



Past Biodiversity: Japanese Historical Monographs Document the Epibiotic Barnacles and Cold-Stunning Event of the Hawksbill Turtle *Eretmochelys imbricata*

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The historical monographs called “*Honzou Gaku*” present the first record of cold-stunning of a hawksbill turtle *Eretmochelys imbricata* (Linnaeus, 1766) in the Echigo region of Japan during the Edo period (1600–1868), and the barnacles attached to the turtle were identified as *Platylepas hexastylus* (Fabricius, 1798). Analysis of this finding adds substantial knowledge to our understanding of the life history of the hawksbill turtles along the coast of Japan. As reported in this study, literature on the historical heritage of other animals or plants can also provide information about their past biodiversity.

Keywords: turtle barnacle, hawksbill turtle, epibionts, *Honzou Gaku*, natural history

INTRODUCTION

The hawksbill turtle, *Eretmochelys imbricata* (Linnaeus, 1766), is a specialized “sponge-eating” sea turtle that occupies a unique position in coral reef ecosystems. Globally, hawksbill turtles are generally recognized as declining, having been both hunted for their keratinized carapacial scutes called *Bekko* materials for Japanese traditional crafts and recorded as by-catch worldwide (Meylan and Donnelly, 1999; Gillman et al., 2010). Understanding the migration strategies and habitat use of sea turtles is necessary to implement effective conservation strategies (Hamann et al., 2010; Mazon et al., 2016). However, the migration routes and patterns of habitat utilization of hawksbill turtles are rather poorly known compared to other sea turtle species (Godley et al., 2008). Epibiotic organisms such as barnacles are useful to track hosts and understand their life history (Hayashi and Tsuji, 2008; Hayashi, 2009; Fuller et al., 2010), for example, fossil records of epibiotic barnacles presented the past migratory routes of extinct whales (e.g., Bianucci et al., 2006; Collareta et al., 2016; Buckeridge et al., 2019; Taylor et al., 2019).

Before binomial nomenclature was introduced by Linnaeus, observations of these barnacles were reported from western historical scholars. The first reference to the whale barnacle *Coronula diadema* (Linnaeus, 1767) dates back to 1751 (Haelters et al., 2010), and the earliest probable reference to a turtle barnacle *Chelonibia testudinaria* (Linnaeus, 1758) was published by

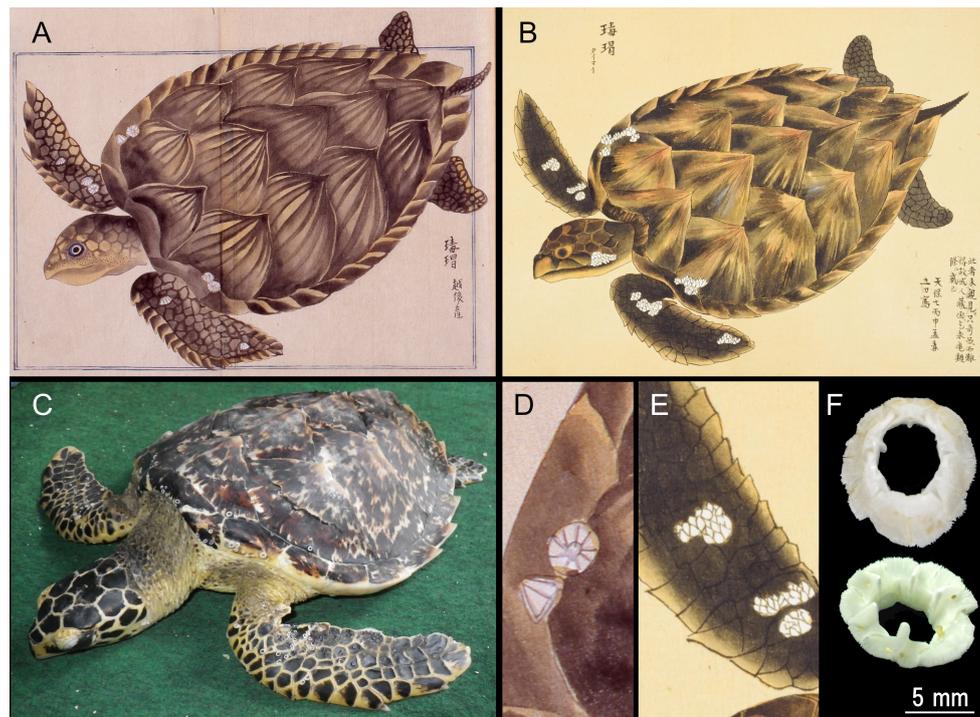


FIGURE 1 | (A,D) Hawksbill turtle with barnacles illustrated by Shunzan Takagi; **(B,E)** Copied illustration by Baien Mouri; **(C,F)** An encrusted living hawksbill turtle and *Platylepas hexastylus*.

Aldrovandi (1606). From the eastern Pacific, Sáenz-Arroyo et al. (2006) reported the 16th–19th century traveler’s descriptions of marine wildlife, including sea turtle species.

Animal illustrations by pioneer Japanese naturalists from the Edo period (17th–19th centuries) indicate that the Japanese people of this period were interested in the diversity of life. However, the contributions of their classical natural history records (the so-called “*Honzou Gaku*”) to modern biology and ecology are not always recognized. In turn, the *Honzou Gaku* records provide an important resource for understanding past patterns of biodiversity. For example, ancient Japanese naturalists recorded epibiotic barnacles attached to marine vertebrates (Hayashi, 2014) and the trans-Pacific migration of black turtle (Hayashi and Yasuda, 2021) while compiling information on Japanese fauna and flora into monographs. Despite the lack of modern evidence, these historical documents offer insight into past migratory patterns. Here, I present the historical records of a hawksbill turtle with epibiotic barnacles in “*Honzou Gaku*” monographs to elucidate the past life history of these organisms.

MATERIALS AND METHODS

A literature survey was conducted using original illustrations and internet databases. The original illustration in **Figure 1A** is deposited in the Iwase Bunko Library (Takagi, 1852). That in **Figure 1B** is deposited in the National Diet

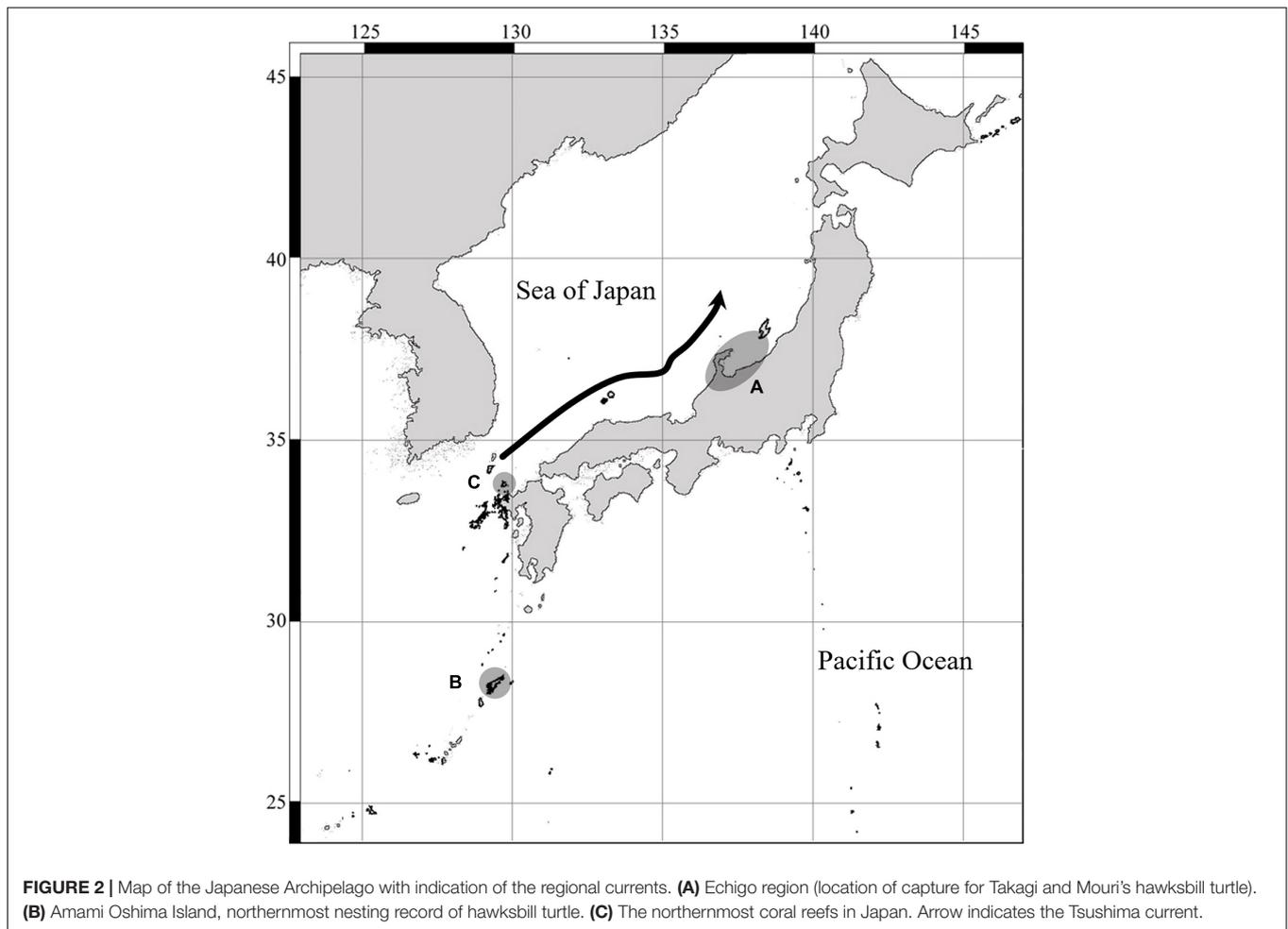
Library of Japan (Mouri, 1839) and it is available to the public online.

RESULTS

To promote domestic production, the early Japanese naturalist Shunzan Takagi (date of birth unknown–1852), was convinced of the need to understand the classical natural history called as “*Honzou Gaku*.” With clearly illustrated drawings of Japanese animals and plants, he made a monograph entitled “*Honzou Zusetsu*” (Takagi, 1852). Takagi edited *Honzou Zusetsu* in the 1830s or earlier. However, the 195 volumes of this monograph were not complete at the time of its death in 1852. He included a color drawing of a hawksbill turtle with epibiotic barnacles in his monograph (**Figure 1A**), and described the location of the turtle only as “*captured in Echigo*” [currently the area around Niigata Prefecture (**Figure 2A**), coast of the Sea of Japan].

Baien Mouri (1798–1851), a retainer of the Tokugawa shogunate and early Japanese naturalist, also included a color drawing of a hawksbill turtle with epibiotic organisms in his monograph, *Baien Kaifu* (**Figure 1B**), deposited in the National Diet Library of Japan (Mouri, 1839). Mouri’s description of his drawing is as follows:

“I did not observe this turtle directly. I asked a person (presumably Shunzan Takagi) who had a detailed drawing to copy it, because this is a very rare species and difficult to get. I made a copy on 5



March 1837. The turtle was captured at Echigo in 1836. A person got this turtle from a fisherman, but this animal was decayed and soon smelled bad. He suspended the animal from a tree, but wind and rain caused it to decay further. I went to his home and saw it, but it was in bad condition. The turtle was a hawksbill turtle and difficult to get, then I asked him to copy his drawing. This turtle was almost the same size as the drawing (ca. 30 cm) and was encrusted with many organisms”.

As described above, Mouri's figure is a facsimile of *Honzou Zusetsu* (Takagi, 1852) with a detailed description. However, his drawings of epibionts are schematic and difficult to identify (Figure 1E). In contrast, Takagi's original drawing, illustrated in Figures 1A,D, clearly shows the acorn barnacles. In Japanese waters, the most conspicuous barnacle on the turtle carapace *C. testudinaria* had not been recorded from the hawksbill turtles, on the other hand, *Platylepas hexastylus* (Fabricius, 1798) were commonly found on Japanese hawksbill turtles (Figures 1C,F). Distribution of *C. testudinaria* is limited to the hard substrate on turtle body such as carapace or plastron, while that of *P. hexastylus* includes on carapace, plastron, head, flipper, legs, and soft skin of sea turtles. For the above mentioned, the illustrated barnacles are identified as *P. hexastylus*.

DISCUSSION

The northern limit of the hawksbill turtle breeding range was recorded in Amami Oshima Island, Kagoshima (Figure 2B, Mizuno, 2013), even though the northernmost coral reef is located on Iki Island (Figure 2C, the entrance to the Sea of Japan) and there are no coral reefs in the Sea of Japan (Yamano et al., 2001). The turtle described by Takagi and Mouri might have been carried away from its native habitat by the Tsushima Current (Figure 2). Recently, some stranding records of hawksbill turtles were reported from the coast of the Sea of Japan near the Echigo region (Hayashi S., 2012; Ishihara et al., 2017). Local sea surface temperatures are too cold for them and cold-stunning events occur at the upper limits of their native habitat range. Hayashi S. (2012) suggested that the hawksbill turtles were transported by the Tsushima Current and wandered from their native habitat during accidental migration, or vagrancy, caused by sea surface temperature rise due to recent global warming. However, the 19th century records of cold-stunning or accidental migration of the hawksbill turtle indicate that aberrations of sea turtle migration into the Sea of Japan occur frequently and are not only recent events.

Seven species of turtle barnacles including *Platylepas hexastylus* have been recorded from hawksbill turtles (Hayashi, 2013), and *P. hexastylus* has been reported from hawksbill turtle in the Sea of Japan (Hayashi R., 2012). The illustrated barnacles are identified as *P. hexastylus*, and the historical record of epibionts is also consistent with recent records. The *Honzou Gaku* records thus prove precious for understanding sea turtle life history in Japan and can expand our knowledge of the past distribution of species.

Early Japanese naturalists have been recording details of fauna and flora since the Edo period, and there is a large amount of natural history data for Japan. Four basic questions regarding the history of marine animal populations (HMAP) were raised by Holm (2003): How has the extent and diversity of these populations changed over the last 2000 years? Which factors have influenced these changes? What is the anthropogenic and biological significance of these changes? What has been the interplay of changing marine ecosystems and human societies? This paper provides some answer to the questions of HMAP in the case of hawksbill turtles and indicates the importance of natural history to gain insight into past patterns of biodiversity. Evaluating historical natural history materials is a valuable approach to understand the state of the ecosystem in the past and can aid in formulating adequate conservation strategies for endangered species.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

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ETHICS STATEMENT

Ethical review and approval was not required for the animal study because the living hawksbill turtle (reported in **Figure 1**) was fishery bycaught.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

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