ABUNDANCE AND PRODUCTION OF *BRANCHIURA SOWERBYI* (OLIGOCHAETA: TUBIFICIDAE) IN TWO TYPICAL SHALLOW LAKES (HUBEI, CHINA)*

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Abstract An April 1996 to March 1997 comparative study on the abundance and secondary production of *Branchiura sowerbyi* Beddard, 1892 in two typical shallow lakes showed that in Houhu, an algae-dominated lake, the worm density (68 ind·m^{-2}) peaked in July, biomass (1.930 g·m^{-2}) peaked in June, while in Biandantang, a macrophyte-dominated lake, standing stock (density: 60 ind·m^{-2}; biomass: 1.019 g·m^{-2} in wet weight) peaked in December. Secondary production of the animal in Houhu Lake was 3.413 g wet wt $m^{-2}a^{-1}$, a little more than that (2.675 g wet wt $m^{-2}a^{-1}$) in Biandantang Lake. Their turnover rates (P/B ratios) were 4.0 and 5.0, respectively.

Key words: abundance, secondary production, *Branchiura sowerbyi*, shallow lakes

INTRODUCTION

Branchiura sowerbyi, a cosmopolitan tubificid, is a predominant zoobenthos in many shallow lakes in China (Liang, 1979). In 1984, the production rates of the species were first estimated in Donghu Lake, Wuhan (Liang, 1984). After that, no data on production of this worm or other zoobenthos were published. Currently, with fishery development in lakes and increasing lake eutrophication, lake management studies have been attracting more and more attention from Chinese hydrobiologists and ecologists. Data on secondary production of zoobenthos, despite their important bearing on lake management, are scanty. To enrich basic knowledge, studies on production rates of benthic macroinvertebrates have been carried out in several lakes since 1996.

This paper presents results of a comparative study on the abundance and secondary production of *B. sowerbyi* in two typical lakes: Houhu (3.3 km^2), an algae-dominated lake located in Wuhan City; and Biandantang (3.3 km^2), a macrophyte-dominated lake in the northeast of Daye City, Hubei Province.

MATERIALS AND METHODS

Samples were collected monthly from April, 1996 to March, 1997 from both lakes. In Houhu Lake, because of the homogeneity of muddy bottom and similarity in ecological

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conditions, four stations were arranged, evenly spaced along the middle transection of the lake. Whereas in Biandantang Lake, owing to the heterogeneity of ecological conditions, especially to the diversity of macrophytes, eight stations were set up, four situated at the middle transection, each spaced 500 m apart; two in lotus-covered bays, one in a vegetation-free region, and one over a *Vallisneria-spiralis* bed (Fig. 1a,b).

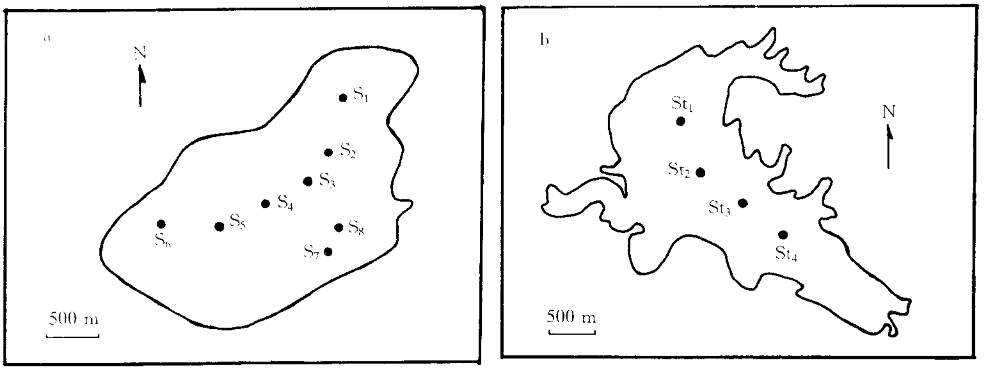

Fig. 1 Sampling sites
a. Biandantang Lake; b. Houhu Lake

For each station one sample was taken with a modified Petersen grab (1/16 m^2). The sample was sieved through a 167 μm mesh net. Residuals were brought back in plastic bags. The worms were placed in a porcelain dish and sorted manually with naked eye , and then preserved in 10% formalin. Each preserved specimen was measured under a dissecting microscope. The weight of each worm was computed from the length-weight relationship for *B. sowerbyi*: $\lg W = 1.94 \lg L - 1.71$ (Liang, 1984). Secondary production was calculated with the size-frequency method (Hynes & Coleman, 1968; Hamilton, 1969; Benke et al., 1984; Menzie 1980; Prat & Rieradevall, 1995). The equation was:

$$P = i \cdot b \sum_{j=1}^{i} (N_j - N_{j+1})(W_j \times W_{j+1})^{1/2}$$

Here we used the number of generation (b) instead of CPI/365, and ignored the correction factor Pe/P, because the data were not available, and negligible error was produced (Hamilton, 1969; Benke, 1984).

RESULTS

Life cycle

Based on the data from the samples during the period from April, 1996 to March, 1997, *B. sowerbyi* in both lakes completed their life cycle in about one year (Fig. 2a, b). In Houhu Lake, spawning mainly occurred in May, September and October, 1996; in April-May, 1996 there were a few particularly large specimens, with body length reaching

100 mm, which might have been the survivors from the former year (Liang, 1984). They died off later on. From the size-distribution graph, *B. sowerbyi* in Houhu Lake apparently had two cohorts a year, one from March to November, 1996, the other from September, 1996 to July of the next year (Fig. 2a). In Biandantang Lake, spawning took place continuously from May, 1996 to February, 1997. It seemed the first spawners (in May, 1996) reached their adult length (60 – 70 mm) in January the next year, then almost all of them died; most worms spawned after September, 1996 might have completed their life cycle in May, 1997. There seemed to be two *B. sowerbyi* cohorts in Biandantang Lake too, but they overlapped a little. Roughly, one cohort was from May, 1996 to January 1997; the other from September, 1996 to May, 1997 (Fig, 2b).

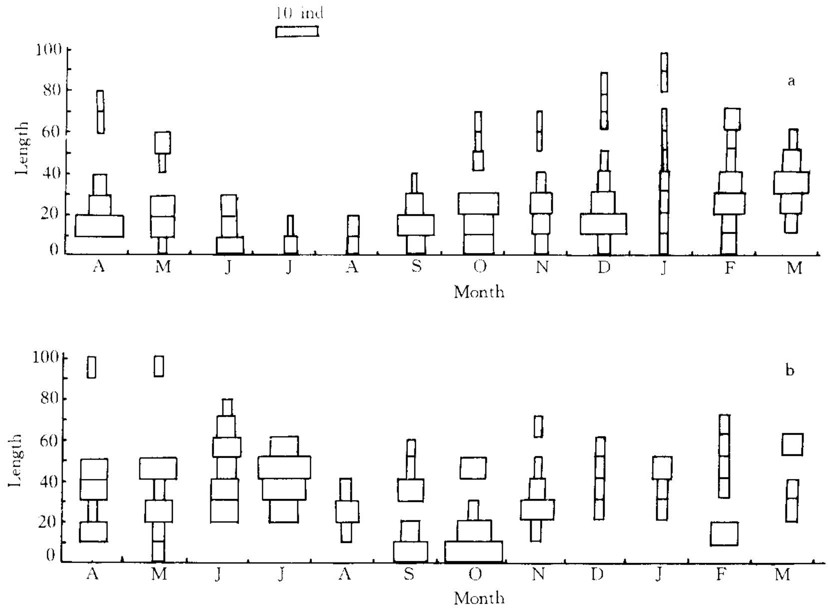

Fig. 2 Size-frequency distribution for each sampling date, the width of the bar represents percentage of each larval instar

Abundance and biomass

The abundance of *B. sowerbyi* in Houhu Lake had the first peak in July, 1996; then the second peak, a little lower than the first, in October, 1996. Population density was lowest (16 ind·m^{-2}) in August and December of 1996, and January and March of 1997, the annual mean density was 37.7 ind·m^{-2}. In Biandantang Lake, the abundance also showed two peaks, the major one in December, 1996, the minor one in October of the same year. The lowest density (8 ind·m^{-2}) occurred in July and August, 1996. Populations of *B. sowerbyi* in the two lakes followed the same trend between August and November, 1996. But in the remaining months, the population dynamics differed from each other markedly (Fig. 3a).

The *B. sowerbyi* biomass in Houhu Lake was maximum (1.9297 $g \cdot m^{-2}$ wet wt) in June, 1996, then decreased sharply to minimum (0.2029 $g \cdot m^{-2}$ wet wt) in August, 1996. After that, it recovered a little, and oscillated around 0.5$g \cdot m^{-2}$ wet weight (Fig. 3b).

In Biandantang Lake, the biomass decreased from 0.6029 $g \cdot m^{-2}$wet wt in April, 1996 to the minimum value of 0.0139 $g \cdot m^{-2}$ in July, 1996; then increased almost steadily to the peak, and remained at a relatively high level (ca. 0.9 $g \cdot m^{-2}$wet wt).

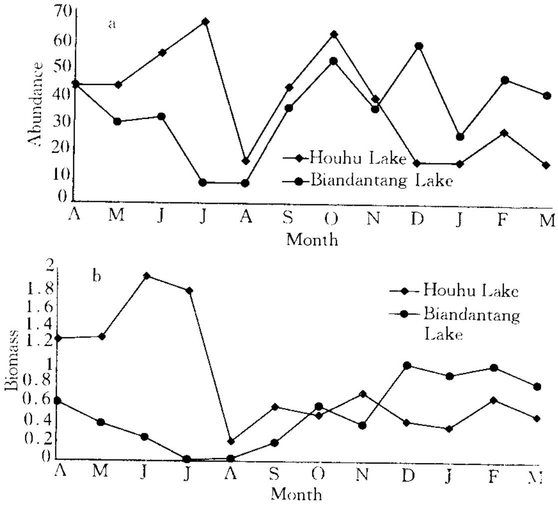

Fig. 3 The dynamics of standing stocks of *B. sowerbyi* in the two lakes

Production

The secondary production was calculated with the size-frequency method. Ten size-classes of 10 mm each were determined. The annual production (wet wt) was 3.413 $g \cdot m^{-2}$ in Houhu Lake, and 2.675$g \cdot m^{-2}$ in Biandantang Lake. The turnover rates (P/B ratios) were 4.0 and 5.0, respectively (Tables 1, 2).

Table 1 Mean density, biomass and annual production of *Branchiura sowerbyi* in Biandantang Lake

Size group (mm)	No./m^2	Mean wt (mg)	Standing stock (g/m^2)	No. loss/m^2	Wt at loss (mg)	Wt loss (g/m^2)	× 10 Production (g/m^2)
0—10	4.3	0.4611	0.0020	-1.4	1.3518	-0.0018	-0.0180
10—20	5.7	3.9630	0.0225	-1.6	6.4887	-0.0108	-0.1080
20—30	7.3	10.6242	0.0746	-0.4	14.0183	-0.0047	-0.0470
30—40	7.7	18.4966	0.1416	-0.3	23.6520	-0.0079	-0.0790
40—50	8	30.2443	0.2417	4.3	37.6044	0.1330	1.3300
50—60	3.7	46.7556	0.1714	2.4	52.9193	0.1235	1.2350
60—70	1.3	59.8956	0.0799	1	66.7336	0.0667	0.6670
70—80	0.3	74.3522	0.0238	0.3	89.5743	0.0299	0.2990
80—90	0	107.9127	0	-0.7	125.2365	-0.0835	-0.8350
90—100	0.7	145.3414	0.0969	0.7	145.3414	0.0969	0.9690
		Standing stock = 0.8591				Total production = 3.413	
		P/B = 4.00					

Table 2 Mean density, biomass and annual production of *Branchiura sowerbyi* in Houhu Lake

Size group (mm)	No./m^2	Mean wt (mg)	Standing stock (g/m^2)	No. loss/m^2	Wt at loss (mg)	Wt loss (g/m^2)	× 10 Production (g/m^2)
0—10	5.7	1.0284	0.0058	-4.6	1.9940	-0.0093	-0.093
10—20	10.3	3.8662	0.0400	1.8	6.1519	0.0111	0.111
20—30	8.5	9.7888	0.0832	4	13.5639	0.0543	0.543
30—40	4.5	18.7950	0.0846	2.2	23.6090	0.0519	0.519
40—50	2.3	29.6560	0.0692	0.8	36.8060	0.0294	0.294
50—60	1.5	45.6798	0.0685	0	53.9643	0	0
60—70	1.5	63.7491	0.0956	1.2	74.0292	0.0888	0.888
70—80	0.3	85.9671	0.0287	0	92.7190	0	0
80—90	0.3	100.0013	0.0333	0.1	120.9115	0.0121	0.121
90—100	0.2	146.1940	0.0243	0.2	46.1940	0.0292	0.292
		Standing stock = 0.5333				Total production = 2.675	
		P/B = 5.00					

DISCUSSION

The size-frequency method has three correction factors, CPI/365, Pe/P and I (Menzie, 1980). Here we used the number of generation (b) instead of CPI/365, and ignored Pe/P, which might result in a small error (Hamilton, 1969; Menzie, 1980). The most important parameter is probably the number of generation (b), which affects the calculation greatly. To determine absolutely if *B. sowerbyi* is univoltine is impossible because of the variable growth rate and the continuous recruiting. However, the size-frequency distribution graphs led us to conclude that *B. sowerbyi* is primarily univoltine. Aston (1968) studied the life cycle of this worm, and thought that its completed life cycle is about one year. Liang (1984) found that the life cycle of *B. sowerbyi* in Donghu Lake was nearly a year. These are in line with our findings in the two lakes.

Table 3 lists estimates of oligochaete production rates and turnover ratios reported in literature. Our production estimates of this species are within the range of these values; and our calculated P/B ratios are within the range of turnover rates of 4 to 7 reported (Water, 1977) for univoltine and bivoltine species.

Production and biomass of *B. sowerbyi* in Houhu Lake are higher than those in Biandantang Lake, probably because the eutrophication of Houhu Lake is more serious than that of Biandantang Lake, as the abundant macrophytes there help improve the quality of lake-water.

Table 3 Comparison of annual production ($g \cdot m^{-2} a^{-1}$ wet wt) and P/B ratios of oligochaete

Taxa	Production	P/B ratio	Author	Locality
Oligochaetes (mostly tubificids)	2.0 – 107.2	1.8 – 12.3	Johnson et al., 1971	Lake Ontario, Canada
Ilyodrilus hammoniensis	7.03	0.7	Joenasson, 1972	Lake Esrom, Denmark
Limnodrilus ssp.	32.20	12.5	Potter et al., 1974	Eglwys Nunydd Reservoir, England
Tubificidae with hair setae	14.81	5.4	Lafont, 1987	Lake Laeman
L. hoffmeisteri	16.67	4.9	Lafont, 1987	Lake Laeman
L. hoffmeisteri	6 – 43	3.3 – 3.6	Poddubnaya, 1980	/
T. tubifex	35 – 2000	1.5 – 5	Poddubnaya, 1980	/
T. tubifex	48.9	5.25	Bonomi et al., 1980	/
P. hammoniensis	2.16 – 10.38	0.58 – 1.35	Joenasson et al., 1976	Lake Esrom, Denmark
L. hoffmeisteri	27.53	4.48	Andreani et al., 1981	/
L. hoffmeisteri	229	6.7	Teal, 1957	Cold Spring, USA
B. sowerbyi	5.7 – 33.5	3.6 – 7.8	Liang, 1984	Lake Donghu, China
Tubificidae with hair setae	0.9 – 8.4	/	Hullae, 1981	/
Tubificidae without hair setae	50.4 – 66	6.1	Hullae, 1981	/
B. sowerbyi	3.413	4.00	Yan & Wang	Houhu Lake, China
B. sowerbyi	2.675	5.00	Yan & Wang	Biandantang Lake, China

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