Proceedings of the Eleventh International Conference on Urban Pests 2025
AF-Borgen, Academic Society, Lund, Sweden
William H Robinson, editor

RESTING PLACES OF ADULT BLACK FLIES IN THE UPPER REACHES OF THE UKAWA RIVER, JAPAN AND IDENTIFICATION OF FLIGHT DIRECTION OF BLACK FLIES USING STICKY TRAPS

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Abstract In order to exterminate and control adult black flies in the upper reaches of the Ukawa River, we selected 10 sites in the Betsumata Area where the density of black flies fly is relatively high, and examined the flight direction of adult black flies using directional sticky traps with an improved flight interception trap. The survey was conducted three times, on July 1-2, August 26-27, and October 8-9, 2023. On the survey days in both July and August, no strong winds or bad weather conditions were observed during the investigation time. In July, a total of 955 individuals were captured at 10 sites, with 8 directions, and at 10 sites/day. At the Tashiro site, where the largest number of flies was caught, a total of 255 individuals/day were captured on 8 surfaces. A total of 1,083 individuals were captured in the August survey, and a total of 266 individuals/8 directions/day of adult black flies were captured at the Sekitoki site. More than 90% of the adult black flies were Simulium (Simulium) arakawae, and many of black flies were oriented in the direction of rivers and small waterways. In addition, a small number of black flies were oriented at all points in the direction of paddy fields, suggesting that they did not fly from the paddy fields.

Key words blackfly, flight direction, sticky trap, *Simulium arakawae*, Ukawa River

INTRODUCTION

Black flies are insects with a body length of about 3-5 mm, of which 78 species are known in Japan with a nationwide distribution from Hokkaido to Kyushu (Takaoka, 2014). Since the larvae live in mountainous environments with low water temperature and extremely good quality water, they are also environmental indicator organisms of low water temperature in clear streams. When people visiting a Satoyama (a border area between villages or towns and natural mountains, with agricultural fields and ponds or woods) or mountainous area for camping or

fishing are bitten by adult black flies, many become red and swollen, and symptoms such as severe itching, pain, and fever appear (Natsuaki, 2013).

In the upper reaches of the Ukawa River, where blackfly larvae live, tributaries coincide with the irrigation waterways for rice paddies. Because of this, chemical control (spraying chemicals such as insecticides over entire areas), which is often adopted overseas, cannot be used due to concerns about the impact on rice paddies, contamination of water sources for drinking and other uses, and adverse effects on mountain river ecosystems. In addition, we hypothesized that the places where human harm is caused by adult black flies are not necessarily close to the waterways that are high-density habitats of the blackfly larvae (Hirabayashi et al., 2018a), and that after the larvae emerge from rivers and become adults, they do not immediately attack humans, but move to resting habitats such as grassy areas near human activity, and then fly from there to feed on human blood (Hirabayashi et al., 2018b). This suggests that it is not sufficient to target control only around high-density larval habitats. It can be assumed that the resting habitats of adult black flies are close to the human sphere of action.

For the extermination and control adult black flies in the upper reaches of the Ukawa River in Kashiwazaki City, Niigata Prefecture, we examined the flight direction of adult black flies using directional sticky traps in the Betsumata Area in Kashiwazaki City. This was done based on the idea that if the direction of the flight of the adult black flies could be identified, their resting habitats or places of emergence could be identified.

MATERIALS AND METHODS

Study site. The length and drainage area of the Ukawa River are ca. 24.6 km and 108.7 km^2, respectively. The river runs north through Niigata Prefecture and flows into the Japan Sea (Figure 1). In this area, there is much precipitation in winter and relatively little in summer. According to Niigata Prefecture (2022), the average annual water temperature of Ukawa River is 13.3°C, and the water quality is good, type AA.

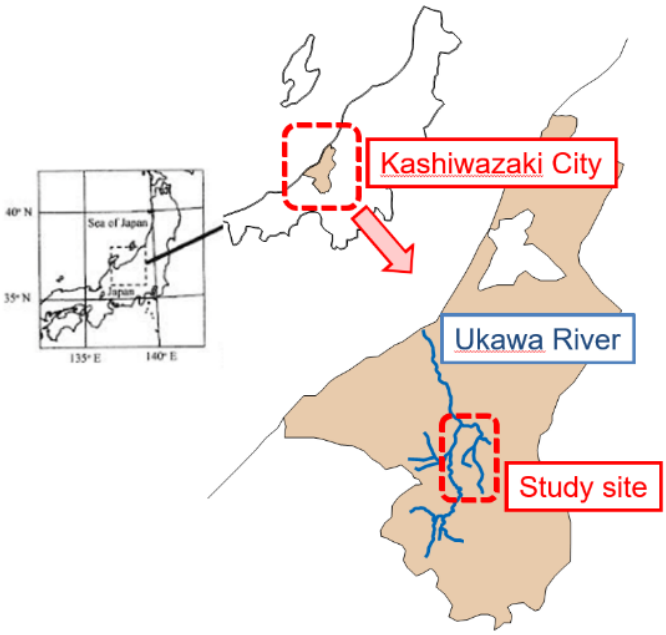

Figure 1. Map of the upper reaches of the Ukawa River, Kashiwazaki City, Japan.

It is a typical rural area consisting of *Satoyama*, undeveloped woodlands near populated areas, mainly broad-leaved forests, and paddy fields at an altitude of about 50 m. There are irrigation waterways between the rice paddies, and a few small streams from the mountains flow into the waterways for fields. The Minakami River, a tributary of the Ukawa River, flows through the center of these paddy fields in the Betsumata Area (Figure 2; short dashed line). Eighty percent of the paddy fields in the Betsumata Area are used in environmentally friendly agriculture, where farmers participate in efforts to create an environment where living organisms can thrive by filling the paddy fields with water after rice cultivation.

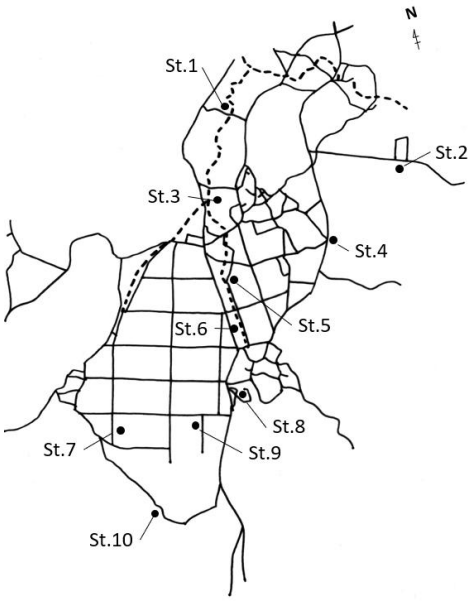

Figure 2. Map of the sampling sites from Station 1 (St. 1) to Station 10 (St. 10) in the Betsumata Area of Kashiwazaki City.

Methods. Surveys were conducted three times, on July 1-2, August 26-27, and October 8-9, in 2023. We selected 10 sites (Table 1) in the Betsumata Area in Kashiwazaki City where the density of adult black flies is relatively high (Hirabayashi et al, 2018b) (Figure 2). We examined the flight direction of adult black flies using directional sticky board traps, which are blue colored boards with an improved flight interception trap (Figure 3 and Figure 4).

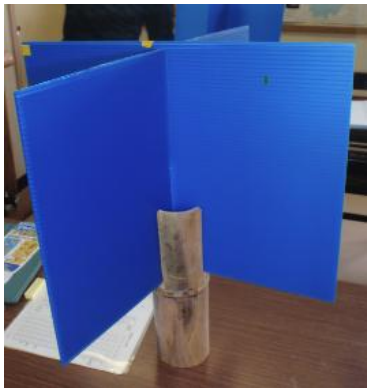

Figure 3. Directional sticky-board trap, which is a blue colored board (30 × 23 cm) with an improved flight interception trap.

Table 1. Station number, site area name and surrounding environment of the trap site.

Station No.	Site area name	Surrounding environment of the trap site
1	Nagatoro	the paddy field near the Mizukami River
2	Former golf course	nera a small pond
3	Teranoura River confluence	Teranoura River and Mizukami River confluence
4	Nakayama	there are some houses (residential area)
5	Middle Mizukami River	reverside of the middle Mizukami River
6	Upper Mizukami River	riverside of the upper Mizukami River
7	Hosogoemaeda	side of the rice paddy field
8	Bunkou paddy field	side of the rice paddy field near the trickle on the mountain side
9	Sekitoki	side of the rice paddy field
10	Tashiro	side of a trickle near the mountain

Traps with 1 kg of dry ice as an attractant were set on poles about 1.5 m above ground level. Traps were set at 3 p.m. every day, left for 24 hours, and collected at 3 p.m. the following day with citizen cooperation. The collected samples were immediately wrapped in plastic cling wrap, put into an ice box, and brought to our laboratory where they were stored in a refrigerator. Adult black flies were then separated from other insects in the laboratory, and the number of adult black flies was counted. Species were identified in part using a stereo microscope.

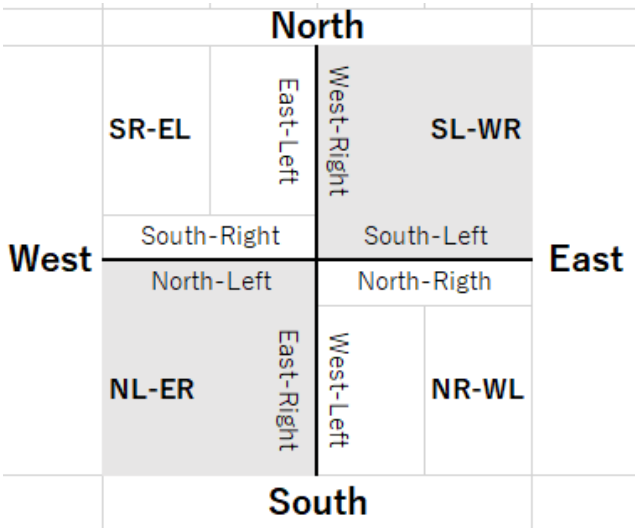

Figure 4. The name of each direction board. For example, facing North, the left board surface is called “North-Left”, and the right board surface is called “North-Right”. The surfaces enclosed by the north-left board and the east-right board planes are called “NL-ER”.

RESULTS AND DISCUSSION

On the survey days in both July and August, no strong winds or inclement weather conditions were observed during the investigation. In contrast, in October, the total number of black flies was as low as 118 individuals per day in 4 directions at the 10 stations due to low air temperature and rain (Table 2). In July, a total of 955 individuals were captured at 10 stations with 4 directions/day. At the Tashiro site (St. 10), where the largest number of flies was caught, a total

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Table 2. Total individual number of blackflies captured (ind. no./each bord face/day) in each investigation month in 2023.

Station No.	July 1 - 2				Total No.	Aug. 26 - 27				Total No.	October 8 - 9				Total No.
	NR-WL	NL-ER	SR-EL	SL－WR		NR-WL	NL-ER	SR-EL	SL－WR		NR-WL	NL-ER	SR-EL	SL－WR	
1	48	8	25	34	115	11	17	34	17	79	0	2	5	2	9
2	14	7	19	28	68	10	8	16	25	59	5	7	2	1	15
3	16	11	22	37	86	9	23	12	28	72	1	1	1	4	7
4	24	23	36	34	117	14	11	16	25	66	4	0	2	4	10
5	3	1	20	16	40	8	6	25	24	63	3	3	2	3	11
6	11	14	29	27	81	5	8	42	17	72	6	5	5	3	19
7	8	16	12	10	46	32	33	43	31	139	1	5	6	1	13
8	12	27	39	5	83	15	34	11	10	70	1	2	2	0	5
9	15	9	17	23	64	61	75	82	48	266	7	6	4	3	20
10	106	53	19	77	255	56	53	28	60	197	7	0	0	2	9
Total No.					955					1083					118

captured on 4 surfaces. A total of 1,083 individuals were captured in the August survey, and a total of 266 individual adult black flies/4 directions/day were captured at the Sekitoki site (St. 9). More than 90% of the adult black flies were *Simulium (Simulium) arakawae.* The flight direction in each month at each site is shown in Figure 5. We focused on the many adult black flies that could be caught in July and August. When classified according to the difference in the direction of flight, we could classify the following three patterns: Pattern 1, in which adult black flies always flew from the same direction at many points, such as at St. 10. Pattern 2 in which the direction of flight was reversed in July and August, such as at St. 1, St. 3, and St. 9. Pattern 3 in which flight from all directions in almost equal proportions was revealed, such as at St. 4 and St. 7. Looking at each location in more detail, we can see that at St. 1, black flies flew from the Mizukami River side in July (NR-WL) and from the opposite mountain side in August (SR-EL). At St. 2, black flies always came from the direction of a pond in a golf course (SL-WR). At St. 3, adult black flies flew from the downstream side of the Mizukami River in July (SL-WR), and from the confluence of the river behind a temple and the Mizukami River in August (NL-ER). At St. 4, they came from all directions from the surrounding residential areas in almost equal proportions. At St. 5, they constantly flew from the Mizukami River (SR-EL). At St. 6, they flew from the direction of trickling water in paddy fields opposite the Mizukami River (SR-EL). At

St. 7, they flew from all directions in almost equal proportions from the surrounding rice paddies. At St. 8, they always flew from the direction of the trickling water on the mountain side (NL-ER). At St. 9, they flew from the direction of the paddy fields of the Mizukami River in July (SL-WR) and from the opposite direction of the paddy fields in August (NL-ER). At St. 10, they always flew from the direction of trickling water near the mountain side (NR-WL).

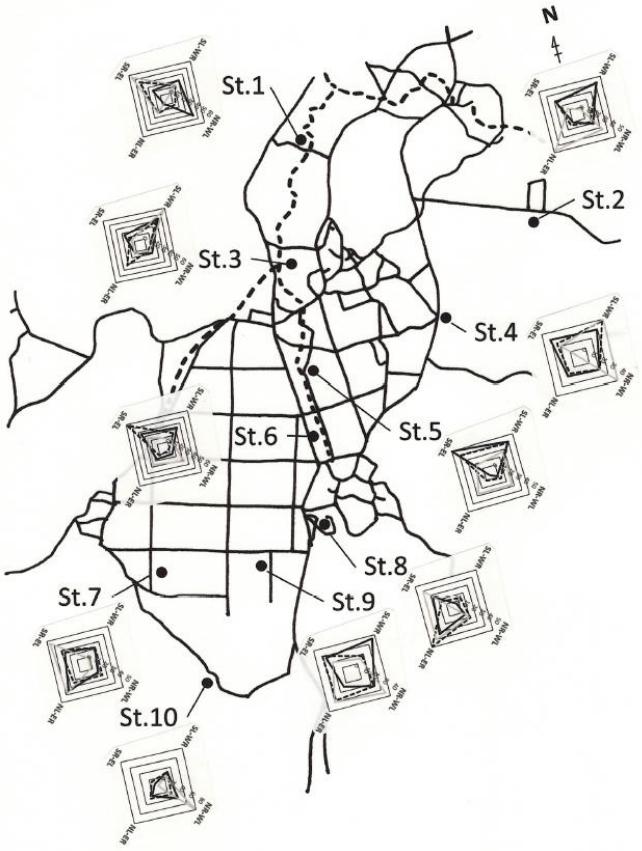

Figure 5. Relative flight density of black flies attracted by dry ice in the 10 stations in the Betsumata Area in each investigation month and each station. Black lines indicate July data, dashed lines indicate August data and gray lines indicate October.

Many black flies were captured in the direction of rivers, small waterways, and creeks. In addition, a small number of black flies were captured at almost all points in the direction of paddy fields (except at St. 6 in August), suggesting that they did not fly from the paddy fields.

From the above, it is inferred that the target area for control should be rivers, waterways/creeks, and that paddy fields could be excluded from the target areas.

ACKNOWLEDGEMENTS

We wish to thank colleagues at the Betsumata area for their generous support and assistance during the research program. This work was supported by JSPS KAKENHI Grant Number 23K09668.

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