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Estimation of the time of death of decomposed or skeletonized bodies found outdoors in cold season in Sapporo city, located in the northern district of Japan

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Abstract

In Sapporo city, located in the northern district of Japan, it is very difficult to estimate the time of death of decomposed or skeletonized bodies found outdoors in cold season (November–April) because postmortem changes are markedly retarded in the season compared with warm season (May–October), and the bodies are often damaged and skeletonized by carnivorous animals such as wild dogs and foxes. However, they cannot damage the brain in the cranium. The brain is mainly damaged by fly larvae. In Sapporo city, we can estimate that the time of death of a cadaver found outdoors in the cold season is in the beginning of November or before if fly larvae hatched in autumn exist on the cadaver, and that the time of death is in the beginning of November or after if fly larvae hatched in autumn do not exist and most of the brain remains in the cranium.

Keywords: Forensic entomology; *Calliphora lata*; *Calliphora vicina*; Oviposition of flies; Cold season; Fly larvae

1. Introduction

Sapporo city located in the northern district of Japan is a snowbound area between December and March. Postmortem changes of the cadavers found outdoors in cold season (November–April) in the region are retarded in a marked degree compared with warm season (May–October), because of the low-temperature surroundings. Suzutani et al. reported that the cadavers at low temperature for 3–5 months after death display the findings corresponding to those of the cadavers at normal temperature for 4–7 days after death [1]. Furthermore, carnivorous animals such as foxes and dogs often skeletonize the dead bodies whose postmortem interval is relatively short. Therefore, it is very difficult to estimate the time of death of decomposed or skeletonized bodies found outdoors in the cold season.

To solve these problems, we had conceived the idea of estimating the time of death by the use of fly larvae existing on the cadavers that we had examined in the past [2]. However, we had neither identified the species of the flies nor understood the precise ovipositional behaviors of the flies.

In this study, we identified the species of eggs and larvae of the flies that we had collected from the cadavers found outdoors from April, 2005 to April, 2007. We also observed whether brain remained in the cranium, and studied ovipositional behaviors of the flies that lay eggs on the cadavers found outdoors in the cold season. Based on these findings, we established a method to estimate the time of death of decomposed or skeletonized bodies found outdoors in the cold season.

2. Materials and methods

2.1. Temperature data

Sapporo city is located at Lat. 43°N and Long. 141°E. We referred to temperature data observed by the Sapporo

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District Meteorological Observatory. The monthly averages of the lowest and the highest temperatures in Sapporo city from 1971 to 2000 are plotted (Fig. 1).

2.2. Experiment

We prepared putrefied pig livers, weighing about 300 g, and put them outdoors in Sapporo city from November 1, 2006 to April 30, 2007. They were placed on a stand about 50 cm above the ground, in the shade to avoid direct sunlight. We observed them at 8:00 a.m. and 6:00 p.m. every day. When we found eggs on the liver, we collected them with the liver, and put another putrefied pig livers as replacement immediately after the collection. We reared them in our laboratory, and identified the species by observing the adult flies morphologically [3].

2.3. The morphological features of adult flies

Calliphora vicina (Robineau-Desvoidy, 1830): the front half of the cheek is reddish orange in color. There are black hairs on the cheeks. The basicosta on the wing is yellowish in color (Fig. 2).

Calliphora lata (Coquillett, 1898): the species is also known as *Calliphora nigribarbis* (Vollenhoven, 1863). The cheek is black in color. The basicosta is black in color. The mesothoracic spiracle is orange in color (Fig. 2).

2.4. Cases

From April 2005 to April 2007, we collected a mass of eggs and dozens of fly larvae existing on cadavers found outdoors in Sapporo area. Then we reared them in our laboratory, and identified the species by observing the adult flies morphologically [3]. We identified their family from the shapes of the posterior plate and the posterior spiracle

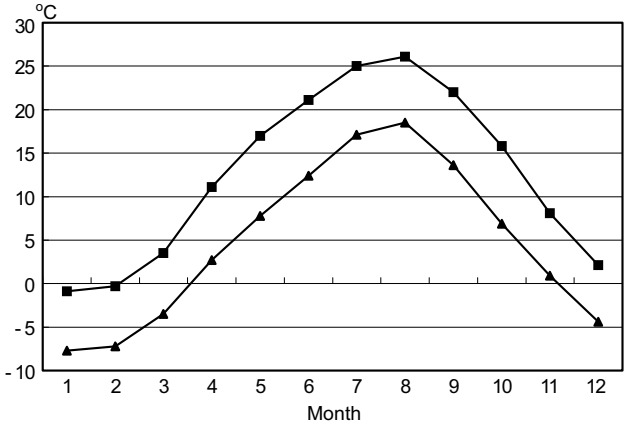

Fig. 1. The monthly averages of the lowest and the highest temperatures (°C) in Sapporo city from 1971 to 2000, measured by Sapporo District Meteorological Observatory. ▲–▲, lowest temperatures; ■–■, highest temperatures.

Fig. 2. The left is *C. vicina*. The right is *C. lata*.

[3]. We chose 10 larvae of various sizes and measured the length of each larva after we killed them with boiling water.

3. Results

3.1. Experiment

We found the last oviposited eggs at 6:00 p.m. on November 9, 2006 in the autumn (Table 1). No eggs were found from November 10, 2006 to April 18, 2007. We

Table 1
The presence or absence of fly eggs in November 2006

Date	8:00 (a.m.)	6:00 (p.m.)	Highest temperature (°C)
1	(–)	(–)	9.0
2	(–)	(–)	11.4
3	(–)	(+)	16.5
4	(–)	(+)	16.9
5	(–)	(+)	16.7
6	(–)	(–)	15.8
7	(–)	(–)	14.8
8	(–)	(+)	14.8
9	(–)	(+)	15.8
10–30	(–)	(–)	1.7–11.3

Table 2
The presence or absence of fly eggs in April 2007

Date	8:00 (a.m.)	6:00 (p.m.)	Highest temperature (°C)
1–18	(–)	(–)	3.9–11.3
19	(–)	(+)	13.6
20	(–)	(–)	11.0
21	(–)	(+)	17.0
22	(–)	(+)	14.9
23	(–)	(+)	13.3
24	(–)	(+)	18.0
25	(–)	(+)	17.6
26	(–)	(–)	10.0
27	(–)	(–)	11.9
28	(–)	(+)	17.7
29	(–)	(+)	19.6
30	(–)	(+)	14.6

Table 3
The species, state of eggs, and larvae of flies attached on cadavers

No.	Date	Time of death	Species	Eggs	Larvae (mm)
1	March (2), 06	January (1), 06	–	–	–
2	March (3), 06	Unknown	–	–	–
3	April (1), 07	October (1), 06	Unknown	–	10–20 (a)
4	April (3), 06	Unknown	–	–	–
5	April (3), 05	October (1), 04	Unknown	–	10–20 (b)
6	May (1), 06	January (1), 06	*C. lata*	+	–
7	May (1), 06	February (1), 06	*C. lata*	+	2
8	May (1), 06	April (3), 06	*C. lata*	+	2
9	May (1), 06	November (3), 05	*C. lata*	+	2–7
10	November (2), 05	October (2), 05	*C. lata*	–	2–20
11	November (2), 06	October (1), 06	*C. lata*	–	2–20
12	November (3), 06	November (1), 06	*C. vicina*	–	10–14
13	December (1), 06	October (2), 06	*C. lata*	–	10–20
14	December (2), 06	December (1), 06	–	–	–
15	January (2), 07	May–June (1), 06	–	–	–

(1) The beginning of the month (date 1–10); (2) The middle of the month (date 11–20); (3) The end of the month (date 21–31). (a) All larvae were dead; (b) most larvae were dead.

found oviposited eggs at 6:00 p.m. on April 19, 2007, for the first time in the spring (Table 2). The species of the flies that had laid the eggs were *C. lata* and *C. vicina*.

3.2. Cases

Table 3 shows the dates of inquest or autopsy of the cadavers, the time of death, the species of flies, the presence or absence of eggs and the length of larvae. No pupa or empty pupal shell of flies was present on any of the cadavers. The species of the eggs and larvae were *C. lata* and *C. vicina*. The larvae of Nos. 3 and 5 were identified as Calliphoridae, but their species were not identified because we could not breed them to adult flies. The time of death listed in Table 3 was determined from the investigation by the police. The cadaver Nos. 2 and 4 were unidentified and their times of death were unknown.

4. Discussion

The species of the flies that had laid eggs on the cadavers found outdoors in autumn and spring were identified as *C. vicina* and *C. lata* (Table 3). They are the same species as those that laid eggs on the decomposed pig livers.

Oviposited eggs were not observed after November 9, 2006 in the autumn. We can explain it was because the highest temperature was lower than 12 °C (Table 1). Oviposited eggs were not observed on November 6 and 7, 2006 because it was rainy all day long, although the highest temperature was higher than 12 °C. Although various factors affect the oviposition of flies, temperature and weather are thought to be the major factors. Therefore, in Sapporo city, the oviposition of flies on cadavers is thought to end at the beginning of November on average, although we must note that the highest temperature in the middle of November can be higher than 12 °C.

In spring 2007, the snow thawed completely on April 3, which was earlier than the average. The first oviposition was observed on April 19. We assume that flies began to oviposit on this day because the highest temperature was over 12 °C (Table 2). In Sapporo city, it seems that flies begin to oviposit on the cadaver in April when the highest temperature goes over 12 °C.

Nos. 1, 2, 4: the cadavers were skeletonized bodies. Especially, the cadaver Nos. 2 and 4 had little soft tissue except for the brain. There were bite marks of carnivorous animals on the bones and remaining soft tissues of the cadavers. However, dura mater and most of their brain remained in the cranium of these three cadavers. Fig. 3 shows the intracranial condition of the cadaver No. 2. We can estimate that the deaths occurred after the begin-

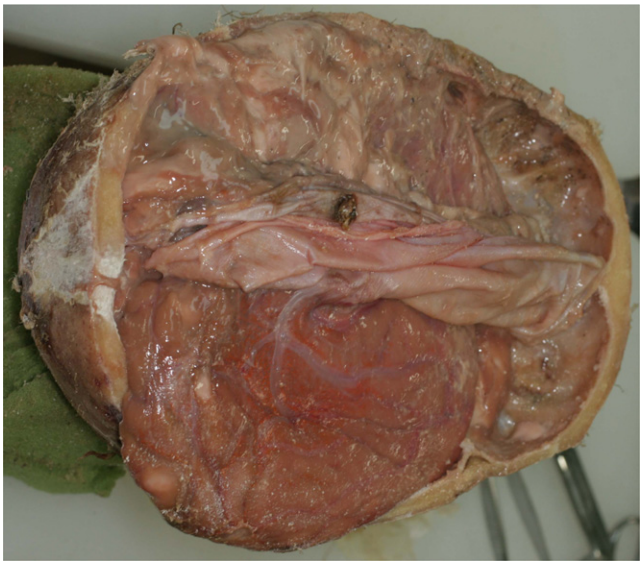

Fig. 3. The intracranial condition of the cadaver No.2.

ning of November of the previous year because there were no larvae on the soft tissues including the brain that mostly remained. It is important for us to observe whether there are larvae and brain in the cranium of a skeletonized body because carnivorous animals such as foxes and wild dogs cannot eat brain in the cranium due to morphological features of their mouths.

No. 3: the cadaver was found after the thaw. This cadaver was partially skeletonized. The bite marks of carnivorous animals such as foxes were observed on the bones and remaining soft tissues. There were dura mater, brain and many dead larvae in the cranium. Fig. 4 shows the intracranial condition. There were neither eggs nor live larvae on the cadaver. We can decide that the dead larvae had been oviposited and hatched in the previous autumn, because the highest temperature in the beginning of April 2007 was lower than 12 °C and flies have not oviposited yet in the spring.

No. 5: the cadaver was partially skeletonized. The bite marks of carnivorous animals such as foxes were observed on the bones and remaining soft tissues. There were many larvae in the cervical region and in the cranium, and most of the larvae were dead. A small amount of brain and dura mater remained. In the spring 2005, because the thaw was later than the average year, the cadaver had been buried in snow. Therefore, the larvae were oviposited and hatched in the last autumn, not in the spring.

As described in the literatures, the mortality of fly larvae hatched in the autumn increases in the cold season as time goes by [4,5]. We assume that the larvae on the cadaver had been exposed to the low temperature for several months. Consequently, most of the larvae failed to overwinter and died in winter.

Nos. 6–9: the tissues of No. 6 remained almost completely. The cadaver Nos. 7–9 were skeletonized bodies, and they had bite marks of carnivorous animals. Especially, cadaver No. 9 had little soft tissue except for brain, and the eggs and larvae were found on the brain in the cranium. There were eggs and larvae on these cadavers. All larvae were alive and their length were shorter than 10 mm (Table 3). The highest temperature was lower than 12 °C after November 8, 2005. Accordingly, oviposition of flies is thought to have ended at the beginning of November, 2005. Deaths occurred after the beginning of November. Therefore, the eggs and larvae were oviposited and hatched in the spring, not in the last autumn. The highest temperatures in the beginning of May were high enough for flies to oviposit on the cadavers. The temperature data also supports our estimation that these eggs and larvae on the cadavers were oviposited in the spring.

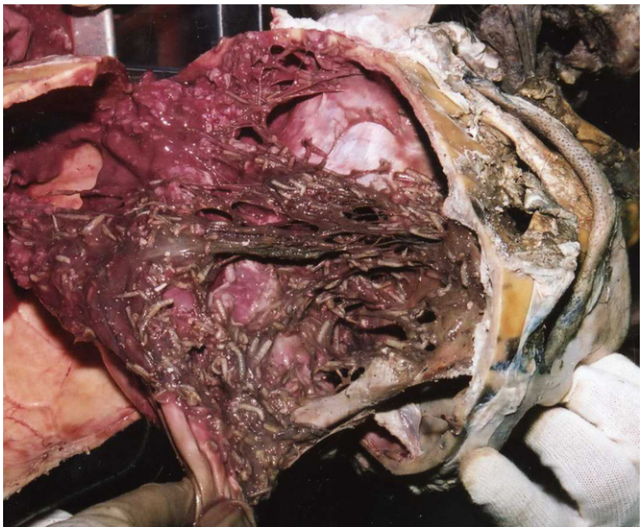

Fig. 4. The intracranial condition of the cadaver No. 3.

Nos. 10–13: most of the tissues including the brain remained in Nos. 10, 12 and 13. Cadaver No. 11 was partially skeletonized and a small amount of brain and dura mater remained. The larvae found on the cadavers had been oviposited by the beginning of November. *C. lata* and *C. vicina* can adapt themselves to low-temperature circumstances [3,5], and larvae of *C. vicina* can grow up even at 4 °C [6]. In the climate of Sapporo city, the larvae oviposited in the beginning of November can grow up by the end of the month. Considering the length of larvae on Nos. 3, 5, 12 and 13, although the species of larvae were not identified in some of the cases, we estimate that they can grow to about 10 mm or more (Table 3).

No. 14: the whole brain and dura mater remained in the cranium, and other soft tissues also remained completely. We estimate that there were no larvae on the cadaver because the death occurred after the beginning of November.

No. 15: the cadaver was a skeletonized body and a small amount of dry soft tissue was adhering to the bones. Bite marks of animals were observed on the bones. In the cranium, brain had disappeared completely, and only the dry dura mater remained partially. We estimate that there was no brain left in the cranium since fly larvae had eaten up the brain in the summer.

If there are fly larvae on a cadaver found in winter, it is easy to conclude that the larvae were oviposited and hatched in the previous autumn because flies do not lay eggs on cadavers in winter. However, if there are larvae on a cadaver found outdoors in spring, we first have to decide whether the larvae were oviposited and hatched after the thaw or in the previous autumn. Starkeby reported a case that there were dead larvae on a cadaver found outdoors in spring in the southeastern Norway where the climate is similar to that of Sapporo city [7]. He assumed that the dead larvae had been oviposited and hatched in the previous autumn, not in the spring, although he concluded that more data was needed to establish this.

In contrast to the dead larvae existing on Nos. 3 and 5, all the larvae on the cadaver Nos. 6–9 were alive. We can explain that the larvae on Nos. 3 and 5 died because they

had been exposed to the subzero temperatures during the cold season. Namely, if many dead larvae exist on a cadaver found in spring, we can decide that they were oviposited and hatched in the previous autumn. Therefore, it is important to observe whether dead larvae exist on a cadaver found outdoors in spring.

It is important to know when flies cease oviposition in autumn in a district where winter climate is cold and freezing because the presence of fly larvae hatched in autumn is useful for estimating the time of death of a cadaver found outdoors in the cold season. The condition of brain in the cranium is also important in estimation of the time of death of a skeletonized body, because soft tissues except brain are often eaten by carnivorous animals and skeletonized.

In Sapporo city, if fly larvae hatched in autumn exist on a cadaver found outdoors in the cold season, we can estimate that the death occurred in the beginning of November or before. If most of the brain tissue remains in the cranium, and if fly larvae hatched in autumn do not exist on the cadaver, we can estimate that the death occurred in the beginning of November or after.

References

[1] Suzutani T, Ishibashi H, Endo M. Studies on medico-legal diagnosis in cold district. Hokkaido J Med Sci 1979;54:329–49, [in Japanese].
[2] Terazawa K, Matoba K, Watanabe N, Watanabe S, Yamada N. Estimation of time of death by the use of the overwintering of flies. Hokkaido J Med Sci 2006;81:265–9, [in Japanese].
[3] Hayashi A, Shinonaga S. Hae – Seitai to Bouzyo (fly – biology and control). Tokyo: Buneido; 1979, [pp. 28–77, in Japanese].
[4] Pitts KM, Wall R. Winter survival of larvae and pupae of the blowfly, *Lucilia sericata* (Diptera: Calliphoridae). Bull Entomol Res 2005;95:179–86.
[5] Saunders DS, Hayward Scott AL. Geographical and diapause-related cold tolerance in blow fly, *Calliphora vicina*. J Insect Physiol 1998;44:541–51.
[6] Donovan SE, Hall MJ, Turner BD, Moncrieff CB. Larval growth rates of the blowfly, *Calliphora vicina*, over a range of temperatures. Med Vet Entomol 2006;20:106–14.
[7] Starkeby M. Dead larvae of *Cynomya mortuorum* (L.) (Diptera, Calliphoridae) as indicators of the post-mortem interval – a case history from Norway. Forensic Sci Int 2001;120:77–8.