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Habitat selection of Corncrakes (Crex crex L.) in Szatmár-Bereg (Hungary) and implications for further monitoring

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In 1997 we carried out a survey of the corncrake in Szatmár-Bereg in eastern Hungary in an area covering 1170 km^2 and containing 137 km^2 of natural grassland. To study corncrake habitat preferences, we compared habitat factors of 17 clearly delimited grassland sites with at least two singing corncrakes with the respectively closest grassland sites of similar size where no corncrakes occurred. We assessed the area of the site, measured vegetation height and density, wet standing crop, an index of humidity and an index of habitat structure and recorded land-use at each site. Corncrake habitats were more productive, more humid and showed more additional structures than grasslands without corncrakes. Concerning land-use, corncrake habitats contained more currently abandoned parts (set-asides) and less intensively grazed parts than non-corncrake habitats. In a logistic regression model, vegetation height, vegetation density and the index of structure were selected as the variables with the largest explanatory power for the presence/absence of corncrakes. We suggest that these indices should be used as tools to monitor changes in corncrake habitat at a large scale.

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1. Introduction

The corncrake (*Crex crex*) is a globally threatened bird species living mainly in extensively used tall wet grasslands of Europe and Central Asia. It is classified as "Vulnerable" at both world and European scales due to a long-term and very steep decline across its entire range. Breeding occurs in 34 European countries but the species has been declining in Europe since the last century. The decline over the last 10 years has been estimated at about 20% to 50% in most European countries (Tucker & Heath 1994).

Corncrakes are rare in south-western Europe but more widespread in Central and north-eastern Europe, where they may occur at high densities in suitable areas. Hungary is one of the westernmost countries with strong corncrake populations. Here, most corncrakes occur in the north-eastern floodplains along the rivers Tisza, Bodrog and Szamos. Recent estimates of the total Hungarian population of the species are ranging from 350-900 singing males (Szép 1991, Miklós Tóth pers. comm.). Previous counts showed large annual fluctuations. The corncrakes in the Szatmár-Bereg area near the river Tisza in Eastern Hungary occupy fragments of grasslands mainly dominated by *Alopecurus pratensis* in a matrix of various seminatural habitat types in an area of about 1170 km^2. These sites can be surveyed from a single point or easily accessible monitoring tracks, and the probability of double-recordings is low because relatively few males call simultaneously at one site. The fragmentation of the population into many clearly separated groups makes it possible to record accurately the corncrake population and to detect small changes in population size and geographical distribution.

Several studies on habitat preferences of corncrakes in Europe (e.g. Flade 1991, Schäffer & Münch 1993, Stowe *et al*. 1993, Schäffer 1999) were mainly based on time-demanding analyses of plant sociology. Such methods are unsuitable for any large-scale monitoring of corncrake populations and their habitats in eastern Europe. Instead, simple quantitative habitat factors should be found to predict patterns of presence/absence of corncrakes or temporal changes in distribution and abundance. Mainly regarding the expected changes of the landuse after the reprivatisation of agricultural lands in Hungary it will become increasingly important to find objective measures of habitat quality.

Here we present results of an ecological corncrake survey conducted using simple field methods for a quick assessment of the structure, productivity, humidity, and the management of corncrake habitat. They confirm results of the previously cited studies and strongly emphasize the importance of high but not dense vegetation in combination with a distinct large-scale structure of the grassland. Our results suggest that these habitat factors are suitable for long-term monitoring. They perform well at predicting the presence or absence of corncrakes, are very quick to record, and they do not require any special biological knowledge. Hence they could also be used by ornithological laypeople. Our methods should prove suitable for efficient monitoring of corncrakes on a much larger scale than has hitherto been made.

2. Methods

2.1. Study species

The corncrake *Crex crex* is a small rail weighing approx. 125 g. It lives in open habitats, mainly wet, tall grasslands, and is a long-distance migrant wintering in the sub-Sahara. Corncrakes arrive on their breeding sites in Eastern Europe at the beginning of May and leave them again from August to October (Green *et al*. 1997).

Male corncrakes are calling more or less continuously between 22.00 hours in the evening and 3.00 hours in the morning from mid-May to early July. Their call can be heard over between 500 and 1000 m depending on weather conditions. If an occupied site is visited twice at a suitable time, the probability of detecting a male corncrake has been estimated at 0.95 (Stowe *et al*. 1993).

2.2. Study area and site selection

Our study area was the Szatmár-Bereg lowland (Important Bird Area HU35, category A1; see Nagy 1998) in the easternmost part of Hungary in a triangle between the rivers Tisza and Szamos and the border with the Ukraine and Romania (48°0'N, 22°40'E, see Fig. 1). A pilot survey of calling corncrakes covering 137 km^2 of grassland was carried out between 15 May and 12 June 1997. The pool of investigated grasslands was determined from Hungarian maps (1:25'000) dating from 1974 that show the extent of natural grasslands. We found 17 clearly delimited grassland sites with at least two singing males (+sites), which we selected for the habitat analyses. On the selected +sites, altogether 68 male corncrakes were recorded with up to seven corncrakes calling at one site.

Additionally, we selected 17 grassland fragments of similar size and habitat type but without calling males (-sites) to compare occupied with unoccupied grasslands. To assure an even geographic representation of +sites and -sites, we selected for each +site the closest site with no calling corncrakes. Corncrakes are known to move strongly within their breeding habitat during the season (Stowe & Hudson 1991) and even within 24 hours (Schäffer & Münch 1993, Schäffer 1999). Therefore, we selected entirely different, unoccupied sites as a comparison with the occupied habitats rather than selecting just the unoccupied parts within an occupied meadow.

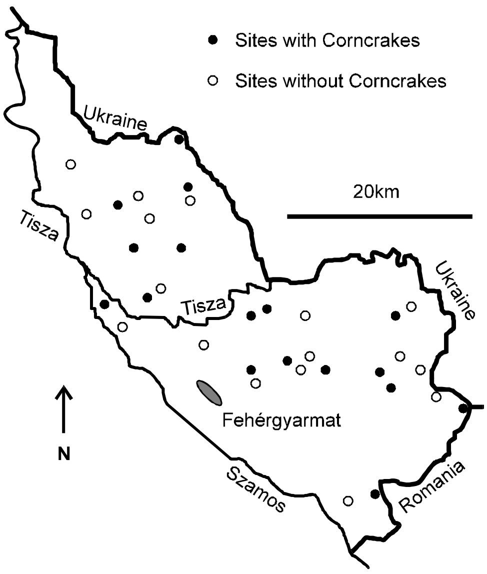

Fig. 1. Location of the study sites for the habitat analysis in Szatmár-Bereg, Hungary.

Our study therefore bears on 34 grassland fragments for a comparison of habitats with or without corncrakes present (Fig. 1). We used the MapInfo v4.0 GIS software for measuring the size of the potential breeding habitats, by identifying the border of the habitats on the digitised and geocoded 1:25'000 map and calculated the area of the identified polygons.

A second survey was made between 26 June and 6 July 1997 in order to check the status of the sites. It concentrated on the central and northern parts of Szatmár-Bereg only because bad weather conditions followed by infrequent calling in later summer did not allow a complete survey any more. The second survey comprised 22 among the 34 original sites from the first survey and confirmed the status of occupancy of all checked study sites that were used for the habitat analysis; at all +sites, calling corncrakes were confirmed while no birds could be found at any of the -sites.

2.3. Data collection

In June 1997, at every study site, we analysed the structure of the vegetation, established an index of humidity and an index of habitat structure for each site.

For the analysis of vegetation, we took five points along a transect across the sites by selecting the points of the left foot-tip after walking intervals of exactly two minutes at constant speed. The total linear transect length was between 600 - 650m. In the -sites, the transects were placed randomly, while in the +sites, they were placed across the area with the highest corncrake density. We did not place them randomly in the +sites, because some of them were so large that they also held large parts of habitat with a very different structure compared with the parts where corncrakes were calling. These could therefore be unsuitable habitats and it would not have been justified to call them typical for corncrakes.

At the selected points, height, density and biomass of the vegetation was measured. As a measure of vegetation height, we took the distance between the soil and the centre of a desk pad (33×24 cm, 420g) that we carefully placed by hands horizontally on top of the vegetation. As a measure of vegetation density, we recorded the average "drag weight" in grams of a corncrake dummy leashed to a spring scale and dragged through the vegetation. This simple model corncrake was made with an empty "Boule"-ball, cardboard and water resistant Scotch tape, building an egg-shaped structure with a 30 cm long cord at the tip (120g, 15×7 cm). As a measure of the biomass of the vegetation, we harvested the standing crop in one randomly placed square of 33×33 cm and weighed it immediately to the nearest gram using a spring scale.

Other habitat variables recorded along the transects were an index of humidity and an index for habitat structure. The index for humidity was meant to quantify the degree to which a site was wet or dry and was calculated as a sum of the following factors:

- the abundance of five typical and conspicuous wetland plants (*Iris pseudacorus, Lythrum sp., Euphorbia palustris, Peucedanum officinale* and *Sanguisorba officinalis* estimated in three categories (0 points: <3 plants ; 1 point: 3-10 plants; 2 points: >10 plants found on the transect counting for every species separately)
- the abundance of a common grass indicating wet soils (*Alopecurus pratensis*) and of a grass typical of dry soils (*Festuca pseudovina*) (0 point: absent or rare; 1 point: not dominant; 2 points: partly dominant; 3 points: dominant at the whole site). Scores for *Festuca pseudovina* were subtracted.

The index for habitat structure was conceived as a measure of the amount of additional large-scale structures that influence the characteristics of the grassland and could therefore influence the habitat choice of the corncrakes. It was calculated as the sum of four factors:

- number of isolated old bushes and number of isolated trees (0 points: <3; 1 point: 3-10; 2 points: >10 visible from the transect (always within the selected grassland site)).
- number of hedges (0 point: none; 1 point: 1-2; 2 points: >2 visible from the transect).
- presence of old riverbeds and other marshy areas caused by natural relief of the surface that were characterised by continuously wet soil (0 points: none; 1 point: 1 or 2 spots; 2 points: more spots or one very large expanse).
- presence of old flowers of *Dipsacus sp.* (0 points: rare or absent; 1 point: dis-

persed; 2 points: fields of old *Dipsacus* present).

We recorded the landuse of the sites until 5 August 97. To quantify the land-use we assessed the relative proportions of each of the following types of grassland: mowed, slightly or heavily grazed (<50% of the vegetation disturbed by the animals, respectively >50% of the vegetation disturbed by the animals), currently set-aside areas and other grasslands.

2.4. Statistical analysis

To determine which habitat variables were most important for the presence and abundance of corncrakes we analysed our data in two ways. First, we included presence/absence of the corncrake at all 34 sites in an analysis using a logistic regression model. Tests in the logistic model were carried out by computing appropriate ratios of mean deviances. Such mean deviance ratios are approximately F-distributed (Francis *et al*. 1993).

Applying a regression model to the presence/absence data of all 34 sites in some way violates statistical logic. Corncrake presence was not truly a random variable, but instead we selected the sites to have corncrakes present or not. One could therefore argue that it would have been more appropriate to analyse the two groups of sites with discriminant function analysis (Mardia *et al*. 1979). However, for three reasons we chose to use logistic regression in an exploratory way. The logistic regression framework has several advantages over discriminant function analysis. First, the fitted values of a logistic regression model of the presence/absence data have a very intuitive interpretation. They are the predicted probability of occurrence of the corncrake at a site, given the statistical model. They can thus be used to predict which unoccupied sites could be the most probable to be occupied in a good corncrake year, or on the other hand, which of the occupied sites appears to be the least favourable. Second, the regression residuals can give valuable insights about which sites are unusual. Third, the effect of different factors can be formally tested, and thus the usual model selection techniques applied. We furthermore qualitatively checked the results from the logistic regression analysis with a discriminant function analysis, and the latter indicated the same important habitat variables as the regression analysis.

Second, we modelled the abundance of corncrakes in all sites (including the -sites) and at the +sites in an ordinary multiple regression analysis. In both the logistic and the ordinary regression, we selected the model that was best able to explain patterns in corncrake occurrence by forward selection of the explaining variables (Neter *et al*. 1990). All statistical analyses were performed with the statistical package Genstat 5.3.2. (Payne 1993).

Many of the measured variables were correlated among each other (Tab. 1) and without carrying out experiments it may therefore be difficult to identify the variables which are causally responsible for the distribution of the corncrakes. But to *predict* corncrake presence, we do not really need to know which variable was causally responsible for a corncrake occupying a certain habitat. Instead, if we are able to find a small set of variables that predicts corncrake presence well, we can make predictions about the occupancy status of hitherto unknown sites if we know the values for these predictor variables at that site.

Tab. 1. Pearson correlation coefficients between the measured habitat variables. Bold-face numbers indicate a significant correlation with P<0.05 (N=34 habitats).

Variable	Area	Standing crop	Vegetation height	Vegetation density	Index of humidity	Index of structure
Area	1.00	-0.03	-0.17	-0.10	-0.32	-0.04
Standing crop		1.00	**0.77**	**0.81**	**0.38**	**0.44**
Vegetation height			1.00	**0.73**	**0.49**	**0.34**
Vegetation density				1.00	0.29	**0.37**
Index of humidity					1.00	**0.34**
Index of structure						1.00

3. Results

The sites with corncrakes could be characterised as moist or temporary moist meadows or pastures with tall grasses. They were often structured by single-standing trees and bushes, hedgerows, old riverbeds and other marshy areas. On average, the occupied sites were 1.36 km^2 large, their fresh standing crop on an area of 33×33 cm weighed 173 g, their vegetation height under the desk pad was 30.6 cm and the drag weight needed to carry the model corncrake through the vegetation was 212 g. Except of the area and the proportions of mown and extensively grazed area, all measured habitat variables significantly differed between grasslands with and without corncrakes (Tab. 2). The average weight of the fresh standing crop was 31% higher and the average height of the vegetation was 46% higher in +sites than in -sites. The grasslands with corncrakes were also more humid because the typical wetland plants considered in the index of humidity were more abundant in +sites. Corncrake grasslands had more additional structure like isolated bushes or trees, hedgerows and soil relief than grasslands where no corncrakes occurred. Concerning land use, the two categories of grassland differed primarily in away that +sites held more currently unused or not yet used parts while in -sites more intensively grazed parts were found (Tab. 2, Fig. 2). Early mowing (before the end of June) was only occasionally observed and without exception, there were some refuge areas left. This could however be related

Tab. 2. Differences in habitat variables among grasslands holding corncrakes (+sites, N=17) and grasslands without them (-sites, N=17). One-way ANOVAs, **: P<0.01, ***: P<0.001.

Habitat variable	+site (means)	-site (means)	R^2 of model	$F_{1, 32}$	P
Area of the grassland	1.36 km^2	1.54 km^2	0.01	0.50	
Standing crop	173 g	132 g	0.29	13.40	***
Vegetation height	30.6 cm	20.9 cm	0.55	39.40	***
Vegetation density	212 g	178 g	0.21	8.70	**
Index of humidity	4.2	1.6	0.26	11.30	**
Index of structure	3.3	1.8	0.30	14.30	***
Proportion mown	24.1 %	20.6 %	0.01	0.20	
Proportion extensively grazed	10.0 %	12.3 %	0.004	0.10	
Proportion intensively grazed	7.6 %	40.0 %	0.26	11.50	**
Proportion set-asides	51.1 %	21.1 %	0.19	7.9	**

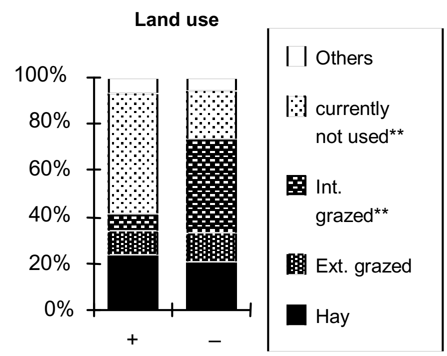

Fig. 2. Cumulated frequency of different land-use forms in 17 grasslands with corncrakes (+) and 17 grasslands without corncrakes (-). ** : significant difference with $P<0.01$ (t-test), $N=34$.

to the exceptionally wet conditions in the first half of 1997.

The variables explaining most of the variation between occupied and unoccupied sites were vegetation height, the index of structure and vegetation density (Tab. 3, Fig. 3). While vegetation density was higher in +sites than in -sites in a simple ANOVA (Tab. 1), the regression models show a negative relation between the vegetation density and corncrake abundance (Fig. 3). That is because in the regression models, vegetation density is adjusted for variation in vegetation height

Tab. 3. Analysis of deviance of cornerakes presence at the studied meadows in Eastern Hungary. Presence of cornerakes was modelled with a logistic regression model. Terms were selected by forward selection. Tests were carried out by dividing the mean deviances due to each term by the residual mean deviance. These mean deviance ratios are approximately F-distributed with 1 and 30 df. *** - $P<0.001$.

Source of variation	df	md	F	
Vegetation height	1	24.85	79.35	***
Index of structure	1	7.33	23.42	***
Vegetation density	1	5.56	17.76	***
Residual	30	0.31		
Total	33	1.43		

and index of structure. This suggests that corncrakes prefer the sparser vegetation at any given vegetation height. The discriminant function analysis confirmed the importance of the height and density of the vegetation and the index of structure. Using these three variables, the status of 32 of the 34 sites was correctly predicted.

Variation in the measured habitat variables could not explain the abundance of the corncrakes within the investigated

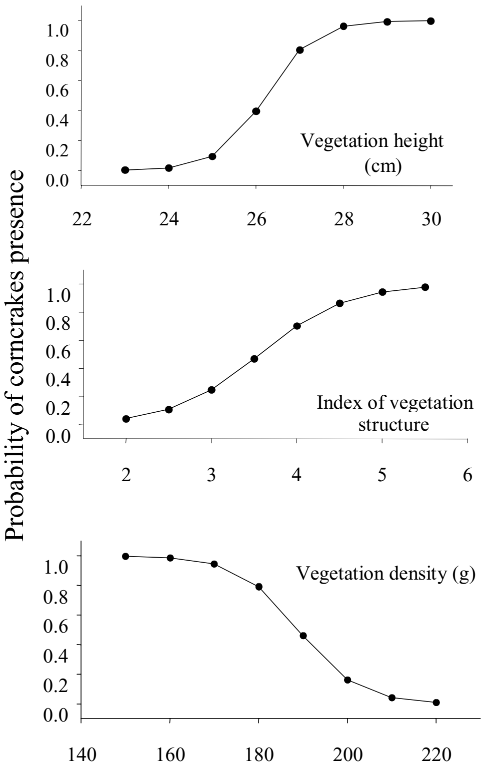

Fig. 3. The relationship between the probability of corncrake presence and vegetation height, the index of structure and vegetation density. Probability of corncrake presence was calculated based on an equation derived from a logistic regression model containing the three explanatory variables for which a graph is shown. The graphs therefore present smoothed relationships. For a definition of the habitat factors index of structure and vegetation density see the methods section.

Tab. 4. Regression model of the abundance of the Corncrake in the studied grasslands (including the sites not occupied). Terms in the minimal adequate model (which explained 45% of the variation in corncrake abundance) were selected by stepwise multiple regression. ***: $P<0.001$, *: $P<0.05$, (*): $P<0.1$.

Source of variation	slope	df	SS	F	
Vegetation height	0.27	1	61.30	18.10	***
Index of structure	0.54	1	17.20	5.10	*
Vegetation density	-0.02	1	13.70	4.00	(*)
Residual		30	101.90		
Total		33	194.10		

+sites. None of the variables was significantly correlated with the abundance of the corncrakes when only the +sites were analysed. When the -sites were included, the same model as for the presence / absence data was selected (Tab. 4) which supports the validity of the model in Tab. 3. To summarise, our results show that the recorded habitat variables were distinctly different between occupied and unoccupied sites, but that they can not explain the abundance of the corncrakes within an occupied site. Therefore, we did find good correlates of corncrake presence, but no good correlates of corncrake abundance.

4. Discussion

The surveyed area in Szatmár-Bereg holds a significant part of the Hungarian corncrake population. It is a typical area of low intensity agriculture, providing good conditions for successful breeding of the corncrake (Green & Rayment 1996). In the survey year (1997), the distribution of the bird was not primarily determined by the actual mowing regime but by differences in the large and small scale structure of the grassland. The clear differences between occupied and unoccupied sites indicate, that the used measures of the habitat quality are indeed suitable for the use in a long-term monitoring of the occupied area, most efficiently by vegetation height and density and the index of structure selected by the logistic model.

Suitable corncrake habitats could be separated from unsuitable habitats by very simple physical measures of the grassland. So we may hope that aided by remote sensing a first assessment of the corncrake distribution in so far unsurveyed areas could be realised. This would be especially important for all the remote areas further east and north of the Carpathians, where detailed surveys are mostly lacking, but which are supposed to host significant parts of the whole European population (Mischenko *et al*. 1995, Keiss 1997). Further research would also be needed to find models to predict the abundance of the corncrakes, i.e. to identify a small set of variables that are strongly correlated with corncrake abundance.

Vegetation height seems to play a key function in the habitat selection of the corncrakes (Schäffer & Münch 1993, Schäffer 1999). Our measure of vegetation height not only gives the simple height of the vegetation, but also contains information about the small scale vegetation structure. It therefore better reflects the conditions relevant for the corncrakes than relatively abstract measures like standing crop. Vegetation height was incidentally also the easiest habitat variable to measure. It can be recorded at any visit to a grassland with a minimal effort. We therefore suggest that it should be measured in any corncrake survey. An international coordination would be helpful to define a small but standardised set of habitat variables and the detailed procedure of their measurement.

The negative relationship between vegetation density and corncrake presence at a given vegetation height indicates that too highly structured and dense vegetation, as for example artificially fertilised meadows with a high proportion of *Fabaceae* species, does not provide suitable habitat any more. It can be supposed that this makes the movements of the bird on the ground too difficult, similar to the effects observed with grasslands damaged by heavy rainfall (Schäffer & Weisser, 1996). Our method to measure vegetation density using a simple corncrake dummy, however, proved to be quite problematic in the heterogeneous vegetation of most grasslands. For the use in long-term monitoring, a better and even simpler measure should be found to measure the vegetation density from the corncrakes' point of view.

The importance of the large scale structure of the corncrake habitats has already been emphasised qualitatively (Flade 1991, Schäffer & Münch 1993). The quantitative results of Schäffer (1999) and of our study confirm this. Our results do not indicate an upper limit of additional structure, maybe resulting from strong bush growth on set-aside grasslands. But because of the fact that many +site were currently set-aside land, it will be interesting to follow the development of such sites with respect to large and small scale vegetation structure. Unfortunately, it has to be supposed that unless special conservation measures are taken, the grasslands will more and more develop into either poorly structured sites with intensive use on the one hand or into abandoned sites where a succession toward forests will start on the other hand. It will be a task of the conservationists to find alternatives (Schäffer & Weisser 1996, Crockford *et al*. 1996, Green *et al*. 1997, Schäffer 1999) and to make them practicable for the farmers. The presented methods and models may be helpful tools for an efficient evaluation of conservation measures for corncrake habitats.

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Összefoglalás

A haris élõhelyválasztása a Szatmár-Beregi síkon, és javaslatok a további monitorozásra

A Szatmár-Beregi sík 1170 km^2-ét mértük fel 1997-ben, benne 137 km^2 természetszerû gyeppel. A harisok élõhelyválasztásának vizsgálatához jól lehatárolható, és legalább 2 éneklõ harist tartalmazó gyepeket hasonlítottunk össze a legközelebbi hasonló nagyságú gyepterülettel, ahol nem volt haris. A gyepek területét, a vegetáció magasságát és sûrûségét, friss biomassza per 33×33 cm, egy nedvességi indexet, egy élõhely-szerkezeti indexet, és a földhasználatot mértük, illetve becsültük minden mintavételi területen. A harisok által lakott gyepek produktívabbak, nedvesebbek, és összetettebb szerkezetûek voltak, mint a haris nélküli gyepek. A harisos élõhelyek több kezeléssel felhagyott illetve kevésbé intenzíven legeltetett részt tartalmaztak, mint a nem lakott gyepek. A haris jelenlétét prediktáló logisztikus regressziós elemzés a vegetáció magasságát, sûrûségét és az élõhely-szerkezetét építette a modellbe. Ezek azok a változók, amiknek a változását nagyobb területen is monitorozni szükséges, hogy a haris élõhelyek alakulását követni lehessen.

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