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Seasonal composition of benthic macroinvertebrates in a spring-fed stream in the Garhwal Himalaya

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Abstract: Benthic macroinvertebrate communities are the excellent indicator of the health or characteristics of the freshwater environment. Present study investigated the seasonal composition of benthic macroinvertebrate communities in a spring-fed stream Takoli Gad in the Garhwal Himalaya, Uttarakhand (India). The altitudinal variations among the different sites influence these communities. Seasonally, genera belonging to order Ephemeroptera, Trichoptera, Coleoptera and Diptera are most important constituents of benthic communities at all sections. Ephemeropterans (47%) were most abundant during spring in downstream region whereas, trichopterans (43%) and Coleopterans (34%) were dominant during winter in midstream and upstream region. The dipterans constituted 24% during autumn in midstream region of the study stream. Plecopterans were also dominant during monsoon in upstream region. The composition of these communities depends upon the local and seasonal fluctuation in abiotic and biotic variables along with geology, land use, upstream–downstream location and vegetation in the riparian zone.

Keywords: Aquatic insects • seasonal composition • spring-fed stream • Garhwal Himalaya

Introduction

The biota present in freshwater habitats reflects the environmental conditions to which they are adapted. Changing environmental condition inevitably influence the ecosystem. Owing to their rapid responses to changing environmental conditions, invertebrate communities are excellent indicator of the health or characteristics of the freshwater environment (Wright et al., 1988). Modification of stream flow, channels, and riparian areas have much greater impacts on aquatic systems. Changes in attributes of streams, such as water discharge, seasonality, peak and lean flow, sediment transport, dissolved oxygen content and temperature regime as a result of development activities have imposed undue stress on the aquatic ecosystems.

The benthic macroinvertebrate have been frequently studied to evaluate streams conditions (Hynes, 1960). These organisms show a wide range of tolerances to varying degree of pollution. *In situ* assessment of environmental stress in aquatic communities has been increasingly utilized in biomonitoring programmes and toxicity test procedure (Wright et al., 1993; Vuori, 1995). Many studies have examined the relative importance of

different physical factors in structuring the benthic community (Culp et al., 1983; Growns and Davis, 1994; Quinn and Hickey, 1994; Robertson et al., 1995; Rempel et al., 2000; Balodi and Koshal, 2015; Koshal et al., 2016). Other factors that can vary seasonally and be important to aquatic insects include temperature (Vannote and Sweeney, 1980; Ward and Standford, 1982), oxygen (Jonasson, 1972; Nagell, 1981), water level (Wiggins et al., 1980) and food (Jonasson, 1972; Wallace and Merrit, 1980).

Variation in the composition of the regional species pool and local environmental conditions over space and time result in much variability in natural communities, but the composition of particular communities nonetheless is governed by a small number of underlying principles (Begon et al., 2005).

Garhwal Himalaya the source region of numerous streams and rivers. Numerous studies on benthic macroinvertebrates suggested that these communities have been used to assess the stream health. Yet, the benthic macroinvertebrate communities in streams in Garhwal Himalayan region remain poorly understood. Therefore, the present study investigated seasonal composition of benthic macroinvertebrate communities in different regions of a spring-fed stream Takoli Gad in the Garhwal Himalayan region of Uttarakhand (India).

Materials and Methods

Study area

The stream Takoli Gad is a small spring-fed tributary of the River Alaknanda of Uttarakhand. Geographically, the study area lies between longitude 78º38'30" to 78º42'45" and latitude 30º21'30" to 30º14'45" (Fig. 1).

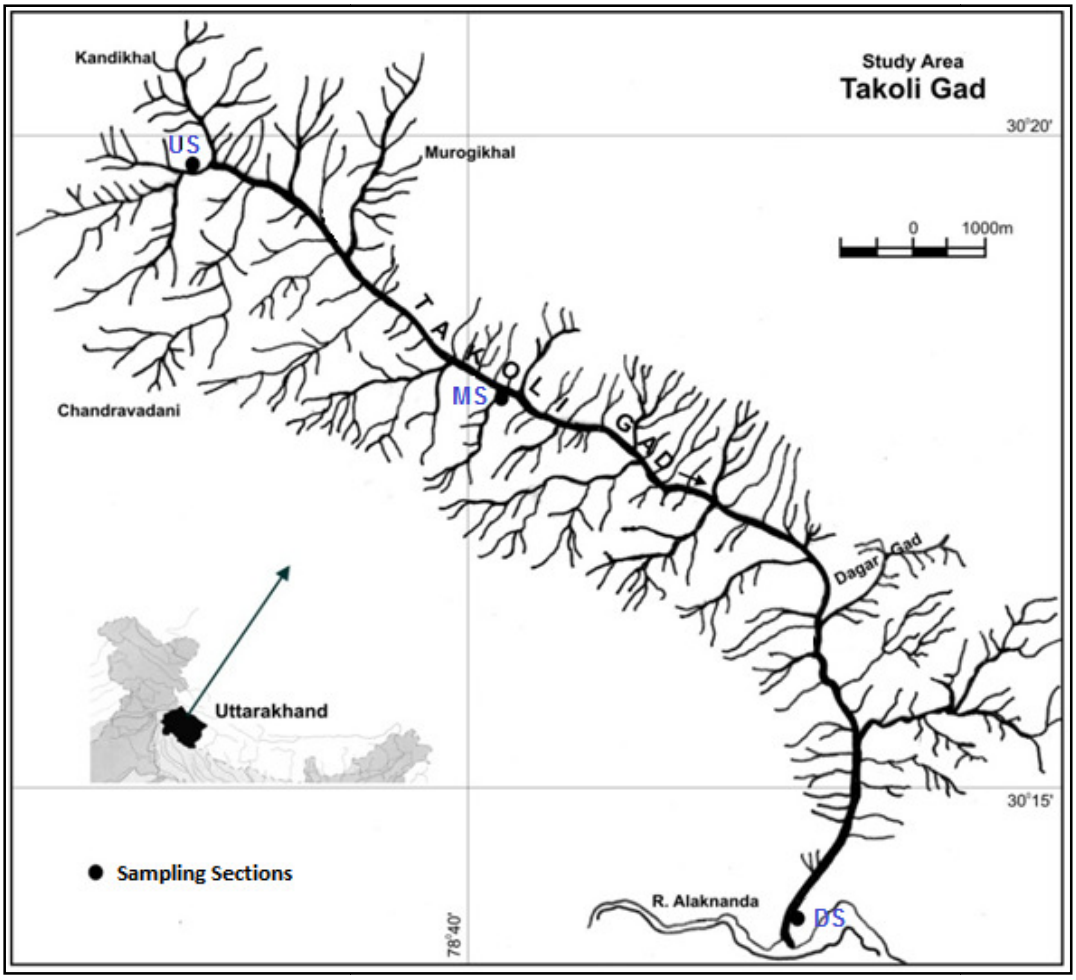

Figure 1 Location map of sampling sections at Takoli Gad.

The present study was conducted during January 2000 to October 2000. Located in the lesser Himalayan region, the study area experiences five more or less distinct climatic seasons namely, winter (November–February), spring (March–April), summer (May–June), monsoon (July–August) and autumn (September–October).

The natural vegetation of the Takoli Gad catchment is Himalayan sub-tropical forest, with the altitude varying from 560–1400m asl (above sea level) (Champion and Seth, 1968). After a preliminary reconnaissance survey of the study area three sampling sections were selected in Takoli Gad. These sections designated as upstream (US) at an altitude of 1100m asl (above mean sea level), midstream (MS) at 850m asl and downstream (DS) at 560m asl represented the altitudinal gradient along the stream.

Benthic macroinvertebrate collection and identification

Sampling to obtain data on benthic macroinvertebrates was undertaken monthly at all sections in Takoli Gad during January 2000 to October 2000. Benthic macroinvertebrates were collected from all the selected sampling sites following random sampling (Cummins, 1962) using modified Surber's square foot sampler (Welch, 1952). These were then transferred to a plastic container and preserved in 10% formalin solution (or 80% ethanol v/v) and taken back to the laboratory. Identification was carried out to the lowest recognizable level usually genera in the laboratory with the help of keys specified by Usinger (1956), Ward and Whipple (1959), Needham and Needham (1962), Usinger (1971), Macan (1979), Tonapi (1980) and Edington and Hildrew (1995).

Results and Discussion

A total of 29 genera of benthic macroinvertebrates were recorded in the stream during the present study. Of these, 7 genera belonged to Trichoptera, 6 to Ephemeroptera and Diptera, 4 to Coleoptera, 2 to Plecoptera and one each to Lepidoptera, Odonata, Hemiptera and Neuroptera (Table 1). Besides, some unidentified genera were also recorded during the present investigation, which have been assigned miscellaneous status. The altitudinal variations among the different sections and many environment variables may influence the distribution and abundance of benthic macroinvertebrate communities. Such as current, substrate temperature and sometimes water chemistry variables such as alkalinity and dissolved oxygen often are the most important variables in fluvial environments, and all organisms show adaptations that limit them to a subset of conditions (Allan and Castillo, 2007). Changes in local and seasonal abundances of the stream biota were response to flow variation. Total macroinvertebrate abundance exhibited a strong negative relation with average monthly rainfall (Flecker, 1992). *Ephemerella*, *Psephenus*, *Leptocella* and *Hydropsyche* were observed during all seasons in the stream throughout the study period. *Dryops* was present and *Corydalus* absent at only at downstream section (Table 1).

Seasonal composition of benthic macroinvertebrate

The benthic macroinvertebrate communities in different sections in Takoli Ggad were numerically dominated by aquatic insects (Fig. 2.1 & 2.2). Seasonally, order Ephemeroptera (15.0–47%), Trichoptera (11.0–43.0%) and Coleoptera (8.0–34.0%) were most important constituents of benthic macroinvertebrate communities at all sites during the present study. The highest percentage of Ephemeroptera, Trichoptera and Coleoptera were recorded during spring (downstream), winter (midstream) and winter (upstream) section respectively. Dipterans were more 24% during autumn in midstream region of the study stream (Fig. 2.1 & 2.2). Plecopterans were also dominant during monsoon in upstream region.

Variations in channel form such as pools, riffles, wide meander loops, and sand bars create variation in water width and depth (Gordon et al., 1992), which also creates microhabitat for aquatic biota. Also, occasional rainfall in dry seasons also altered the benthic communities. Although additional factors also influence the composition, including interactions among species and the taxon richness at

the regional scale, the abiotic environment provides an important starting point in investigations of species distributions and abundances (Allan and Castillo, 2007).

Table 1 Check list and occurrence of benthic macroinvertebrates taxa along different sections in Takoli Gad during January 2000 to October 2000.

Phylum	Order	Family	Genera	Upstream Section					Midstream Section					Downstream Section				
				WI	SP	SU	MO	AU	WI	SP	SU	MO	AU	WI	SP	SU	MO	AU
Arthropoda	Ephemeroptera	Heptageniidae	*Heptagenia*	–	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Class Insecta			*Rithrogena*	–	–	+	+	–	–	+	+	+	+	+	–	–	–	–
			Cinygma	+	+	–	–	+	+	+	+	–	+	+	–	+	–	+
		Baetidae	*Baetis*	+	+	+	–	+	+	+	–	–	+	+	+	+	+	+
		Ephemerellidae	*Ephemerella*	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
		Caenidae	*Caenis*	+	–	+	–	+	+	–	+	–	+	–	+	–	–	+
	Odonata	Gomphidae	*Hagenius*	+	–	+	–	+	–	+	+	+	–	–	+	–	–	–
	Plecoptera	Perlidae	*Perla*	+	+	+	–	+	+	+	+	+	+	+	+	+	–	+
			Isoperla	–	+	+	+	+	+	+	+	–	+	+	+	+	–	+
	Hemiptera	Corixidae	*Hesperocorixa*	–	+	+	–	–	+	+	+	–	–	+	+	–	–	–
	Neuroptera	Corydalidae	*Corydalus*	+	+	+	–	+	–	+	+	+	–	–	–	–	–	–
	Coleoptera	Psephenidae	*Psephenus*	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
		Dryopidae	*Dryops*	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–
		Elmidae	*Promoresia*	+	+	+	+	+	+	+	+	+	+	+	+	+	–	+
		Hydrophilidae	*Hydrophilus*	–	+	+	–	–	–	+	+	–	–	–	+	+	–	–
	Trichoptera	Hydropsychidae	*Hydropsyche*	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
		Philopotamidae	*Philopotamus*	–	+	+	+	+	–	+	+	–	+	+	–	+	–	+
			Chimarra	–	+	–	–	–	+	+	–	–	–	–	+	–	–	–
		Rhyacophilidae	*Rhyacophila*	–	+	+	–	+	–	+	+	–	–	–	+	–	–	–
		Glossosomatidae	*Glossosoma*	+	+	+	–	–	+	+	–	–	–	+	–	–	+	+
		Limnephilidae	*Limnephilus*	+	+	+	–	+	+	–	+	+	+	–	+	+	+	+
		Leptoceridae	*Leptocella*	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	Lepidoptera	Ichneumonidae	*Nymphula*	–	+	–	–	–	–	+	+	–	+	–	+	+	–	–
	Diptera	Blephariceridae	*Bibiocephala*	+	+	+	–	+	–	–	+	–	+	+	+	–	–	–
		Simuliidae	*Simulium*	+	+	+	+	+	–	+	–	+	+	+	–	+	–	–
		Athericidae	*Atherix*	–	+	–	+	–	+	–	+	+	+	+	–	+	+	–
		Chironomidae	*Chironomus*	+	+	+	+	+	+	–	+	+	+	+	+	+	–	–
		Tipulidae	*Hexatoma*	–	+	–	–	–	–	–	–	–	+	–	–	–	–	+
			Antocha	–	+	+	+	+	+	+	+	+	+	+	–	–	–	–
Miscellaneous				–	+	+	+	–	+	+	+	+	+	–	–	–	–	+

+ indicate presence; **–** indicate absence of benthic taxa

Frost (1942) reported the importance of the mayflies *Ephemerella* and *Baetis* among aquatic mosses, where they feed mostly on algae, but occasionally on bryophytes (Hynes, 1961; Chapman and Demory, 1963). The Caenidae are small sprawlers in quiet and sometimes stagnant water as well as streams (Caenidae, 2014). They are adapted to the relatively low oxygen of silt. When mosses

increased in growth downstream from impoundments, the Heptageniidae diminished or were eliminated completely (Brittain and Saltveit, 1989). Also, *Rithrogena* sp. avoided mosses. Trichoptera is a large order, surpassing Ephemeroptera, Odonata, and Plecoptera in the number of genera (Wiggins and Mackay, 1978).

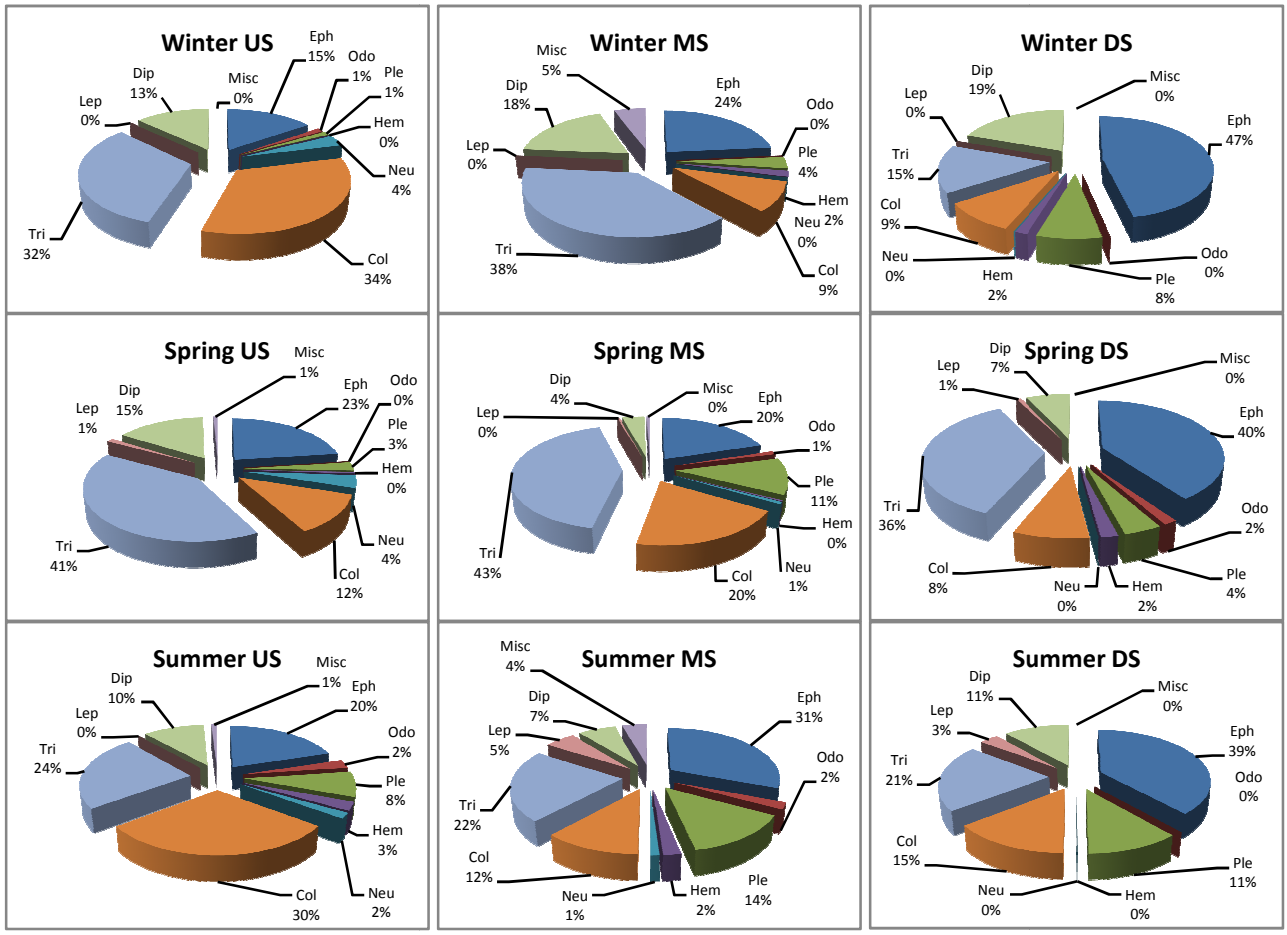

Figure 2.1 Seasonal composition (%) of various macroinvertebrate orders in Takoli Gad at sampling sections during the present study. (US=Upstream Section, MS=Midstream Section, DS=Downstream Section, Eph=Ephemeroptera, Odo=Odonata, Ple=Plecoptera, Hem=Hemiptera, Neu=Neuroptera, Col=Coleoptera, Tri=Trichoptera, Lep=Lepidoptera, Dip=Diptera, Misc=Miscellaneous).

Larvae of most Trichoptera are aquatic, and many may also use the bryophytes as a site for pupation and emergence. Most of the filter-feeders found in the deciduous forest biome. In addition to filter feeders, they are represented by grazers, especially upstream in the mountains where waters are cool. Shredders, especially in the Limnephilidae, can be found in lakes, ponds, streams, and even terrestrial habitats. Shredder-collectors are more common upstream and grazer-collectors are more common downstream. Temperature can signal that it is time to pupate. At least some *Hydropsyche* species cannot live below 8.0ºC (Kaiser, 1965). Instead, they build loose cases and go into the pupa state in autumn. Sleight (1913) found *Hydropsyche* pupae among mosses in strong currents in the eastern USA. Whereas, *Rhyacophila* minor (Rhyacophilidae) preferred moss-covered stones (Singh et al., 1984). Most *Rhyacophila* sp. are carnivores that do not make cases, but the *Verrula* group eat photosynthetic organisms with their hypognathous heads (oriented downwards), feeding on algae, diatoms, and particularly bryophytes (Smith, 1968; Thut, 1969). The caddis larvae of

Rhyacophila sp. begin their early instars by feeding equally day and night, but by the 4th to 5th instar they shift to feeding almost totally at night (Elliott, 2005). They can feed on other insects inhabiting their moss habitat, such as Ephemeroptera (mayflies), Simuliidae (blackflies), and Chironomidae (midges).

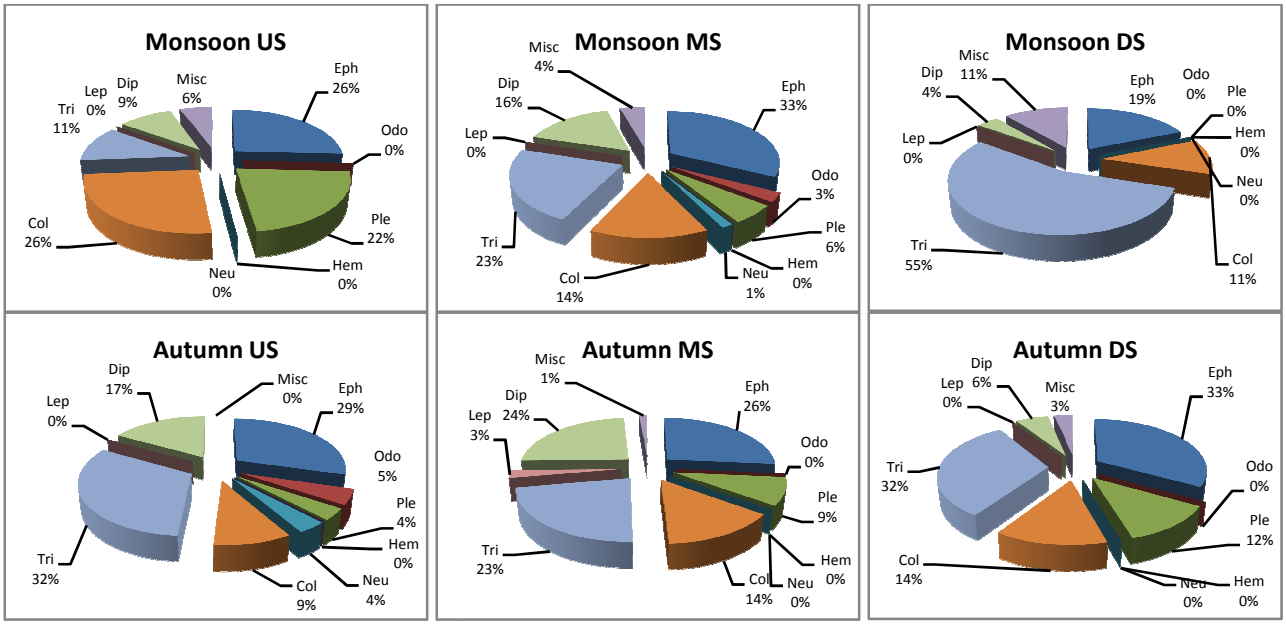

Figure 2.2 Seasonal composition (%) of various macroinvertebrate orders in Takoli Gad at sampling site section during the present study. (US=Upstream Section, MS=Midstream Section, DS=Downstream Section, Eph=Ephemeroptera, Odo=Odonata, Ple=Plecoptera, Hem=Hemiptera, Neu=Neuroptera, Col=Coleoptera, Tri=Trichoptera, Lep=Lepidoptera, Dip=Diptera, Misc=Miscellaneous).

The macroinvertebrate distribution pattern in Takoli Gad showed slight variation along the longitudinal gradient. In general, the distribution pattern encountered is dominance of a few species and regular distribution of other species along with presence of some rare species.

The distribution and abundance of these resources are influenced by size of stream or river, shading, substrate, and many other variables and the relative availability of food resources changes predictably from headwaters to river mouth (Vannote et al., 1980). Many taxa were seasonally absent in different sections of the stream.

All this contributed to the comparatively low diversity of benthic taxa in Takoli Gad, especially during rainy season. Owing to the swift nature of Takoli Gad, the benthic life take refuge under boulders, stones, detritus and also on clump off moss and the covering of algae on the upper surface of stones. Macroinvertebrate collected from different sites representing altitudinal gradient along the stream Takoli Gad, revealed that the density was invariably lowest during monsoon and highest during winter at all the sites. The reason for being minimum during monsoon may be attributed to the disturbance in substratum, increased water level, depth of stream, current velocity and turbidity (Crayton and Sommerfeld, 1979).

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