



Drifting Behaviour of Aquatic Mites and Regulating Ecological Parameters in Khankragad Stream, A Springfed Tributary of Alaknanda River, Rudrarayag, Garhwal, Uttarakhand, India

Shailza Negi¹ • Pankaj Bahuguna^{2*} • Anoop Dobriyal¹

¹*Department of Zoology, HNB Garhwal University (A Central University), BGR Campus, Pauri (Garhwal) -246001 Uttarakhand, India*

²*Department of Zoology, BD Govt. P.G. College Lansdowne, Jaiharikhal- 246193, Pauri Garhwal, Uttarakhand, India.*

*Corresponding Author Email id: pankajpauri@gmail.com

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Abstract: Water mites are a large group of macroinvertebrates that are very vulnerable to contamination and environmental changes. As a result, they are often used to monitor water quality. Khankra gad stream, a third-order perennial spring-fed stream of the Alaknanda River in Uttarakhand, India, was studied to determine the drift behavior of water mites and water quality. Drift nets were set up for 24 hours in both spots of the Khankra stream where there was little or no human influence over a two-year sampling period (June 2018-20). Every four hours, the nets were changed out with new ones. Water mites signify a particular drift month and diel drift pattern. The majority of the drift mite species were present in considerably higher numbers in the daytime. During the two-year study period, a total of 2503 mite samples were collected from the Khankra stream, from which 204 water mite species drifted. The least number of Hydrachnidia (694) were collected from Spot-1, and the highest (1809) were collected from Spot-2, with 106 water mites drifting from Spot-1 and 134 mites drifting from Spot-2 during the study period. From Spot-2 maximum 25 mite species were collected and minimum 19 mite species were collected from Spot-1. For various mite species, the DBDI value ranged from 0.155 (July) to 0.204 (April) in Spot-1 and 0.134 (July) to 0.149 (February) in Spot-2. It was also observed that maximum water mite species were day-drifter. The physico-chemical parameters of the Khankra stream were also reported. The effect of ecological parameters on mite drift was investigated using Canonical correspondence analysis (CCA).

Key Words: Water mites • Drift • Spring-fed stream • Water quality • Garhwal Himalaya • CCA.

Introduction

Drifting behavior of aquatic insects, including mites, have a great bearing on the ecosystem productivity and sustainability. The term "drift" was first of all coined by Muller (1954) to describe the downward movement of benthic invertebrates. According to Brittan and Eikeland (1988) the drifting is a natural mechanism in lotic ecosystems. Due to its significant role in the dispersal and colonization of aquatic organisms the drift is considered a vital part of the lotic ecology (Towsend, 1989; Hughes, 1998).

Though the drift in benthic insects has been studied by several workers, yet the mites as such are largely ignored. Also, it is important to find

out the ecological and interactive detrimental parameters which cause for insect drift. Certain environmental conditions make drifting species more likely to move away from the stream's bottom and be swept downstream. According to Schreiber (1995) in rivers and streams, invertebrate drift is a natural phenomenon that plays an important role in the ecological cycles. Waters (1962), Muller (1974), and Elliott (1967) were the pioneer to study invertebrate drift diel periodicity, and their results piqued the interest of a number of other researchers (Flecker, 1992; Brewin and Ormerod, 1994). Drift is an important consideration in the study of macrobenthic



ecosystems since it is correlated with secondary development of aquatic environment, an important source of fish food, and an effective way for some species to colonize new areas (Waters, 1972; Williams & Williams, 1993; Allan, 1995; Pringle and Ramrez, 1998).

The distribution and density of water mites in Garhwal Himalayan region has been recently attempted by some workers (Kumar and Dobriyal, 1992; Kumar et al., 2006, 2007; Pesic et al., 2007a, b; Pesic and Panesar, 2008; Pesic et al., 2012; Pesic et al., 2019a,b; Bahuguna et al., 2019; Pesic et al., 2020 a, b; Bahuguna and Negi, 2020 and Bahuguna et al., 2020), but the drift behavior remains unexplored. Bahuguna et al., (2020) observed macrozoobenthos drifting behaviour in Kyunja gad from Garhwal Himalaya. Bahuguna and Dobriyal (2020) investigated the drift patterns of aquatic mites for the first time in Randi gad from the Garhwal Himalayas. The current research aims to investigate the drift in aquatic mites and ecology of Khankra gad, a spring-fed stream of Garhwal Himalaya.

Material and Methods

Study area: The study was conducted in Khankra gad, a third-order perennial spring-fed stream of the Alaknanda River, which is situated near Khankra village of Rudraprayag district (30°17'15.1"N and 78°58'41.4"E) in Uttarakhand. (Fig. 1). It originates from the Bansoun peak in Garhwal Himalaya. Two sampling sites were selected, Spot-1 was located upstream at 30°14'37.12"N and 78°55'06.00"E, and Spot-2 was located downstream at 30°14'45.76"N and 78°54'55.84"E. The Khankra stream is used to deliver water for drinking and irrigation purposes nearby. The stream has a sandy and rocky bottom with mostly pine as riparian vegetation.

Sample analysis

From July 2018 to June 2020, monthly sampling was carried out. In the morning, water samples were taken and physicochemical parameters were determined, like Temperature (°C), Velocity (m.sec⁻¹), pH, were analyzed at the spot. For further analysis of other parameters such as

Dissolved Oxygen (mg.l⁻¹), Total Alkalinity (mg.l⁻¹), Total Hardness (mg.l⁻¹), water samples were brought in the laboratory. Water samples were analyzed in accordance with Welch (1948) and APHA (2012).

Drift experiments were carried out at two sampling spots located along the stream. The drifting sampling methods were followed as per Smock (1996) and Bahuguna and Dobriyal (2020). A drift net of diameter 1m was fixed at a depth of 0.2m for 24 hrs. The net was set for 4 hours at each spot, which was replaced by another net. Mite samples were preserved on the spot in Koenike's fluid and brought to laboratory for further investigations. A number of keys were used to identify the water mite species (Kumar et al., 2007; Cook, 1967, 1974; Prasad, 1974; Gerecke, 2003; Pesic and Panesar, 2008). For drift density study, the Dobriyal-Bahuguna Drifting Index (DBDI) was used.

The formulae for DBDI index:

$$DBDI = \sqrt[3]{(Ddm/Tmp.T)}$$

Where: D.B.D.I.= Dobriyal-Bahuguna Drifting Index.,

Ddm = No. of drifting mites (units per 0.04 m³.sec⁻¹ for 24 Hours), (i.e., mouth of net 1 m, depth of sampler 0.2 m, current velocity 0.2m.sec⁻¹), Tmp = Total mite population in stream (units.m⁻²)

T = Time used in collecting sample in 24 hours.

Results

Physico-chemical parameters: Table 1 displays the average (Mean±S.D) range of the physico-chemical parameters of water collected at the two sampling sites of the stream.

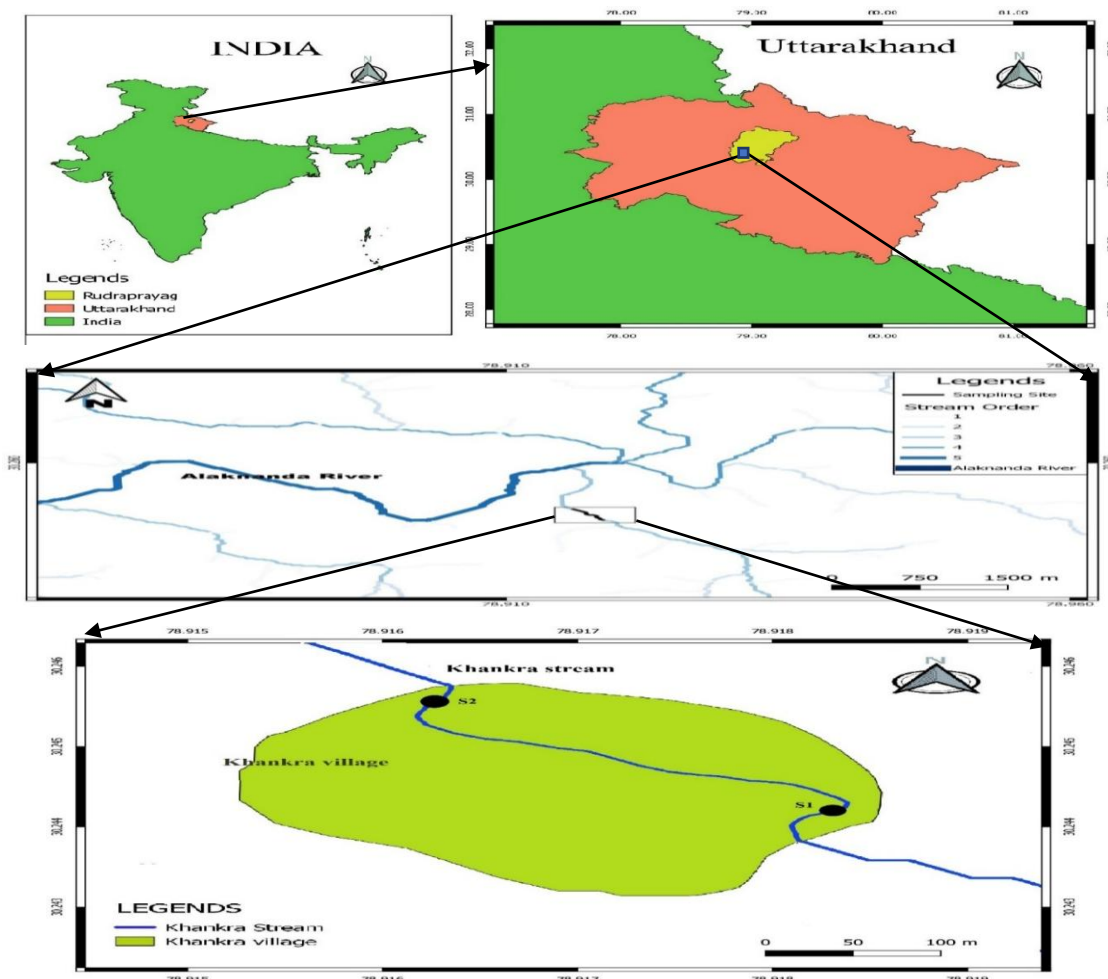


Fig 1. Sampling locations (Spot-1 and Spot-2) in Khankra gad, a spring-fed tributary of river Alaknanda, Uttarakhand, India.

Table 1: Average (Mean±S.D) range of the physico-chemical parameters of sampling Spots (Spot-1 and Spot-2) of Khankra gad stream during 2018-2020.

Physico-chemical parameters (2018-20)	Spot-1	Spot-2
WT (°C)	7.6±0.1 to 12.8±0.2	9.7±0.2 to 18.4±0.8
pH	7.4±0.1 to 7.9±0.1	7.3±0.1 to 7.8±0.3
CV (m.sec ⁻¹)	0.26±0.02 to 0.61±0.01	0.25±0.01 to 0.53±0.01
TA (mg.l ⁻¹)	81.2±0.8 to 99.1±1.1	75.7±0.8 to 94.7±1.3
TH (mg.l ⁻¹)	82±0.3 to 121.9±6.2	85.2±1.4 to 109.8±13.2
DO (mg.l ⁻¹)	7.3±0.1 to 8.8±0.3	7.2±0.1 to 8.4±0.1

The temperature of the water in the current study varied between 12.8±0.2 to 7.6±0.1°C at Spot-1, and 9.7±0.2 to 18.4±0.8 °C at Spot-2. The pH values ranged from 7.4±0.1 to 7.9±0.1 at Spot-1, and 7.3±0.1 to 7.8±0.3 at Spot-2. Velocity was

fairly good through-out the year, the values recorded ranged between 0.61±0.01 to 0.26±0.02 m.sec⁻¹ at Spot-1, and 0.53±0.01 to 0.25±0.01 m.sec⁻¹ at Spot-2. The total alkalinity observed was ranged between 81.2±0.8 to 99.1±1.1 mg.l⁻¹ at



Spot-1, and 75.7 ± 0.8 to 94.7 ± 1.3 mg.l^{-1} at Spot-2. The total hardness values were ranged from 82 ± 0.3 to 121.9 ± 6.2 mg.l^{-1} at Spot-1, and 85.2 ± 1.4 to 109.8 ± 13.2 mg.l^{-1} at Spot-2. DO values ranged from 7.3 ± 0.1 to 8.8 ± 0.3 mg.l^{-1} at Spot-1, and 7.2 ± 0.1 to 8.4 ± 0.1 mg.l^{-1} at Spot-2 (Table. 1).

During the two-year study period, a total of 2503 mite samples were collected from Khankra stream, from which 204 water mite species drifted (Table 2 and Table 3).

Dobriyal-Bahuguna Drifting Index (DBDI):

DBDI index for Spot-1 and Spot-2 is shown in Table 4.. DBDI value ranged from 0.155 (July) to 0.204 (April) in Spot-1 and 0.134 (July) to 0.149 (February) in Spot-2. From DBDI values, it is revealed that April, May and August were conducive for mite population at Spot-1 and February and December at Spot-2.

Diel drifting:

Overall drifting pattern of water mites from Khankra stream is presented in the Fig.2 and Fig.3 respectively. Most of the drifting water mite species were caught during day time in Spot-1 (Fig. 2) and Spot-2 (Fig.3). At Spot-1 *Torrenticola kumari*, *T. uttarakhandensis*, *Monatractides garhwaliensis*, *Sperchon indicus*, *S. garhwalensis*, *Atractides indicus*, *A. garhwali* and *Feltria*

Total 25 mite species were collected from Spot-2, and a minimum of 19 mite species were collected from Spot-1. The highest diel drifting species were recorded in January and lowest in July month at both Spot-1 and spot-2. The least number of Hydrachnidia (694) were collected from Spot-1, and the highest (1809) were collected from Spot-2, with 106 water mites drifting from Spot-1 and 134 mites drifting from Spot-2.

In both sampling sites, the following species were observed: *Torrenticola wonchoeli*, *T. uttarakhandensis*, *T. kumari*, *T. nana*, *T. semisuta*, *Monatractides oxystomus* and *M. garhwaliensis* (family Torrenticolidae Piersig 1902), *Sperchon garhwalensis*, *S. indicus* (family Sperchontidae Thor, 1900), *Atractides garhwali*, *A. incertus*, *A.*

indicus, *A. ootacamundis* and *Hygrobates fluviatilis* (Cook) (family Hygrobatidae). *Torrenticola tetraporella*, *T. nana*, *Sperchonopsis verrucose*, *Atractides panesari*, *A.* were day-drifter. Whereas, *Torrenticola nana*, *T. muranyii*, *Monatractides kotschani*, *Sperchon ootacamundis*, *Atractides ootacamundis* (Cook) were night-drifter and *Torrenticola wonchoeli*, *T. semisuta*, *Monatractides oxystomus*, *Atractides incertus*, *Hygrobates fluviatilis*, *Feltria gereckeii* drifted in dawn time. At Spot-2 *Torrenticola uttarakhandensis*, *T. chatterjeei*, *T. turkestanica*, *T. kumari*, *Monatractides garhwaliensis*, *Sperchon indicus*, *S. garhwalensis*, *Atractides indicus*, *A. garhwali* and *Hygrobates gangeticus* were day-drifter. However, *ootacamundis* (Cook), *Kongsbergia indica*, and *K. himalayaensis* were night-drifter species and *Torrenticola wonchoeli*, *Torrenticola semisuta*, *Monatractides Tuzovskyi*, *M. oxystomus*, *Atractides incertus*, *Hygrobates fluviatilis* and *Lebertia spp.* drifted during dawn time.



Table 2: Average species composition of the aquatic mites (units.m⁻²) and observance of drifting mite species (units. 0.04 m³.sec⁻¹ for 24 hours) in the Spot-1 (S-1) of Khakhra stream of Garhwal, Uttarakhand (2018-20)

Name of Species	Jul		Aug		Sep		Oct		Nov		Dec		Jan		Feb		Mar		Apr		May		Jun	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
<i>Torrenticola uttarakhandensis</i>	03	0±0	02	01	05	01	04	01	10	02±	12±	02±	17±	03±	10±	01±	09±	02	07±	02±	04±	04±	01	01
	±1.4		±1.4	±1.4	±2.8	±1.4	±1.4	±1.4	±2.8	1.4	2.8	2.8	5.6	2.8	2.8	1.4	2.1	±1.4	1.4	1.4	2.8	2.8	±0	±0
<i>Torrenticola wonchoeli</i>	0±0	0±0	0±0	0±0	0±0	0±0	0±0	0±0	0±0	0±0	0±0	0±0	09±	01±	06±	01±	04±	01±	0±0	0±0	0±0	0±0	01	0±0
					±1.4				1.4				1.4	1.4	1.4	1.4	2.8	1.4					±1.4	±0
<i>Torrenticola nana</i>	02	0±0	01	0±0	0±0	0±0	04	01±1.4	01±	0±0	04±	01±	09±	01±	0±0	0±0	02	0±0	0±0	0±0	0±0	0±0	0±0	0±0
	±1.4		±1.4				±2.8		1.4		2.8	1.4	2.8	1.4			±0						±0	±0
<i>Torrenticola kumari</i>	01	0±0	0±0	0±0	01	0±0	0±0	0±0	02±	0±0	06±	01±	07±	01±	04±	01±	0±0	0±0	03±	01±	05±	05±	03±	0±0
	±1.4				±0				1.4		4.2	1.4	2.8	1.4	2.8	1.4			1.4	1.4	1.4	4.2	2.8	2.8
<i>Torrenticola semisuta</i>	0±0	0±0	0±0	0±0	0±0	0±0	01	0±0	0±0	0±0	06±	01±	11±	01±	03±	01±	0±0	0±0	04±	0±0	0±0	0±0	0±0	0±0
							±0				4.2		2.8	1.4	1.4	1.4			2.8				±0	±0
<i>Torrenticola muranyii</i>	0±0	0±0	02	0±0	0±0	0±0	02	0±0	0±0	0±0	04±	01±0	08±	0±0	0±0	0±0	03±1.4	0±0	01±0	0±0	0±0	0±0	0±0	0±0
			±1.4				±1.4				2.8		2.8											
<i>Monatractides garhwaliensis</i>	01	0±0	03	01	0±0	0±0	04	0±0	09±	01±1.4	11±	02±	17±	03±	05±	01±	06±	0±0	0±0	0±0	04±1.4	04±	02±	0±0
	±1.4		±2.8	±1.4			±4.2		1.4		2.8	2.8	7.1	2.8	1.4	1.4	1.4				0	1.4	1.4	±0
<i>Monatractides oxystomus</i>	0±0	0±0	0±0	0±0	01	0±0	0±0	0±0	04±	0±0	0±0	0±0	07±	0±0	0±0	0±0	0±0	0±0	03±	01±	0±0	0±0	0±0	0±0
					±0				1.4				2.8						1.4	1.4				
<i>Monatractides kotschani</i>	0±0	0±0	01	0±0	0±0	0±0	02	04±	01±1.4	0±0	0±0	0±0	05±	0±0	03±	01±	0±0	0±0	03±	01±	0±0	0±0	01±0	0±0
			±1.4				±0	±1.4	2.8				.8		1.4	1.4			1.4	1.4				
<i>Sperchon indicus</i>	03	01	05±	01	07	02	09	01	11±	03±2.8	14±	02±	21±	03±	16±	01±	11±	02	09±	02±	07±1.4	07±	02±	0±0
	±1.4	±1.4	2.8	±1.4	±2.8	±1.4	±4.2	±1.4	2.8	2.8	2.8	2.8	2.8	2.8	1.4	1.4	1.4	±1.4	2.8	1.4	2.8	2.8	1.4	1.4
<i>Sperchon garhwaliensis</i>	0±0	0±0	01±	0±0	04±	01±	07±	0	09±	01±1.4	11±	02±	15±	01±	09±	01±	08±	0±0	06±	01±	02	02±	02±	0±0
			1.4		1.4	1.4	4.2	±0	1.4		1.4	1.4	5.6	1.4	1.4	1.4	1.4	1.4	2.8	1.4	±0	1.4	2.8	2.8
<i>Sperchon ootacamundis</i>	0±0	0±0	0±0	0±0	0±0	0±0	0±0	01±1.4	01±1.4	0±0	02±	0±0	08±	0±0	0±0	0±0	01±0	0±0	0±0	0±0	0±0	0±0	01±	01
											1.4		2.8										1.4	±0
<i>Atractides indicus</i>	01	0±0	05	01	04	01	07±	0±0	09±7.1	02±2.8	12±	01±1.4	17±	01±	09±2.8	0±0	04±	02	05±	0±0	03±	03±	02±	0±0
	±1.4		±2.8	±1.4	±1.4	±1.4	4.2			2.8		7.1	1.4				2.8	±1.4	1.4		1.4	1.4	2.8	±0
<i>Atractides garhwali</i>	0±0	0±0	03±	0±0	0±0	0±0	07±	01±	06±	0±0	09±	0±0	14±	01±	08±	0±0	04±	0±0	03±	01±	0±0	0±0	0±0	0±0
			1.4				1.4	1.4	1.4		2.8		2.8	1.4	1.4		2.8		1.4	1.4				
<i>Atractides incertus</i>	0±0	0±0	01±	0±0	0±0	0±0	04±	0±0	01±0	0±0	03±	01±	04±	01±	0±0	0±0	0±0	0±0	02±	0±0	03±	03±	0±0	0±0
			1.4				2.8		1.4		1.4	1.4	1.4	1.4					1.4	1.4		1.4	2.8	
<i>Atractides ootacamundis</i> (Cook)	0±0	0±0	0±0	0±0	01	0±0	02±	0±0	0±0	0±0	0±0	0±0	01±	01±	0±0	0±0	03±	0±0	0±0	0±0	01	01	0±0	0±0
					±1.4		1.4		±1.4				1.4	1.4			1.4				±0	±0		
<i>Hygrobatas fluviatilis</i>	0±0	0±0	0±0	0±0	03	0±0	0±0	0±0	01	01	02	01±	03	01±	0±0	0±0	01	01	0±0	0±0	01	01	01	0±0
					±2.8				±1.4	±0	±1.4	1.4	±0	1.4			±0	±0			±0	±0	±1.4	±0
<i>Feltria gereckei</i>	0±0	0±0	0±0	0±0	0±0	0±0	01	0±0	0±0	01	0±0	0±0	02±	0±0	01±	01±	0±0	0±0	03±	01±	0±0	0±0	01±	0±0
							±0		±0				1.4	1.4	1.4	1.4			1.4	1.4			1.4	
<i>Feltria indica</i>	0±0	0±0	0±0	0±0	02±	0±0	01±	0±0	0±0	0±0	0±0	0±0	02±0	01±	01±0	0±0	0±0	0±0	0±0	0±0	0±0	0±0	0±0	0±0
					1.42		1.4						1.4	1.4										
TOTAL	11±	01±	24±	04±	31±	05±	55±	09±8.4^b	73±	12±	96±	15±	177±56.5^a	22±	75±	12±	56±	09±	49±	10±	30±	05±	17±	02±
	8.4^a	1.4^b	18.2^a	5.6^b	15.5^a	5.6^b	29.6^a		28.3^a	9.8^b	32.5^a	16.9^b		24^b	19.7^a	12.7^b	17.6^a	7^b	19.7^a	11.1^b	9.8^a	12.7^b	16.9^a	1.4^b

{ A= Density of mite species(unit.m⁻²), B = No. of drifting species (unit.0.04m³.sec⁻¹ for 24 hour), a = Total density



Table 3: Average species composition of the aquatic mites (units.m⁻²) and observance of drifting mite species (units. 0.04 m³.sec⁻¹ for 24 hours) in the Spot-2 (S-2) of Khakhra stream of Garhwal, Uttarakhand (2018-20)

Name of Species	Jul		Aug		Sep		Oct		Nov		Dec		Jan		Feb		Mar		Apr		May		Jun	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
<i>Torrenticola</i>	01±	0±0	02±	01±	04±	01±	0±0	0±0	11±	02±	13±	02±	15±	02±	13±	01±	11±	01±	14±	0±0	12±	02±	09±	01±
<i>uttarakhandensis</i>	1.4		1.4	1.4	2.8	1.4			1.4	1.4	5.6	1.4	2.8	0	4.2	1.4	1.4	1.4	1.4	0±0	1.4	0	2.8	0
<i>Torrenticola chatterjeei</i>	0±0	0±0	01±	0±0	06±	0±0	05±	01±	0±0	0±0	08±	01±	10±	0±0	05±	01±	0±0	0±0	0±0	0±0	0±0	0±0	07±	0±0
			1.4		2.8		1.4	0			4.2	1.4	2.8		2.8	0							1.4	
<i>Torrenticola turkestanica</i>	0±0	0±0	0±0	0±0	0±0	0±0	0±0	0±0	05±	0±0	0±0	0±0	07±	01±	0±0	0±0	03±	0±0	0±0	0±0	0±0	08±	0±0	0±0
									2.8				2.8	1.4			1.4					5.6		
<i>Torrenticola wonchoeli</i>	0±0	0±0	0±0	0±0	0±0	0±0	04±	0±0	0±0	0±0	0±0	0±0	01±	01±	06±	0±0	03±	0±0	0±0	0±0	0±0	01±	0±0	0±0
							2.8						0	1.4	2.8		0					0		
<i>Torrenticola tetraporella</i>	0±0	0±0	0±0	0±0	0±0	0±0	05±	0±0	03±	0±0	04±	01±	08±	01±	0±0	0±0	02±	0±0	0±0	0±0	0±0	0±0	0±0	0±0
							0		1.4		2.8	1.4	2.8	1.4			2.8							
<i>Torrenticola semisuta</i>	02±	0±0	03±	0±0	05±	0±0	21±	01±	12±	01±	11±	01±	13±	01±	11±	0±0	17±	0±0	16±	01±	10±	0±0	07±	0±0
	2.8		2.8		1.4		2.8	0	2.8	0	1.4	1.4	4.2	1.4	1.4		5.6		4.2	0	2.8		2.8	
<i>Torrenticola nana</i>	0±0	0±0	0±0	0±0	05±	0±0	06±	0±0	12±	01±	08±	01±	09±	01±	07±	0±0	05±	0±0	07±	0±0	04±	0±0	0±0	0±0
					2.8		1.4		4.2	1.4	1.4	1.4	1.4	1.4	2.8		1.4		4.2		1.4			
<i>Torrenticola kumari</i>	0±0	0±0	02±	0±0	09±	0±0	07±	0±0	10±	0±0	10±	01±	11±	01±	10±	01±	06±	01±	09±	01±	08±	01±	08±	01±
			2.8		1.4		1.4		1.4		4.2	0	1.4	0	2.8	0	1.4	1.4	5.6	1.4	2.8	1.4	4.2	1.4
<i>Monatractides garhwaliensis</i>	0±0	0±0	02±	0±0	11±	01±	10±	0±0	15±	03±	15±	02±	18±	02±	15±	0±0	12±	01±	10±	01±	09±	01±	11±	01±
			2.8		1.4	1.4	1.4		1.4	1.4	5.6	0	4.2	0	2.8		1.4	0	4.2	1.4	2.8	1.4	1.4	0
<i>Monatractides tuzovskiyi</i>	0±0	0±0	0±0	0±0	09±	0±0	08±	01±	09±	01±	14±	01±	13±	0±0	16±	0±0	15±	01±	12±	01±	10±	01±	08±	0±0
					4.2		4.2	1.4	2.8	1.4	4.2	1.4	2.8		1.4		2.8	0	2.8	1.4	1.4	1.4	4.2	
<i>Monatractides oxystomus</i>	0±0	0±0	01±	0±0	05±	0±0	0±0	0±0	0±0	0±0	0±0	0±0	01±	01±	04±	0±0	0±0	0±0	06±	0±0	0±0	0±0	0±0	0±0
			1.4		1.4								1.4	1.4	2.8				2.8					
<i>Sperchon indicus</i>	03±	01±	05±	0±0	08±	02	15±	02±	19±	03±	25±	03±	27±	03±	27±	03±	20±	02±	18±	02±	15±	02±	12±	01±
	2.8	1.4	4.2		2.8	02	2.8	1.4	4.2	1.4	7.1	1.4	5.6	1.4	2.8	1.4	1.4	1.4	8.4	1.4	4.2	1.4	4.2	0
<i>Sperchon garhwaliensis</i>	02±	0±0	0±0	0±0	0±0	0±0	12±	01±	16±	0±0	21±	02±	28±	0±0	26±	03±	21±	02±	20±	02±	16±	03±	12±	01±
	2.8						4.2	0	4.2		4.2	1.4	4.2		5.6	1.4	1.4	1.4	4.2	1.4	2.8	0	4.2	1.4
<i>Sperchon plumifer</i>	03±	0±0	04±	0±0	06±	0±0	07±	0±0	06±	0±0	08±	0±0	09±	0±0	0±0	0±0	18±	01±	12±	01±	10±	0±0	08±	0±0
	2.8		2.8		2.8		1.4		4.2		4.2		2.8				1.4	0	2.8	0	1.4		4.2	
<i>Sperchonopsis verrucosa</i>	0±0	0±0	0±0	0±0	0±0	0±0	06±	0±0	08±	0±0	05±	0±0	01±	0±0	05±	01±	0±0	0±0	0±0	0±0	0±0	0±0	0±0	0±0
							2.8		1.4		2.8		1.4		2.8	0								
<i>Atractides indicus</i>	04±	0±0	04±	01±0	12±	02±	16±	01±	19±	01±	21±	01±	25±	02±	21±	02±	18±	0±0	16±	01±	13±	0±0	11±	01±
	2.8		2.8		2.8	1.4	2.8	1.4	4.2	1.4	9.8	1.4	9.8	1.4	1.4	1.4	1.4		4.2	0	1.4		1.4	1.4
<i>Atractides garhwali</i>	0±0	0±0	0±0	0±0	05±	0±0	10±	01±	13±	01±	14±	01±	18±	01±	22±	02±	17±	01±	12±	01±	14±	0±0	09±	01±
					2.8		1.4	1.4	2.8	1.4	1.4	1.4	1.4	0	5.6	1.4	4.2	1.4	1.4	0	2.8		2.8	1.4
<i>Atractides incertus</i>	0±0	0±0	01±	0±0	02±	0±0	06±	01±	06±	0±0	07±	0±0	02±	0±0	09±	01±	08±	01±	0±0	0±0	0±0	0±0	01±	0±0
			1.4		0		2.8	1.4	2.8		4.2		0		2.8	1.4	2.8	1.4					0	
<i>Atractides panesari</i>	0±0	0±0	0±0	0±0	0±0	0±0	05±	0±0	0±0	0±0	06±	0±0	08±	01±	04±	01±	03±	0±0	0±0	0±0	0±0	0±0	0±0	0±0
							4.2				4.2		5.6	1.4	2.8	1.4	1.4							
<i>Atractides ootacamundis</i> (Cook)	0±0	0±0	0±0	0±0	01±	0±0	0±0	0±0	06±	0±0	0±0	0±0	05±	01±	0±0	0±0	0±0	0±0	05±	01±	0±0	0±0	01±	0±0
					1.4				1.4				4.2	1.4					2.8	0			0	



<i>Hygobates gangeticus</i>	0±0	0±0	01±0	0±0	0±0	0±0	0±0	0±0	0±0	0±0	0±0	0±0	06±1.4	01±1.4	0±0	0±0	08±2.8	01±1.4	0±0	0±0	0±0	0±0	0±0	0±0
<i>Hygobates fluviatilis</i>	0±0	0±0	0±0	0±0	01±1.4	00	05±1.4	01±1.4	06±1.4	0±0	10±2.8	0±0	12±5.6	0±0	10±2.8	0±0	08±2.8	01±1.4	05±2.8	0±0	0±0	0±0	04±1.4	0±0
<i>Kongsbergia indica</i>	02±1.4	0±0	0±0	0±0	0±0	0±0	06±2.8	01±1.4	0±0	0±0	09±5.6	0±0	10±7.1	0±0	09±5.6	0±0	06±2.8	01±1.4	03±1.4	0±0	05±1.4	0±0	0±0	0±0
<i>Kongsbergia himalayaensis</i>	0±0	0±0	0±0	0±0	0±0	0±0	06±2.8	01±1.4	0±0	0±0	06±1.4	0±0	09±5.6	01±1.4	0±0	0±0	0±0	0±0	0±0	0±0	0±0	0±0	0±0	01±1.4
<i>Lebertia spp.</i>	0±0	0±0	01±0	0±0	0±0	0±0	0±0	0±0	05±1.4	0±0	0±0	0±0	08±2.8	0±0	06±1.4	02±1.4	07±1.4	0±0	04±2.8	0±0	0±0	0±0	0±0	0±0
TOTAL	17±16.9^a	01±1.4^b	27±29.6^a	02±1.4^b	89±31.1^a	06±4.2^b	160±45.2^a	12±11.3^b	181±48.1^a	13±9.8^b	215±77.7^a	17±14.1^b	274±84.8^a	21±22.2^b	226±57.9^a	18±11.3^b	208±42.4^a	14±12.7^b	169±56.5^a	12±7.1^b	135±32.5^a	10±5.6^b	108±35.3^a	08±7.1^b

{A= Density of mite species(unit.m⁻²), B = No. of drifting species (unit.0.04m³.sec⁻¹ for 24 hour), a = Total density (T_{mp}), b = Total drift (D_{dm})}



Canonical Correspondence Analysis (CCA), between water mites drift and environmental method was used to determine the relationship variables (Fig 4 and 5).

Table 4: Dobriyal-Bahuguna Drifting Index (DBDI) of mites in Khakhra stream for the period of July 2018 to June 2020.

Months (2018-20)	DBDI for Spot 1	DBDI for Spot 2
July	0.155	0.134
August	0.191	0.145
September	0.188	0.141
October	0.189	0.146
November	0.189	0.144
December	0.186	0.148
January	0.173	0.147
February	0.188	0.149
March	0.188	0.141
April	0.204	0.143
May	0.191	0.145
June	0.169	0.145

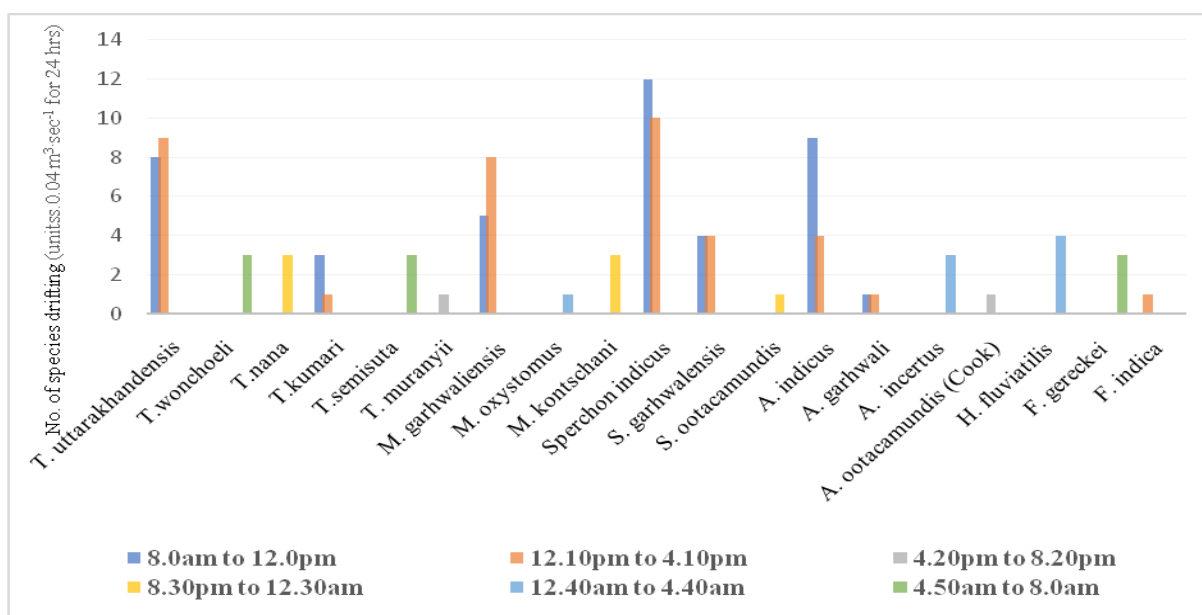


Fig. 2 Overall drifting pattern of aquatic mites in Spot-1 (S-1) of Khakhra stream (units. 0.04 m³.sec⁻¹for 24 hours) for the period of July 2018 to June 2020.

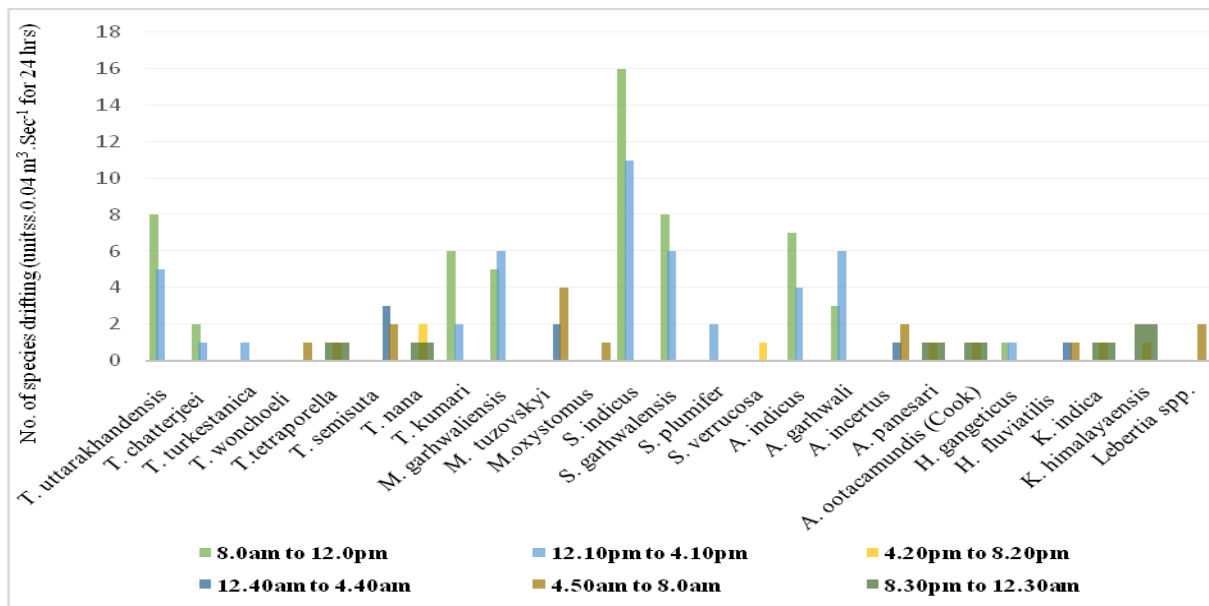


Fig. 3 Overall drifting pattern of aquatic mites in Spot-2 (S-2) of Khakhra stream (units. 0.04 m³.sec⁻¹for 24 hours) for the period of July 2018 to June 2020.

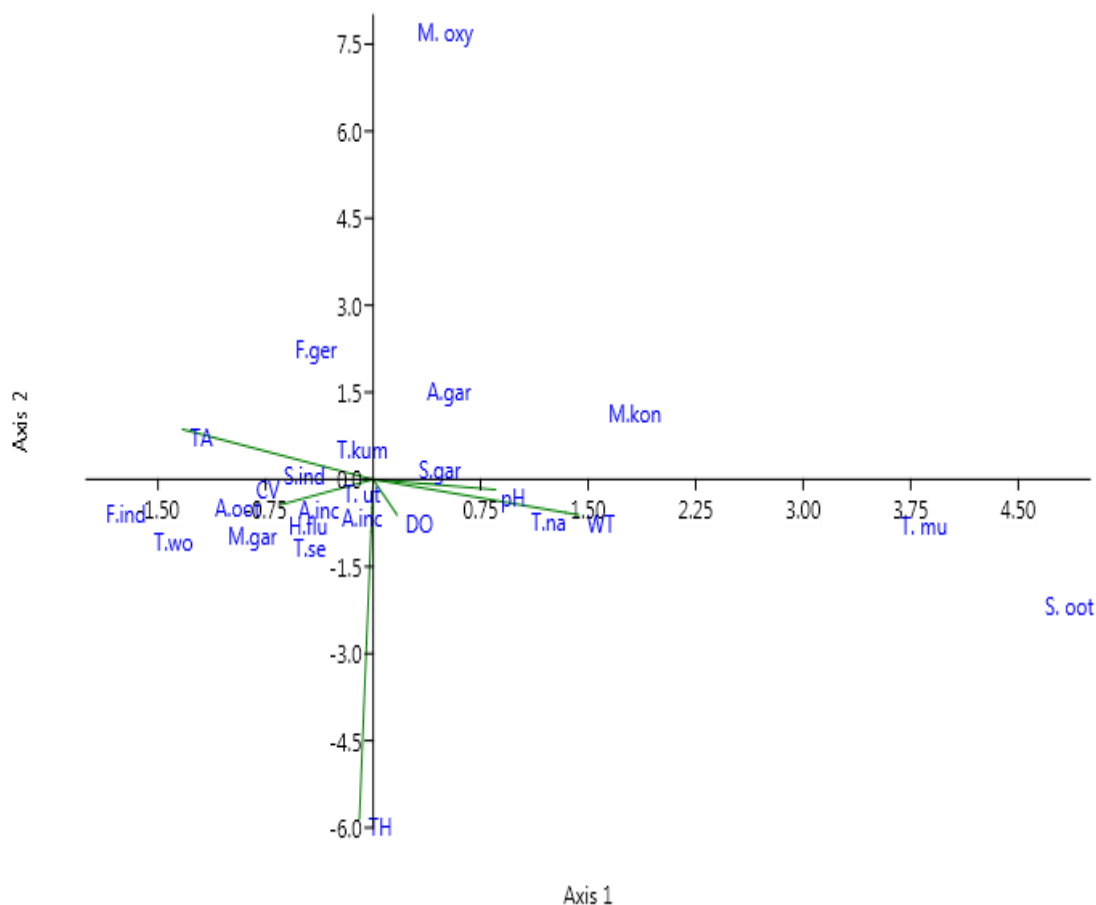


Fig.4 CCA bipot at Spot-1 between physico-chemical parameters and drifting water mite species during the period of 2018-20.



(T. utt-*T. uttarakhandensis*, T. wo- *T. wonchoeli*, T. na- *T. nana*, T. kum-*T. kumari*, T. sem- *T. semisuta*, M. gar-*M. garhwaliensis*, M. oxy- *M. oxystomus*, S. ind- *Sperchon indicus*, S.gar- *S. garhwalensis*, T. mu- *T. muranyii*, M. kon- *M. kotschani*, F. ger- *Feltria gereckei*, F. ind-*F. indica*, A.ind- *Atractides indicus*, A.gar- *A. garhwali*, A inc- *A. incertus*, A. oot-*A. ootacamundis* and H.flu-*Hygrobatas fluviatilis*).

Each site's percentage of variance and Eigen values were found to be higher in axis 1 than in axis 2. Liu et al. (2010) observed similar findings. CCA was drawn between six physico-

chemical parameters and 19 mite species at Spot-1. At Spot-1, Eigen value for axis 1 (0.244) explained 37% correlation and axis 2 (0.179) explained 27.88% correlation between physico-chemical parameters and drifting species. DO, pH and water temperature indicate close relationship with *T. nana*, *T. muranyii*, and *S. garhwalensis*. *S. indicus*, *T. uttarakhandensis*, *a. incertus*, *himalayaensis*, *M. garhwaliensis*, *T. wonchoeli*, *F. indica*, and *A. ootacamundis* (Cook) indicates a positive correlation with the current velocity. *M. oxystomus* was found to be least affected by these physico-chemical parameters.

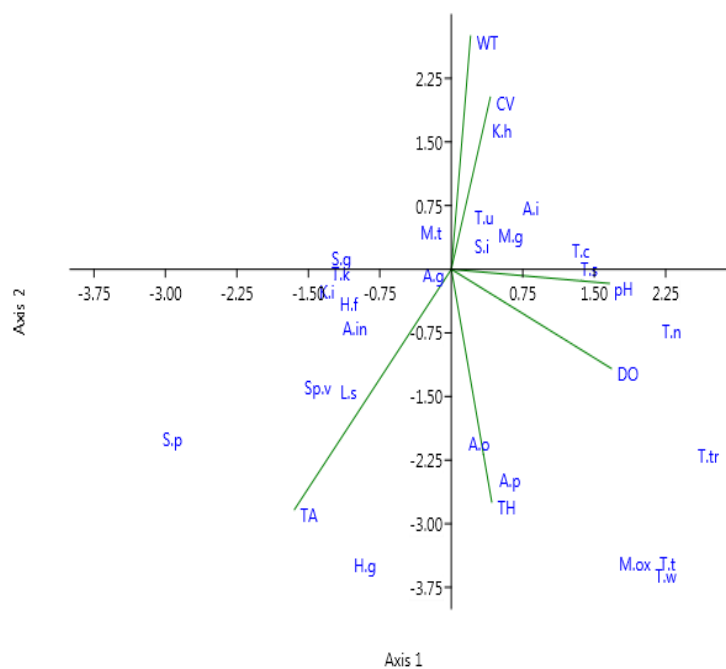


Fig.5 CCA biplot at Spot-2 between physico-chemical parameters and drifting water mite species during the period of 2018-20.

(T. utt-*T. uttarakhandensis*, T. wo- *T. wonchoeli*, T. na- *T. nana*, T. kum-*T. kumari*, T. sem- *T. semisuta*, M. gar-*M. garhwaliensis*, M. oxy- *M. oxystomus*, S. ind- *Sperchon indicus*, S.gar- *S. garhwalensis*, T. cha-*T. chatterjeei*, T. tur-*T. turkestanica*, T. tet- *T. tetraporella*, M. tuz- *M. tuzovskyi*, S.plu- *S. plumifer*, Sph. v-*verrucosa*, A. pan- *A. panesari*, H. gan- *Hygrobatas gangeticus*, K. ind- *Kongsbergia indica*, K. him- *K. himalayaensis*, L.spp-*Lebertia spp.*, A.ind- *Atractides indicus*, A.garh- *A. garhwali*, A.inc-

A. incertus, T. oot- *A. ootacamundis* and H. flu- *Hygrobatas fluviatilis*).

At Spot-2, 6 physico-chemical parameters and 25 species were taken into consideration to draw CCA (Fig. 3). At axis 1, Eigen value (0.167) explained 33.06 % and Eigen value (0.124) value at axis 2 explained 24.53 % correlation between physico-chemical parameters and drift mite species. *T. nana*, *T. turkestanica*, *T. tetraporella*, *T. wonchoeli*, *M. oxystomus*, and *A. ootacamundis* (Cook) indicate a positive relationship with DO,



pH, and total hardness. *Sperchonopsis verrucosa*, *A. indicus*, *S. plumifer* and *A. garhwali* show a positive correlation with total Alkalinity. *T. uttarakhandensis*, *K. himalayaensis*, *T. uttarakhandensis*, *A. incertus*, *M. garhwaliensis*, *T. chatterjeei*, and *T. semisuta* show a positive correlation with water temperature and current velocity.

Discussion

To analyze stream ecology, certain physicochemical variables were examined. It was reported that water temperature values varied from 12.8 ± 0.2 to 7.6 ± 0.1 °C at Spot-1, and 9.7 ± 0.2 to 18.4 ± 0.8 °C at Spot-2. Water temperature fluctuations disrupt the ecology of aquatic ecosystems. Chakrabarty *et al.* (1959) discovered a similar trend in the Yamuna river. In the analysis, the pH of the water was mostly alkaline. The pH values ranged from 7.4 ± 0.1 to 7.9 ± 0.1 at Spot-1, and 7.3 ± 0.1 to 7.8 ± 0.3 at Spot-2. The pH of the water was mostly alkaline throughout the study period. The pH limits for drinking water set by the BIS (Bureau of Indian Standards) are 6.5-8.5.

The inclusion of limestone rocks increases the pH level (Ormerod *et al.*, 1990). Strong primary production is aided by alkaline water (Kumar and Prabhakar, 2012). Throughout the year, velocity was reasonably consistent, with values ranging from 0.61 ± 0.01 to 0.26 ± 0.02 m.sec⁻¹ at Spot-1, and 0.53 ± 0.01 to 0.25 ± 0.01 m.sec⁻¹ at Spot-2. Verma (2013) and Sharma *et al.* (2007) also reported a similar finding. Spot-1 DO values ranged from 7.3 ± 0.1 to 8.8 ± 0.3 mg.l⁻¹, while Spot-2 DO values ranged from 7.2 ± 0.1 to 8.4 ± 0.1 mg.l⁻¹. Sharma *et al.* (2007) discovered a similar finding for DO in the Chandrabhaga stream of Garhwal Himalaya.

The amount of dissolved oxygen in natural and waste water is determined by the water body's physical, chemical, and biological activities. The WHO (World Health Organization) recommended that the DO norm be greater than 5.00 mg/l. The presence of salt in the catchment area is expressed in the higher alkalinity levels. The overall

alkalinity observed ranged from 81.2 ± 0.8 to 99.1 ± 1.1 mg.l⁻¹ at Spot-1, and from 75.7 ± 0.8 to 94.7 ± 1.3 mg.l⁻¹ at Spot-2. Because of the high concentrations of carbonates in natural water, it is predominantly alkaline (Todd, 1995). A similar finding was made by Kumar *et al.* (2010). The interaction of calcium and magnesium ions causes the water to be hard. Spot-1 total hardness values ranged from 82 ± 0.3 to 121.9 ± 6.2 mg.l⁻¹, while Spot-2 total hardness values ranged from 85.2 ± 1.4 to 109.8 ± 13.2 mg.l⁻¹. Researchers agree that biotic and abiotic parameters are inextricably linked, and that any change in one is likely to result in a significant change in the other. It has been noted that water temperature, pH and velocity are the main controlling factors, which can be directly correlated with density and drift behavior of aquatic insects (Bahuguna and Dobriyal, 2020, Dobriyal and Singh, 1981, 1988, 1989). We may infer that the Khankra stream is not polluted and has good water quality based on the study of physicochemical parameters.

A major drift pattern of the water mites was observed in the current analysis, which varied in both sampling spots due to ecological factors. Nitrogen cycles, food chains, and invertebrate population patterns are all influenced by invertebrate drift, which is a significant ecological aspect of river systems. In the present study of Khankra gad spring-fed stream, the aquatic mites were recorded maximum in January and minimum in July in both the sampling spots. Many aquatic invertebrates exhibit diurnal periodicity in activity. According to Elliott (2002), the process of invertebrate drift often results in a rise in upstream migration. Some stream invertebrates become more active at night. In general, the density of drifting species is greatest at night and then at dusk. (Waters 1972 and Allan 1995). Water (1972) and Muller (1974) discovered the role of sunlight in the regulation of drift behaviour. Elliott (2002) and Bahuguna *et al.*, (2020) observed how the distribution of benthic invertebrates in a rocky stream shifted during the day and night. Bahuguna *et al.* (2019) have discovered a connection between fish predation and Odonata drifting.



The DBDI Index was used, which indicates the maximum number of mites that migrated away from the total number of mites present at the time and place (Bahuguna and Dobriyal, 2020). For drifting mites in Khankra gad, the DBDI value indicated monthly variations. DBDI value was higher in April (0.204) at Spot-1 and February (0.149) at Spot-2. From DBDI values revealed that April, May and August were conducive for mite population at Spot-1 and February and December at Spot-2. Most of the species were day-drifter. From Spot-1 maximum eight species i.e., *Torrenticola uttarakhandensis*, *T. kumari*, *Monatractides garhwaliensis*, *Sperchon indicus*, *S. garhwaliensis*, *Atractides indicus*, *A. garhwali* and *Feltria* and from Spot-2 ten species i.e., *Torrenticola uttarakhandensis*, *T. chatterjeei*, *T. turkestanica*, *T. kumari*, *Monatractides garhwaliensis*, *Sperchon indicus*, *S. garhwaliensis*, *Atractides indicus*, *A. garhwali* and *Hygrobatas gangeticus* were found to be drifting at day time. Bahuguna and Dobriyal (2020) also reported that there was a clear preference for drifting during the day instead of drifting at evening or in the night. The drifting of aquatic insects in lotic water rises during the day, according to many reports using direct observations (Graesser and Lake 1984; Allan et.al. 1986).

Most stream invertebrates speed up their drifting behavior at night. In spot-1 five species i.e., *Torrenticola nana*, *T. muranyii*, *Monatractides kotschani*, *Sperchon ootacamundis*, *Atractides ootacamundis* (Cook) were night-drifter and from Spot-2 seven species i.e., *Torrenticola tetraporella*, *T. nana*, *Sperchonopsis verrucose*, *Atractides panesari*, *A. ootacamundis* (Cook), *Kongsbergia indica*, and *K. himalayaensis* were night-drifter. The drifting of invertebrates became more frequent at night (Bishop and Hynes, 1969). Dawn time drifting was also observed in the water mites of both the spots (Spot-1 and Spot-2) of Khankra stream. At Spot-1 six species i.e., *Torrenticola wonchoeli*, *T. semisuta*, *Monatractides oxystomus*, *Atractides incertus*, *Hygrobatas fluviatilis*, *Feltria gereckeii* and seven species i.e., *Torrenticola wonchoeli*, *Torrenticola semisuta*, *Monatractides Tuzovskyi*,

M. oxystomus, *Atractides incertus*, *Hygrobatas fluviatilis* and *Lebertia spp.* from Spot-2 drifted during dawn time. Waters (1972) and Allan (1995) both observed aquatic insects drifting at dawn. There are a variety of hypotheses as to why these invertebrates drift. Drifts may be caused by a number of reasons, including the scramble for food and substratum, as well as predator avoidance and unfavourable environmental conditions (Hauer and Resh 2006).

CCA plot suggested that the few species were correlated with water temperature, pH, DO, TH, and Total alkalinity in both spots, but the majority of the species were influenced by water velocity. Bahuguna et al., (2019); Bahuguna and Dobriyal, 2020 reported similar findings.

Based on the results of this analysis, it is possible to infer that some species displayed a specific diel drifting pattern. Drought and flood susceptibility, food, organism competition, shade, and zoogeography, as well as water current, temperature, substratum, vegetation, and dissolved substances, each of these factors influence the occurrence and distribution of stream invertebrates (Hynes 1970).

Conclusion

Current research summarizes the monthly variations of physicochemical parameters and their influence on the drifting behaviour of water mites in Khankra stream with an explanation. Drift is an essential characteristic of water mite species. Water mites drifting behaviour has an effect on the survival of other aquatic species. Upper stretch of the stream shows fewer drifting species, whereas in lower stretch more drifting species were recorded. Based on a number of conditions, it can be nocturnal, diurnal, or dawn-time. Water mites drifting behaviour has an effect on the survival of other aquatic species.

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