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Diet of Common Buzzards (*Buteo buteo*) in southern Norway determined from prey remains and video recordings

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We examined the diet of six breeding Common Buzzard (*Buteo buteo*) pairs in southern Norway, by analysing pellets and prey remains collected around and in nests, and by video recording prey delivery at the nests. Mammals, birds and reptiles were the major prey groups. Amphibians were underestimated when identified from pellets and prey remains compared to video recording, while birds >120 g were overestimated. Selection of avian prey was studied by comparing the proportions of different weight groups of birds among prey with their proportions in the bird community, as estimated by point counts around each nest. Common Buzzards selectively preyed upon medium-sized birds and neglected many of the numerous small passerines.

1. Introduction

The majority of studies on the diet of Common Buzzards (*Buteo buteo*) conducted in northern, eastern and central Europe identify voles as the most important prey, with birds as an important alternative prey (Pinowski & Ryszkowski 1962, Spidsø & Selås 1988, Reif *et al.* 2001). Studies conducted in Great Britain and Spain indicate lagomorphs (Graham *et al.* 1995, Mañosa & Cordero 1992) and birds (Tubbs & Tubbs 1985) as primary prey groups. Medium-sized birds dominate among avian prey taken (Tubbs & Tubbs 1985, Spidsø & Selås 1988, Jedrzejewski *et al.* 1994, Selås 2001). The diet of the Common Buzzard has usually been studied by analyses of prey remains and regurgitated pellets (e.g. Spidsø & Selås 1988, Mañosa & Cordero 1992, Graham *et al.* 1995, Reif *et al.* 2001). The accuracy of such methods depends on whether different types of prey are truly represented in the pellets and prey remains. The wide variation in prey taken by buzzards increases the risk of errors due to different digestibility of different prey groups (Simmons *et al.* 1991). Suomus (1952) assessed buzzard diet in Finland by direct observation. His results on some of the prey groups differed significantly from that of other studies conducted in northern Europe, indicating a problem of bias when diet studies are based on analyses of pellets and prey remains.

A raptor is likely to prefer prey that gives the highest net energy gain in relation to the costs of

prey handling (e.g. Krebs & Davies 1993). Prey with low profitability should not be selected when prey with higher profitability are available (Swann & Etherigde 1995). The Common Buzzard is not morphologically well adapted to hunt birds (Tubbs & Tubbs 1985), and compared to ground-dwelling animals like mammals, reptiles and amphibians, birds are probably less profitable (e.g. Newton 1979).

However, within each of these prey categories, there is probably an optimal prey size. For Common Buzzards in Norway, any preference for prey size should be easiest to detect among avian prey, because of the high species diversity and thus size diversity of this group. Such size-dependent prey preference has been reported for the sympatric bird-specialized raptors Sparrowhawk (*Accipiter nisus*)(e.g. Selås 1993, Solonen 1997, Rytkonen *et al.* 1998, Solonen 2000) and Goshawk (*A. gentilis*) (e.g. Selås 1989, Tornberg 1997).

We have studied the diet of Common Buzzards in southern Norway by collecting pellets and prey remains in and around six nests, and by video recording the same nests. The latter method is judged to be the best indicator of diet because it represents a direct account of what breeding buzzards bring to the nest (Kochanek 1990, Simmons *et al.* 1991). The aim of our study was to describe the diet of breeding Common Buzzards, compare the two methods of diet estimation, and to examine selection of avian prey in relation to their availability.

2. Materials and methods

2.1. Study area and study species

In spring 2003, eleven Common Buzzard pairs, all showing signs of breeding performance, were monitored in the main study area in Aust-Agder County (58°35'–58°46' N; 8°45'–8°51'E). In spite of an intermediate vole population, four of these buzzard pairs abandoned their nests in May, possibly because of much rain. Because we were not able to make video records on two of the remaining nests, we did not obtain data from more than five nests this year. As six individuals are regarded as an absolute minimum for composite analyses (Aebischer *et al*. 1993), we investigated one more nest in 2005. For practical reasons, this was done in Akershus County (59°34' N; 10°44'E).

The study area in Aust-Agder, described by Selås (2001), is dominated by different age-classes of coniferous and mixed forests, though intermixed with bogs, small lakes and some agricultural land (< 2%). In the study area in Akershus, the general land productivity and thus the proportion of agricultural land is much higher (37%), but the structure of the forests around the selected buzzard nest is rather similar to that of the former study area. In both areas, the relatively strong fragmentation of the small-sized forest stands of different age-classes results in a variation in landscape composition within each Common Buzzard territory.

2.2 Analysis of prey remains

Most pellets and prey remains were collected at plucking posts close to the nests (usually <50 m from the nest). The area around each nest was searched for pellets and prey remains in the evening after each video recording session. To reduce disturbance, climbing of the nest trees was usually avoided during the nestling period. When the fledglings had left the nests, nest trees were climbed to search for pellets and prey remains in the nests. In total, all nest sites were visited four or five times to collect pellets and prey remains during this study.

A total of 105 pellets and 42 prey remains were collected, from which 148 prey items were detected. Most mammals and reptiles were identified from pellets, but one Mountain Hare (*Lepus timidus*) and some reptiles were identified from prey remains (skin). Mammals were identified from skulls or teeth in pellets. Each pellet containing more than 33% reptile scales was counted as one reptile individual (see Selås 2001). Reptile scales were identified as either Slow-worm (*Anguis fragilis*), Smooth Snake (*Coronella austriaca*) or unidentified snake. Unidentified snake-scales were either Adder (*Vipera berus*) or Grass Snake (*Natrix natrix*). One Common Lizard (*Lacerta vivipara*) found in this study was identified from skin remains. All birds and amphibians were identified from prey remains. Because Com-

Table 1. Information for each of the six investigated Common Buzzard nests. Five prey items that could not be identified are omitted from the video recording list.

Nesting territory	Study area and year	No. of young	Hours of video recording	Video rec.	No. of prey pellets and prey remains
1	Aust-Agder, 2003	1	27	8	20
2	Aust-Agder, 2003	1	27	15	33
3	Aust-Agder, 2003	2	27	15	30
4	Aust-Agder, 2003	2	27	17	16
5	Aust-Agder, 2003	2	21	19	17
6	Akershus, 2005	2	23	8	32
Total		10	152	82	148

mon Buzzards pluck birds before eating them, bird prey could be identified to species from wing and tail feathers. A few birds were identified from skeletal remains.

2.3. Video recordings of prey deliveries

Video recording was conducted during late May and June, when nestlings were 5–25 days old. The recordings normally started at around 08:00 and ended around 17:30. Four nests were video recorded for nine hours in each of three days, one nest was video recorded in two days, for twelve and nine hours, and one in three days for eight, nine and six hours (Table 1).

Each nest contained one or two nestlings. The video recordings were obtained by mounting a Hi8 video camera recorder (Sony CCD-TR748E, 20× optical zoom) on a special mounting bracket, usually in a tree near the nest. For one nest, situated in a cliff, the camera was mounted on a regular tripod placed on the ground. When the camera had been mounted and adjusted towards the nest, the recordings were made continuously, only interrupted by the change of videocassettes every third hour and ten minutes.

In Aust-Agder, four of the nests were located in relatively steep terrain with a general good view over the surroundings, so that the buzzards could follow the movement of the observer when he withdrew from the area after having started the recording or changed the videocassette. We therefore doubt that our disturbance influenced on the results obtained by the video recording, although there is the possibility that disturbed adult buzzards will consume some small prey themselves, instead of bringing them to the nest. The buzzards recorded in Akershus seemed to be more adapted to human disturbances, and at the last visit, the female returned to the nest when the observer was still searching for prey remains approximately 50 m from the nest.

Out of the 87 prey items delivered during the video recordings, 82 were identified to species or group of species (snakes, thrushes, small passerines, unidentified birds or small mammals). The remaining five prey items were impossible to identify either because branches or the buzzards themselves hid the prey from the camera's view. The fact that birds had often been plucked before delivery made further identification difficult, but most of them could be classified to one of the three size categories used (see below).

Rodents and shrews could often be identified by studying ear size and tail length, in addition to the coloration of the fur and shape of the head. Reptiles were distinguished mainly by the coloration, but the Slow-worm could also be identified because it is somewhat less agile than snakes. The two amphibian species identified, Common Frog (*Rana temporaria*) and Common Toad (*Bufo bufo*), were distinguished by the coloration and the texture of the skin, and by the length of their hind legs.

Because video recordings were conducted in restricted periods of the breeding season, where also early morning and evening hours were omit-

ted, the results are not directly comparable with the prey remain collections, which reflected most of the breeding season. Rather, the video recording should be regarded as a sample-inquiry to reveal serious biases connected to the prey remain method. This could be achieved if some prey occur in much higher numbers or proportions during the video recordings than in the prey remain collections.

2.4. Bird census data

The relative occurrence of different species in the bird community around each nest was estimated using the point count method. A total of 20 point count stations were laid out in a fixed pattern around each nest. With the nest as centre, five stations were placed 200 m apart (300 m in Akershus because of longer distances between buzzard nests) in each cardinal point around the nest, starting 200 m from the nest (300 m in Akershus). A GPS-receiver (Garmin GPS 12XL) was used to locate the points. Except from survey points in lakes, all environments were included, regardless of their possible suitability as buzzard hunting habitat. All birds seen or heard within 50 m of survey points were recorded during a 7-min period. The survey was not conducted on days with heavy rain or high wind. Bird surveys were conducted between 26 May and 14 June. Surveys started at around 0500 h and were completed by 0900 h. During the study a total of 585 individuals of 46 bird species were recorded.

The avian prey selection was examined by use of compositional analysis (Aebischer *et al*. 1993), which is based on proportional utilisation by individual animals. The first step is to test whether the utilization of prey is random or not. This is a multivariate test based on the log-ratio differences between available and utilised prey for each individual. If the utilization differs from random, the next step is to make an inter-comparison of all pairs of relative use of prey with data from each buzzard nest. The different prey categories can then be ranked in relation to relative use, and significant between-rank differences can be located (Aebischer *et al.* 1993).

In the analyses, the bird species were divided into three weight groups, according to their mean adult body weight as given by Haftorn (1971): (1) <50 g, (2) 50–120 g and (3) >120 g. All juveniles, except one Common Teal (*Anas crecca*) duckling, were assumed to weigh 80% of adults. The Common Teal duckling, identified on a videocassette, was estimated to weigh 60 g. With the given weight groups all juveniles, except the Common Teal duckling, were assigned the same weight group as adults.

The list of birds found as prey remains was supplemented with the birds identified on the videocassettes. Most birds delivered at the nest were partly plucked, possibly at a plucking post close to the nest, where we also collected prey remains. When a bird species was identified both on videocassette and as fresh prey remain at a plucking post on the same day, the bird from the videocassette was omitted. A bird not identified to species from the video recording, but to one of the three avian prey categories, was omitted if we on the actual day found prey remains from a species that belonged to the same prey category. On two occasions there were weight groups available but not utilized by the buzzard. As a zero value is invalid and cannot be used in the compositional analysis, the replacement values for the "utilized" proportions were set to 0.01 (Aebischer *et al*. 1993).

3. Results

Field Vole (*Microtus agrestis*) was the most common mammal species among prey detected from pellets and prey remains, followed by Wood Mouse (*Apodemus sylvaticus*), Bank Vole (*Clethrionomys glareolus*) and Common Shrew (*Sorex araneus*) (Table 2). Eighteen bird species were identified, ranging in size from Willow Warbler (*Phylloscopus trochilus*) to adult Common Teal (Table 2). The Jay (*Garrulus glandarius*) was the most common bird species, followed by Song Thrush (*Turdus philomelos*) and Blackbird (*T. merula*). The Slow-worm was the most frequent reptile (Table 2). A few amphibians, both Common Toad and Common Frog, were also found (Table 2), all identified from prey remains.

Small rodents and shrews made up 97% of the mammals identified from video recordings, with Bank Vole as the most common species (Table 2).

Table 2. Number of different prey species, with mean body weights (g) in brackets, identified at nest sites of six Common Buzzard pairs in southern Norway. Mean weights of amphibians, reptiles and mammals are based on measurements of both immature and adults collected by the authors, D. Dolmen and G. A. Sonerud (pers. comm.), whereas mean weights on adult birds are taken from Haftorn (1971). I = Video recordings, II = Pellets or remains.

Species	I	II
Amphibians		
Common Toad *Bufo bufo* (42)	3	1
Common Frog *Rana temporaria* (43)	6	2
Unidentified amphibians	0	1
Reptiles		
Slow-worm *Anguis fragilis* (16)	8	31
Lizard *Lacerta vivipara* (4)	0	1
Smooth Snake *Coronella austriaca* (62)	2	1
Grass Snake *Natrix natrix* (80)	4	1
Adder *Vipera berus* (61)	1	0
Unidentified snakes	2	13
Birds		
Common Teal *Anas crecca* (316)	1	2
Common Goldeneye *Bucephala clangula* (646)	0	1
Woodcock *Scolopax rusticola* (311)	0	1
Great Spotted Woodpecker *Dendrocopos major* (90)	0	1
Tree Pipit *Anthus trivialis* (22)	0	5
Pied Wagtail *Motacilla alba* (21)	1	0
Dunnock *Prunella modularis* (20)	0	2
Robin *Erithacus rubecula* (18)	0	2
Fieldfare *Turdus pilaris* (107)	1	1
Blackbird *Turdus merula* (100)	0	6
Song Thrush *Turdus philomelos* (75)	1	7
Redwing *Turdus iliacus* (68)	0	4
Unidentified thrushes	8	1
Willow Warbler *Phylloscopus trochilus* (9)	2	2
Goldcrest *Regulus regulus* (6)	0	1
Great Tit *Parus major* (18)	0	2
Red-backed Shrike *Lanius collurio* (34)	0	1
Jay *Garrulus glandarius* (161)	0	10
Magpie *Pica pica* (220)	0	1
Unidentified small passerines	8	3
Unidentified birds	4	0
Mammals		
Common Shrew *Sorex araneus* (8)	4	5
Eurasian Water Shrew *Neomys fodiens* (15)	1	0
Mountain Hare *Lepus timidus* (1,000)	0	1
Red Squirrel *Sciurus vulgaris* (273)	1	0
Brown Rat *Rattus norwegicus* (283)	0	1
Wood Mouse *Apodemus sylvaticus* (19)	2	12
Bank Vole *Clethrionomys glareolus* (19)	12	9
Field Vole *Microtus agrestis* (32)	5	16
Unidentified small mammals	5	0
Total	82	148

Table 3. Selection of different weight groups of avian prey by six breeding Common Buzzard pairs in southern Norway. The matrices give the mean log-ratio differences (mean ± SE) based on comparing proportional prey utilisation with proportional prey availability within the territory of each pair. Log-ratio differences are given above the diagonal, and the corresponding P-values subdiagonally. Rows are ranked according to the number of positive log-ratio differences.

Bird weight (g)	<50	50–120	>120	Rank
< 50		–4.704	–2.161	0
50–120	0.003		0.381	2
> 120	0.074	0.716		1

In addition to small mammals, one Red Squirrel (*Sciurus vulgaris*) was delivered. Most birds were small and medium-sized passerines (Table 2). Slow-worm was the dominating species among reptiles, but all three snake species present in the area were also recorded (Table 2). Finally, both Common Toad and Common Frog were delivered during the video recordings (Table 2).

The proportion of different prey groups differed significantly between the pellets and prey remains sample and the video recording sample (χ^2 = 9.72, d.f. = 3, P < 0.001; Fig. 1). This was mainly because very few amphibians were identified from prey remains. If amphibians were omitted, there was no significant difference between the two samples (χ^2 = 3.03, d.f. = 2, P = 0.219). The proportion of different groups of bird size also differed between the two sample methods (χ^2 = 8.42, d.f. = 2, P = 0.015; Fig. 2), as large birds (>120 g) appeared only as prey remains. When omitting birds >120 g, there was no difference between the two remaining weight groups (χ^2 = 0.41, d.f. = 1, P = 0.523).

When using the pooled material on bird prey, the proportion of the three weight groups of birds in the buzzards' diet differed significantly from that of the buzzard territories (Wilk's lambda = 0.107, χ^2 = 20.15, P = 0.003). In the inter-comparison of relative use of bird weight groups, bird species with mean weight 50–120 g ranked highest, followed by birds weighing >120 g, but the difference was significant only between birds weighing 50–120 g and birds weighing <50 g (Table 3).

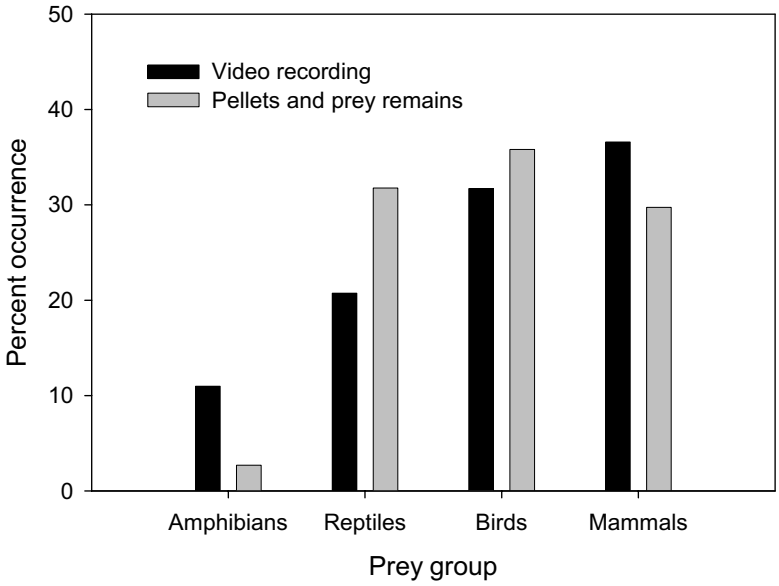

Fig. 1. Proportion of different prey groups identified by video recording (n = 82) and by analyses of pellets and prey remains (n = 148) from six Common Buzzard nests in southern Norway. Five unidentified prey items were excluded from the videotape data.

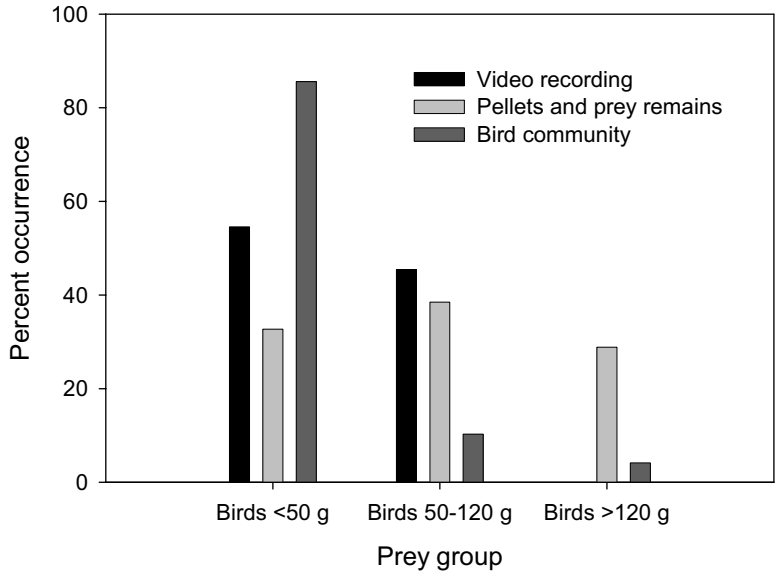

Fig. 2. Proportion of different weight groups of bird prey identified by video recording (n = 22) and by analyses of prey remains (n = 52) from six Common Buzzard nests in southern Norway, and the proportion in the bird communities according to point censuses.

4. Discussion

Although our data from only six Common Buzzard nests may be too small for strong conclusions, results are largely in accordance with former studies conducted in Fennoscandia, where small rodents have been the main prey and birds the most important alternative prey (Spidsø & Selås 1988, Reif *et al.* 2001, Selås 2001). In the present study, with intermediate rodent populations, mammals, birds and reptiles seemed to be of approximately equal importance, and the methods used did not discriminate significantly between these prey groups. It should be noted, however, that our study was not intended to reveal small differences in prey detectability.

Amphibians seem to be significantly underestimated when we estimated buzzard diet from pellets and prey remains. The videotapes show that amphibians constitute 11% of all identified prey,

while only 3% of the prey items identified from pellets and prey remains are amphibians. In fact, more amphibians were identified from video recordings conducted during 2–3 days at each nest, than from the combined prey remains on the entire nestling period. The main problem seems to be that amphibian bones are digested and not regurgitated as pellets as is the case for the scales in reptilian skin and bones of small mammals (Simmons *et al.* 1991). Buzzards will sometimes pluck female frogs and toads for eggs and also flay the toad before eating, but at the video recordings, the nestlings swallowed all frogs and toads without any plucking or flaying.

Suomus (1952), who estimated the diet of Common Buzzard using direct observation, found that amphibians were one of the major prey groups, compromising 21% of all prey identified. In contrast, Reif *et al.* (2001) found only 0.7% amphibians in a sample of 1,906 prey items, and Selås (2001) only 0.8% in a sample of 839 prey items. In Spain, amphibians constituted 8% of the prey from buzzard stomachs analysed in the winter, but only 0.1% of prey identified from pellets and prey remains collected in spring and summer (Mañosa & Cordero 1992). It seems evident then that this prey group is significantly underestimated when buzzards' diet are analysed from prey remains.

When considering the three weight groups of birds, there was a significant lower proportion of large species in the video sample, suggesting that large species are overestimated in the collections of pellets and prey remains. Most likely, the main reason for this discrepancy is that there will usually be more remains from large birds, because the buzzards will discard more of their feathers, and also their bones and legs (Goszczynski & Pilatowski 1986).

We found that birds weighing 51–120 g (mostly thrushes) were caught more often, and birds weighing <50g less often than expected from their proportion in the bird community. The utilization of birds >120 g did not differ from that of the other two size categories, but since we used the pooled material on bird prey, large birds were most likely over-represented in the sample. This should, however, not influence the conclusion with regard to the difference between small sizes and thrush-sized birds. There is the possibility that adult raptors feeding young at the nest eat smaller prey where they catch them and only bring larger prey to the nest (Sonerud 1992), but we find it unlikely that the load-size effect can account for the entire difference observed. The vulnerability of a bird species to avian predators will be influenced by habitat and foraging habits (Selås 1993). Hence, our results may partly reflect that more small passerines than thrushes are found in habitats (shrubs and young forests) that are too dense for the buzzards to hunt. However, we believe that this bias is reduced by the fine-grained mosaic of small-sized habitat patches in our study areas, because this means that a high proportion of dense habitats occurs as edges along habitats that are utilized by the buzzards, such as bogs, clear-cuts and old forests.

Common Buzzards are likely to neglect small birds because the energy gain obtained from these prey will be low compared to the time and energy spent hunting. In northern Scotland, a buzzard population feeding on large prey, including large birds, like adult Woodpigeon (*Columba palumbus*) and Pheasant (*Phaisianus colchicus*) chicks, produced twice as many fledglings per clutch laid compared to another population where passerines, like Meadow Pipit (*Anthus pratensis*) and Chaffinch (*Fringilla coelebs*), were the main avian prey (Swann & Etherigde 1995). The buzzard's dependence on medium-sized birds, especially thrushes, seems widespread in northern and central Europe (Tubbs and Tubbs 1985, Spidsø and Selås 1988, Jedrzejewski *et al.* 1994, Selås 2001), and is likely to reflect a specialization of the buzzard for hunting both adult and young thrushes.

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Hiirihaukkojen ruokavaliosa saalisjätösten ja videotarkkailun perusteella

Tutkimme kuuden hiirihaukkaparin ravinnonkäyttöä analysoimalla oksennuspallot ja saalisjäänteet pesimäpaikoilta sekä tarkastelemalla videolta pesille tuotuja saaliita. Tärkeimpiä saaliseläimiä olivat nisäkkäät, linnut ja matelijat. Saalisjäänteistä ja oksennuspalloista määritettynä sammakkoeläinten osuus saaliista olisi tullut aliar-

vioitua ilman videomateriaalia. Yli 120 g painvien lintujen osuus saaliista olisi vastaavasti yliarvioitu ilman videomateriaalia. Kun pyydystettyjen lintujen osuutta verrattiin vastaavan kokoisten lintujen osuuteen pesäpaikkojen ympäristössä, selvisi, että hiirihaukat suosivat saaliinaan keskikokoisia lintuja väheksyen määrällisesti runsaampia pieniä varpuslintuja.

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