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Research Note

Chironomid midges (Diptera, Chironomidae) in filtration plants in Japan during summer—Filtration plants in Honshu compared with those in the Sakishima Islands

Kimio HIRABAYASHI[1], Masaru YAMAMOTO[2] and Nobutada NAKAMOTO[1]

[1] *Department of Applied Biology, Faculty of Textile Science and Technology, Shinshu University, Ueda, Nagano, 386–8567 Japan*
[2] *Kankyou-kagaku Kabushiki-gaisha, 2–21–7, Nakasakurazuka, Toyonaka, Osaka, 560–0881 Japan*

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Abstract: Chironomid fauna in slow sand filter beds were investigated and compared with those at two different water filtration plants; one in southwestern Japan, i.e., the Sakishima Islands, and the other in a plateau area, i.e., Honshu Island. As a result, the midges were found to be dominated by three taxa, *Cricotopus*, *Paratrichocladius rufiventris* and *Tanytarsus oyamai* at two filtration plants in the center of Honshu Island. On the other hand, in the Sakishima Islands, the most abundant species was *Polypedilum nubifer*, which was also collected on Honshu Island. In addition, we recorded two chironomid species from the Sakishima Islands.

INTRODUCTION

Slow sand filter beds are water-filled containers used by municipalities to purify water for drinking purposes. The beds, which make up water treatment works, are identical in size and in the homogeneity of their sand substratum all over the world (Rachwal et al., 1996; Brink and Parks, 1996). Therefore, they provide replicates for following the development of community structures over a range of durations. This can be traced from a known date when beds are refilled after cleaning.

The filter beds have a substratum of sand on which a rich coating of organic particles (schmutzdecke layer) develops during the passage of water through the bed. Research on the ecology of slow sand filter beds has been limited (Duncan, 1988). In particular, the invertebrates (protozoans, nematodes, oligochaetes and larvae of caddisflies, mayflies, and chironomids) associated with the schmutzdecke layer have either been ignored, or no relevant studies have yet been published. Chironomids were mentioned both in a brief review by Sladeckova (1991) of the biota associated with water supply systems and in a study of the algal flora of filter beds by Brook (1954). However, Duncan (1988), while reviewing the ecology of interstitial meiofauna and flora, made no reference to chironomids. According to Hirabayashi and Wotton (1998) and Wotton and Hirabayashi (1999), chironomid larvae in the filter beds achieve high population densities, and these large numbers of larvae have an impact on and play an important role in the filtration process. The conditions of these filter beds are unlike temporary natural habi-

tats (transient ponds, i.e., rain-pools, etc.) where seasonal droughts and rainfall can affect extensive areas.

Despite being known to reach impressively high numbers, the chironomids living in and partly responsible for developing the organically rich coating of the sand surface have been little studied (Wotton et al., 1992, 1996). The purpose of this paper is to record the chironomid fauna in slow sand filter beds in Japan. Therefore, chironomid fauna in slow sand filter beds were investigated by comparing two different areas of filtration plants; one in southwestern Japan, i.e., the Sakishima Islands (Sodeyama and Ishigaki filtration plants) and the other in the plateau area of Honshu Island (Someya and Ishibune filtration plants).

Materials and Methods

Description of slow sand filter beds

Slow sand filter beds are used to purify water passing from rivers or storage reservoirs into the drinking water supply. Beds consist of enclosed rectangular ponds which have a concrete base overlain with gravel and then a thick layer of sand. The surface of the sand is a smooth, markedly homogeneous and level substratum. The depth of water is also uniform, varying from 1.0–2.0 m. With a continuous supply of particulate food passing to and becoming trapped at the filter surface, very large populations of animals accumulate.

Sampling areas

The Sakishima group consists of a large

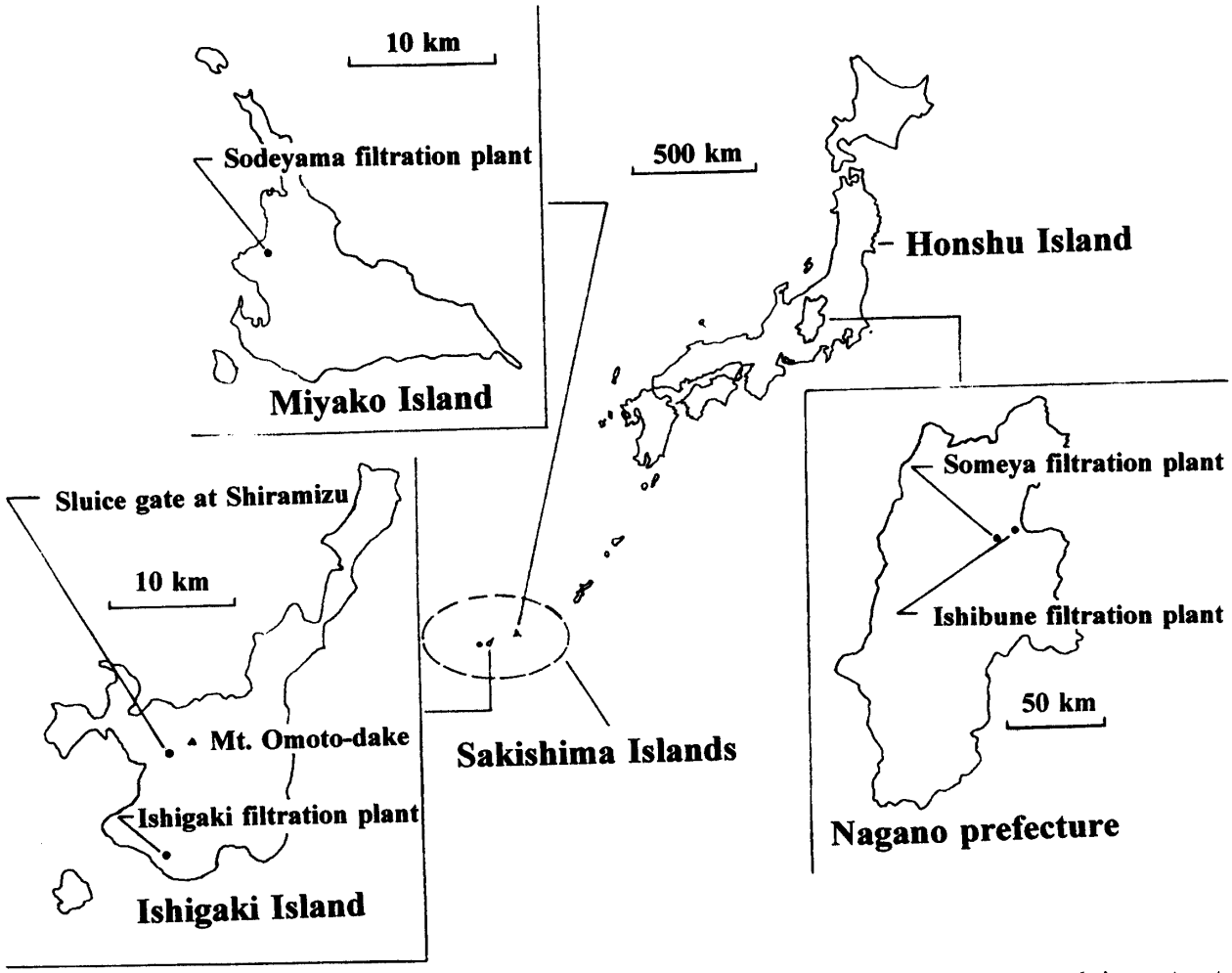

Fig. 1. Map of four filtration plants (Sodeyama, Ishigaki, Someya, and Ishibune) and one sluice gate at Shiramizu in the Shiramizu River.

Table 1. Location (latitude and longitude), altitude, sampling dates and water temperature for each sampling station.

Sampling stations	latitude/longitude	Altitude (m)	Sampling dates	Water temp. (℃)
Sodeyama filter plant	24°47/125°18	53	June 29–30, 2000	26.0
Ishigaki filter plant	24°21/124°10	58	July 2, 2000	27.0
Shiramizu sluice gate	24°24/124°10	11	July 2, 2000	23.0
Ishibune filter plant	36°27/138°19	720	July 6, 2000	16.3
Someya filter plant	36°24/138°16	500	July 6, 1997	17.0
			July 6, 2000	17.3

number of islands in the western Pacific forming a chain between Okinawa and Taiwan in the subtropical zone (24°N–25°N). These islands are further divided into the Miyako group (Miyako Island, Irabu Island, etc.) and the Yaeyama group (Ishigaki Island, Iriomote Island, Yonaguni Island, etc.). Both groups are in Okinawa Prefecture. The fauna and the flora of Sakishima are mainly those of the Oriental Region, but are also known to include many indigenous species, some of which are the same as those recorded from the Palaearctic part of Japan by many workers. In this study, two filtration plants, Sodeyama and Ishigaki, were chosen for investigation. On the other hand, Nagano Prefecture is located at the center of the main island of Honshu in an inland climate area. Two Honshu filtration plants, Someya and Ishibune, were chosen and investigated (Fig. 1).

Chironomid midges were collected from a total of four filtration plants, Sodeyama (Hirara City, western Miyako Island, Okinawa Prefecture), Ishigaki (Ishigaki City, southern Ishigaki Island, Okinawa Prefecture), Someya (Ueda City, eastern Nagano Prefecture) and Ishibune (Sanada Town, eastern Nagano Prefecture), as well as from one sluice gate at Shiramizu (Shiramizu River, at the foot of Mt. Omoto-dake, Ishigaki Island). Location (latitude and longitude), altitude, sampling dates and water temperatures are shown in Table 1 for each filtration plant and sluice gate. The water temperature differed by about 10℃ between Sakishima and Honshu, although the investigation periods were almost identical.

Collection of adult midges

Nets were used for daytime collections of adult midges resting around slow sand filter beds and along the shore of the Shiramizu River. In the filtration plant, one investigator collected as much as possible during a 5-minute period from around one filter bed employing the method of quantitative collection. Six filter beds were investigated. Collected chironomid midges were preserved in 70% ethanol for later identification. Adults were identified at the generic or specific level using the keys provided by Pinder (1978), Wiederholm (1989), Sasa and Kikuchi (1995) and Saether et al. (2000).

Results

The total number of adult midges caught by sweeping nets at two filtration plants in Nagano Prefecture are presented in Table 2. A total of 292 adults were collected, and we identified a total of 11 genera and 17 species belonging to 2 subfamilies, i.e., 5 genera and 7 species of Chironominae (41.2%) and 6 genera and 10 species of Orthocladiinae (58.8%). At the Someya plant in July 1997 and 2000, 10 genera and 14 species were recorded, whereas 7 genera and 8 species were recorded at the Ishibune plant in July, 2000. The most abundant genus was *Cricotopus*, especially, *C. bicinctus* and *C. trifasciatus*, which were collected at both filtration plants where *Chironomus kiiensis, Polypedilum nubeculosum* and *Tanytarsus oyamai* were also obtained. The midges from the filter beds in Someya are dominated by three species (in order of abundance), *C.*

Table 2. List of chironomid midges collected with insect nets around slow sand filter bed in Someya and Ishibune filtration plants (6 filter beds).

	Someya plant 1997. 7. 6 (♂, ♀) Total	Someya plant 2000. 7. 6 (♂, ♀) Total	Ishibune plant 2000. 7. 6 (♂, ♀) Total
Chironominae (5 genera 7 species) (41.2%)	2G. 3S. (30.0%)	4G. 6S. (66.7%)	3G. 3S. (37.5%)
Chironomus kiiensis Tokunaga		(1, 0) 1	(0, 1) 1
Microchironomus tener (Kieffer)	(1, 0) 1		
Paratanytarsus stagnarius (Tokunaga)		(1, 0) 1	
P. sp.		(0, 1) 1	
Polypedilum nubeculosum (Meigen)	(0, 1) 1	(5, 2) 7	(0, 2) 2
P. nubifer (Skuse)	(0, 1) 1	(0, 9) 9	
Tanytarsus oyamai Sasa		(0, 2) 2	(63, 68) 131
Orthocladiinae (6 genera 10 species) (58.8%)	5G. 7S. (70.0%)	2G. 3S. (33.3%)	4G. 5S. (62.5%)
Cricotopus bicinctus (Meigen)	(5, 3) 8	(15, 9) 24	(1, 0) 1
C. triannulatus (Macquart)	(2, 1) 3		
C. trifasciatus (Meigen)	(11, 12) 23	(0, 3) 3	(1, 0) 1
Hydrobaenus biwaquartus (Sasa et Kawai)			(2, 1) 3
Orthocladius sp. (nr. *yugashimensis* Sasa)			(10, 6) 16
O. sp.	(0, 1) 1		
Paratrichocladius rufiventris (Meigen)	(34, 7) 41	(0, 1) 1	
Psectrocladius sordidellus Zetterstedt	(2, 3) 5		
P. sp.			(0, 1) 1
Rheocricotopus chalybeatus Edwards	(3, 0) 3		
Total number 292	87	49	156
Total 11 genera 17 species (100%)	7G. 10S. (100%)	6G. 9S. (100%)	
	10G. 14S.		7G. 8S. (100%)

bicinctus (32 individuals in both years), *C. trifasciatus* (26 individuals) and *Paratrichocladius rufiventris* (42 individuals). On the other hand, the most abundant species was *T. oyamai* (131 individuals) in the Ishibune plant. *Hydrobaenus biwaquartus*, *Orthocladius* sp. (near *O. yugashimensis*) and *Psectrocladius* sp. were collected only at Ishibune.

Table 3 shows the total number of adult midges caught at two filtration plants and one sluice gate in the Sakishima Islands. A total of 339 adults were collected, and we identified a total of 6 genera and 6 species belonging to Chironominae. In the Ishigaki plant, 3 genera and 3 species were recorded, the most abundant being *P. nubifer* (319 individuals) which was also collected at the Someya plant in Nagano Prefecture. In the Sodeyama plant on Miyako Island, only one species, *C. circumdatus*, was collected in the present study.

Discussion

Chironomid fauna in slow sand filter beds

Until now, there have been few reports of chironomid fauna in slow sand filter beds. This is the first report of chironomid fauna of slow sand filter beds in Japan. Wotton et al. (1996) reported that 19 genera and 23 species belonging to 3 subfamilies, i.e., 11 genera and 13 species of Chironominae (56.5%), 4 genera and 6 species of Orthocladiinae (26.1%) and 4 genera and 4 species of Tanypodinae (17.4%), were recorded at the slow sand filter bed of Ashford Common Water

Table 3. List of chironomid midges collected with insect nets around slow sand filter bed in Sodeyama and Ishigaki filtration plants (6 filter beds), and a sluice gate at Shiramizu in the Shiramizu River.

Name of island	Ishigaki Island		Miyako Island
Sampling points	Shiramizu River	Ishigaki plant	Sodeyama plant
Date	2000. 7. 1	2000. 7. 2	2000. 6. 29
Individual No.	(♂, ♀) Total	(♂, ♀) Total	(♂, ♀) Total
Chironominae (6 genera 6 species)	2G. 2S.	3G. 3S.	1G. 1S.
Chironomus circumdatus Kieffer			(0, 1) 1
Cryptochironomus javae Kieffer		(2, 1) 3	
Dicrotendipes septemmaculatus (Becker)	(1, 0) 1		
Einfeldia sp. (new species)	(7, 2) 9		
Hanochironomus tumerestylus Ree		(1, 5) 6	
Polypedilum nubifer (Skuse)		(63, 256) 319	
Total individual number 339	10	328	1

Treatment Works where Thames Water plc. purify some of the domestic water supplied to London, whereas 13 genera and 20 species were also recorded in Japan in the present study (Table 2 and 3). In the Sakishima Islands, far fewer chironomid species (i.e., 4 genera and 4 species, all Chironominae) were obtained in comparison to other slow sand filter beds (Table 3). In Nagano Prefecture, the number of species was similar to that collected in London, although Tanypodinae were not collected there (Table 2). Wotton et al. (1992) found a distinct chironomid community, and samples of its adult midges and larvae were dominated by three species, *C. sylvestris, Psectrocladius limbatellus* and *T. fimbriatus*. During the summer, *C. sylvestris* was usually dominant, with *P. limbatellus* and *T. fimbriatus* usually sub-dominant. In this study, several chironomid species, i.e., the *Cricotopus*, and *Paratrichocladius rufiventris, T. oyamai* and *P. nubifer* were collected around filter beds. These species are well suited to temporary habitats, as they each have a relatively short life cycle (LeSage and Harrison, 1980; Wiederholm, 1989; Okazaki and Yano, 1990). This results in a significant proportion of the larvae emerging as adult midges before the filter bed is drained for cleaning (Wotton et al., 1992). The only genera common to all slow sand filter beds were *Chironomus* and *Polypedilum*. On the other hand, the common genus between London and Sakishima was *Cryptochironomus* and 4 genera, *Tanytarsus, Cricotopus, Orthocladius* and *Psectrocladius*, were common to Nagano Prefecture and London.

In conclusion, in this study we suggested that the chironomid fauna of slow sand filter beds are not always composed of the same or closely related genera, though they all exist in a similarly stable and artificial control system. We proposed two reasons for this. First, the water source was different. Filter beds are used to purify water passing from rivers or storage reservoirs into the drinking water supply. Such a difference may have been a consequence of differences in food quality (different fauna and flora of plankton) for chironomid larvae, resulting in a different genus dominating the substratum. Secondly, the different water temperature possibly results in a difference in the speed of decomposition of the organic matter on the substratum and the growth rate of larvae.

Chironomid fauna in Sakishima Islands

We presented a chironomid fauna in the Sakishima region in summer. Until now, 14 genera and 27 species have been found by Sasa and Hasegawa (1983, 1988), Hasegawa and Sasa (1987) and Sasa (1990) in winter. Recently, Sasa and Suzuki (2000)

reported that 10 genera and 12 species were also recorded on the slope of Mt. Omoto-dake in Ishigaki Island in summer. There was no common species between our results and those of Sasa and Suzuki (2000). *Hanochironomus tumerestylus*, which was first recorded from Japan in this study, had been found in Korea by Ree (1992). Moreover, *Einfeldia* sp. will be described as a new species (Yamamoto, personal communications). *Chironomus circumdatus*, which has been recorded on Miyako Island by Sasa and Hasegawa (1983), was first recorded from Ishigaki Island in our investigation. To these we added the three chironomid species found in summer during this study. Consequently, a total 22 genera and 40 species were recorded on Miyako and Ishigaki Islands.

However, since the present study was carried out over only a few days, further follow-up field investigations are necessary to collect more adult midges by other collecting methods, e.g., light traps and/or sticky traps. Such studies should be conducted during different seasons to further improve our understanding of the chironomid fauna of slow sand filter beds.

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References

Brink, D. R. and Parks, S. 1996. Update on slow sand/advanced biological filtration research. *In*: Advances in Slow Sand and Alternative Biological Filtration (ed. Graham, N. and Collins, R.), pp. 11–18, Wiley, Chichester.

Brook, A. J. 1954. The bottom-living algal flora of slow sand filter beds of waterworks. *Hydrobiologia*, 6: 333–351.

Duncan, A. 1988. The ecology of slow sand filters. *In*: Slow Sand Filtration: Recent Developments in Water Treatment Technology (ed. Graham N. J. D.), pp. 163–180, Ellis Horwood, Chicester.

Hasegawa, H. and Sasa, M. 1987. Taxonomical notes on the chironomid midges of the tribe Chironomini collected from the Ryukyu Islands, Japan, with description of their immature stages. *Jpn. J. Sanit. Zool.*, 38: 275–295.

Hirabayashi, K. and Wotton, R. S. 1998. Organic matter processing by chironomid larvae. *Hydrobiologia*, 382: 151–159.

LeSage, L. and Harrison, A. D. 1980. The biology of *Cricotopus* (Chironomidae: Orthocladiinae) in an algal enriched stream: 1 Normal biology. *Arch. Hydrobiol. Supplbd*, 57: 375–418.

Okazaki, A. and Yano, K. 1990. Biology of *Tanytarsus oyamai* Sasa (Diptera: Chironomidae). *Trans. Shikoku Entomol. Soc.*, 19: 89–99.

Pinder, L. C. V. 1978. A key to adult males of the British Chironomidae (Diptera). *Sci. Publ. Freshwater Biol. Assoc.*, 37: 1–169.

Rachwal, A. J., Bauer, M. J., Chipps, M. J., Colbourne, J. S. and Foster, D. M. 1996. Comparisons between slow sand and high rate biofiltration. *In*: Advances in Slow Sand and Alternative Biological Filtration (ed. Graham, N. and Collins, R.), pp. 3–10, Wiley, Chichester.

Ree, H. I. 1992. A new genus and new species of Chironomidae from Korea. *Jpn. J. Sanit. Zool.*, 43: 19–22.

Saether, O. A., Ashe, P. and Murray, D. A. 2000. Family Chironomidae. *In*: Contributions to a Manual of Palaearctic Diptera—Appendix. (ed Papp, L. and Darvas, B.) pp. 113–334, Science Herald, Budapest.

Sasa, M. 1990. Studies on the chironomid midges (Diptera, Chironomidae) of the Nansei Islands, southern Japan. *Jpn. J. Exp. Med.*, 60: 111–165.

Sasa, M. and Hasegawa, H. 1983. Chironomid midges of the tribe Chironomini collected from sewage ditches, eutrophicated ponds, and some clean streams in the Ryukyu Islands, southern Japan. *Jpn. J. Sanit. Zool.*, 34: 305–341.

Sasa, M. and Hasegawa, H. 1988. Additional records of the chironomid midges from the Ryukyu Islands, southern Japan (Diptera, Chironomidae). *Jpn. J. Sanit. Zool.*, 39: 229–256.

Sasa, M. and Kikuchi, M. 1995. Chironomidae (Diptera) of Japan. 333 pp. University of Tokyo Press, Tokyo.

Sasa, M. and Suzuki, H. 2000. Studies on the chironomid species collected on Ishigaki and Iriomote Islands, Southwestern Japan. *Trop. Med.*, 42: 1–37.

Sladeckova, A. 1991. The role of periphyton in water supply. *Verh. Internat. Verein. Limnol.*, 24: 2174–2178.

Wiederholm, T. 1989. Chironomidae of the Holarctic region. Keys and diagnoses. Part 3. Adult males. *Entomol. Scand. Suppl.*, 34: 1–532.

Wotton, R. S., Armitage, P. D., Aston, K., Blackburn, J. H., Hamburger, M. and Woodward, C. A. 1992. Colonisation and emergence of midges (Diptera: Chironomidae) in slow sand filter beds. *Neth. J. Aquat. Ecol.*, 26: 331–339.

Wotton, R. S., Chaloner, D. T. and Armitage P. D. 1996. The colonization, role in filtration and potential nuisance value of midges in slow sand filter beds. *In*: Advances in Slow Sand and Alternative Biological Filtration (ed. Graham, N. and Collins, R.), pp. 149–157, Wiley, Chichester.

Wotton, R. and Hirabayashi, K. 1999. Midge larvae (Diptera: Chironomidae) as engineers in slow sand filter beds. *Water Res.*, 33: 1509–1515.