Nest types and nest-site selection of the Little Bittern *Ixobrychus minutus* breeding in fishpond habitat in south-eastern Poland

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ARTICLE INFO

Regular research paper published in
Pol. J. Ecol. (2016) 64: 268–276

received after revision
March 2016

doi
10.3161/15052249PJE2016.64.2.010

key words
Little Bittern
Ixobrychus minutus
nest types
nesting habitat
reed beds
fishponds

ABSTRACT

The paper describes chosen habitat conditions determining the occurrence and nesting of the Little Bittern *Ixobrychus minutus* and their effect on the nest type (breeding nest BN or mock nest MN). The Little Bittern is a monogamous bird whose male can build a couple of nests during the breeding season. The main questions posed in this work are: (1) what habitat is chosen for the nesting site, and (2) do habitat conditions influence the nest type? The study was carried out in a fishpond complex in the Lasy Janowskie Landscape Park (SE Poland) during the breeding seasons of 2010–2012. All 44 nests (23 BN and 21 MN) were built in a waterside belt of perennial Common Reed *Phragmites australis*. All nests were built at sites with water depth between 11 and 101 cm. The type of the nest did not depend on the date when it was built during the breeding season. There was a significant difference in the width of the nests between breeding and mock nests. Moreover, obtained results showed a significant influence of the reed belt height and reed stem diameter on the nest type. Further studies on the Little Bittern's nesting habitat, protection of suitable wetlands, and proper water management are important for the conservation of this vulnerable species.

INTRODUCTION

The occurrence of reed bed bird species largely depends on the availability of all kinds of wetlands, the most limited and degraded habitats in the world (Semlitsch and Bodie 1998, Leibowitz 2003). Many recent studies showed that environmental factors, such as water depth and vegetation structure, affect the choice of nest-site selection and the survival of broods in marshland birds and other animals living in wetland areas (Saunders *et al.* 1991, Tscharntke 1992, Johnson 2001, Benassi *et al.* 2009). The area and density of reed bed patches determine which of them will be used for breeding or feeding (Pezzo and Benocci 2001, Martinez-Vilalta *et al.* 2002, Paracuellos 2008). Optimal water level management is a fundamental ecological requirement for breeding birds such as certain heron species living in artificial habitats, for example, on fishponds or flood polders (Báldi and Kisbenedek 1998, Battisti *et al.* 2006).

The Little Bittern *Ixobrychus minutus* (L.) is the smallest of European breeding herons. It is a highly secretive bird inhabiting areas of dense marsh vegetation, which makes it very difficult to survey (Voisin 1991, Kushlan and Hancock 2005). Knowledge about the basic breeding biology of the species has been studied across the range of Western Palearctic (Bozic 1992, Cempulik 1994, Martinez-Abrain 1994, Marion *et al.* 2006, Pardo-Cervera *et al.* 2010, Samraoui *et al.* 2012). It occurs mostly in natural wetland areas (reed swamps, eutrophic lakes, inundated river valleys) and anthropogenic habitats (fishponds, post-mining lakes), even near human settlements (Cramp and Simmons 1977, Marion 1997). The European population breeds in old, tall and dense stands of emergent plants, such as reed, reed mace, and bulrush, or shrubs and trees, such as alders and willows (Voisin 1991, Kushlan and Hafner 2000). In Poland, the Little Bittern is a widespread but sparse breeding bird with a population size estimated at 700–1000 pairs, 60% of which occurs on fishponds (Flis and Betleja 2015). To date, there is still very little information about nesting habitat requirements and environmental changes affecting the occurrence of this area-sensitive species, strictly related to reed beds (Kushlan and Hancock 2005, Benassi *et al.* 2009).

The Little Bittern is a monogamous, territorial and different, non-colonial heron species that nests mainly solitarily, rarely semi-colonially (Kushlan and Hancock 2005). Its unusual and poorly known mating strategy distinguishes this species from other north-temperate herons (Voisin 1991). After arriving at the breeding grounds, the male starts to build a nest alone at a selected site in its territory, repeating an advertising call to attract a female. If the mating call is successful, a female accepts the nest, which will be finished by both sexes and used for nesting (breeding nest). If it is unsuccessful, the male abandons the nest, which is then called a mock nest, and builds another, still endeavouring to attract a female. The male does not return to the abandoned nest (Cramp and Simmons 1977, Voisin 1991). The question arises whether the nest type (breeding nest or mock nest) depends only on the male's ability to display? Perhaps the nest type also depends on optimal habitat conditions, especially the uncut patches of old marsh vegetation.

In this paper, I address the following questions: (1) what habitat is chosen for the nesting site, and (2) do habitat conditions influence the nest type?

STUDY AREA

Material for this work was gathered during intensive field studies in the breeding season (May-August) of 2010–2012 at the fishpond complex Stawy Małe (60 ha), situated in the Lasy Janowskie Landscape Park, south-eastern Poland (50°36′N; 22°24′E; Fig. 1). The area of eight fishponds in the study complex (Little Bitterns were nesting on five of them) varied from 3.3 to 19.5 ha, and the ponds were partially covered (range 7–21%) by marsh plants, dominated by Common Reed *Phragmites australis* (Cav.) Trin. ex Steud. and Reed Mace *Typha angustifolia* L. The water level in emergent vegetation varied from 0 to 140 cm. The ponds were similar in water depth (from 0.9–1.5 m) with occasional reed cutting and a semi-intensive production system of the Common Carp *Cyprinus carpio* L. (95% of biomass) (Dobrowolski 1995). Three carp age classes, irregularly exchanged between the ponds from one year to another, were distinguished: the young-of-the-year (0+), with an individual weight of *ca* 1.5–3.0 mg to 8–15 g in July; 1-year-olds (1+), weighing 30–50

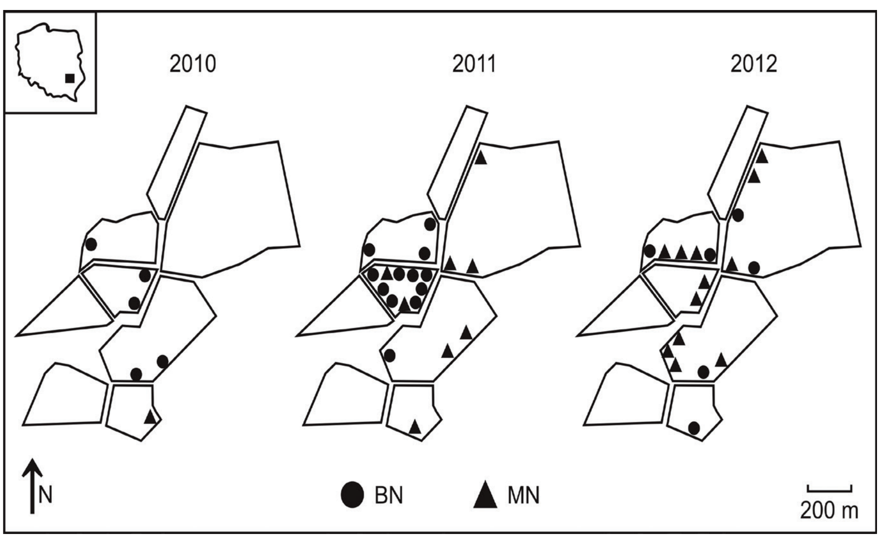

Fig. 1. Map of the study area with distribution of the breeding nests (23 BN) and the mock nests (21 MN) in 2010-2012 on the Stawy Małe fishpond complex.

g; and 2-year-olds (2+), weighing 150–250 g (Kloskowski 2009).

MATERIAL AND METHODS

Data collection

Potential nesting sites were determined by observing birds flying over particular areas and listening for males calling in their territories (Boileau and Barbier 1997, Morin and Bommé 2006, Flis and Betleja 2015). All activities were recorded on a map at a scale of 1:5000. Nests were located by systematically searching potential nesting sites, wading through patches of emergent vegetation. During the breeding season, each pond where nests were found was inspected at least once every three weeks during the period from 15 May to 15 August. The geographical coordinates of the found nests were determined by GPS. The Little Bittern is a very human-tolerant species, and must be very disturbed to abandon the nest or eggs, even in the early stage of building or incubation. The construction of the Little Bittern nests is very delicate, and must be often improved (Flis – unpublished). Nests were identified as breeding nests (BN) or mock nests (MN) on the basis of at least three controls, during which breeding attempts were recorded. A newly built breeding nest looks like a small wicker basket, and was identified as breeding nest when eggs were found inside, or when nest was depredated. The mock nest is smaller than the breeding nest, because is usually unfinished, and is very similar to a flat platform located inside the reed beds (Cramp and Simmons 1977). Predated breeding nest does not look like a mock nest, because the construction of nest has always visible damages, or signs of predation by leaving some remains (Flis – unpublished).

The habitat parameters of particular nesting sites and nest parameters were determined for all 44 nests found (23 BN and 21 MN). Habitat parameters (height above the water surface, water depth, distance from open water and terrestrial habitat, width and height of the reed belt, and reed steam diameter) and nest parameters (length and width) were recorded immediately after finding a nest because of the varying water level in the ponds. The nest parameters for BN were also measured after that when the first egg was laid. This was the sign that, female accepts the nest, and we can be sure that this nest was BN. The length and width of BN from this period was taken to the analysis. To determine whether a BN was overbuilt during the breeding season, its length was also measured after chicks had left the nest, and the difference between the two results was calculated. In the case of MN, the nest parameters were measured at least three times (min. 3 inspections was done for MN), and every MN was checked whether was not overbuilt by the male from the time of the first nest inspection. The largest length and width of each MN was taken to the analysis. Nest parameters were measured to an accuracy of 1 cm. The methodology for determining habitat conditions was similar to that used in studies of the Great Bittern *Botaurus stellaris* (L.) and was based on measurements within a square (Tyler *et al.* 1998, Polak 2007, Polak *et al.* 2008). All habitat parameters were estimated from 2 × 2 m square quadrats centred on the nest. The average height of the reed belt was established by measuring 5 randomly selected reed stems with a measuring tape to an accuracy of 10 cm. The mean reed stem diameter was estimated by measuring 10 randomly selected reed stems at the nest-site location with a digital calliper to an accuracy of 0.1 mm. The water depth and the height above the water surface were measured at the centre of the square to an accuracy of 1 cm. The water depth was measured directly beneath the nest. The height above the water surface was measured from the water surface to the bottom base of the nest. The distance from open water, the distance from terrestrial habitat, and the width of the reed belt were measured with a measuring tape to an accuracy of 10 cm. Because of the fact that the Little Bittern is territorial, distances between two nearest nests (distances from BN to nearest BN, and from MN to nearest BN) were also determined by means of the ArcGIS 9 software (ESRI 2006). For comparison of the selected habitat conditions in two subsequent years at the same fishpond, additional measurements of the height and width of the reed belt, and the water depth were performed in

2012 (using GPS coordinates) at sites where 8 BN were found on one fishpond in 2011. In 2012, no BN were found at this same pond.

Statistical analysis

The variables did not have normal distributions (verified by the Kolmogorov-Smirnov test), and therefore non-parametric tests were used. To determine the effect of habitat conditions on the nest type, the Mann-Whitney test was used. Habitat conditions (height above the water surface, water depth, distances from open water and terrestrial habitat, width and height of the reed belt, reed stem diameter) were chosen as dependent variables, and the nest type (BN and MN) as the independent variable. The Mann-Whitney test was also used to evaluate the differences between the nest types in terms of their length and width. The chi-square test was used to examine the relationship between the nest type and the pond area, between the nest type and the age of fish, and between the nest type and the date of building a nest in the breeding season. The habitat conditions examined on one pond in two subsequent years were compared by the Wilcoxon test. If the probability of type I error was equal to or less than 0.05, results were considered statistically significant. The average values were presented with a standard deviation (± SD). The statistical analysis was performed using the STATISTICA 10 packet (StatSoft Inc. 2011).

RESULTS

Nest characteristics

The nests (n = 44) were built from three plant species: Common Reed, Black Alder *Alnus glutinosa* (L.) Gaertn., and White Willow *Salix alba* L. Material from *Phragmites* was used in 72.7% of nests (16 BN, 16 MN), a mix of *Phragmites/Alnus* in 22.7% of nests (6 BN, 4 MN) and a mix of *Phragmites/Salix* in 4.6% of nests (1 BN, 1 MN). The type of the nest did not depend on date when it was built during the breeding season: 6 BN and 3 MN were built from 15 May to 4 June (20.5% of all nests), 4 BN and 4 MN from 5 to 25 June (18.2%), 9 BN and 12 MN from 26 June to

Table 1. Comparison of the nest size and the nest site parameters of two different types of the Little Bittern nests at the study site.

	Breeding nests (n = 23)	Mock nests (n = 21)	Mann-Whitney test	
			Z	P
Nest size				
Length (cm)	17.7 ± 2.8 (12–22)	15.1 ± 5.1 (7–23)	1.762	0.078
Width (cm)	22.9 ± 2.6 (19–30)	16.9 ± 2.7 (12–21)	**5.263**	**<0.001**
Nest site				
Height above the water surface (cm)	15.4 ± 16.8 (0–65)	15.3 ± 10.9 (3–34)	-0.529	0.597
Water depth (cm)	39.6 ± 21.4 (11–101)	46.2 ± 15.1 (15–67)	-1.551	0.121
Distance from open water (cm)	304.3 ± 141.7 (90–740)	310.5 ± 157.8 (110–680)	0.153	0.879
Distance from terrestrial habitat (cm)	190.9 ± 120.2 (20–580)	249.1 ± 212.6 (80–1050)	-0.799	0.424
Width of the reed belt (cm)	597.4 ± 164.8 (350–890)	622.4 ± 276.8 (240–1500)	0.117	0.906
Height of the reed belt (cm)	390.4 ± 61.4 (250–520)	341.9 ± 55 (180–430)	**2.514**	**0.012**
Reed stem diameter (mm)	9.4 ± 1.2 (7.2–11.6)	8.1 ± 1 (6.7–10.2)	**3.442**	**<0.001**

Note: Values that are significantly different are shown in bold type.

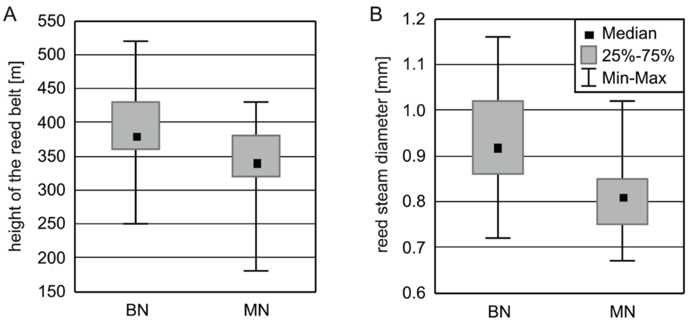

Fig. 2. Comparison of the height of the reed belt (A) and reed steam diameter (B) between the breeding nests (23 BN) and the mock nests (21 MN).

16 July (47.7%), 4 BN and 2 MN from 17 July to 6 August (13.6%) ($\chi2 = 2.008$, df = 3, $P = 0.571$). The length of the nest for the two nest types did not differ statistically (Table 1). In eight cases, BN were overbuilt, on average by 6.8 ± 5.7 cm (2–20). The mean width of BN was greater because of the presence of the clutch and because MN are usually unfinished. The difference in this nest parameter was statistically significant (Table 1).

Nesting habitat

Only one type of marsh vegetation, perennial pure reed beds, was distinguished within a radius of 10 m around all nests (n = 44). There was a dependence between the nest type and the pond area: 17 BN and 9 MN on 3 fishponds <10 ha, 6 BN and 12 MN on 2 fishponds >10 ha ($\chi2 = 4.38$, df = 1, $P = 0.036$). The age of fish in particular carp ponds had no influence on the nest type: 4 BN and 4 MN on 0+ carp ponds, 9 BN and 9 MN on 1+ carp ponds, 10 BN and 8 MN on 2+ carp ponds ($\chi2 = 0.132$, df = 2, $P = 0.936$). The results for other nesting habitat parameters are presented in Table 1. The values for the height of the reed belt and reed stem diameter were higher for BN, and only in these two cases the differences were statistically significant (Fig. 2). The average width of the reed belt was slightly higher for MN than for BN, and 63.7% of all nests (17 BN, 11 MN) were located in reed belts with a width from 5 to 10 m. Distances from open water and from terrestrial habitat were higher for MN (Fig. 3). The height above the water surface was similar for both nest types. The base of 4 BN was lying directly on the water surface or was partially submerged. The difference in the water depth at the nest sites for the two nest types was not statistically significant. The distance between two nearest BN in each year amounted on average to 124.1 ± 74.3 m (30–263 m; n = 23), whereas the distance from MN to the nearest BN was 135.7 ± 81.2 m (2–276 m; n = 21). In 2011, 8 BN were found at the same time on one fishpond (3.8 ha), and the distance between them varied from 39 to 140 m, with a mean of 64.6 ± 37.1 m. No BN were discovered on the same fishpond in 2012, which was

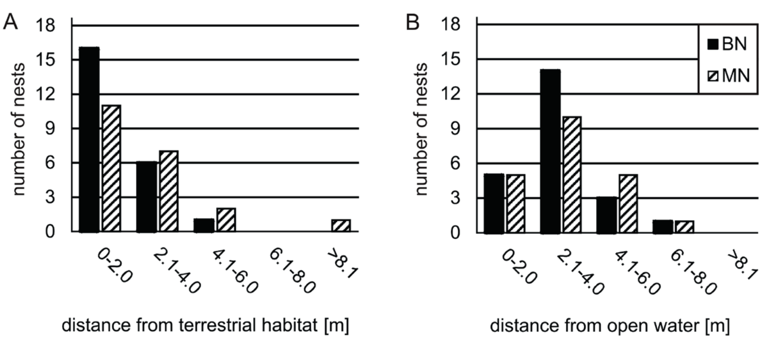

Fig. 3. The location of the breeding nests (23 BN) and the mock nests (21 MN) in relation to the nearest terrestrial habitat (A) and open water (B).

Table 2. Comparison of the habitat conditions in 2011 and 2012 on one fishpond with an area of 3.8 ha, where Little Bittern nests were recorded only in 2011 (n = 8).

	2011	2012	Wilcoxon test	
			T	P
Width of the reed belt (cm)	526.3 ± 152.7 (350–810)	228.6 ± 110.5 (0–350)	**0.00**	**0.012**
Height of the reed belt (cm)	420 ± 77.1 (320–520)	283.7 ± 147.8 (0–450)	**0.00**	**0.012**
Water depth (cm)	34.5 ± 15.3 (16–60)	45.6 ± 9.2 (30–58)	4.50	0.059

Note: Values that are significantly different are shown in bold type.

caused by fragmentary reed cutting. A comparison of habitat conditions on this fishpond in 2011 and 2012 is presented in Table 2. Statistically significant differences were noted for the height and width of the reed belt.

DISCUSSION

The Little Bittern is still the least studied European heron species, which proves to be well adapted to large variations in habitat availability. The occurrence of this widespread, but elusive bird in a particular area depends on the suitability of habitat conditions (Kushlan and Hancock 2005). Obtained results indicate that some factors related with nest microhabitat may be important for the Little Bittern females when considering proposed nest site for breeding. Recent studies showed that a high density of old reed stems plays an important role in the selection of nesting sites by marshland species (Polak *et al.* 2008). The Little Bittern breeding nests in comparison to mock nests were localised in taller reed beds. The adaptational value of the preference for higher and denser marsh vegetation most probably results from the better concealment of nests, which lowers predation risk (Martin 1993, Cempulik 1994). Besides, sufficiently large width and height of the reed belt as well as water depth, and nest-site location at the optimal distance from terrestrial habitat are the main factors reducing the nest failure of the Little Bittern and other marsh birds caused by potential predators, such as the Red Fox *Vulpes vulpes* (L.), the Raccoon Dog *Nyctereutes procyonoides* (Gray) or the Marsh Harrier *Circus aeruginosus* (L.) (Martin 1993, Polak 2007, Flis – unpublished).

Like other marsh herons, such as the Great Bittern, the Purple Heron *Ardea purpurea* L., and the Squacco Heron *Ardeola ralloides* (Scop.), the Little Bittern depends on old reed beds for nesting and feeding (Kushlan and Hafner 2000). At the surveyed fishponds, the Little Bittern nested in reed beds of at least 350 cm in width, but on the Wielikat fishponds in Upper Silesia (Poland) it also nested in reed beds of only 300 cm in width (Cempulik 1994). In contrast to the Great Bittern, the Little Bittern does not need large and unbroken areas of marsh vegetation, but is able to adapt to habitats with small, narrow patches of dense and tall emergent plants or even small trees and shrubs. Research on Mediterranean wetlands showed that the Little Bittern had a relatively large individual home range (from 3.2 to 12.4 ha) and occurred on marshland fragments larger than 4 ha (Pezzo and Benocci 2001) and 4.6 ha (Benassi *et al.* 2009). This heron is a strongly territorial species, but in some cases, if the habitat conditions are favourable, may nest in loose colonies in which pairs are spaced apart at a distance from 3 to about 50 m (Kushlan and Hancock 2005). Moreover, the Little Bittern is a very area-sensitive species when the breeding habitat conditions will drastically change, especially when there is an intensive reed cutting (Szlivka 1958, Voisin 1991). Such a situation occurred in the study area in 2012, when a fragmentary reed cutting was done in some ponds, and after that no breeding nests were found at these ponds to the end of the breeding season.

The Little Bittern's nests are mainly built of old reeds or sticks and have a short durability, usually one breeding season (Voisin 1991). In every breeding season, new nests are built. Old nests from previous years, if survived, are not used by pairs. Even when a second brood occurs or the clutch is replaced after failure, a new nest is built every time.

To date, information about the nest types of the Little Bittern has been presented only by Cramp and Simmons (1977). The possibility of building the two nest types confirms that this species has a different mating system than other European herons. Until now, the occurrence of mock nests has not been recorded even in the other seven *Ixobrychus* Billb. species in the world (Kushlan and Hancock 2005). The mock nest is a part of the Little Bittern's courtship display, and its main task is to attract a female. It could play a similar role as mating platforms used by some *Podiceps* Lath. species, which build several platforms before one is completed as a breeding nest (Kloskowski *et al.* 2012).

Males can build mock nests throughout the breeding season. Whether a given nest will be a breeding nest or another mock nest depends on the male's ability to display, on the availability of females, and potentially also on habitat conditions. This research showed that breeding nests were built at sites with higher and thicker reed beds than those where mock nest were built. Other nest site parameters were similar. Unmated males can build several mock nests in their territory during a single breeding season, and use them as a form of display to lure prospective females. These nests are incomplete, smaller than breeding nests, abandoned, and not used again after pair formation (Flis – unpublished). Such behaviour is known of some bird species, such as the Southern Masked Weaver *Ploceus velatus* Vieill. or the Penduline Tit *Remiz pendulinus* (L.), but they are usually polygamous (Walsh *et al.* 2010, Czyż *et al.* 2012). The building of several nests by a male belonging to monogamous birds is somewhat incomprehensible and may entail an unnecessary expense of energy. This behaviour is reasonable for polygamous birds (*e.g.* males of the Eurasian Wren *Troglodytes troglodytes* (L.)), which, by building more than one nest and displaying to several females, can transmit their genes to abundant offspring (Wesołowski 1983, Ketterson and Nolan 1994, Soler *et al.* 1998).

The Little Bittern is known as a monogamous bird, and there is no strong evidence of polygamy (Cramp and Simmons 1977, Voisin 1991, Kushlan and Hancock 2005). Nevertheless, we cannot exclude that extra-pair copulations or facultative polygyny occurs in some populations nesting in high density. Perhaps in these situations mock nests are built to attract additional females. The present research showed that the type of the nest did not depend on date when it was built during the breeding season. This may indicate that, after successful mating, some males try to attract another female. In the case of the African subspecies of the Little Bittern *I. m. payesii* (Hartl.), Langley (1983) observed one copulation in which an incubating female was raped by a colour-ringed male that was not her mate. Only detailed information concerning the behaviour of individually marked individuals or molecular analyses could provide reliable data on the reproductive system of the Little Bittern, in which sexual dimorphism is highly visible, unlike in other European heron species.

The results of this study have important implications for the protection of wetland habitats and correct water management in fishponds or dam reservoirs because every significant environmental change, such as intensive reed burning or cutting, causes a rapid decline in the population of this vulnerable species. However, we still need some information about, why the Little Bittern male builds a mock nest, and this article is only the first step to solve this problem.

ACKNOWLEDGMENTS: I would like to thank Agata Flis for help in the field work. I also thank three anonymous reviewers for useful comments on the manuscript. This research was supported by the Institute of Nature Conservation PAS and was in compliance with current Polish law.

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