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Using time-lapse video monitoring to study prey selection by breeding Goshawks *Accipiter gentilis* in Central Norway

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Two nests of breeding goshawks were monitored by means of time-lapse video monitoring in boreal coniferous forests in Central Norway in 1996. One was located in a large-scale forestry area, the other in a mixed agricultural/forestry area. Altogether 311 prey items were registered during 915 hours of recordings and 75 remain items were collected at or near the nests. About 70% of the prey were identified to family level or higher from video, but species identification was more difficult. In contrast, ca. 85% of remain items were identified to species level. The video method proved superior in detecting unfeathered young and small prey, and it was fairly reliable and involved little disturbance. Thrush-sized birds (fledglings/juveniles) were the dominating prey group. Line transects showed a high abundance of thrush-sized passerines, but low densities of larger prey. At the first site the proportions between prey groups found by video corresponded to those from line transects. At the second site there was a significant preference for thrush-sized birds, and the overall prey density there was twice that of the first area. Significantly larger prey were brought to the nests in the last part of the breeding season when both parents hunted, compared to the early part when the male was hunting alone. Video monitoring is a valuable tool for studying the food brought to the nest by raptors, as it is able to provide better quantitative information on prey selection and the differences between the sexes regarding hunting effort and prey choice.

1. Introduction

The main aim of this study was to test the use of video monitoring equipment of food brought to Goshawk nests. This was done in combination with bird censuses along transect lines in their nesting areas to study prey selection. Earlier studies have revealed that much new detail emerges by using automatic recording devices (Wille & Kampp 1983). We also wanted to compare automatic recording to the classical remains-collecting method during the same study, to evaluate the suitability of each for future work of this type. Such tools may help to improve the understanding of Goshawk breeding biology, and may be used to improve the habitat quality of the Goshawk in the boreal forests. Due to limited resources we only studied two nests in one season, and the results regarding prey selection must therefore be seen in this context, and treated with due caution.

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2. Material and methods

2.1. Study area

The study was carried out in two areas, Mosvik on the north side, and Inderøy on the south side of the Trondheimsfjord, Nord-Trøndelag county, central Norway, between 63°45′–55′N and 10°35′–11°13′E. The altitude ranged from 150 to about 500 m a.s.l. in Mosvik and 0–200 m in Inderøy. One Goshawk nest was studied in each area in the breeding-season of 1996. The nests were located in mature Norway spruce *Picea abies* stands. Both areas were influenced by activities of forestry and farming. The relative distribution of land cover types was estimated using satellite images from a Landsat V scene taken on 6 Sep 1996, track 199, frame 15. Open water was omitted from calculations. The breeding territory in Mosvik was mostly covered by conifer forest (ca. 67%), dominated by Norway spruce and Scots pine *Pinus sylvestris*, often found in admixture with birch *Betula pubescens*. The main forestry practice involves large clear cuttings of mature stands subsequently being replanted with Norway spruce. The coverage by deciduous tree species was ca. 18%, including clearcuts in which birch had grown to a fair size. Open areas with heath and bogs were common (ca. 13%). The agricultural activities were modest and dominated by small-scale sheep and cattle farming (ca. 2%). The farming was more diverse in Inderøy, where small and medium-sized farms for milk, vegetable and cereal production surrounded the forest patches, and they accounted for ca. 44% of the area. Smaller woodlands and edges of shrubs and deciduous trees often separated the fields. Norway spruce mixed with Scots pine and deciduous tree species dominated the forest. The conifers amounted to ca. 41% of the area, and deciduous tree species ca. 14%. Clear cuttings were small and replanted by spruce. Bogs amounted to only ca. 0.3% of the land, while ca. 2% was urban land

2.2. The video study

The set-up of the video equipment in relation to the nest is shown in Fig. 1a, and the camera housing and mounting in Fig. 1b. A coaxial cable (RG58) connected the camera to a time-lapse video recorder. Another 1.5 mm^2 cable delivered power to the camera from a battery that was charged by a solar panel. To prevent power loss during night a diode was mounted on one of the cables from the solar panel. The bracket and the cylinder were sprayed with black paint. The time-lapse video equipment was mounted and the recordings started 5–7 days after hatching and lasted until the adults stopped bringing prey to the nest. The recording rate was 48 frames per minute. In Mosvik we used a GP-KR222E Panasonic Industrial Colour CCD camera with 16 mm/2.8 aperture lens (minimum illumination; 3 lux at F1.4 + 0 dB gain setting, horizontal resolution 480 lines), a TLVCR 964 Asutsa time-lapse video recorder (horizontal resolution 260 lines) powered via a 9150 Mascot 220 V inverter and a 12 V 75 Ah battery charged by two 51 W solar panels. In Inderøy a DXC-101 Sony CCD camera with a Tamron TV-zoom-lens 8–80 mm/1.2 aperture (minimum illumination; 30 lux at F1.4 + 12 dB gain setting, horizontal resolution 320 lines), a TLS 1500P Sanyo time-lapse video recorder (horizontal resolution 250 lines), one 51 W solar panel and a 75 Ah battery were used.

The videotapes were played back on the Sanyo 1500P and viewed on a 20" colour TV. The prey items were identified from size, colour of feathers or fur, bill and legs. Many of the prey items were completely or partially plucked and some were brought to the nest as parts. In many cases, only the birds' legs were visible, and the morphology and size of these were used for classification. In Mosvik the birds were marked by rings and radio transmitters. Time and date were registered automatically on the video recordings. The nest in Mosvik was video monitored 14 June–19 July 1996 and the one in Inderøy 9 June–19 July 1996 (Fig. 2). Due to technical problems involving power failure (less power than expected was delivered from the solar panel) and insufficient training of personnel, the system in Mosvik gave less recording time than in Inderøy. About 90% of the prey items were delivered during recordings (Table 1), the rest were collected on the nests when the cameras needed restarting after power-failure.

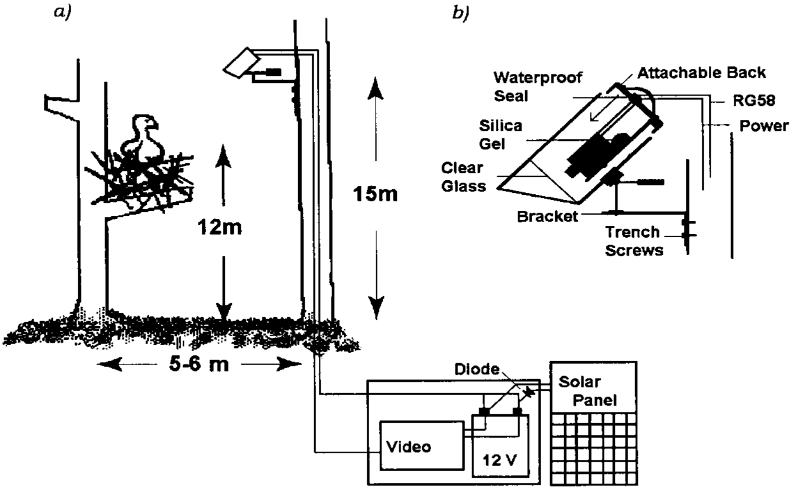

Figure 1. a) The video equipment was mounted in a neighbouring tree with the camera aimed down at the nest at an angle of ca 45 degrees from a distance of 5–6 m. The video recorder and battery were placed in a waterproof box on the ground together with one or two solar panels. **b)** The camera was placed in a waterproof PVC-cylinder with a built-in clear glass window, protecting it against rain and sun glare. To prevent condensation, silica gel packages were placed in the cylinder. A removable back was pressed into the cylinder and sealed. A bracket was used to attach the cylinder to the tree with trench-screws.

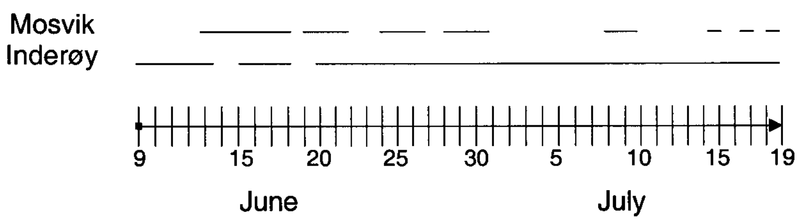

Figure 2. The lines indicate the periods covered by video recordings at the two sites.

2.3. Prey remains

During the nesting period the Goshawk plucks its prey on particular places close to the nest (Sulkava 1964). Fallen trees, stumps, big stones and other outcrops within 200 meters of the nests were systematically searched for prey remains at most visits during 1 June–15 August 1996. Pellets were not collected, as raptors digest most skeletal parts (Opdam et al. 1977). At the end of the breeding season the nests themselves were also searched. The Goshawk sometimes plucks a prey on different locations (Sulkava 1964). Selås (1989a) proposed that the probability of the hawk to switch place while plucking a prey is dependent on the handling time of the prey. The larger the prey, the larger is the chance of the hawk to switch place. To prevent double counting we therefore carefully checked primaries and secondaries with feathers collected from other plucking locations at the same time. A pair of legs of the same species, sex and age collected at the same time from two close pluck-

Table 1. The numbers of identified prey items present on the nests at the start of recordings, delivered during recordings, and the total number of hours recorded at the different sites.

Site	Prior to recordings	During recordings	Total	Hours recorded
Mosvik	10	80	90	300
Inderøy	17	204	221	615
Total	27	284	311	915

ing places was therefore counted as one individual. Identification from feathers was done through comparisons with bird skins at the Museum of Natural History and Archaeology of Trondheim. Skeletal remains were identified and determined to species by the staff of the Museum of Zoology in Bergen. The number of each species identified from skeletal remains was compared to the number identified from feathers. The highest number was used (Sulkava 1964). The same method was used with feathers collected on the nest.

2.4. Bird censuses

The relative bird density was obtained from line censuses as described by Bibby et al. (1992), but one of the transect lines in each of the areas extended into the middle of the day. In Mosvik and Inderøy the total transect lengths were 23.4 and 11.5 km respectively, and all lines were censused three times throughout the breeding season. The parallel lines were located in the nesting habitat. The length of the lines were 0.85–1.85 km, placed at least 200 m away from a neighbouring line. On each side of the line all the observation units (singing male, pair, female, a party of fledglings) were registered. Two adjoining 50 m belts were split in an inner 25 m (belt 1) and an outer 25 m belt (belt 2) (Fig. 3). Birds more than 50 m away from the line were assigned to an outer belt (belt 3) of infinite width. The birds were assigned to the belt where they were first observed, using the perpendicular distance from the transect line. To adjust for species differences in detection rate a correction coefficient was computed as

$$k = 40 - 40 \times \sqrt{1-p} \qquad (1)$$

where p is the proportion of observations in belt 1 (Järvinen & Väisänen 1983). For thrush-size and smaller birds only observations within belts 1 and 2 were noted, while for larger species observations in belt 3 were recorded also. Using the correction coefficient the density (D; observation units ("pairs") of birds per km^2) was computed for each species by the equation

$$D = N \times \frac{k}{L} \qquad (2)$$

where N is the sum of observation units in all belts and L is the total length of the transect lines in the area. Some species were not observed during transects, but were observed present in the area or in the remains. Wood pigeon *Columba palumbus* was not observed in belt 1 in Inderøy. The density obtained from a similar Goshawk nesting area in an area nearby (Levanger) was therefore used (own unpubl. data). Likewise, the density of Hooded Crow *Corvus corone* was set to 0.5 pairs/km^2, a mean value obtained from transects in forested areas in Trøndelag (P. G. Thingstad pers. comm.).

2.5. Prey weights

Young thrushes are unfeathered up to the age of about 5 days. A juvenile Blackbird *Turdus merula* weighs 30 grams at that age, which is 30% of the adult mass (Glutz von Blotzheim & Bauer 1988). Unfeathered thrushes were therefore assigned 30% of their adult weights. The weight of young Blackbirds levels off at 75 g (Glutz von Blotzheim & Bauer 1988). This is about 75% of adult weight (Haftorn 1971), and was used to estimate the weight of unidentified feathered juvenile thrushes in general. It was not possible to identify unfeathered thrushes to species. We therefore calibrated the weight of this prey group using the numerical relationships in the remains collected at or near each nest. In Mosvik, e.g., there were 12 small thrushes (Redwing *T. iliacus* and Song Thrush *T. philomelos*) and eight Fieldfare *T. pilaris*. The weight of an unfeathered young was therefore set to $(20{\times}12 + 32{\times}8)$g/20 = 25 g. The same procedure was applied to the Inderøy material, which gave a weight of unfeathered young of 30 g. As above, we used frequency data from the remains at each nest to estimate the weight of juvenile and adult thrushes of unknown species. We used 350 g as the weight of juvenile Hooded Crows (Rofstad 1986). One young undetermined Magpie *Pica pica* or Hooded Crow was assigned the average weight of these species. From skeletal remains, a Mountain Hare *Lepus timidus* was estimated to be a subadult, and its weight was set to 1 500 grams using the weight curves in Walhovd (1965). The weight of a Red Squirrel *Sciurus vulgaris* was set to 300 grams (Engelstad 1990). Birds smaller than thrushes were excluded from the analyses regarding prey selection.

2.6. Data analyses

When testing frequency distributions on the nominal level, the log-likelihood ratio test (G-test) (Sokal & Rohlf 1995), with Williams correction was used. A Mann-Whitney U-test was used to test prey numbers and weights between sites. All statistical analyses, except for the G-test, was carried out in SPSS/Windows version 8.0 (Norusis 1993). The level of significance was set to $P < 0.05$.

3. Results

3.1. Time-lapse video versus remains

About 99% of the prey were identified to family or higher level from remains, as compared to 87–89% from video (Table 2). However, the video method recorded a larger number of prey; more than 90 and 221 prey items at the respective sites, while only 45 and 30 were found as remains. The remains method identified more species than video; 15 vs. 11 in Mosvik and 12 vs. 4 in Inderøy. When the bird prey were classified to age, the two methods gave significantly different prey age distributions (more young birds) in Inderøy (G_3, $P < 0.001$) and showed a noticeable tendency also in Mosvik (G_3, $P = 0.063$) (Table 3). Caution must however be taken due to the large number of prey of undetermined age. There were 35.4% of prey of unknown age in Mosvik and 49.0% in Inderøy. At both sites, 2.0% of adults were registered from video, while the proportions were 11.6 and 41.4%

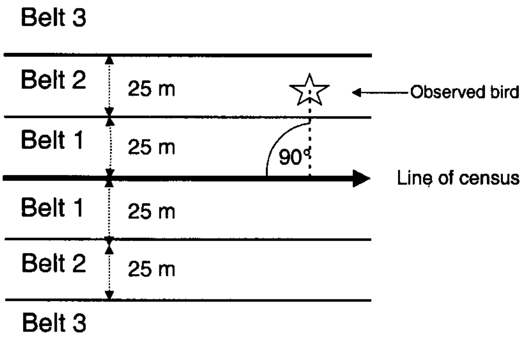

Figure 3. The transect line with inner (b1), and outer (b2) belts of 25 m each, and an outer belt (b3) of indefinite width. The observed bird was assigned to the belt where it was first detected using the perpendicular distance from the transect line.

in the remains. Unfeathered young were only registered by video. Significantly more small prey were identified from video vs. remains in Inderøy (G_1, $P < 0.001$), but not in Mosvik (G_1, $P = 0.357$) (Table 4).

3.2. Prey selection

Thrush-sized birds dominated in both sites, while larger prey had low occurrence (Fig. 4). In Inderøy, the overall density of birds and the density of thrushes were nearly twice as high as in Mosvik (Table 5). No significant prey preference was found in Mosvik (G_4, $P = 0.82$), contrary to Inderøy where there were far more thrush-sized birds in the video-material than was expected from the line transects (G_3, $P < 0.01$).

Table 2. Identification levels of prey recorded by video 9 June–19 July and of remains collected 1 June–15 August.

Identification level	Mosvik				Inderøy			
	Video		Remains		Video		Remains	
	N	%	N	%	N	%	N	%
Species	23	25.6	36	80	5	2.3	28	93.3
Family	57	63.3	8	17.8	187	84.6	2	6.7
Unidentified	10	11.1	1	2.2	29	13.1	0	0
Total	90	100	45	100	221	100	30	100

3.3. Goshawk sex and prey size

The female in Mosvik was radio-tagged on the 25th of June. She was registered far away from the nest for the first time on 5 July, and from that date we assumed that both parents were hunting. In Inderøy, the video recordings indicated that the female started to spend more time away from the nest, probably for hunting, from ca 1 July. In the period when both parents were assumed hunting, they were identified to sex in 57.1% of the deliveries in Mosvik and 39.1% in Inderøy (Table 6). This difference was partly due to a better camera in Mosvik, and partly because the adults in Mosvik were marked. The average weights of the prey items delivered in the first period by both sexes combined were significantly lower than those delivered in the second period in both areas (Mann Whitney U-test, Z = -2.3,1, P = 0.02 (Mosvik), Z = -4.06, P < 0.01 (Inderøy), Table 6, tested values in underscored bold italics). The male alone delivered smaller prey in the first period than in the second, but not significantly (Mann Whitney U-test, Z = -1.63, P = 0.10 (Mosvik), Z = -1.35, P =

Table 3. The age distribution of bird prey of identified species at or near the Goshawk nests as determined from video and remains.

Age	Mosvik				Inderøy			
	Video		Remains		Video		Remains	
	N	%	N	%	N	%	N	%
Juveniles	47	57.3	26	60.5	85	42.9	7	24.1
Unfeathered young	4	4.9	0	0	12	6.1	0	0
Adult	2	2.4	5	11.6	4	2.0	12	41.4
Unknown	29	35.4	12	27.9	97	49.0	10	34.5
Total	82	100	43	100	198	100	29	100

Table 4. The number of the different prey groups as determined from video recordings and remains at Mosvik and Inderøy.

Prey group	Mosvik		Inderøy	
	Video N	Remains N	Video N	Remains N
Finch size	4	4	3	1
Thrush size	58	25	186	18
Sum small prey	62	29	189	19
Corvids	2	1	2	6
Grouse	6	5	0	1
Pigeons/ducks/Woodcock	2	7	0	0
Waders/gulls	5	1	1	3
Unident. bird >thrush	5	0	6	0
Mammals	2	1	0	1
Sum large prey	22	15	9	11
Total	84	44	198	30

0.18 (Inderøy), tested values in underscored plain bold). The female in Inderøy did not bring significantly larger prey than the male during the second period (Mann Whitney U-test, Z = -0.92, P = 0.36). The overall prey delivery rate showed a decreasing tendency throughout the season, but expressed as weight units per hour, the rate was stable or increased (Fig. 5).

4. Discussion

4.1. Choice of method

Collection of remains from nests and plucking places has been the most common method used to study the Goshawk's diet (Sulkava 1964, Tornberg 1997). However, the method is known to overestimate large prey and underestimate small (Sulkava 1964, Selås 1989a). Some of the studies have involved complementary study methods e.g. 1) direct observations of nests with binoculars (Sulkava 1964, Lørdahl 1975), and 2) the cage method (Höglund 1964), where the chicks are kept in a cage on the nest and prey is collected after each delivery. The first method gives good data of delivery rates, activity and sex-roles, but is very time-consuming. The second method gives a more correct picture of the prey brought to the nest, but

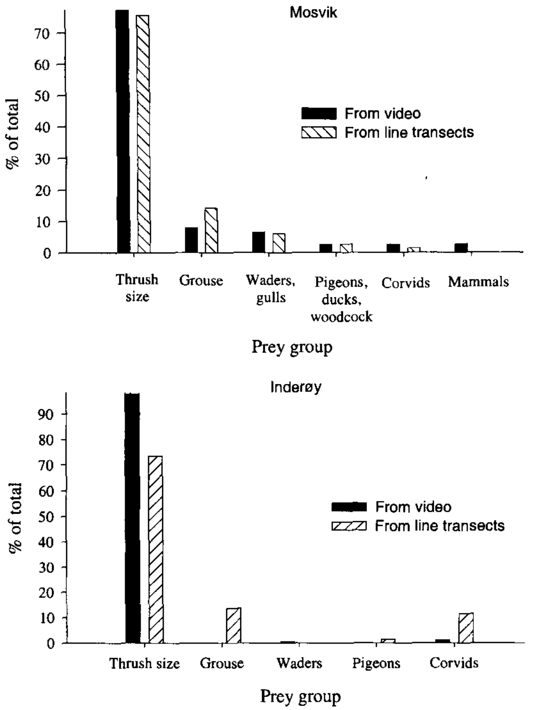

Figure 4. The percentage of prey brought to the nest in Mosvik (upper) and Inderøy (lower) as determined by time-lapse video recordings and the percentage of available prey estimated from line transects in the same area and period (prey smaller than thrushes and unidentified birds were excluded).

Table 5. The densities of available bird prey larger than finch size (D = pairs/km^2) compared to the number delivered as prey in Mosvik and Inderøy. The expected number of each prey group was calculated as ((Density of prey group)/(total density)) x (number of prey recorded on video). ND = No data.

Prey group	Mosvik			Inderøy		
	Avail.	Deliv.	Exp.	Avail.	Deliv.	Exp.
Grouse	5.1	6	11	8.8	0	27
Corvids	0.5	2	1	7.3	2	22
Pigeons/ducks/Woodcock	0.9	2	2	0.9	0	3
Waders/gulls	2.2	5	5	ND	1	ND
Unident. birds > thrush	5			6		
Sum large birds	8.7	20	19	17.0	9	52
Thrush size	27.1	58	59	47.1	186	143
Total	35.8	78	78	64.1	195	195

involves a high grade of disturbance and much field effort. Compared to these methods, video monitoring requires little field effort, involves a low degree of disturbance and provides good data on activity and sex roles at the nest. Recently video has been used in studies of Common Buzzard *Buteo buteo* (Hubert et al. 1994), White-tailed Sea Eagle *Haliaeetus albicilla* (Staven 1994) and Osprey *Pandion haliaetus* (Kristian et al. 1996).

4.2. The video method

Rain and moisture did not affect the system even though the temperature ranged from approximately + 4 to + 25° C. A fully charged battery provided power for an average of 49.8 and 34.1 hours of recording in Inderøy and Mosvik, respec tively. From the technical specifications of the camera, video recorder and cables the power consumption was computed to be 22.4 and 26.6 W. Theoretically, the systems should run for 40.2 and 34.1 hours using 12V/75Ah batteries. These values were close to the actual recording times and indicate that the solar panels had surprisingly little effect. Consequently, batteries had to be charged and replaced every second day. Factors such as shadowing by large trees and prevalent cloudy weather may have contributed to the low charging efficiency by the solar panels. In lack of external power sources future video studies could take advantage of using systems requiring less power, involving use of wireless transmission of the camera signal (Kristian et al. 1996). The power-consuming video-recorder or PC can then be placed several kilometres away and powered by a local AC or DC source. Fibre optics may also be used to transmit the signals up to a few km. When the sun casts strong shades on the nest, the pictures become difficult to analyse. Most of the recorded images, however, were clear, showing details of the chicks' and parents' feathers and of the prey, and even of small insects moving in the nest bowl.

The different light sensitivity and resolution of the cameras led to marked differences in prey identification rates between sites (Table 2), the oldest equipment yielding poorest results. The Mosvik site had both the best video-recorder and the best camera. Overall, ca. 88% of the prey were categorised to the level of family or better. The low number of remains collected per territory has been a characteristic of most Goshawk studies. The video technique is an improvement since all prey items delivered to the nest can be registered. Therefore, it is especially well suited for the study of prey delivery rates.

The fact that unfeathered young were completely eaten and that thrush-sized and smaller birds left very few feathers made species identification difficult. In addition, the female regularly cleans the nest early in the nestling period (Sulkava 1964, own obs.). The main difference between the two methods was therefore the video's superiority in recording small and unfeathered young bird prey. The treatment of some prey items such as plucking, dividing and sometimes decapitation prior to delivery made determination and classi-

Table 6. The numbers of prey delivered in the nestling period by the male and the female, the mean weight (M.W.) in grams ± SD. The nestling period is divided in two; 1) the early period when only the male was hunting, and 2) the later period when both adults were hunting. For the numbers in underscored bold and italics, see text.

Site Period	Male			Female			Unknown			Group totals		
	No.	M.W.	SD	No.	M.W.	SD	No.	M.W.	SD	No.	M.W.	SD
Mosvik												
1	56	**85**	74							56	***85***	74
2	14	**167**	208	2	181	168	12	312	434	28	***231***	322
Inderøy												
1	111	**69**	15							111	***69***	15
2	24	**72**	11	10	92	56	53	68	101	87	***92***	58

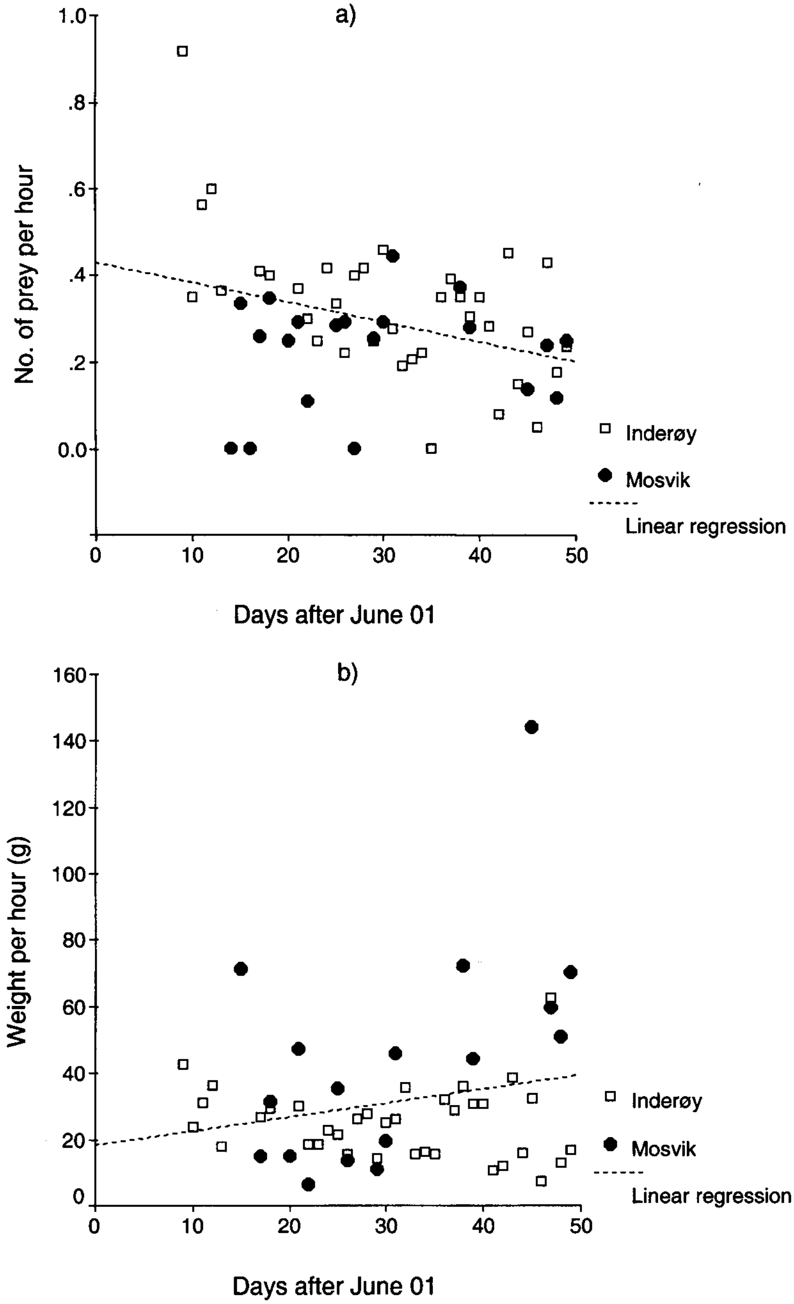

Figure 5. The number and weight of prey delivered to the nest per recording hour during the nesting season in a) Mosvik, and b) Inderøy. Days with no prey deliveries are excluded.

fication difficult. Sometimes the parents or the young obstructed the view of some prey. The system has inherent low resolution, thus making the quality of the video camera and recorder very essential. The digital systems now available have large potential for the improvement of the remote recording technique.

It is probable that not all prey items were brought to the nest. Small prey may often be eaten by the parents, as it might not be energetically economic to carry them to the nest (Orians & Pearson 1979). As the female does not hunt in the period from incubation until late in the nestling phase (Sulkava 1964), it is clear that both methods reflect mainly male hunting and therefore give a larger proportion of small prey than later in the breeding season. On the other hand, some large prey like Mountain Hare and Capercaillie *Tetrao urogallus* may be underestimated since they are too large for the hawks to be carried whole, (Bernhoft-Osa 1973), increasing the risk that other predators remove them before they are brought to the nest (Selås 1989a).

Identification of the parents' sex when bringing prey to the nests was difficult as the camera covered only the nest bowl. This caused problems when they were sitting on the edge of the nest or on branches next to it, as did blurring caused by rapid movements. Setting the zoom lens to a high focal length facilitated identification of the prey but sacrificed some opportunities to identify the parents. We recommend use of a zoom setting that covers the whole nest including the rim. The results from Mosvik showed that video equipment of good quality still allows most prey items to be identified.

4.3. Prey availability

The censused area represented 6 and 2 km^2 in Mosvik and Inderøy respectively. (Nygård et al. 1998) found that Goshawks in this part of the country have home-ranges of 25–150 km^2 in the breeding season. It is therefore likely that our line transects were not fully representative of the whole hunting area. Using the mapping method (Enemar 1966) Tømmerås et al. (1997) found a density of 19 pairs of thrushes/km^2 in the Mosvik area in the same year. Our somewhat higher estimate (27 pairs/km^2) may be caused by chance effects (heterogeneity of the habitat) and methodical differences.

4.4. Prey selection

Small proportions of large prey were found in the diet (Table 7) and during censuses (Table 6). This was in contrast to other studies that reported grouse, corvids, Red Squirrel *Sciurus vulgaris* and pigeons to be the most important food during the nestling period (Sulkava 1964, Lindén & Wikman 1983a, Selås 1989b). In northern America the Goshawk selected its hunting habitats (moderately dense, mature forests) more by prey availability than by prey density (Beier & Drennan 1997). On this background, it was not surprising to find thrush-sized birds as the most important prey by number and weight. This has not been recognised by studies of collected remains only (Sulkava 1964, Opdam 1975). However, using direct observations Lørdahl (1975) revealed thrushes as important food (Table 7). There was no preference for high prey weight in our study (see also Tornberg 1997).

In Inderøy we found the selected proportion of thrush-sized birds to be significantly higher than

Table 7. Percentages of prey by numbers (No%) and weight (W%) in the nestling season observed by video (own obs.) and data from direct observations of Goshawk nests in Southern Norway 1973—75 (Lørdahl 1975) and in Finland 1954—56 (Sulkava 1964). ND = no data.

Method	Video				Direct observations			
Locality	Mosvik		Inderøy		Vegårshei		Finland	
Species	No%	W%	No%	W%	No%	W%	No%	W%
Grouse ssp.	7.1	13.9	0	0	5.7	ND	45.7	54.3
Thrush size	69.0	30.7	93.9	85.1	65	ND	6.0	ND
Corvids	2.4	6.2	1	3.9	10	ND	11.2	10.3
Sparrow size	4.8	0.7	1.5	0.3	10	ND	6.0	ND
Mammals	2.4	16.1	0	0	5	ND	21.8	ND
Others	14.3	32.3	3.5	10.7	4	ND	9.3	14
Total	100.0	100.0	100.0	100.0	99.7	ND	100.0	ND

available. On the other hand, the Goshawks in Mosvik acted as generalists taking prey according to the proportions available. However, the relatively small censused area in Inderøy may have led to inaccuracy of the density estimates, and the interpretations therefore must be made with caution. The difference in behaviour might be due to area differences. The higher density of thrush size birds in Inderøy could have led to a functional response involving switching. The high prevalence of young birds as prey during the nestling period have also been reported in other studies (Sulkava 1964, Selås, 1989b, Tornberg 1997).

4.5. Difference between the sexes.

Our results support the view that female European Goshawks catch larger prey than males (Höglund 1964, Opdam 1975, Kenward et al. 1981), which may reduce intersexual competition for available food, and broaden the combined food niche. Boal and Mannan (1996) did not find such differences between the sexes of the subspecies *A. g. atricapillus* in Arizona, but in their case mammals accounted for about 80% of the food, compared to 95% birds in our case. The increase in prey size in the late nestling period was probably mainly due to the female participation. The Goshawks seem to have compensated the lower prey delivery rate late in the fledgling period by catching larger prey (Fig. 5) to meet the increasing need of food by the growing chicks (Lindén & Wikman 1983b). This has also been documented for the Sparrowhawk (Newton 1989). As the male often delivers prey to the female near the nest, it can seldom be proved which of the sexes actually made the kill. However, our telemetry studies (unpublished) showed that the female used as large an area and as much time for hunting as the male from the time she started to participate, indicating an active role as a provider for the chicks.

5. Conclusion

We consider the ability of the video to register small prey, especially unfeathered and young birds, a major improvement, as it gives a more correct picture of the diversity, size and age of the prey items of the Goshawk. The video method gives very good quantification of the prey brought to the nest and of the events taking place at the nest. It provides good identification to the family level, but poor on the species level and of prey age compared to studying remains. The video method proved to be relatively reliable and involved little disturbance. Disadvantages of the system are high initial costs and the time required to study the video recordings. With access to a reliable power source only the storage capacity of the videocassettes will limit the system. With better cameras and especially digital recording devices the quality of the pictures will improve, making automatic time-lapse recording even more useful for the study of raptor and other birds' diets in the future.

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Sammanfattning: **Bruk av 'time-lapse' video övervakning i studiet av bytesval hos häckande duvhök *Accipiter gentilis* i Mitt-Norge.**

Två bon med häckande duvhök i boreal barrskog i centrala Norge bevakades med 'time-lapse' video i 1996. Det ena boet låg i ett område med storskaligt skogsbruk, det andra i ett område med blandat jordbruksmark och skog. Sammanlagt 311 bytesobjekt registrerades under 915 timmar med videoupptagningar, och lämningar av 75 byten insamlades på eller intill bona. Omkring 70% av bytena kunde identifieras till familjenivå eller högre från videon, men bestämning till artnivå var svårare. Däremot kunde ca. 85% av bytesresterna bestämmas till art. Videometoden visade sig vara överlägsen i att upptäcka icke fjäderklädda, unga och små byten, den var tämligen tillförlitlig och förorsakade lite störning. Fåglar av traststorlek

(nyligen flygga ungar och juveniler) var den dominerande bytesgruppen. Linjetransekter visade riklig förekomst av traststora tättingar men låga tätheter av större byten. Vid den första lokalen överensstämde proportionerna mellan bytestyperna som registrerades med video med dem som registrerades från transekten. Vid den andra lokalen var det en signifikant preferens för fåglar av traststorlek, och den sammanlagda bytestillgången där var dubbelt så stor som vid den första lokalen. Signifikant större byten togs till bona under den sista delen av häckningen, när båda föräldrarna jagade, jämfört med den tidigare perioden när endast hannen jagade. Bevakning med videokamera är en värdefull metod för att studera byten tagna till boet av rovfåglar, eftersom den ger bättre kvantitativ information om bytesval och skillnader mellan könen i bidrag till jakten och i bytesval.

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