para lo nidificación de *F. subbuteo*.

[Traducción de Ivan Lazo]

Raptors nesting on trees may be greatly affected by forest management. While complete deforestation has obvious negative consequences (Newton 1991), minor habitat modifications can have varying degrees of impact. Several studies have tried to define the nesting site habitat requirements of raptors, either by describing features of the nest and the surrounding habitat (e.g., Newton et al. 1981) or by comparing the site occupied to available trees and forest tracts (McEwan and Hirth 1979, Andrew and Mosher 1982, Edwards and Collopy 1988, Wood et al. 1989, Bosakowski et al. 1992). Mosher et al. (1986) have examined some problems associated with developing habitat models for woodland hawks.

Some rare or vulnerable species are negatively affected by forest exploitation, e.g., the red-shouldered hawk (*Buteo lineatus*; Bryant 1986, Morris and Lemon 1983), the bald eagle (*Haliaeetus leucocephalus*; McEwan and Hirth 1979), and the three accipiter hawks of Oregon (Reynolds et al. 1982). Afforestation, on the other hand, had caused some concern for the preservation of the important open ground-nesting population of merlins (*Falco columbarius*) in Scotland (Avery and Leslie 1990), but tree nesting is now becoming common and forest merlins are the subject of forest management plans, since new plantations are intensively managed during the first years after planting (Orchel 1992).

In Italy the Hobby (*Falco subbuteo*) is a species which mainly nests in plains interspersed with for-

ests. The densest nesting population has been found in forest belts along the rivers of the Po plain (Bogliani 1992). Few riverine forests still survive, and the most important examples are protected within nature reserves or regional parks along the rivers Ticino and Adda. Forest destruction was massive during the Roman period in northern Italy and, after a pause during the Middle Ages, has continued up to the present day (Tomaselli and Tomaselli 1973). During this century, the forest belt which occupied a large part of the flood plains of the Po and the other large rivers has been almost completely replaced by intensive poplar plantations. In the Po plain these plantations cover an area of about 1000 km^2 (Lapietra et al. 1980).

It might be asked whether poplar plantations functionally replace the primary habitat of forest birds in the plain. Previous studies have shown that canopy dwellers are less affected by habitat change than understory dwellers (Bogliani 1988). The hobby seems to be a fairly frequent canopy nesting species in poplar plantations; it mainly searches for food away from the plantations and mostly captures birds on the wing. However, before laying the adults largely feed on insects (Milsom 1987, Bogliani 1992) which could be contaminated by pesticides.

The aim of this study is to describe the factors affecting habitat use, nesting density and breeding success in the hobby, in order to assess whether the new artificial habitat has successfully substituted the primary habitat.

STUDY AREA

We surveyed nests in a 40 km stretch of the seasonal flood plain of the river Po, in northern Italy, from the confluence with the Tanaro to that with the Ticino (45°N, 9°E), over an area of 62 km^2 of which over 20 km^2 is covered by poplar (*Populus* × cultivar) plantations.

Most of the poplars belong to the same clone (I-214) and are therefore genetically identical. The trees are planted with a regular spacing, in a quadrat or rectangular design with a distance of 5–6 m between trees and a usual density of 320–350 trees/ha. The ground is harrowed at least twice a year during the first 4 yr, and thereafter only once a year. Sometimes harrowing is suspended when trees are 9–10-yr old. The trees are felled when they reach 10 yr of age; sometimes felling is delayed until 11 or 12 yr, but seldom more. Pesticides are widely used on the trunk and on the canopy to control insects and fungi infestations. Poplars grow rapidly and in the study area mean trunk circumferences of the I-214 clone at 1.30 m are: 3rd yr 38 cm, 4th 49 cm, 5th 59 cm, 6th 68 cm, 7th 76 cm, 8th 83 cm, 9th 89 cm, 10th 94 cm, 11th 98 cm, and 12th 101 cm (Prevosto 1965).

The Po is only partially embanked within the study area, and its course is meandering. Sand and shingle banks and islets are fairly extensive and are partially covered by herbaceous vegetation and willow (*Salix* spp.) bushes and trees. Mature forests dominated by the pedunculated oak *Quercus robur,* the primary habitat that occupied more fertile soils, have been completely replaced by cultivation. A phytosociological description of the natural vegetation of this area is given by Bracco et al. 1984. The flood plain which is not occupied by poplar plantations or by natural areas is mainly cultivated as corn and soybean.

During 1987 hobby nests were also surveyed within the boundaries of the Garzaia di Valenza Nature Reserve (2.1 km^2), whose habitat is similar to that of the main study area; apart from a larger proportion of marsh and natural wood, the latter is dominated by *Salix alba, Populus nigra* and *Alnus glutinosa.*

METHODS

In 1987 and 1988, from the middle of June each year nests were systematically surveyed throughout the study area by visiting all hooded crow (*Corvus corone cornix*) nests which were the only nests potentially available to the hobby. During 1985 and 1986 the nest search was nonsystematic. The alarm behavior of hobbies greatly helped in finding occupied nests, as did the presence of woodpigeon (*Columba palumbus*) nests which we have found to concentrate around hobby nests (Bogliani et al. 1992) Nests were inspected by tree climbing or by observing the contents with a mirror on a pole reaching 18 m.

We tested whether some habitat features were selected by sampling from available options. Because of the homogeneity of the tree type and management techniques of the poplar plantations, the easiest woodlot characteristic to measure was tree size. Tree height, crown height, and trunk circumference at 1.30 m, are intercorrelated, and therefore the simplest measure to collect, trunk circumference, was used to describe tree size; variables of nest and nest tree are shown in Table 1. The availability of crow nests in poplars of different size was recorded in a 3 km^2 randomly selected plot (area A). In another 1.5 km^2 random plot the availability of poplars of different sizes and the use of these trees as nest sites by crows was taken (area B).

Most nests were discovered during incubation or when containing chicks. Only the nests found when containing eggs were considered for calculation of breeding success.

Table 1. Nest and nest tree characteristics for hooded crow nests in poplar plots where the hobby was nesting. Values are given for nests used by the hobby and for unused nests within 100 m of those used by the hobby. All differences between used and unused nests were not significant (Student's t-test).

	USED BY THE HOBBY (N = 39)		UNUSED (N = 76)	
	$\bar{x}$	SD	$\bar{x}$	SD
Nest height (m)	15.3	3.5	15.0	3.3
Nest tree height (m)	21.9	3.7	22.0	3.3
Mean height of five nearest trees (m)	22.0	3.7	22.3	3.3
Height of lowest branch of the tree (m)	10.3	3.6	10.6	3.3
Nest tree circumference (m)	0.99	0.14	0.96	0.12
Mean circumference of five nearest trees (m)	0.92	0.16	0.95	0.08
Distance to nearest wood edge (m)	60.0	58.4	69.3	60.0

The breeding success calculated is therefore probably overestimated, because some nests which might have failed during laying or early incubation could have been missed.

Regularity of spacing between nests was tested with the G test (the ratio of the geometric mean to the arithmetic mean of the squared nearest neighbor distance) described by Brown (1975). Values of G range between 0 and 1; values less than 0.65 indicate randomness, values closer to one indicate local regularity.

RESULTS

Census. In 1987, 18 occupied hobby nests were found, with an overall density of 29 nests/100 km^2 (Fig. 1a) and three nests were found in Garzaia di Valenza Nature Reserve. In 1988, 12 occupied nests were found; the density was 19.3 nests/100 km^2 (Fig. 1b); four other pairs were located by their alarm calls and territorial displays early in the season in the area occupied the previous year, but nests were not found, and presumably they did not reproduce that year because of extensive timber harvesting in the nesting area.

Nest spacing. In 1987 the mean nearest neighbor distance (nnd) between nests was 1602 m (SD = 545, N = 21). In 1988 only the western part of the study area was not affected by extensive cutting; mean nnd was 1041 m (SD = 899, N = 8). The G value was 0.79 in 1987 and 0.24 (calculated only in the western part) in 1988, indicating that nests tended to be regularly spaced in 1987 but not in 1988.

Woodlot choice. Generally nests were found close to that of the previous year, if poplars had not been felled. All but one of the 46 nests visited over 4 yr were on poplars; one was on a willow (*Salix alba*). Among the available crow nests on poplars of different size, hobbies tended to choose the largest trees (Fig. 2). The hobby selected for the oldest poplar lots and avoided the youngest ones (χ^2 = 38.1, N = 39, $P < 0.001$). However, crows also selected woodlots with the largest trees (χ^2 = 58, N = 166, $P < 0.001$); expected frequency of various tree size calculated for 87 000 poplars of the plot where crow nests were censused) but the availability of plots with the largest trees was limited and probably crows, which were very abundant, tended to space out their nests and therefore also used poplars of less preferred size classes. Crow nest height was correlated with tree height (r = 0.69, N = 115; $P < 0.001$) and with trunk circumference (r = 0.31, N = 115, $P < 0.001$).

Nest choice. Only crows' nests were used by the hobby. The nests chosen were mainly built by crows during the preceding spring; young crows usually fledge during the second half of May (G.B. pers. obs.), while the hobby started laying relatively late in the season (mean laying date of the first egg = 18 June; Bogliani 1992). In a few instances the previous year's nests were used; in one case the crow's nest was occupied by a breeding pair of hobbies one year and then by long-eared owls (*Asio otus*) in the following season. Many crow nests are usually avail-

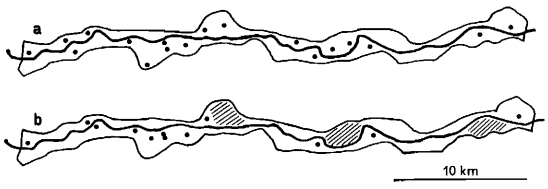

Figure 1. Distribution of hobby nests in a 62 km^2 study area along the River Po, northern Italy. The study area in a) 1987, and b) 1988. Hatched areas in b) indicate large scale logging the previous winter.

Table 2. Nesting density of some European hobby populations.

STUDY AREA	AREA (km^2)	HABITAT	NND[a] (km)	DENSITY (NESTS, PAIRS OR TERRITORIES/ 100 km^2)	SOURCE
Northern Italy	62	poplar plantations	1.5 ± 0.7	25.8–29.0	this study
Berlin 1956–1965	151	forest	—	17.2–20.5	Fiuczynski 1991
Berlin 1970–1988	151	forest	—	6.0–9.9	Fiuczynski 1991
Danube Delta–Rumania	4340	wetland	—	6.9	Müller and Rohde 1991
England					
Midlands	302	crops	4.6	3.8–4.8	Fuller et al. 1985
New Forest	290	forests	3.9 ± 0.4	4.9	Parr 1985
South A	580	crops	5.0 ± 0.5	1.6	Parr 1985
South B	250	crops	4.0 ± 0.6	2.8	Parr 1985

[a] Nearest neighbor distance.

able within each woodlot, therefore one can ask whether the hobby chooses its nest on the basis of some particular features. To answer this question, comparisons were made of the nest and nest tree characteristics (listed in Table 1) of 39 nests used by the hobby and 76 nests not used and within a radius of 100 m from the occupied nest. No differences (Student's t-test) were found between average measures and the ratios between them (nest height/nest tree height, nest height/height of lowest branch of the tree, nest tree circumference/mean circumference of five nearest trees) for used and unused nests. Equally, no choice was evident in relation to the rank of distance of used and unused nests from the edge of the woodlot ($\chi^2 = 1.74$, $N = 26$, df = 3, N.S.; expected number of nests of each rank of distance calculated by assuming that each nest of an occupied woodlot was used by the hobby with the same probability as any other surrounding nest).

Breeding success. Mean clutch size was 2.7 (SD = 0.8, range 1–4, mode = 3, $N = 19$). The mean number of fledged young was 1.9 (SD = 1, range 1–3, mode = 2, $N = 21$) for all nests, and 2.2 (SD = 0.8, $N = 19$) for successful nests. Only two unsuccessful nesting attempts were observed. One involved a nest with three feathered chicks which was destroyed by poplar felling. In the second instance a pair ceased brooding while logging was being carried out within 100 m, probably because of continuous disturbance.

Table 3. Breeding success of some European hobby populations.

STUDY AREA	PERIOD	NO. OF NESTS	NO. OF SUCCESSFUL NESTS (%)	NO. OF YOUNG FLEDGED PER SUCCESSFUL PAIR	NO. OF YOUNG FLEDGED PER OBSERVED PAIR	SOURCE
Northern Italy	1985–1988	21	19 (90.5)	2.2	1.9	this study
Berlin	1956–1972	358	— (77.4)	2.4	1.9	Fiuczynski 1991
Berlin	1977–1988	143	— (62.2)	2.4	1.6	Fiuczynski 1991
England	1930–1972	—	47 —	2.3	—	Fiuczynski and Nethersole-Thompson 1980
Southern England	1981–1982	51	46 (90.0)	2.1	1.9	Parr 1985

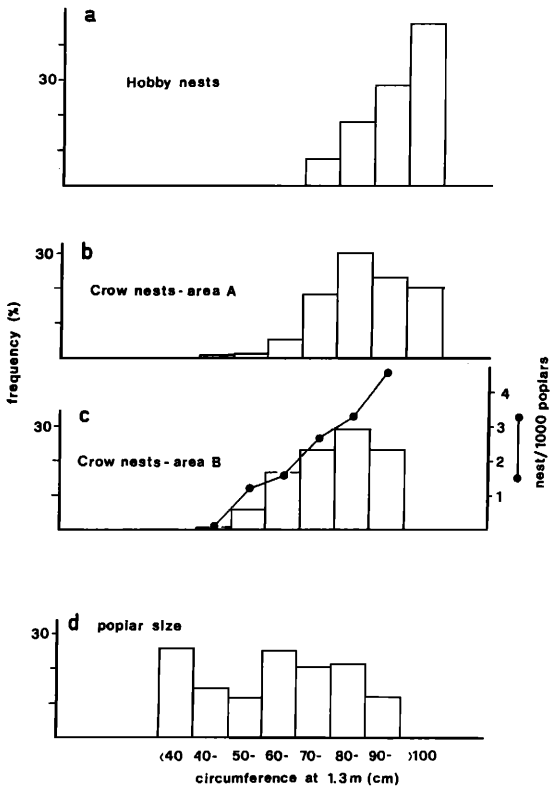

Figure 2. Frequency of nests on poplars of different size classes used by a) the hobby (N = 39), b) the hooded crow in area A (N = 368), c) the hooded crow in area B (N = 166) and the number of crow nests per 1000 trees in area B, d) the availability of poplars of various size classes in area B (N = 87 000).

Discussion

Poplar plantations along the River Po host a very dense population of hobbies. Comparison with other areas shows that the population studied was very dense and equally productive as other studies (Tables 2 and 3). The hobby had no strong requirements according to the nest-tree species and had no need of primary habitat to nest if few requirements were met. The only parameters of habitat suitability for nesting were the size of trees and the presence of old crow nests. Unused nests were locally overabundant even in trees of the preferred size and no difference was shown between used and unused nests within the occupied plots; however, some patches did not contain crow nests in big trees. Where a suitable nesting habitat was evenly available, breeding pairs had a regular dispersion pattern, as observed in 1987. The lack of regularity in 1988, also observed in the western part of the study area outside the areas affected by extensive cutting, was caused by displacement of some pairs and their concentration in the few oldest woodlots because of small-scale cutting of previously occupied lots. If old woodlots become irregularly scattered, hobbies can either avoid reproduction within the previously inhabited area or choose woodlots already occupied by other breeding pairs. The scarcity of old crow nests can limit the breeding population of other territorial falcons, such as the European kestrel (*Falco tinnunculus*; Village 1983).

The turnover of mature plantations is irregular and unpredictable, since poplar growers decide to harvest and to replant on the basis of the price of poplar wood and of alternative crops, on government and European Community grants, etc. (Lapietra et al. 1980). It is therefore not feasible to predict habitat suitability for the future.

The fact that poplar plantations are among the most intensively managed open field crops in northern Italy does not prevent the hobby from reaching a high nesting density in them and from attaining a good breeding success. The use of machinery allows intensive cultivation with a minimum amount of time spent near the nest, thus reducing disturbance to breeding pairs. The local large scale use of pesticides has an impact on target and non-target species living mainly on or close to poplar crops (Allegro 1989). Further concern is caused by the predictable increase of pesticide use to control the recently introduced defoliating moth (*Hyphantria cunea*), which is increasing at an impressive rate and causing much damage.

At present poplar plantations are a suitable nesting habitat for the hobby in northern Italy. The economic interest in maintaining this crop supports a good population of a species that would otherwise be restricted to few areas with protected natural forests.

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