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EXTRACTION OF TEMPORAL AND SPATIAL PROPERTIES ON HABITAT OF RIVER SNAIL BY MEANS OF STATISTICAL APPROACH

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ABSTRACT: National Monitoring of Biological Indices in Rivers has been conducted in Japan. The data of biology and other indices have been accumulated in qualitative form. In recent years, since river engineering works in consideration of the biological environment are required, utilization of the survey data is expected. In this study, river snail (*Semisulcospira libertina*) was focused as a biological index. Civil parameters such as river width, depth, and flow velocity, temperature, turbidity, and bed material are mainly used for analysis on rivers selected from all of Mie Prefecture. Area properties and temporal properties on snails were obtained by analyzing data set using both quantification theory and Borda count. Properties of habitat were investigated on Oomatagawa River in the south of Mie Pref. by using self-organizing map (SOM). The relationship between habitat of snail and civil parameters was investigated by the means of statistical methods. River width, bed material, and turbidity made a large contribution to the habitat of time series properties. These three parameters were also important for the habitat of local area properties. Because there is a less organic matter of river water as feed-in Higashi-Kisyu, periphyton on gravel surface could largely contribute to the habitat of snails. The possibility of habitat for river snail was showed on a SOM. It was possible to distinguish between easy habitat and a difficult one to live.

Keywords: Snail, Hydraulic, Water quality, Soil, Quantification theory, Self-organizing map

1. INTRODUCTION

It is well known that precipitation affects benthos in the river such as river snails (*Semisulcospira libertina*), as well as civil parameters such as flow discharge and bed materials. These are closely related to each other.

Biological monitoring methods in Japan have been improved, and their data has been accumulated for many years [1]. Part of the data is made public on the Internet. It is expected that monitoring data will be investigated and applied. While public work is carried out considering the care of rare species and their habitat, sometimes the care is not sensitive enough to the environment. Water channels suitable for fireflies similar to habitats in natural environments are often developed to enrich human life quality [2]. It is expected that monitoring data will be used to develop management procedures and protection procedures for habitats.

Mie Prefecture is suitable to investigate the impact of rivers on benthos as shown in Fig. 1. Because Mie Pref. stretches far to the north and south, and a local region in Mie Pref. has one of the heaviest rainfalls. Rainfall can affect the habitat of benthos in rivers such as snails. In this study, the relationship between civil parameters, habitat, and their properties are grasped. First, the time series properties and local area properties are grasped by quantification theory and Borda count. Next, the properties of potential habitats are extracted by a self-organizing map (SOM).

2. DATA AND METHOD

2.1 Data and Quantification Theory

2.1.1 Data of Hydraulics, Water Quality, Soil, and Biology

Data of National Monitoring of Biological Indices in Rivers are offered by the Ministry of the Environment [3] in Japan. It is characterized that monitoring is carried out on the basis of reliable procedures and not only organism species in rivers but also civil parameters are measured. Almost all of the monitoring was carried out in the summer vacation because many elementary and junior high school students participated in the monitoring. They identified organism species with assistance from experts in biology.

The data on rivers selected in all of Mie Pref. were analyzed between June and September between 2004 and 2009. Fig. 2 shows the location of observation stations for analysis. Table 1 shows the number of observation stations. A total of 270 stations for 58 rivers were investigated for six years.

The number of stations where the one-year analysis was used was between 37 and 51 stations. The number of the station for the local area analysis

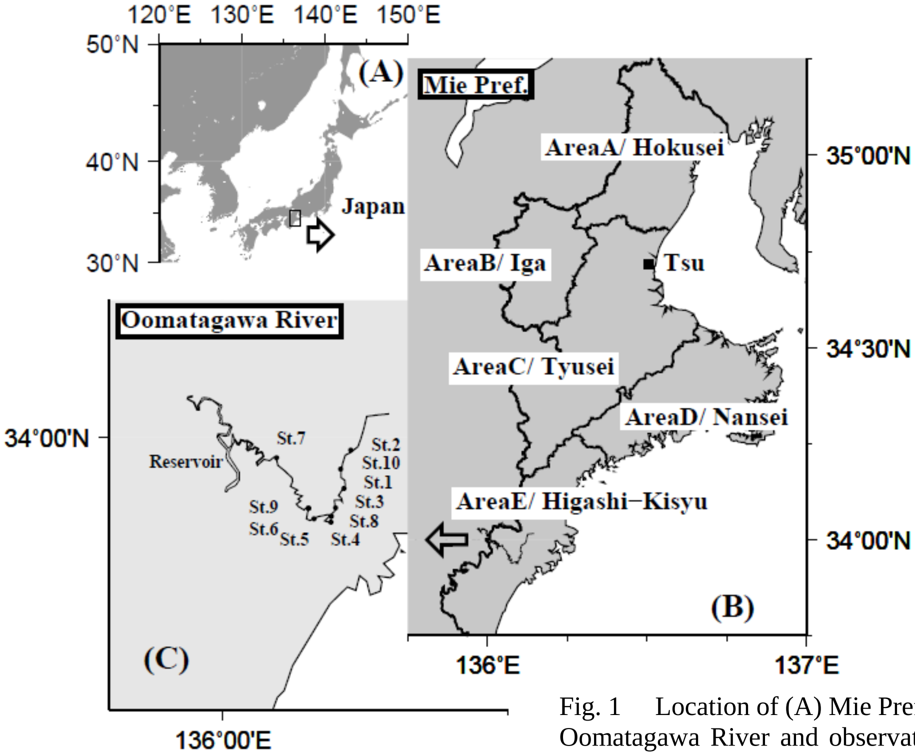

Fig. 1 Location of (A) Mie Pref., (B) local areas, (C) Oomatagawa River and observation sites in the river (JDG2000)

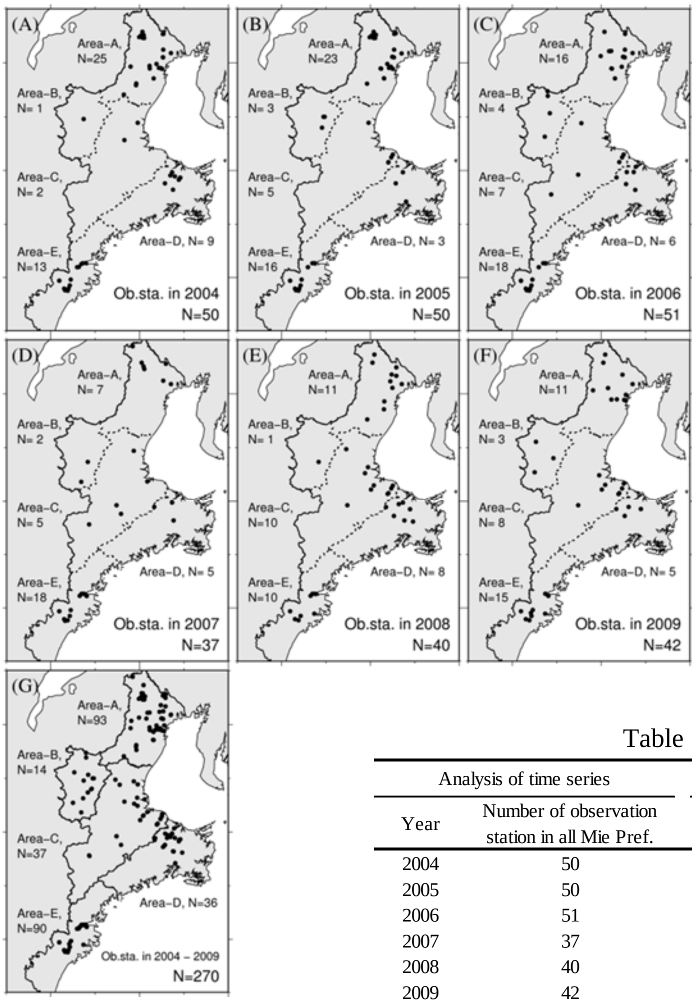

Fig. 2 Location of observation sites between 2004 and 2009

(A) to (F) are used for time series analysis; (G) is for local area analysis.

Table 1 Number of dataset

Analysis of time series		Analysis of local area	
Year	Number of observation station in all Mie Pref.	Local area	Number of observation station for six year
2004	50	Area A / Hokusei	93
2005	50	Area B / Iga	14
2006	51	Area C / Tyusei	37
2007	37	Area D / Nansei	36
2008	40	Area E / Higashi-kisyu	90
2009	42		
Total	270	Total	270

Table 2 Parameters and quantify of dataset

Quantity	Hydraulics: Width (river width)	Hydraulics: Depth (river depth)	Hydraulics: Flow (flow velocity)	Water quality: WT (water temperature)	Water quality: Turbidity	Soil: Bed (bed material)	Quantity	Biology: Snail
1	0 - 5 m	0 - 10 cm	Slow / 0 - 30 cm/s	<10°C	Clear	Head-sized gravel	0	None
2	5 - 10 m	10 - 20 cm	Normal / 30-60 cm/s	10 - 20°C	Low	Fist-sized gravel	1	Few
3	10 - 20 m	20 - 30 cm	Fast / >60 cm/s	20 - 30°C	High	Small gravel and sand	2	Many
4	>20 m	>30 cm	—	>30°C	—	Sand and mud	—	—
5	—	—	—	—	—	Wide particle size distribution	—	—
6	—	—	—	—	—	Others	—	—

totaled between 14 and 93 stations during 2004 - 2009.

Hydraulics parameters such as river width, depth, and flow velocity, and water quality parameters such as temperature, turbidity, and soil parameters of bed material are selected for analysis from the many items measured in civil parameters. We analyzed the river snail as benthos.

2.1.2 Rejection and Translation of Datasets

After rejecting incorrect datasets, the qualitative datasets are quantified for analysis. Datasets lacking in analysis items and a few datasets measured on rainy days were rejected from the analysis. Furthermore, the research manual advised avoiding swollen streams and rivers [4]. Thus, datasets used in analysis seem to be the ones for normal river conditions. It appears that turbidity is composed of less soil particle components and more organic algae components. Next, datasets suitable for analysis of hydraulics, water quality, soil, and river snails were translated into integers on the basis of Table 2.

2.1.3 Precipitation, BOD, and COD

Using data on precipitation between 2004 and 2009 provided by the Japan Meteorological Agency [5], the annual amount of precipitation was calculated for five regions in Mie. Mie Pref. publishes monthly data on biochemical oxygen demand (BOD) and chemical oxygen demand (COD), which are reported on the Yearly Data Book of Water Quality in Public Waters [6]. Annual average BOD and COD are calculated for five regions in Mie during 2004 and 2008.

Table 3 Data list of Oomatagawa River for SOM analysis

Year	Observation site in the river	Site number in Fig.1	Mark in Fig.6	1 WT °C	2 Width m	3 Depth cm	4 Flow Slow	5 Flow Normal	6 Flow Fast	7 Bed Head-sized gravel	8 Bed Fist-sized gravel	9 Bed Small gravel and sand	10 Bed Sand and mud	11 Bed Wide particle size distribution	12 Bed Others	13 Turbidity Clear	14 Turbidity Low	15 Turbidity High	16 Snail None	17 Snail Few	18 Snail Many
2004	Asuka elementary school	St.1	★(1)04	22	10	30	0	1	0	1	0	0	0	0	0	1	0	0	0	1	0
	Tyobokujyou lumberyard	St.2	(2) 04	20	10	25	0	1	0	0	0	1	0	0	0	1	0	0	1	0	0
	Shikinosato	St.3	★(3)04	23.5	8	30	0	1	0	0	1	0	0	0	0	1	0	0	0	1	0
	Genbokuichiba market	St.4	(4) 04	24	10	30	1	0	0	1	0	0	0	0	0	1	0	0	1	0	0
	Sawataribashi bridge	St.5	(5) 04	23.9	20	20	1	0	0	0	1	0	0	0	0	1	0	0	1	0	0
	Nishin elementary school	St.6	☆(6)04	22	13	20	0	0	1	1	0	0	0	0	0	1	0	0	1	0	0
	Itsusato elementary school	St.7	(7)04	24.7	30	40	0	1	0	0	1	0	0	0	0	1	0	0	1	0	0
	Itsusato elementary school	St.7	(7) 04	26.7	30	30	1	0	0	0	1	0	0	0	0	1	0	0	1	0	0
2005	Tyobokujyou lumberyard	St.2	(2)05	18	8	15	0	1	0	0	0	0	0	1	0	1	0	0	1	0	0
	Asuka elementary school	St.1	☆(1)05	19	10	15	0	0	1	0	0	0	0	1	0	1	0	0	1	0	0
	Shikinosato	St.3	☆(3)05	21	10	20	0	0	1	0	0	0	0	1	0	1	0	0	1	0	0
	Genbokuichiba	St.4	(4) 05	24	15	15	1	0	0	0	0	0	0	1	0	1	0	0	1	0	0
	Sawataribashi Bridge	St.5	(5)05	21	10	10	0	1	0	0	0	0	0	1	0	1	0	0	1	0	0
	Nishin elementary school	St.6	☆(6)05	19	10	15	0	1	0	0	1	0	0	0	0	1	0	0	1	0	0
	Itsusato elementary school	St.7	(7)05	23.5	15	20	0	1	0	1	0	0	0	0	0	1	0	0	1	0	0
	Itsusato elementary school	St.7	(7) 05	23.5	15	20	1	0	0	0	0	1	0	0	0	1	0	0	1	0	0
2006	Asuka elementary school	St.1	☆(1)06	20.5	10	20	0	0	1	1	0	0	0	0	0	1	0	0	1	0	0
	Tyobokujyou lumberyard	St.2	(2) 06	19	10	20	0	1	0	0	1	0	0	0	0	1	0	0	1	0	0
	Shikinosato	St.3	★(3)06	21.5	10	20	0	0	1	0	0	1	0	0	0	1	0	0	0	1	0
	Genbokuichiba	St.4	(4)06	23	10	20	1	0	0	0	0	1	0	0	0	1	0	0	1	0	0
	Nishin elementary school	St.6	☆(6)06	20.5	18	25	0	0	1	0	0	1	0	0	0	1	0	0	1	0	0
	Sawataribashi Bridge	St.5	(5) 06	22	10	10	0	1	0	0	0	0	0	1	0	1	0	0	1	0	0
	Itsusato elementary school	St.7	(7) 06	22.5	15	40	1	0	0	0	1	0	0	0	0	1	0	0	1	0	0
	Itsusato elementary school	St.7	(7)06	25	15	20	1	0	0	0	1	0	0	0	0	1	0	0	1	0	0
	Itsusato elementary school	St.7	(7) 06	23.5	10	15	1	0	0	0	0	1	0	0	0	1	0	0	1	0	0
	Itsusato elementary school	St.7	(7) 06	25.5	8	15	1	0	0	0	0	0	0	1	0	0	1	0	1	0	0
2007	Nishin elementary school	St.6	★(6)07	19	20	20	0	0	1	0	0	0	0	1	0	1	0	0	0	1	0
	Sawataribashi Bridge	St.5	(5) 07	18.8	15	20	0	1	0	0	0	0	0	1	0	1	0	0	1	0	0
	Asuka elementary school	St.1	☆(1)07	20.5	10	25	0	0	1	0	0	0	0	1	0	1	0	0	1	0	0
	Tyobokujyou lumberyard	St.2	(2) 07	19	10	25	0	1	0	0	0	0	0	1	0	1	0	0	1	0	0
	Marubuchi	St.8	☆(8)07	22.5	15	30	0	1	0	0	0	0	0	1	0	1	0	0	1	0	0
	Itsusato elementary school	St.7	(7) 07	24.8	15	40	1	0	0	0	0	0	0	1	0	1	0	0	1	0	0
	Itsusato elementary school	St.7	(7) 07	24.5	15	20	1	0	0	0	0	0	0	1	0	1	0	0	1	0	0
2008	Asuka elementary school	St.1	★(1)08	18.2	10	20	0	1	0	0	0	0	0	1	0	1	0	0	0	1	0
	Marubuchi	St.8	★(8)08	21.8	10	25	1	0	0	0	0	0	0	1	0	1	0	0	0	1	0
	Noguchi	St.9	☆(9)08	19	20	25	0	0	1	0	1	0	0	0	0	1	0	0	1	0	0
	Itsusato elementary school	St.7	(7) 08	27	10	35	1	0	0	1	0	0	0	0	0	1	0	0	1	0	0
2009	Itsusato elementary school	St.7	(7) 09	19.2	10	40	1	0	0	1	0	0	0	0	0	1	0	0	1	0	0
	Marubuchi	St.8	☆(8)09	18	10	25	1	0	0	0	0	0	0	1	0	1	0	0	1	0	0
	Noguchi	St.9	★(9)09	19	20	25	0	1	0	0	0	0	0	1	0	1	0	0	0	1	0
	Tyobokujyou lumberyard	St.2	(2)09	16.8	10	25	0	0	1	0	0	0	0	1	0	1	0	0	1	0	0
	Asuka elementary school	St.1	☆(1)09	18.7	10	20	0	1	0	0	0	0	0	1	0	1	0	0	1	0	0
	Ikedataira	St.10	(10) 09	21	20	30	0	1	0	0	1	0	0	0	0	1	0	0	1	0	0

2.1.4 Analysis by Quantification Theory and Borda count

Mathematical quantification theory class II shows the explanation of external criterion as qualitative through explanatory variables are shown as qualitative [7], [8]. Civil parameters such as hydraulics, water quality, and soil correspond to explanatory variables, and the snail parameter is equal to the external criterion.

The method of mathematical quantification theory class II was used for time series analysis and local area analysis. Boulder count was applied to the results obtained by quantification theory and the detailed items were scored. The Boulder count is known as a way to select a candidate who is widely supported rather than majority voting candidate for election [9]. Concerning time series analysis, datasets in all of Mie Pref. were subjected to analysis one by one year as shown in Fig. 2 (A) - (F). the area and data of Mie Pref. are divided into five regions: Hokusei, Iga, Tyusei, Nansei, and Higashi-Kisyu as shown in Fig. 1 (B). Data composited for six years for each area were analyzed (Fig. 2 (G)).

2.2 Data on Oomatagawa River and Analysis by Self-Organizing Map

The studying of the potential of habitat focused on only Oomatagawa River as shown in Fig. 1 (B) and (C). The fact that there were few snails in the rivers of Higashi-Kisyu indicates that the environment will be sensitive to the effects on snails. A lot of monitoring points were set up and have continued to investigate the situation in Oomatagawa River. Oomatagawa River is suitable for investigating the existence of habitat.

It is noted that only Oomatagawa River was focused on than comparing various rivers because of avoiding the particular effect of pesticide, releasing snail in the river, and heavy metals [10]. Furthermore, it is difficult to analyze the rivers of many snails because of keeping the same condition.

2.2.1 Data on Oomatagawa River

Table 3 lists the monitoring data of observation stations for Oomatagawa River shown in Fig. 1 (C). The data are selected between June and September between 2004 and 2009 to grasp the recent trend. Parameters, such as river width, depth, and water temperature in Table 3 are continuous values, the others are flag values. The parameter of river snails is excluded from the analysis. The analysis data has 15 dimensions. The values of BOD and COD are not measured in individual observation stations.

Analysis data are normalized in most of the SOM study. In this study, data are normalized so that the mean is equal to zero and dispersion is equal to one.

2.2.2 Analysis by Self-Organizing Map

A self-organizing map (SOM, also called Kohonen’s map) was used as an analysis method [11], [12]. The SOM produced a two-dimension map from multidimensional elements on monitoring data, and it visualized classification. Kohonen et al. (1995) of Helsinki University of Technology developed the software of SOM_PAK called Basic SOM and publish it on their website [13]. The 15-dimension data of Oomatagawa River on factors such as hydraulics, water quality, and soil property were applied to the analysis. The class of observation stations is visualized to consider the results.

The values of learning parameters for SOM were set as follows: map size is 15 in the x-direction and 10 in the y-direction, limit on time iteration is 10,000, learning restraint is 0.05, and neighborhood function is 21.

3. RESULTS AND DISCUSSION

3.1 Characteristics for Analysis Data Based on Statistics

The modal class on civil parameters is 5-10 m of river width, 20-30 m of depth, normal flow velocity, fist-sized gravel bed material. Data selected during the summer observation caused the water temperature to be 20-30°C at most, and there was no data for below 10°C. Clear turbidity was most common, low turbidity was present in 52 out of 270, and high turbidity, which was rare, was present in three out of 270.

Fig. 3 indicates the number of river snails for the time series and each local area. River snails were observed in many sites in 2008 as shown in Fig. 3 (A). Iga and Tyusei, Hokusei and Nansei, and Higashi-Kisyu were ranked in descending order of snails in each area. There were fewer snails in Higashi-Kisyu/Area E than in other areas.

Fig. 4 shows the amount of rainfall in each local area. In accordance with the local area, rainfall in Higashi-Kisyu/Area E, where it naturally rains a lot, is markedly high.

Fig. 5 shows the annual average BOD and COD in rivers. BOD and COD are low in all of Mie Pref. In accordance with the environmental quality standard in Japan [14], river water meets the level of drinking water needing normal purification. Water in all of Mie Pref. is recognized as clear; in particular, water from Higashi-Kisyu showed in

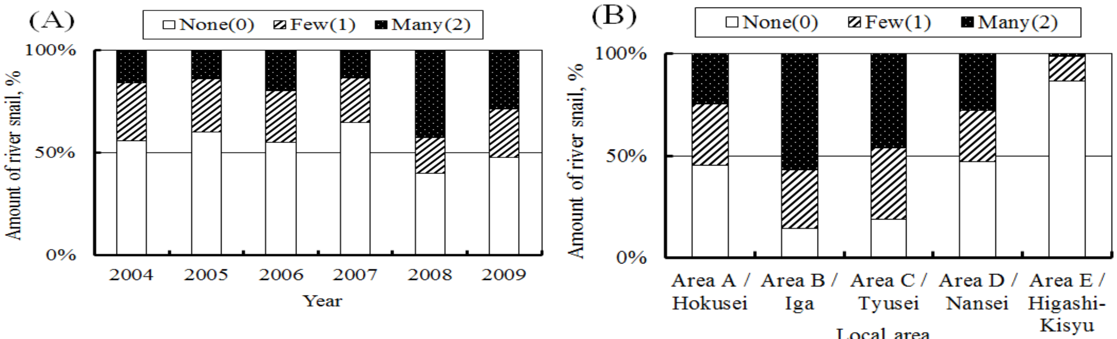

Fig. 3 (A) Change of amount of river snail with time in all Mie Pref., (B) amount of river snail in local area for six years

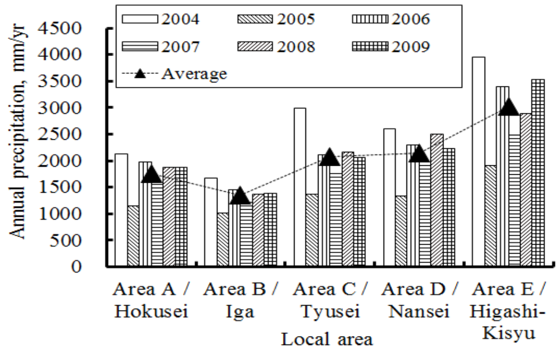

Fig. 4 Annual precipitation in local areas

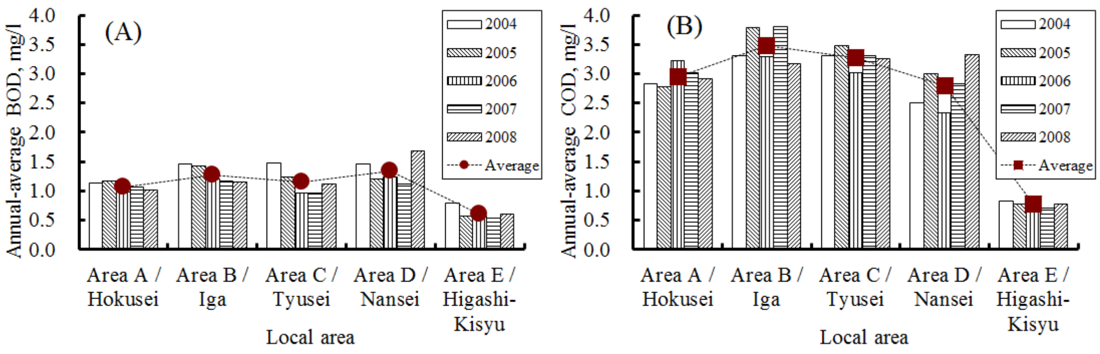

Fig. 5 (A) Annual-average BOD concentration, and (B) annual-average COD concentration in local areas

Fig. 1 (B) as Area E, is clear. Therefore, the organic matter on which snails feed is less in Higashi-Kisyu.

3.2 Properties of Time Series Using Quantification Theory and Borda Count

Table 4 indicates the results of the analysis. Bed material, river width, and turbidity seem to contribute highly to snail habitat as shown in Table 4(A). It is difficult to understand the properties without including the data shown in Table 4(B). To provide the scores depending on the order, Table 4(C) was rearranged using the following Borda count Eq (1):

$$SC(X_i) = \sum_{yr} \{SA_{yr} \times Y(X_i - DB)\} \qquad (1)$$

where SC is a score of X_i, X_i is a detail in Table 4(C), DB is a detail in Table 4(B), yr is year, SA is the score in Table 4(A), and Y is the step function; if $X_i = DB$, $Y = 1$, and if X_i is not equal to DB, $Y = 0$.

Table 4(C) shows that the properties of the time series resulting from aggregating the contents shown in both Table 4 (A) and (B) have greater accuracy. 0-5 m of river width (24 points), sand and mud bed material (17 points), clear or high turbidity (both 9 points), and other items such as flow velocity, depth, and water temperature are presented in descending order of points.

First, the top three of all items: river width, bed material, and turbidity are explained as follows. The relatively narrow 0-5 m river width corresponds to a flume or small stream in Japan. Snails prefer narrow rivers into wide rivers (Murakami (2007) [15]). The analysis results agree with his description.

Table 4 Result of time series analysis ((A), Item; (B), Detail; (C), Total Evaluation)

(A) Ranking and score (*SA*) of items

Year	No.1 6 pt	No.2 5 pt	No.3 4 pt	No.4 3 pt	No.5 2 pt	No.6 1 pt
2004	Bed	Turbidity	Depth	Flow	Width	WT
2005	Bed	Depth	Turbidity	Flow	Width	WT
2006	Bed	Turbidity	Width	Flow	Depth	WT
2007	Bed	Turbidity	Width	Depth	Flow	WT
2008	Width	Bed	Flow	Turbidity	Depth	WT
2009	Width	Bed	Turbidity	Depth	Flow	WT

Note; Bed=bed material; WT=water temperature; Flow=flow velocity

(B) Ranking of details (*DB*)

Year	No.1	No.2	No.3	No.4	No.5	No.6
2004	Wide particle size distribution	Cloudy	20-30cm	Normal	0-5m	20-30°C
2005	Sand and mud	>30cm	Dirty	Normal	0-5m	20-30°C
2006	Others	Dirty	0-5m	Fast	20-30cm	10-20°C
2007	Sand and mud	Clear	0-5m	10-20cm	Normal	20-30°C
2008	0-5m	Sand and mud	Fast	Cloudy	>30cm	10-20°C
2009	0-5m	Wide particle size distribution	Clear	0-10cm	Slow	20-30°C

(C) Details (*Xi*) and their score (*SC*)

Item						
Width	0-5m	5-10m	10-20m	>20m		
	24pt	0pt	0pt	0pt		
Depth	0-10cm	10-20cm	20-30cm	>30cm		
	3pt	3pt	6pt	7pt		
Flow	Slow	Normal	Fast			
	2pt	8pt	7pt			
WT	<10°C	10-20°C	20-30°C	>30°C		
	0pt	2pt	4pt	0pt		
Turbidity	Clear	Low	High			
	9pt	8pt	9pt			
Bed	Head-sized gravel	Fist-sized gravel	Small gravel and sand	Sand and mud	Wide particle size distribution	Others
	0pt	0pt	0pt	17pt	11pt	6pt

Note; Bed=bed material; WT=water temperature; Flow=flow velocity

Sand and mud bed material showed a high point. Furujo and Tomiyama (2000) [16] indicated that snails prefer gravel, sand, and mud. Murakami (2007) [17] also indicated that that snails in upstream sites feed on periphyton on gravel and withered leaves. It is considered that since the light material such as sand, mud, and withered leaves are easy to sediment in the condition of low velocity, snails prefer the sedimentary surrounding.

The effect of turbidity as feed will be an important factor for snails because non-clear turbidity, summing up eight points of low and nine points of high turbidity, is more than the nine points of clear turbidity. Non-clear turbidity affects the habitat of snails.

Next, Flow velocity, depth, and water temperature in the low ranks are explained. Snail on river beds can be flushed away at flow velocities of more than one m/s [18]. Snails are observed in riffles with high velocities [16]. It does not mean that high velocity is a bad condition. Thus, the fact that the flow condition is uncertain leads to a low position in Table 4.

Snails are fed on by predators such as fireflies, river crabs, rats [19]. Deep water may protect snails from these predators. However, snails are observed regardless of the depth of the river [16]. It is considered that the habitat condition on depth is ambiguous. The reason why data of water temperature was restricted in summer caused to be low points in Table 4.

3.3 Properties of Local Area Using Quantification Theory

Table 5 indicates the results of a local area analysis. As shown in Table 5(A) and (B), the analyzed order of local area resulted in difference from each other. Area A / Hokusei has sand and mud bed material, low turbidity, and 0-5 m river width in sequence. Area B / Iga has head-sized gravel bed material, fast flow velocity, and 0-5 m river width. Area C / Tyusei has wide particle size distribution bed material, 5-10 m river width, and 10-20 cm depth. Area D / Nansei has over 30 cm depth, other bed material, and 5-10 m river width. Area E / Higashi-Kisyu has low turbidity, 0-10 cm depth, and fist-sized gravel bed material.

Thus, the property of a local area is similar to the property of time series regarding the importance of river width, bed material, and turbidity. The property of Higashi-Kisyu is different from the others; turbidity resulted in high contribution toward the habitat of snails.

There are few snails in Higashi-Kisyu as described in section 3.1. Snails in clear or pure rivers like the upper portion of a river feed on periphyton on gravel or spoiled leaves [17]. A lot of rainfall causes damage to the surface of gravel by their rolling, and it is hard for periphyton to grow on gravel. This may result in few snails and in less BOD and COD considered as a feed index.

3.4 Results using SOM

Fig. 6 indicates the SOM on Oomatagawa River. Black stars mean that the snail was captured in a year, white stars mean the snail was not captured in the year but was captured in another year, no mark

Table 5 Result of local area analysis ((A), Item; (B), Detail)

(A)	Ranking of items					
Local area	No.1	No.2	No.3	No.4	No.5	No.6
Area A / Hokusei	Bed	Turbidity	Width	Flow	Depth	WT
Area B / Iga	Bed	Flow	Width	Depth	WT	Turbidity
Area C / Tyusei	Bed	Width	Depth	Flow	Turbidity	WT
Area D / Nansei	Depth	Bed	Width	Flow	Turbidity	WT
Area E / Higashi-kisyu	Turbidity	Depth	Bed	WT	Width	Flow

(B)	Ranking of details					
Local area	No.1	No.2	No.3	No.4	No.5	No.6
Area A / Hokusei	Sand and mud	Low	0-5m	Slow	20-30cm	20-30°C
Area B / Iga	Head-sized gravel	Fast	0-5m	0-10cm	10-20°C	Low
Area C / Tyusei	Wide particle size distribution	5-10m	10-20cm	Normal	High	20-30°C
Area D / Nansei	>30cm	Others	5-10m	Slow	Low	20-30°C
Area E / Higashi-kisyu	Low	0-10cm	Fist-sized gravel	10-20°C	>20m	Normal

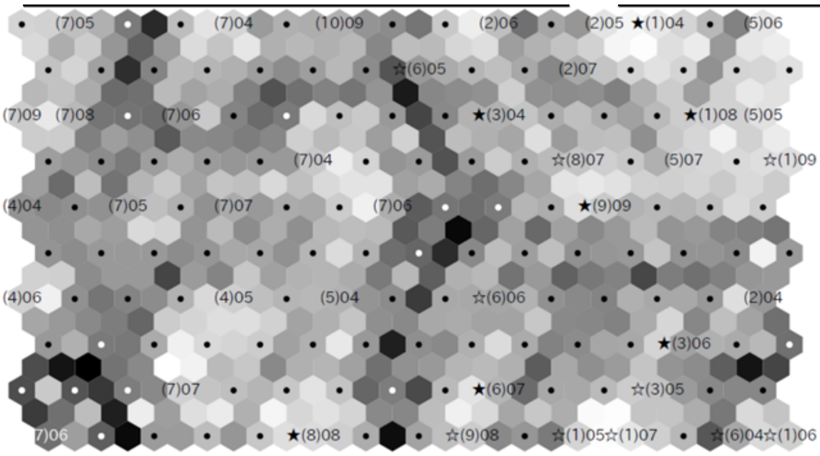

Fig. 6 Self-organizing map on observation sites in Oomatagawa River

Sites location and marks are showed in Fig.1 and Table 3. (number) and two - digit number show site number and observation year respectively. Black stars mean that snail was captured in the year, white stars mean that snail have been captured in years, and no star means that snail have not been captured in years.

means the snail was not captured. Looking at Fig. 6, a line of dark hexagons is arranged in the center of the SOM from top to bottom, and it seems that the SOM is divided into left and right. In other words, the meaning seems to be different on the left and right of SOM. Not-captured sites like Itsusato elementary school shown as (7) in Fig.6 or St.7 in Fig.1(C) are located on the left side of the map. Most of the black stars, all of the white stars, and a few of the locations with no marks such as Sawataribashi Bridge shown as (5)/St.5 and Tyobokujyou lumberyard shown as (2)/St.2 are located on the right side. The right side is under mixed conditions.

This analysis revealed the presence and absence characteristics of river snails. It is almost impossible to observe snails on the sites of the left side in the SOM because almost all had not been captured. However, it is highly possible to observe snails on sites of the right side in the SOM because of the mixing conditions. The characteristics of the presence and absence of river snail are expected to the application to river engineering works considering ecosystems.

Snails have not been observed at the Itsusato site. It will be hard to observe snails there. The Itsusato site is located on the nearby reservoir and downstream with wide river width (Fig. 1(C)). Thus, it is considered that sand accumulated around the Itsusato site damages periphyton on the gravel surface and no snails are observed.

4. CONCLUSIONS

In Japan, a database on aquatic organisms has been accumulated, and this paper was designed with the view that the database should be used effectively. The purpose is to extract useful information from the accumulated data set and to show that it can be an effective use case of the database.

The civil parameters exerted on the habitat of river snail and the possibility of habitat were investigated in this paper. Data of civil parameter on rivers and snail concerning Mie Pref. in Japan were analyzed by the method of both quantification theory and Borda count, and self-organizing map (SOM). The following conclusions are drawn based on the study.

1) The relationship between habitat of snail and the civil parameter was investigated by the means of quantification theory and Borda count. Compared with references published by the experts and their experience, river width, bed material, and turbidity made a large contribution to the habitat of time series properties. These three items were also important for the habitat of local area properties. Bed material was most important for habitat in Hokusei, Iga, and Tyusei. The habitat of Nansei and Higashi-Kisyu was different from one of the other three areas. Because there is a less organic matter of

river water, turbidity made a large contribution to the habitat of Higashi-Kisyu.

2) Because there is a less organic matter of river water as feed-in Higashi-Kisyu, periphyton on gravel surface could largely contribute to the habitat of snails. The possibility of habitat for river snail was showed on a SOM in this paper. It was possible to distinguish between easy habitat and a difficult one to live. It was suggested that the rolling of gravel and sedimentation cause variable bed and make habitat for the continuously-growing snail harder by damaging periphyton on a gravel surface.

3) Useful information was extracted from the accumulated data set, and it was proved that it can be an effective case of the database. We believe that the engineering parameters obtained by quantification theory and Borda count can be useful ones for building firefly channels for ecosystem protection, and SOM can provide on the presence information of organisms in rivers: the characteristics of the presence and absence of river snail clarified from SOM is expected to the application to river engineering works considering ecosystems.

REFERENCES

[1] Tanida K., Index Biology on River Environment, Tokyo, Hokuryukan Publishing, 2010, pp.142-151.

[2] Sekine M., Goto M., Ito N., Tanaka K., Kanao M., and Inoue T., Construction of a Firefly Stream by Using a Physical Habitat Evaluation Method, Ecol. Civil Eng. Vol.10, Issue 2, 2007, pp.103-116.

[3] Ministry of the Environment (2004-2009), Data of National Monitoring of Biological Indices in Rivers, <https://water-pub.env.go.jp/water-pub/mizu-site/mizu/suisei/>, browsed on December 1st, 2018.

[4] Ministry of the Environment and Ministry of Land, Infrastructure, Transport and Tourism, Kawa no ikimono wo sirabeyou (research manual), Japan Society on Water Environment, 2000, p.33.

[5] Japan Meteorological Agency (2004-2009), Table of Hourly Weather Observations, < http://www.jma.go.jp/en/amedas_h/map38.html>, browsed on December 1st, 2018.

[6] Mie Pref., Yearly Data book of Water Quality in Public Waters and groundwater, Mie Pref., 2004-2009.

[7] Hayashi C., On the Quantification of Qualitative Data from the Mathematico-Statistical Point of View -An Approach for Applying This Method to the Parole Prediction-, Annals of the Institute of Statistical Mathematics, Vol.2, 1950, pp.35-47.

[8] Hayashi C., On the Prediction of Phenomena from Qualitative Data and the Quantification of Qualitative Data from the Mathematico-Statistical Point of View, Annals of the Institute of Statistical Mathematics, Vol.3, 1951, pp.69-98.

[9] Balinski M. and Laraki R., Majority Judgment: Measuring, Ranking, and Electing, MIT Press, Cambridge, 2010, pp.1-432.

[10] Iskizaki S. and Hamada H., Effects of Heavy Metals on the Freshwater Snail, Semisulcospira bensoni, in a Closed Mining Area, Japanese Journal of Limnology, Vol.48, Issue 2, 1987, pp.91-98.

[11] Kohonen T., Self-Organizing Maps, 3rd edition, Tokyo, Springer, 2010, pp.1-479.

[12] Ookita M., Tokutaka H., Fujimura K., and Gonda E., Self-Organizing Maps and its Software, Tokyo, Springer, 2008, pp.1-226.

[13] Kohonen T., Hynninen J, Kangas J, and Laaksonen J, SOM_PAK -Self-Organizing Map Program Package, Helsinki University of Technology, 1995, pp.1-27.

[14] Announcement by Ministry of the Environment (1971), Environmental Standards Concerning Water Pollution -Appended Table 2-, <http://www.env.go.jp/kijun/mizu.html>, browsed on December 1st, 2018.

[15] Murakami M., How to Breed and to Photograph Firefly in Freshwater, Tokyo, Powersha, 2007, p.87.

[16] Furujo Y. and Tomiyama K., Distribution and Microhabitat of Coexisting Two Freshwater Snail Species, Semisulcospira libertina (Gould) (Prosobranchia; Pleuroceridae) and Clithon retropictus (Martens) (Prosobranchia : Neritidae), Venus : the Japanese Journal of Malacology Vol.59, Issue 3 , 2000, pp.245-260.

[17] Murakami M., How to Breed and to Photograph Firefly in Freshwater, Tokyo, Powersha, 2007, p.4.

[18] Mori S., Some Ecological Notes on the Fresh Water Snails - Second -, Venus, Vol.6, Issue 1, 1936, pp.15-21.

[19] Tokyo Fireflies Ecology Institute, Hotaru Hyakka, Tokyo, Maruzen, 2004, p.35.