Hunting-yield and habitat-use in the Montagu's Harrier

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Abstract

Little is known about habitat use in hunting Montagu's Harriers *Circus pygargus*, although knowlegde about hunting behaviour may be essential in the protection of this rare and endangered species.
We studied hunting behaviour and habitat-use of 2 adult breeding male Montagu's Harriers in the Northeast of the Netherlands, which were provided with a tail-mount radio transmitter. From our analysis on hunting-observations it showed that age of the nestlings and/or date was very strongly correlated with hunting-yield, strike-frequency and strike-success. The vegetation type was only related to hunting-yield and strike-success. Mowing significantly affected strike-succe, with freshly mowed plots gaining the highest success rates.
Home-range was estimated for both males. Home-range size for male Korengarst was estimated 69 km^2 and for male Blijham 33 km^2.
Males spent more time and caught more prey than expected on Lucern, grass-land, grass-seed based on the proportion of these crops available in the home-range. Our data give a clear indication of which crops are important for hunting Montagu's Harriers. These findings may be important in the conservation of the Montagu's.

Introduction

Until the 19th century the Montagu's Harrier *Circus pygargus* was a common breeding bird in the Netherlands with an estimated minimum of 500 breeding pairs (Zijlstra & Hustings 1992). Around that time there was a wide choice in breeding and hunting habitats: heaths, moor, wet hayland, swamps and other uncultivated land. With the disappearance of breeding- and hunting-habitats, caused by cultivation of wild-land and the intensification of agriculture, the number of breeding pairs had declined to only 4 breeding-pairs in 1987 (Koks *et al.* 2001). In 1989 the EU decided that part of the agricultural land was to lie fallow (McSharry-setaside). A large part was situated in East-Groningen in the Netherlands, where 20 % of the total surface (ca 10,000 ha) was laid fallow and was sown with grass and grass-seed (Koks & Van Scharenburg 1997; Aukes 2000). This caused an enormous increase of the vole-population (*Microtus arvalis*) as well as an increase in the number of breeding-pairs of agricultural birds. The high prey densities attracted many raptors, amongst others Montagu's Harrier (Zijlstra & Hustings 1992; Koks 1992; Koks & Van Scharenburg 1997) and the number of Montagu's breeding pairs increased spectacularly during the setaside-period (1990-1992) to 39 breeding pairs in the Netherlands. After the cancelling of the McSharry-setaside the number of Montagu's Harriers did not decline dramatically due to the maintenance of some fallowland and nest-protection and till today the Harriers manage to survive in the open landscape of Groningen. The number of breeding-pairs has stabilised around 33 (Koks *et al.* 2001).

Montagu's Harriers can be protected in several ways. First, protection can be focused on the nest-habitat. Most of the breeding-pairs in our study area have their nests in agricultural land, which makes them very vulnerable to harvesting activities. Since several years, large numbers of volunteers and professionals are working on nest-protection. These activities have been very successful and resulted in a substantial improvement of the Montagu's Harrier's reproductive success, but is still necessary to avoid collapse of the existing population (Koks & Visser). Second, protection of the hunting habitat is an option too. Little is known about habitat use in hunting Montagu's Harriers. Male Montagu's Harriers usually hunt over extensive distances (up to 12.2 km Flevoland (Schipper 1977; Cramp & Simmons 1982), up to 6.0 km France radio-tracked birds (Salamolard 1997)).

In this study we focused on habitat-use and hunting-behaviour of adult males in the East of Groningen during the nestling period. After providing the males with tail-mount radio-transmitters we tracked and observed these birds to estimate home range and hunting behaviour of Montagu's Harriers. Our specific questions are: (I) How large are the home ranges of breeding males; (II) Which vegetation-types are preferred for hunting; (III) What is the hunting-yield to each vegetation-type; (IV) How does mowing and harvesting affect the hunting preference and hunting-yield? These data should function as a scientific base for protection activities concerning agricultural management of potential hunting habitat and vegetation.

Methods

Study area and data collection

This research was conducted in the East of Groningen, the Netherlands. Data were collected from 17 June to 4 August 2003.

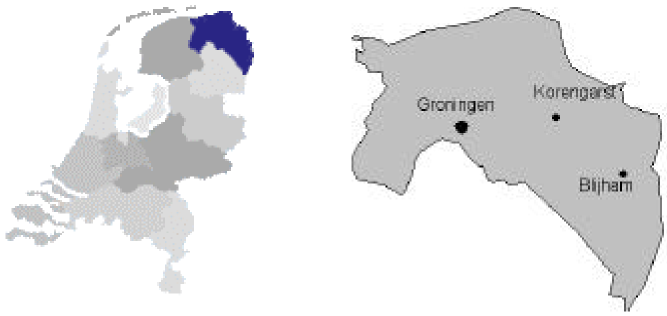


Fig. 1. The study site in the Netherlands (left): province of Groningen (right) with the two main study site Korengarst and Blijham indicated

Two adult males with breeding females were captured with the use of a catching-pole which was placed near the nest and was used to pluck prey and expel pellets. After catching the males were ringed, measured, photographed and provided with a tail-mount transmitter (ATS Inc, type 4570, weight 4.7 gr., 1.88% resp 1.73% of bodyweigth). This device was glued onto the basis of the quills and stabilised with tiny thread.
Male Korengarst, born in 1998, had its nest in Korengarst, north of Noordbroek (fig 1). Male Blijham, born in 1993, was caught near Blijham (fig 1). This male was bigamous.
The two radio tracked males were breeding in different parts of the province.
Male Korengarst was caught 22nd june and observed during 19 days and male Blijham was caught 10th of june and observed during 10 days (appendix 1)
For the observers, tracking male Blijham was more difficult due to the lower accessibility of the area (nature-reserve) and the overview of the area. 55 days after catching, the transmitter broke down. Combination of both factors resulted in relatively few data on hunting in male Blijham, causing data on male Blijham not be used in data-analysis.

Each male was observed during the nestling-period, approx. 8 hours observation per day. Usually this was done by two observers in a car. Males were tracked with the help of a 3-element Yagi antenna. The receiver produced a signal when the male was within a 0-2000 m radius.
During observations, activities were recorded every 60 seconds as well as details on hunting vegetation and strikes (attempts to catch prey) as well as their outcome. Whenever the male was observed, its location was marked on a map scaled 1:69,000 (sighting-point). Recorded activities (every 60 seconds) were: UB (bird not seen, not in the area); V (flying); J (hunting); Z (sitting, usually on pole or ground, including plucking prey and preening); C (circling, flying without moving wing); and I (interaction, species mentioned in the details). Strikes were noted whenever observed. Strikes could be either positive (prey caught), negative (prey not caught) or unknown (not sure whether prey caught or not).
The following hunting-variables were calculated; 1) hunting-yield: number of caught prey per hour of hunting; 2) strike-frequency: number of strikes per hour of hunting; 3) strike-success: number of caught prey relative to the total number of strikes; 4) time spent hunting relative to the time male was actually in sight
Vegetation-type and mowing-regime were noted as mowed, date of mowing, not mowed, harvested, date of harvest.

Data analysis

For both males the home range was calculated, based on all sighting-points during the observation period. Home range was defined as the area within the outermost sighting points, joined by a straight line over the edges of kilometre-squares (fig 4).

In August 2003 vegetation-mappings of the areas around the nests in both Blijham and Korengarst were made. This was done by drawing and coding fields onto detailed maps of the area (scale 1:69,000). 14 vegetation types were distinguished: potatoes, grain (wheat, barley, oat), grass-land (grass used for mowing), grass-seed (harvesting grass-seed), meadow (grass used for grazing), sugar-beets, Lucern, maize, set-aside (fields and strips), infrastructure (roads, buildings), water (small rivers, canals, ditches), other (hemp, horticulture in cold ground, rape, Phacelia) and unknown vegetation (unknown during mapping). For each male the relative share of each vegetation-type per kilometre-square was calculated, as well as for the whole home range.

For the graphs data were summarised per clock-hour (e.g. 9:00-10:00 AM). Hours in which the males had been seen hunting for less than 3 minutes were excluded. This is to avoid unnecessary biases in hunting-variables.

Working with data summarised per clock-hour, the hunting variables were calculated in the following way:

*Hunting-yield = number of positive attempts * 60 / minutes spent hunting*

*Strike-frequency = total strikes * 60 / minutes spent hunting*

Strike-success = number of positive strikes / total strikes

Hunting-yield = strike-frequency * strike-success

The factors which may affect male hunting behaviour were analysed using binary logistic regression (SPSS version 11.0). The results of hunting-yield, strike-frequency and strike-success were recoded as binary data per minute the bird was seen hunting.
Hunting-yield; a minute recorded hunting without catching a prey (0), or with catching a prey (1).
Strike-frequency; a minute recorded hunting with no attempt to catch prey (0) or with an attempt to catch prey (1).
Strike-success; failed attempt or uncertain attempt (0) or successful attempt (1)

In the analysis of hunting-data only the data of male Korengarst were used, because of too few data on male Blijham (hunting-yield n=270 minutes hunting, strike-frequency n=270 minutes hunting, strike-success n=29 strikes)

Logistic binary regression was conducted using backward elimination procedure. The effect of all independent variables was estimate by assessing the change in deviance (Δ deviance) and statistical significance was tested by the Wald statistic, which fallows a χ^2 distribution. All minutes the bird was seen hunting were included.
We analysed the factors that may influence hunting-yield, strike-frequency and strike-success. The following factors were included: age of nestlings/date of observation, vegetation-type, mowing of the fields and number of days since mowing. Age of nestlings and date were treated as the same variable. This is because age of the nestlings and date were 100% correlated.

The vegetation was lumped into 13 categories (appendix 2). The categories forest and meadow are left out of the analysis for birds have not seen hunting on these types.

Fields can be either mowed or not mowed. In this analysis only vegetation that can be mowed was included (grass, grass-seed, set-aside, Lucern).
For the age of mowed field, we discriminated between 3 types: freshly mowed (not longer than 3 days ago), old-mowed plots (longer than 3 days ago) and not-mowed plots.

To analyse which vegetation types the males prefer when hunting we compared the frequency of the number of prey caught on the different vegetation types with the supply of these vegetation types within the home range using χ^2 (SPSS 11.0).
We also compared the distribution of time spent hunting on the different vegetation types with the supply of these vegetation types within the home range using χ^2.
To compare the distribution of prey caught on the different vegetation types with the time spent on these vegetation types we used a Spearman-Rank correlation (SPSS version 11.0)

Results

Table 1. *Correlates of hunting-yield, strike-frequency and strike-success*
A summary of the results of the binary logistic regression-analysis on the data of male Korengarst

	Hunting-yield				**Strike-frequency**				**Strike-success**			
	χ^2	**B**	**df**	**p**	χ^2	**B**	**df**	**p**	χ^2	**B**	**df**	**p**
Model A												
Vegetation	18.428		9	**.031**	24.606		9	**.003**	14.389		7	**.045**
Age nestlings/Date	16.643	0.117	1	**.000**	22.017	0.066	1	**.000**	6.309	0.092	1	**.012**
N=	950				950				105			
Model C												
Age mowed plots	4.232		2	.121	0.353		2	.838	6.865		2	**.032**
Not mowed	0	0			0	0			0	0		
Freshly mowed	2.955	0.618		.086	0.006	-0.021			3.763	0.762		.052
Old mowed	1.092	-0.381			0.344	0.151			1.858	-0.583		
Age nestlings/Date	12.098	0.079	1	**.000**	29.455	0.093	0	**.000**	2.710	0.062	1	.100
N=	522				522				77			

Three models were tested to analyse the factors affecting hunting behaviour and success (table 1). Model A tests both age of the nestlings and vegetation type, model B tests both age of the nestlings and mowing and model C tests age of the nestlings and age of mowed plots.

Male hunting-yield

Age of the nestlings correlated significantly with hunting-yield (table1). The older the nestlings the higher the hunting-yield (fig 3a). Vegetation-type also had a significant effect on hunting-yield (table 1, fig 2a). Mowing had no effect on the hunting-yield; hunting-yield was similar in mowed fields and unmowed fields. The age of mowed field had no statistically significant effect on the hunting-yield (table 1). But we can clearly see some indications for a difference in the effect of freshly mowed and old-mowed plots. Freshly mowed plots tended to positively influence hunting-yield where old-mowed plots negatively influenced hunting-yield compared with unmowed plots

Strike-frequency

When analysing strike-frequency, it appeared that both age of the nestlings and the vegetation-type did strongly influence the frequency of strikes (table 1). The older the nestling the higher the strike-frequency (fig 3b). Again vegetation had a significant effect on strike-frequency (fig 2b). Mowing had no influence on the frequency of strikes. Age of the mowed plots had no influence on strike-frequency (table 1).

Strike-success

Strike-success was also influenced by the age of the nestlings and vegetation type (table 1). The older the nestlings the higher the strike-success (fig 3c) There was also a significant difference between the vegetation types. On Lucern hunting had a significantly higher strike-success, where hunting on grass resulted in a significantly lower strike-success as compared to hunting on the reference type. Mowing did not have a significant effect on the success of strikes (table 1, fig 2c).

In contrast age of the mowed plots did influence the success of the strikes. Also here we can clearly see a difference between the effect of recently mowed and old-mowed. Freshly mowed plots tended to positively influence the success of hunting where old-mowed plots negatively influenced strike-success compared to unmowed plots (table 1).

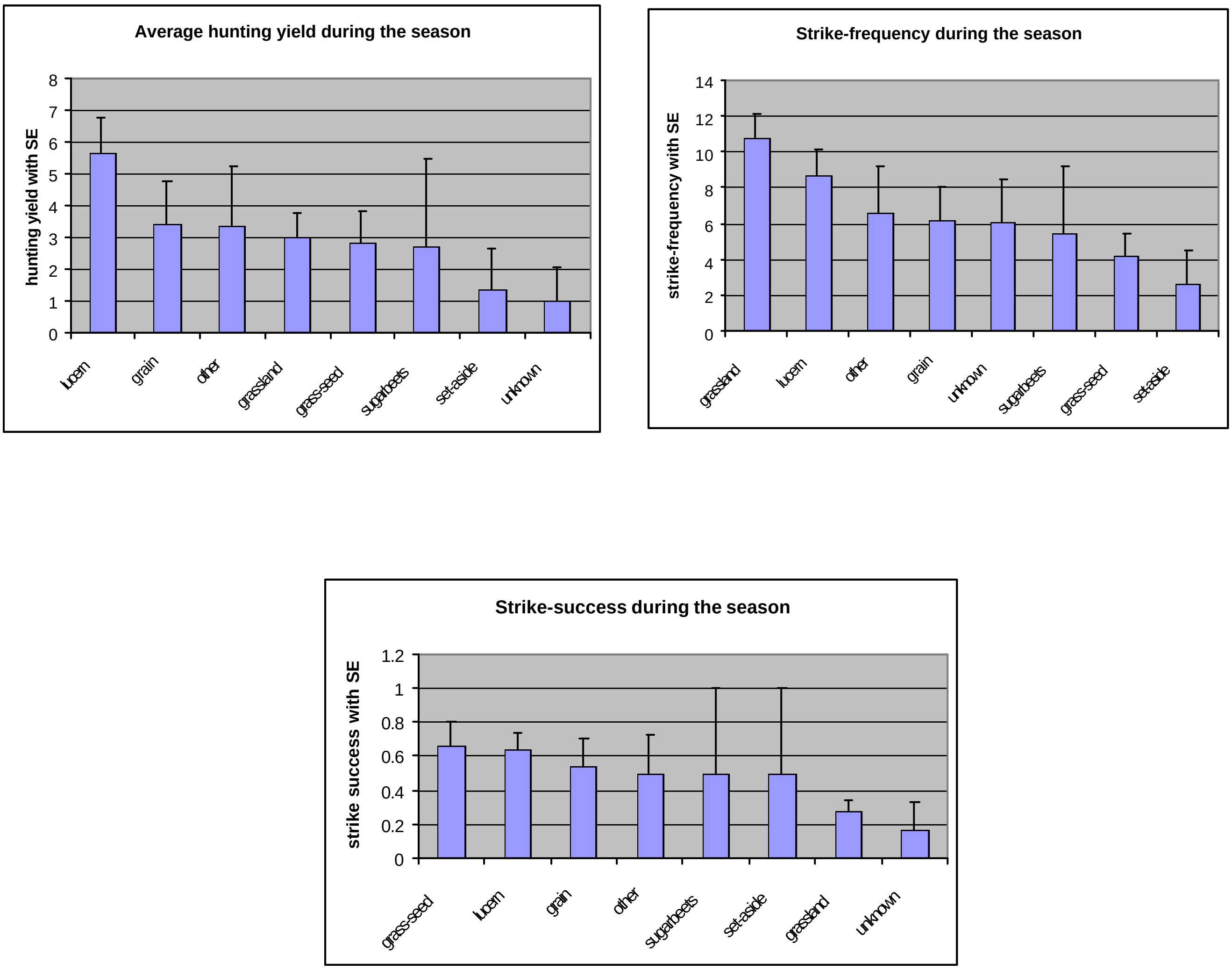


Fig. 2. Hunting-yield, Strike-frequency and Strike-success in relation to vegetation type

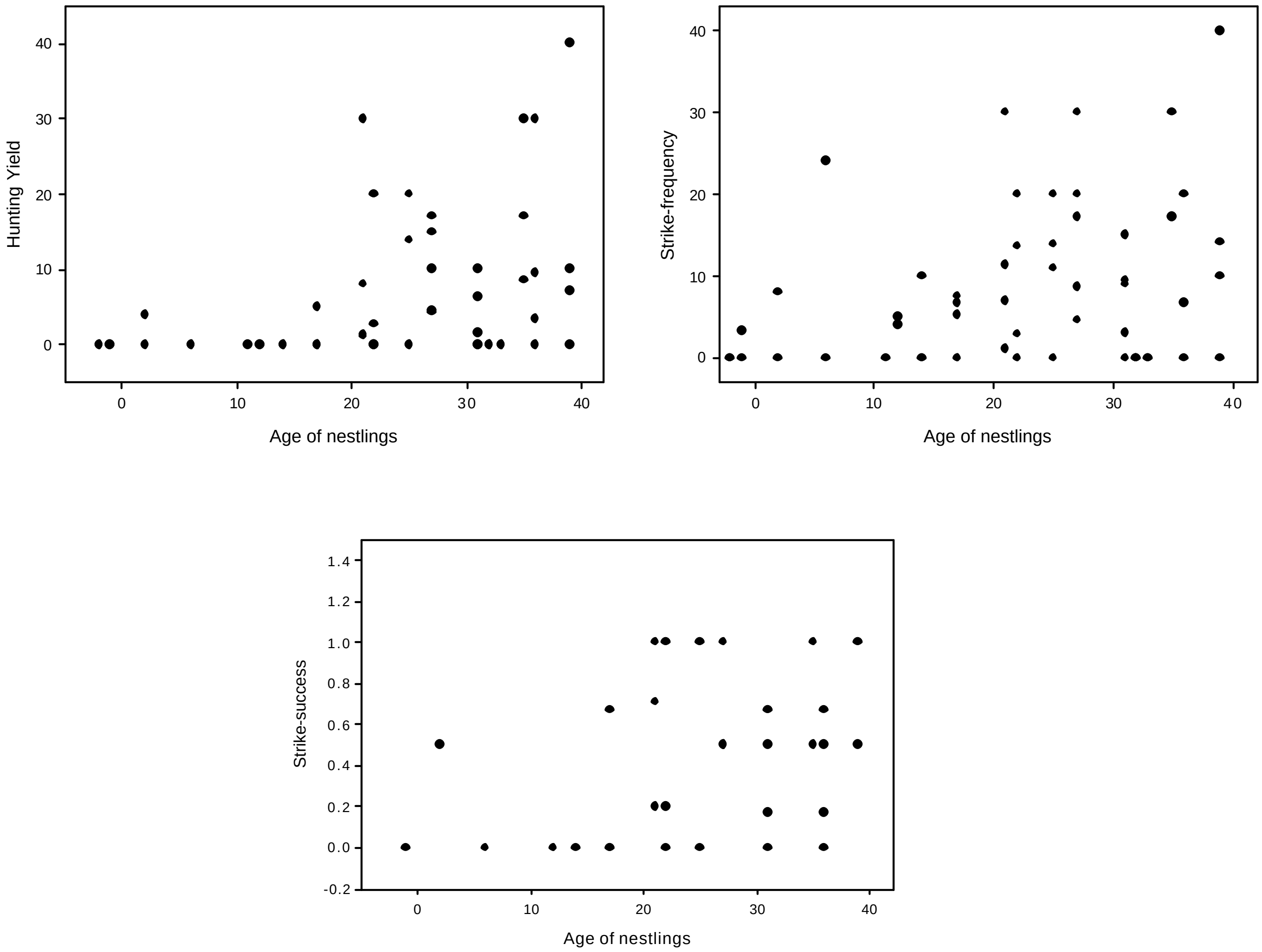


Fig. 3. Hunting-yield, Strike-frequency and Strike-success in relation to age of the nestlings

Home range and habitat use

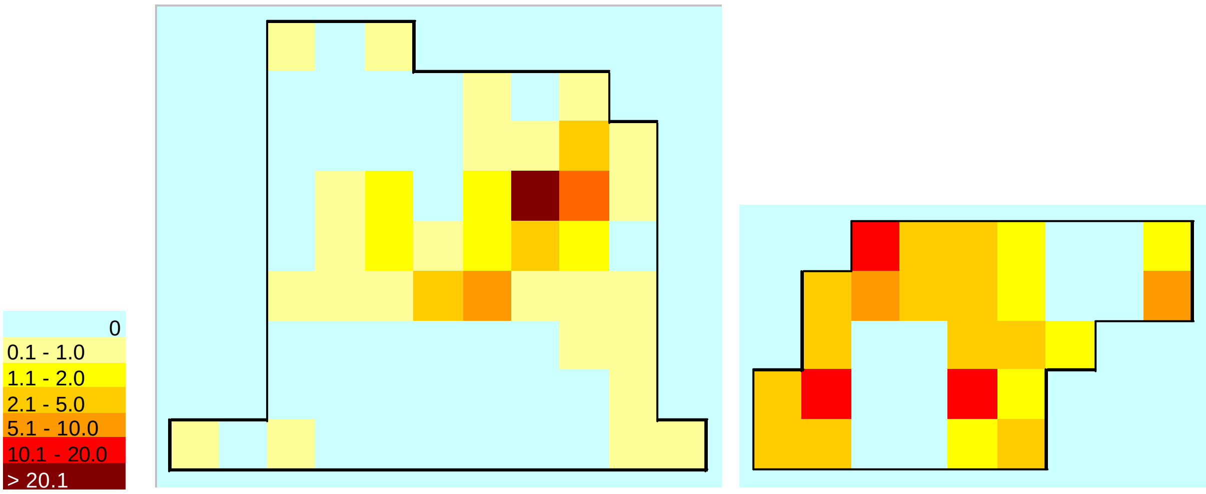


Fig. 4. The home-ranges of male Korengarst (left) and of male Blijham (right)
Colours represent the relative amount of sightings in a Km-square

Home-range

The home ranges for the males in Korengarst and Blijham were calculated. Figure 4 shows the relative number of all sightings in a certain kilometre square. The home-rage of male Korengarst existed of app. 69 km^2 around the nest. In figure 3, the home range is shown, within the black-line. It shows dearly that the male was seen most of the time near its nest (km square 07-47-35, 195 sightings, 53.72% of all sightings). This male has more areas, which he visits often while hunting. The male did not often visits the outermost regions of the home range.
Male Blijham has a smaller home range of 33 km^2 around the nest. The male is seen most of the time near the nest (km-square 13-12-33, 12 sightings, 14.46% of all sightings). It shows also the favourite hunting spots of this male: 13-22-12 and 13-22-15: A fire-break in a forest and a nature-reserve with lots of grass-land.

Vegetation in home-range

The home range of male Korengarst existed mostly of grains, potatoes and infrastructure (table 2). The male spent his hunting-time mostly on grass, Lucern and grass-seed (table 2). These vegetation-types are also the vegetation that can be mowed.
Most of the prey the male has been seen catching, were caught in Lucern, grass and grass-seed (total n=52) (table 2).The home range of male Blijham existed mostly of grains, infrastructure and grass (table 2). The male spent his hunting-time mostly on grass, Lucern, grain and unknown vegetation (table 2). The first 2 types were also the vegetation types that can be mowed.
Most of the prey the male has been seen catching, were caught in Lucern although the number of prey we actually saw him caught is very low (n=5) (table 2).

The distribution of prey-captures in the vegetation types was significantly different from the expected distribution based on the available area of vegetation types in the home range ($\chi 2=453.25$, df=9, $p<.000$). More prey-captures than expected were made on Lucern, grass-land and grass-seed (fig 5a). In contrast less prey-captures than expectes were made on grain, potatoes, sugar-beets, maiz, meadow and forest.

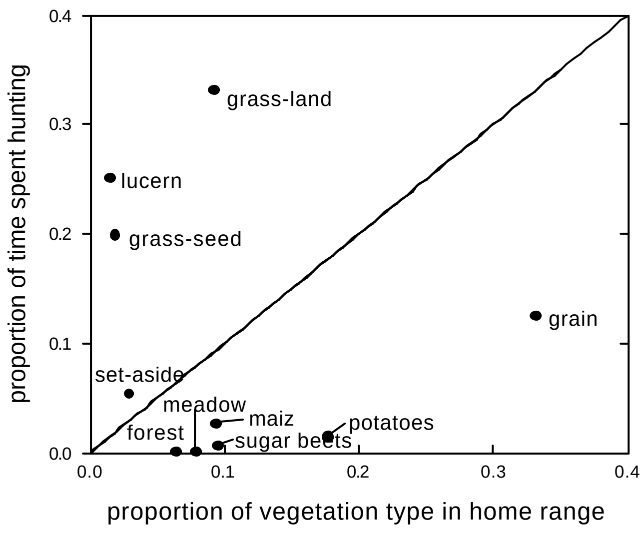
The distribution of captured prey in the vegetation types was not significantly different from the expected distribution of prey based on the times spent hunting on the vegetation types ($\chi 2$=8.63, df=6, n.s.) (fig 5b).

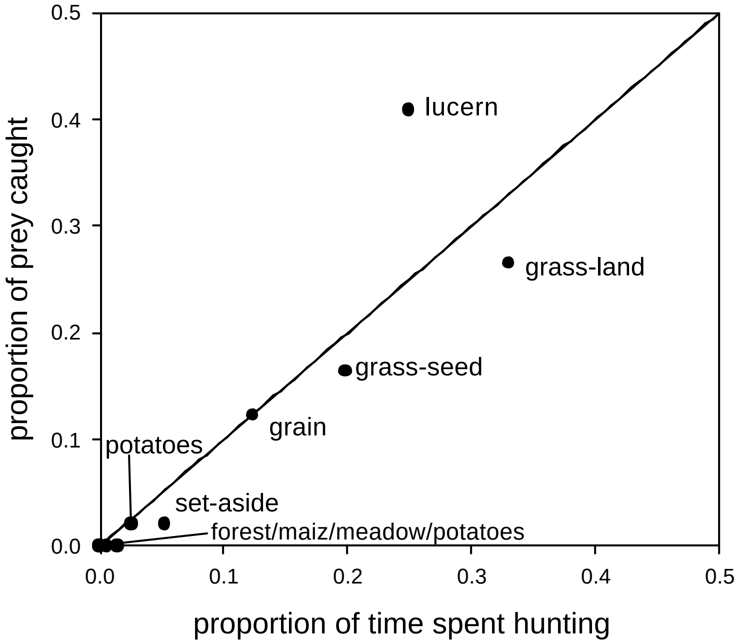
The distribution of time spent on the different vegetation-types was not associated with the distribution of vegetation-types available in the home range (r_s = -.255, df = 9, p =.476). Though there are very strong indications that this was also very different from each other. Spearman-Rank correlation showed that the association between both variables was not significant (fig 5c).

***Table 2**: Vegetation in home ranges Korengarst and Blijham: distribution over the area, distribution of time hunting and distribution of caught prey.*

The category 'Rest' includes Infrastructure (21.2% surface resp 13.8% surface), water (0.9% resp 0.7%) and unknown vegetation (7.2% resp 0.6%). These categories are left out of the analysis

Vegetation	**% surface**		**% time spent hunting**		**% prey caught**	
	Korengarst	Blijham	Korengarst	Blijham	Korengarst	Blijham
Potatoes	12.4	2.7	1.3	0	0	0
Grain	23.0	44.9	11.2	11.9	11.5	0
Grass-land	6.5	10.3	29.8	51.1	25.0	20.0
Grass-seed	1.3	0.05	17.9	0	15.4	0
Meadow	5.5	5.4	0	0	0	0
Sugar-beets	6.5	6.6	2.3	0	1.9	0
Lucern	1.1	1.2	22.5	11.9	38.5	40.0
Maiz	6.6	3.5	0.5	0	0	0
Forest	4.5	3.3	0	6.3	0	0
Set-aside	2.0	2.5	4.7	4.8	1.9	0
Other	1.2	3.8	2.7	3.3	3.9	20.0
Rest	30.5	18.9	7.1	11.5	1.9	20.0
N=	69 km^2	33 km^2	950 min	270 min	52	5





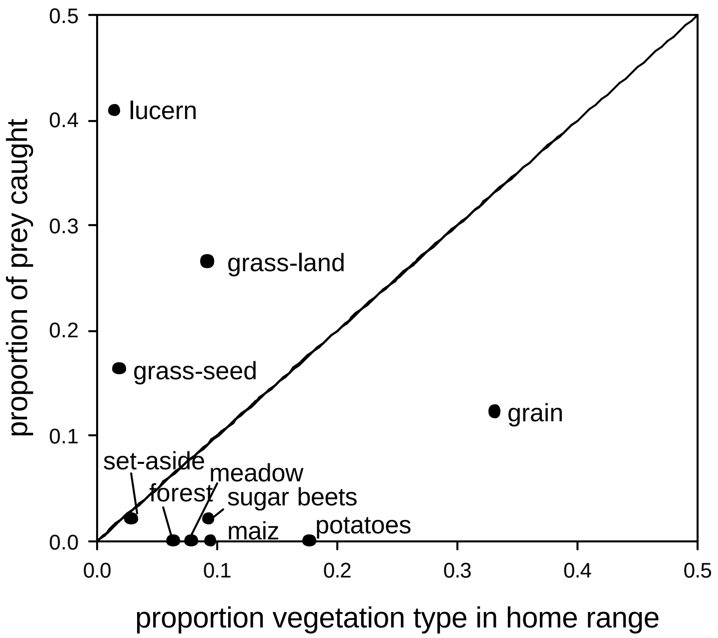


Fig. 5. Relation between the proportion of vegetation type in home-range, proportion of time spent hunting and proportion of prey caught in male Korengarst

Discussion and Conclusion

The age of the nestlings cq date of the year had the strongest effect on hunting-yield, strike-frequency and strike-success. It was difficult to distinguish between these 2 factors. Age of the nestlings and date may both influence hunting behaviour. The relationship between date and hunting-yield is not supprising for later in the season more prey is available through reproduction and so hunting yield will be higher as has been shown in the European Kestrel (Masman 1986). It is also possible that later in the season prey become more accessable through e.g. mowing activities and increased vole surface activity in daytime. This may also cause hunting-yield and strike-success to increase.

Mowing had an positive effect on strike-success when divided into not mowed, freshly mowed and old mowed it. Hunting males tended to make less strikes on freshly mowed plots but had a significant higher strike-success and therefore tended to have a higher hunting-yield on freshly mowed plots. This clearly indicates the benefits of hunting on freshly mowed plots for Montagu's Harriers, as has already been proven for the European Kestrel (Dijkstra et al. 1995).

The estimated home-ranges of the males Korengarst and Blijham were resp. 69 km^2 (6900 ha) and 33 km^2 (3300 ha). From literature it is known that in general Montagu's Harrier have large home-ranges (854 to 2346 ha, by radio-telemetry, France (Salamolard 1997)). The 2 Dutch male had much larger home-ranges. Cause of the very large home-ranges in the observed males may be found in differences in habitat and vegetation compared to the France study. The Dutch Montagu's Harriers breed in agricultural areas where prey may not be abundant in comparison to areas with more natural vegetation. This may also be indicated by the 2 males observed. Male Blijham has been frequently observed hunting in a grassy nature-reserve nearby its nest. The home-range of this male is two times smaller than male Korengarst who had no such area in the proximity of its nest. Favourable spots nearby may decrease home-range sizes considerably.
Another explanation of the large home-ranges may be found in the possible preference for hunting on sandy soils. There are indications that both males tended to spent their hunting-time on fields on sandy soils instead of fields on clay soils nearby. This tendency has to be tested further. Probably preferred hunting spots on sandy soils are further away from the nest of male Korengarst compared to male Blijham which caused a larger home-range in male Korengarst.

Males may want to spend as less energy in hunting as possible and may choose to hunt on good hunting grounds in the proximity of the nest. Larger hunting distances may indicate poor circumstances for hunting and this may force the male to extended hunting trips. From literature (Cramp & Simmons 1982; Clarke 1996) it is know though that Montagu's Harriers spend much time hunting far away from the nest. Although this seems energeticly costly it has to be taken into account that the gliding way of foraging of the harriers is a relatively low-cost hunting method (Pennycuick 1972; Clarke 1996) compared to more active way of foraging of e.g. Falcons (Masman 1986).

Male Korengarst spent more time than expected hunting on the vegetation types Lucern, grass-land and grass-seed. The male also caught more prey on these vegetation types than expected, based on the surface available of these vegetation types. The results are as we expected from our observations. From vole census held in august 2003 it appeared that these 3 types contain large numbers of potential prey (Koks, pers comm.(Trierwieler 2004). Normally these prey are not easy accessable for hunting males because of the dense cover, but when mowed, they become available for raptors as Montagu's Harrier. This explains why mowing has a significant effect on strike-success. Freshly mowed fields contain the largest number of available prey, which can be seen in the positive effects of freshly mowed fields on hunting-yield and strike-success as expected.
The expected frequency of prey caught in the vegetation types based on the time spent on the vegetation types is for most types approximate to the actual number of caught prey, except for Lucern. The male caught more prey in Lucern than was expected on the base of time spent

there. Males hunt exclusively on mowed Lucern. This indicates that mowed Lucern is excellent hunting ground, although our vole-census does not indicate this. The number of voles caught in Lucern during the census is average. The high strike-success may be due to dead or injured voles caused by the mowing machine. It may also indicate that male Korengarst put extra time in hunting on Lucern.

It was expected that set-aside fields and strips are very important hunting areas (Koks, pers. comm). In this study it proved not to be important, at least not in the nestling period. Probably set-aside may be a very important vegetation type for hunting in the early breeding season, especially because mowing of grass starts early summer and mowing of Lucern and grass-seed only mid-summer. This hypotheses has to be tested in future pre-breeding seasons.

The results of this study may be taken into consideration in future conservation plans on Montagu's Harriers. Vegetation type and mowing appears to be important in hunting. Stimulating farmers to grow more of the preferred vegetation types in areas with nests may help hunting males. This can be established by subsidized crop-growing.

Tracking male Montagu's Harriers is a very difficult and exhausting job and one would expect data on hunting behaviour and habitat-use to be more precise and reliable when the birds are observed for more hours a day or at least for longer observation bouts. For this, tracking and observing one bird with e.g. 2 teams by car consisting of each 2 persons, who would be in constant contact with each other, would be a great improvement. Even more ideal would be a presence of a permanent station at the nest besides the observation-teams. Observing hunting males in the incubation period may give an even better view on hunting behaviour and habitat-use but it is questionable if catching males very early in the season is feasible. Most breeding pairs are not even found that early in the breeding season, males are not as nest-bound early in the season as they are later on and are not as used to the catching-pole yet. Since this study was the first conducted in the Netherlands, results can only improve.

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Appendix 1: Overview on the observation-days

Date	Pair	Age nestlings	Observers	Nestobserv	Data used
6-17	Blijham	2	CT & MdV	-	Yes
6-24	Korengarst	-2	CT & MdV	No	Yes
6-25	Korengarst	-1	CT & MdV	No	Yes
6-26	Blijham	11	CT & MdV	-	Yes
6-28	Korengarst	2	CT & MdV	No	Yes
6-29	Blijham	14	CT & JM	-	Yes
6-30	Blijham	15	CT & MdV	-	No
7-1	Blijham	16	CT & MdV	-	Yes
7-2	Korengarst	6	CT & MdV	No	Yes
7-3	Blijham	18	CT & MdV	-	Yes
7-7	Korengarst	11	CT & MdV	HH	Yes
7-8	Korengarst	12	MdV	HH	Yes
7-10	Korengarst	14	MdV	CT	Yes
7-11	Blijham	26	MdV	-	Yes
7-13	Korengarst	17	MdV & BK	CT	Yes
7-16	Blijham	31	MdV	-	Yes
7-17	Korengarst	21	MdV & MvM	HR, CT	Yes
7-18	Korengarst	22	CT & MdV	No	Yes
7-21	Korengarst	25	MdV & BK	CT	Yes
7-22	Blijham	37	CT & MdV	-	Yes
7-23	Korengarst	27	MdV & BK	CT	Yes
7-24	Blijham	39	MdV	-	No
7-27	Korengarst	31	CT & MdV	No	Yes
7-28	Korengarst	32	MdV & BK	CT	Yes
7-29	Korengarst	33	MdV & EV, & BK	CT	Yes
7-31	Korengarst	35	MdV	CT	Yes
8-1	Korengarst	36	MdV	CT	Yes
8-2	Korengarst	38	MdV	CT	No
8-4	Korengarst	39	CT & MdV	No	Yes

Notes on observers:

CT: Chris Trierweiler
BK: Ben Koks
HH: Hans Hut
EV: Erik Visser
MdeV: Marlien de Voogd
JM: Jeroen Minderman
MvM: Marjan van Meerloo
HR: Hans Rademakers

Appendix 2: Overview on vegetation types used in binary logistic regression analysis of hunting-yield

code	vegetation
0	Unknown
1	Grass-land, Hay-land, Meadow
2	Grass-seed
3	Set-aside fields, set-aside strips
4	Lucern
5	Wheat, Barley, Oat
6	Sugar-beets
8	Other: Rough, dikes, sides of roads and ditches, forest-edges, plot-edges, rape
12	Potatoes
13	Maiz
16	Forest