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Lake Biwa: Interactions between Nature and People

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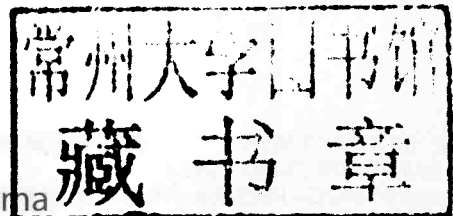
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ISBN 978-94-007-1782-4 ISBN 978-94-007-1783-1 (eBook)
DOI 10.1007/978-94-007-1783-1
Springer Dordrecht Heidelberg New York London

Library of Congress Control Number: 2012935426

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Printed on acid-free paper

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Lake Biwa: Interactions between Nature and People

Preface

Lake Biwa is situated in the centre of Honshu Island in the Japanese Archipelago. It is 670.3 km² in area, and 41.2 m and 103.6 m in mean and maximum depth, respectively. The lake is separated into two parts, the northern main and deeper basin and the southern small and shallower one. The transparency at the centre of the main basin has been decreasing during the past 50 years but is still 4–9 m, while that of the south basin is 2–3 m.

It is one of the world's ancient lakes, having been formed originally about 4.5 million years BP about 50 km south of its present site. Around 400,000 years BP it came to its present site and became deeper. Fossils of the same species or a close relative of the largest fish found in the lake at present, the Biwa catfish *Silurus biwaensis*, have been discovered even in sediments from the oldest age of the lake. Some other endemic fish species in the lake, however, evolved *in situ*, especially after the lake deepened. In such cases, the newly derived species have a more pelagic mode of life or live in open water or show adaptations for survival in rocky shores, compared to the ancestral species which are mainly sandy or muddy littoral inhabitants with a benthonic mode of life. There is a species flock of pleurocerid snails, *Semisulcospira* (*Biwamelania*), and its supposed ancestor *S. (B.) habei* had already appeared by 400,000 years BP.

It is believed that human beings have lived around Lake Biwa for more than 20,000 years, and archaeological evidence demonstrating the relation of human beings and the lake goes back to 8,000 years BP. Most remarkable is the Awadu Lake Bottom sites, around 5,000 years BP, from which it is clear many species of fishes and molluscs were eaten by ancient human settlers for a rather long time. Traces of special fishing installations remain since ancient days: i.e. a 'yana' fishweir at a river mouth and 'eri' pound-net for fish since 2,000 and 1,500 years BP, respectively. Both wooden floats for angling and many types of ceramic net-sinkers have also been discovered, dating since the third century.

Various historical documents pertaining to the lake fisheries survive back to the eighth century. For example, an edict promulgated in 863 prohibited any officer from taking fish away for the imperial court from the fishing grounds around the lake except from fishweirs located in the 4 specified rivers. In 927, the 'Engi-shiki', a collection of laws and regulations, was promulgated, whereby we know that in Ohmi Province surrounding Lake Biwa the following goods were produced and sent to the imperial court: 'fish cheese' of crucian carp and of Biwa salmon, crucian carp with soy sauce, salted crucian carp, boiled ayu-fish with salt, and juvenile ayu-fish.

Given its archaeological and historical background, Lake Biwa is not only an ancient lake in the geological and biological senses but also in a cultural sense, because the relation between human beings and nature, especially the lake, can be traced back to several thousand years BP. In other words, Lake Biwa has developed as a 'life-culture complex' over a long time.

The present book on Lake Biwa is written from this point of view.

*

Around the lake there are many academic institutions. The oldest are the Shiga Fishery Research Station and the Otsu Hydrobiological Station (now the Center of Ecological Research) of Kyoto University, established in 1900 and 1914, respectively. The staffs of these stations have devoted their efforts to limnological, biological, and fisheries research continuously since then, and many scientific results have been cumulated up to now. Rather recently, the Lake Biwa Research Institute, LBRI (now Lake Biwa Environmental Research Institute, LBERI), was established in 1982 and the Lake Biwa Museum (LBM) in 1996, both being set up and operated by the Shiga Prefectural Government. The former is dedicated mainly to research on environmental problems and issues related to the planning of prefectural policy, and the latter is a research-oriented museum dedicated to the 'relation between lake and people', with exhibitions, nature observations, lectures, etc. and with much involvement of the general public.

Concerning Lake Biwa many scientific books has been published up to now but most of them are written in Japanese. In 1975, 'Productivity of freshwater communities in Lake Biwa' edited by the JIBP-PF Research Group of Lake Biwa (chief: T. Miura) was published as a chapter in the book "Productivity of Communities in Japanese Inland Waters". Its coverage was restricted, however, mainly to Shiodu Bay, at the northern end of the lake, as one result of the International Biological Programme in Japan. In 1984 the book "Lake Biwa" (ed. S. Horie) appeared as a volume of the series "Monographiae Biologicae". It was a rather comprehensive book that included six chapters conveying general features, geoscientific features, modern limnology (meteorology, physical, chemical and biological limnology, and metabolism),

paleolimnology (non-biological features, Pleistocene climatic change, ancient lake viewed from paleobiostratigraphy and paleogeochemistry), biogeography, and influence of human activities. In particular it was based on the results of analyses of several boring cores taken from the lake sediments in the 1970s and early 1980s.

In 1997, the 'International Conference on Ancient Lakes: Their Biological and Cultural Diversities' was held at the Lake Biwa Museum, and most papers read at the conference appeared in three books: "Ancient Lakes, their Cultural and Biological Diversity" (ed. H. Kawanabe, G. W. Coulter and A. C. Roosevelt 1999), "Ancient Lakes: Biodiversity, Ecology and Evolution" (ed. A. Rossiter and H. Kawanabe 2000), and "Archaeology of World Lakes" (ed. A. Matsui and K. Makino 2000). In these volumes, respectively, 2, and 3, 8 chapters were dedicated to various aspects of Lake Biwa.

*

The concept of the present book was first suggested in 1999 by Professor David L. G. Noakes, Oregon State University, and several members of LBM and LBERI have discussed in recent years how to achieve it. As was mentioned above Lake Biwa is a 'Life-culture complex'. To reflect this the book includes the following seven chapters: (1) Geological history; (2) Biology; (3) Ecological change; (4) Historical relations of people and the lake; (5) People's use of the lake and their life-style; (6) History of the lake and Yodo River basin management; and (7) Environmental conservation. Each chapter had section editor(s) as indicated in the contents.

As the general supervisor of this book, I would like to extend my sincere thanks to my old friend David L. G. Noakes for his kind suggestion and for establishing our connection to the publisher, and to Drs. M. Akiyama (University of Shiga Prefecture), M. Maehata (LBM), M. Nakamura (former Director of LBRI), M. Nishino (LBERI), K. Takahashi (LBM), and M. Yoda (LBM) for their efforts as each section editor for their extreme efforts to make this book. Thanks are also given to Drs. M. J. Grygier (LBM) and R. Smith (LBM) for polishing the English of much of the submitted manuscripts.

21st January, 2012: The starting day of the coldest 2 weeks in Japan according to traditional beliefs

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Profile of Lake Biwa



Area of Shiga Prefecture	4,017.00 km ²
Catchment area of the lake	3,174.00 km ²
Area of the lake	670.25 km ²
Length (North-South)	63.49 km
Maximum width (East-West)	22.80 km
Minimum width (East-West)	1.35 km
Circumference	235.20 km
Elevation	85.614 m above the lowest sea level of Osaka Bay 84.371 m above mean sea level of Tokyo Bay
Maximum depth	103.58 m
Mean depth (North Basin)	44.0 m
Mean depth (South Basin)	3.5 m
Volume	27.5 billion m ³
Residence time of water	5.5 years
Number of the first grade river flowing into the lake	118
Number of natural outlet	1 (Seta River)
Age of the present lake	ca. 400,000 years

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Topic 1 The Naming of Lake Biwa

Yoshihiro Kimura

Lake Biwa, which is one of the oldest lakes in the world, formed near its present location about 4 million years ago. Despite its long history, the current name of the lake, *Biwa-ko* in Japanese, was introduced to the public only quite recently, approximately 320 years ago. The origin of the name is described here.

Literature sources reveal that the lake had various names in the beginning, before being called *Biwa-ko*. In *Keiranshuyoshu*, a book compiled in the early fourteenth century, it was mentioned for the first time that the lake's outline resembled the shape of a *biwa*, a traditional Japanese lute (see Color page 1). According to this book, the name-giver of the lake was Benzaiten, the goddess enshrined on the island of Chikubushima in the northern part of the lake. Benzaiten was originally the goddess of water, Sarasvati, who presided over a mystical river of the same name in Hindu mythology, and she is depicted as holding a *biwa*. As a guardian deity of water and Buddhism, she was brought to Japan along with Buddhism in the Nara Period (710–794 AD), from India through China.

Why would the shape of the lake be associated with the *biwa* held by Benzaiten? Koso (1274–1347), a famous monk of Enryakuji temple on Mt. Hiei overlooking the lake, who wrote *Keiranshuyoshu*, viewed Benzaiten as a goddess protecting both Mt. Hiei and the lake. From the top of the mountain at a height of 843 m, he may have contemplated the shape of the lake while being inspired by the *biwa* held by Benzaiten. Actually, the top of Mt. Hiei offers a greater view of Lake Biwa than any other mountains surrounding the lake.

The current Japanese name of Lake Biwa first appeared in a literature source in the early sixteenth century. This was *Kojo Hakkei* (Eight Views of the Lake), a collection

of Chinese poetry composed by Keijoshurin, a monk of Shokokuji temple in Kyoto. The use of the name *Biwa-ko* became common after 1689 because of the popular diary of the Confucianist scholar Kaibara Ekiken. In his diary, after describing the overall shape of the lake and that of the stringed instrument *biwa*, he explicitly stated, “it is therefore called *Biwa-ko*.” Thereafter, this name started to appear in literature, *ukiyo-e* (a genre of Japanese woodblock prints), and maps, and its use became ubiquitous. In particular, Ino Tadataka, a famous geographical surveyor in the mid-eighteenth century, completed an accurate map of the lake using the name of *Biwa-ko*.

As for how the name *Biwa-ko* became popular, its relation with the sound of the *biwa* might be one reason. Words describing waves have been commonly used since ancient times in Japanese poetry as epithets, or *makurakotoba*, in reference to Lake Biwa. The sound of the *biwa* is reminiscent of the sound of waves lapping on the shore. Benzaiten is also known by the name of Myōōnten or Bionten, who presides over sound.

There are countless lakes in the world, among which Lake Kinneret (the Sea of Galilee) in Israel is one of those named after an instrument, like Lake Biwa. The name Kinneret originated from *kinnor*, a Hebrew word for harp. The local people believe that it is derived from the sound of the waves, resembling the tones of a harp. If so, this constitutes a remarkable parallel with the naming of Lake Biwa. It can draw inference from this fact that the shape of the lake and the similarity in the sound of *biwa* and lapping waves of the lake are deeply associated with the naming of Lake Biwa. It is a precious lake providing us with beautiful scenery along with cultural affection.

Y. Kimura (✉)

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Color Plates



'Biwa': Japanese traditional instrument. Lake Biwa is named after this instrument. See **Topic 1** (photo courtesy of Hikone Castle Museum)



Aerial view of Lake Biwa showing Chikubushima Island in the foreground (photo courtesy of Shiga Prefectural Government)



Aerial view of Lake Biwa: around the Biwa-ko Ohashi Bridge (photo courtesy of Shiga Prefectural Government)



Aerial view of the southern part of Lake Biwa: residential and business districts of Otsu City, the Omi-Ohashi Bridge, and an *eri*-fishing trap in the foreground (photo by R. J. Smith)

Changing seasons around Lake Biwa



Spring: Oura is known for its magnificent cherry trees (photo courtesy of Shiga Prefectural Government)



Summer: Omi-Maiko Beach, one of many swimming beaches in the western shore of Lake Biwa (photo courtesy of Shiga Prefectural Government)



Autumn: Chikubushima Island before sunset: a small island in northern Lake Biwa. See Topic 1 (photo by M. Matsuda)



Winter: Lake Biwa becomes a paradise for waterfowl in this season (photo by M. Maehata)



Chapter 1 Geological history of Lake Biwa and its biota



Outcrop of the Ko-Biwako Group in the Hattori River. This area was the site of the first paleo-lake, ca. 3.5 Ma. See Chapter 1-2 (photo by Y. Satoguchi)



This clay bed formed on the bottom of Lake Katata. Faults like that in this photo occurred around Lake Biwa after ca. 0.4 Ma. See Chapter 1-2 (photo by Y. Satoguchi)



Eb-Fukuda Tephra. This bed of volcanic ash from 1.75 Ma represents fallout from an explosive volcanic eruption 200 km away to the east. See Chapter 1-2 (photo by Y. Satoguchi)



Pharyngeal tooth fossils of *Cyprinus* (*Mesocyprinus*) *okuyamai* unearthed from the Oyamada clay layer formed ca. 3.5 Ma. See Chapter 1-3 (photo by T. Nakajima)

Chapter 2 Biodiversity and its changes in Lake Biwa

(1) Extinct organisms in and around Lake Biwa



Japanese otter *Lutra nippon*: Stuffed specimen at the Shimono-kae Elementary School, Kochi Prefecture, Shikoku Island. See Topic 6 (photo by M. Ando)



Japanese rose bitterling, *Rhodeus ocellatus kurumeus*, 4-5 cm standard length (SL) (photo by H. Akiyama)



Kissing loach (*Parabotia curta*), 15-20 cm SL (photo by H. Akiyama)

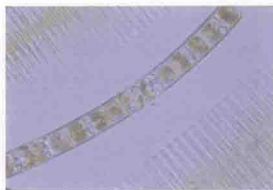


Golden venus fish (*Hemigrammocypripis rasborella*), 4-6 cm SL. This fish has not been found in Lake Biwa for near 30 years (photo by H. Akiyama)

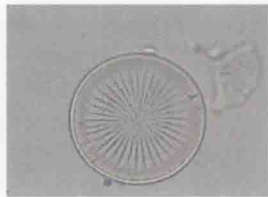


Potamogeton dentatus from Lake Tega-numa, Chiba Prefecture, the Kanto District (photo by E. Hamabata)

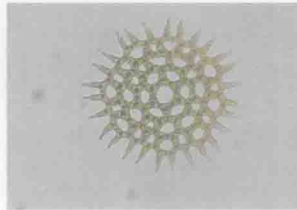
(2) Endemic species & varieties of protists and plants of Lake Biwa



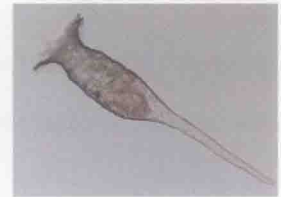
Aulacoseira nipponica
(photo by S. Ichise)



Stephanodiscus suzukii
(photo by S. Ichise)



Pediastrum biwae
(photo by S. Ichise)



Diffflugia biwae
(photo by S. Ichise)



Vallisneria asiatica var. *biwaensis* (photo by E. Hamabata)



Potamogeton biwaensis (photo by E. Hamabata)

(3) Endemic benthic invertebrates of Lake Biwa

(photographs by M. Nishino)

<BL: body length, SL: shell length, SH: shell height, SW: shell width> See Chapter 2



Hyriopsis schlegeli (adult: 22.4 cm SL)



Oguranodonta ogurae
(adult: 7.7 cm SL)



Inversiunio reinianus
(adult: 4.75 cm SL)



Corbicula sandai (adult: ca. 41 mm SL (left);
small shell: 4.8 mm SL (right))



Pisidium kawamurai
(adult: 5.1 mm SL)



Radix onychia (adult: 11.1 mm SH (left); live:
ca. 11.0 mm SH (right))



Valvata biwaensis (adult: 4.2 mm SW)



Gyraulus biwaensis (adult: 3.8 mm SW)



Semisulcospira (Biwamelania) multigranosa
(adult: 27.7 mm SH; embryonic: 5.0 mm,
3.2 mm SH)



Semisulcospira (Biwamelania) reticulata (adult: 43.3 mm SH;
embryonic: 3.6 mm SH)



Semisulcospira (Biwamelania) ourense (adult: 28 mm SH;
embryonic: 2.6 mm SH)



(3) (continued) **Endemic of benthic invertebrates of Lake Biwa** (photographs by M. Nishino)



Jesogammarus
(*Annanogammarus*) *annandalei*
(male: 10.9 mm BL)



Kamaka biwae, (male: 2.4 mm long (upper); female: 2.5 mm long (lower))



Ephoron limnobium (larva: 13.0 mm BL, (left); male: BL unmeasured (right) (photos by S. Ishiwata)



Bdellocephala annandalei (adult: 21 mm BL (left); cocoon: 2.7 mm in diameter (right))



Copulating *Apatania biwaensis*

(4) **Endemic species & subspecies of fish of Lake Biwa, See Chapter 2-5**

(Photographs courtesy of Lake Biwa Museum (LBM))



Biwa salmon, male (*Oncorhynchus masou* subsp.),
30-60 cm in standard length (SL)



Biwa ayu (*Plecoglossus altivelis* subsp.), 8-10 cm SL



Oily minnow (*Sarcocheilichthys biwaensis*), 15-17 cm SL



Biwa minnow (*Sarcocheilichthys variegatus microoculus*), 13-20 cm SL



Sugo gudgeon (*Squalidus chankaensis biwae*), 10-13 cm SL

(4) (continued) **Endemic species & subspecies of fish Lake Biwa, See Chapter 2-5**



Round crucian carp (*Carassius auratus grandoculis*), 20-35 cm SL



Biwa culter (*Ischikauia steenacheri*), 25-40 cm SL



Deep-bodied crucian carp (*Carassius cuvieri*), 20-40 cm SL



Willow minnow (*Gnathopogon caerulescens*), 8-13 cm SL



Yodo gudgeon (*Biwia yodoensis*) 5-6 cm SL



Biwa striated spined loach (*Cobitis* sp. S), 7-8 cm SL



Biwa yellow-gill (*Rhinogobius* sp. BW), 3-4 cm SL



Biwa sculpin (*Cottus reinii*), 10-12 cm SL



Large striated striped loach (*Cobitis* sp. L), 8-11 cm SL



Biwa goby (*Gymnogobius isaza*), 6-8 cm SL



Rock catfish (*Silurus lithophilus*), 50-60 cm SL



Biwa catfish (*Silurus biwaensis*), 70-110 cm SL

Chapter 4 (partially Chapter 5) History of the relationship between people and Lake Biwa



The last *Maruko-bune*. See Chapter 4-2-4 (photo by M. Yoda)



Investigation of remains under water. See Topic 11 (photo courtesy of Shiga Prefectural Board of Education)



The Awazu Site on the lake-bottom. See Chapter 4-1-1 (photo courtesy of Shiga Prefectural Board of Education)



Hiyoshi San'nosai [San'no Festival of the Hiyoshi Grand Shrine]. See Topic 14 (photo by M. Yoda)



Awazu Goku [Offering to the lake god]. See Topic 14 (photo by M. Yoda)



Funa-zushi. See Chapter 5-2-3(1) (photo by M. Maehata)