Preface

Why Are Eels So Fascinating?

A good question—it may be because eels are an important food resource for humankind, or perhaps because they are an interesting model species for scientists studying animal migration and reproductive ecology. There may be another reason, though. Biologically, they are fish, but they appear to be more than that; their unique morphology draws a clear line between them and other fish, and their bodies are not streamlined as are those of ordinary fish, but elongate, closely resembling snakes, which are reptiles. Moreover, eels appear superficially to lack many of the characteristics used to identify fish, for instance, gills, fins and scales, although they do have all these features. Another characteristic of eels that attracts our attention and evokes curiosity is their unpredictable behaviour and inconceivable strength, enabling them to move over wet land and to climb rocks beside high waterfalls. All these features lead to us considering eels as enigmatic creatures or metaphysical entities beyond human intelligence; indeed, they have even been deified in parts of the world.

In this book, the various authors attempt to explain as much as they can about eels, focusing on social and cultural aspects wherever they are found. A wealth of eel-related topics is covered, including eel fishing, resources, distribution, aquaculture, economics, cuisine, environment and ecosystems, idioms, arts, tradition, legends, mythology, archaeology and even memorial services, as shown in Fig. 1.

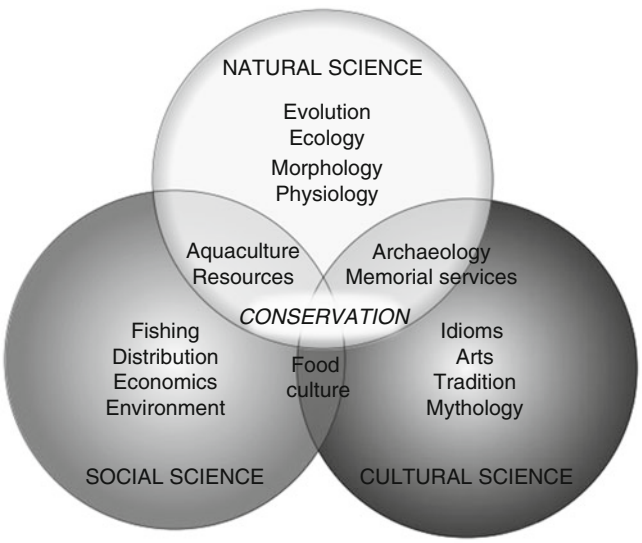


Fig. 1 Various aspects of eel-related science. Comprehensive understanding of such issues enhances public awareness of their importance and helps to conserve the species all around the world

The Natural Science of Eels

Articles or tales about eels often start with or soon mention the word "mysterious". This is because their spawning areas are located far offshore and their spawning ecology was virtually unknown until relatively recent times. Aristotle, the Ancient Greek philosopher and naturalist, famously postulated that eels had to generate naturally from mud, because he could find no larvae or adults with mature gonads. Centuries later, Italian physicians and anatomists took an interest in eel reproduction and ecology. They included Francesco Redi (1626–1697), Marcello Malpighi (1628–1694), Antonio Vallisneri (1661–1730) and Carlo Mondini (1729–1803).

Even so, there was no major breakthrough in knowledge of eel ecology until two Italian scientists, Giovanni Battista Grassi (1854–1925) and Salvatore Calandruccio (1858–1908), made a landmark discovery in 1897. They proved that the fish then known as *Leptocephalus brevirostris*, which resembles a transparent leaf, eventually metamorphoses into the glass eel of *Anguilla anguilla*, the European eel. Until that discovery, the genus *Leptocephalus* had been regarded as a different fish taxon altogether, entirely unrelated to the eel, but with their breakthrough it was finally accepted that freshwater eels develop from the leptocephalus larvae found in the sea. Despite this discovery, it was not until the early twentieth century that superstitions involving autogenesis in eel reproduction—the notion that they originated, for example, from yams (East Asia) or horsetail hair (Europe)—were finally laid to rest by Danish oceanographer Johannes Schmidt (1877–1933). It was he who discovered the spawning area of both European and American eels in the Sargasso Sea. Two of his pupils then continued his work, culminating in further major contributions to the advancement of eel science: Vilhelm Ege (1887–1962) established the taxonomy of freshwater eels in the genus *Anguilla*, and Poul Jespersen (1891–1951) laid the foundations for leptocephalus biology throughout the world.

Thanks to these discoveries, we now know much about the life history of freshwater eels. They are catadromous, spawning in the sea, far from the freshwater they occupy for much of their life. Hatched larvae quickly develop into the larval form known as a leptocephalus, which is morphologically quite different from its appearance as a juvenile (known as a glass eel). Leptocephali grow as they are carried along by ocean currents for long periods after hatching, for anything between 3 months and a year, or perhaps even more. Then, on approaching the freshwater habitats of islands or continents, they metamorphose into glass eels and most enter rivers to swim upstream, when they are known initially as elvers before they settle in a wide range of habitats, from rivers and lakes to estuaries, though some even stay in saline coastal water. Once settled they are referred to as yellow eels, and these grow large on a diet of smaller fish and crustaceans for several years (sometimes tens of years). Then, with the onset of maturation, yellow eels metamorphose into silver eels in preparation for spawning migration back out to sea. The downstream migration commences in autumn and marks the end of the animal's feeding stage, and the silver eels migrate back into and across the ocean to their preferred and specific spawning area where, on arrival, they reproduce and then die.

Various advances in eel science were made in the decades following Schmidt's discovery in 1922 of where European and American eels spawn, and recently a new species (*Anguilla luzonensis*) has been discovered on Luzon Island in the Philippines, the first new discovery since Ege's taxonomic study some 70 years earlier. Today, 19 species and subspecies are described for the genus *Anguilla* and molecular phylogenetic studies have been completed for all the world's anguillids. Surveys of the spawning area of Japanese eels in the Pacific have made huge progress over the past decade alone; newly hatched larvae, spawned eel eggs and adult eels in spawning condition have been collected, and the precise spawning site can be predicted based on oceanographic and geological characteristics of the general spawning

area. Further, the behaviour of adult eels during their spawning migration is being studied for European, New Zealand and Japanese eels, using swim tunnels in the laboratory and pop-up tags in the field.

The Social Science of Eels

Eels appeared on earth tens of millions of years ago, but it was only seven million years ago that our own ancestors diverged from apes. We can easily imagine, therefore, that early humans would catch eels in rivers and consume them, starting the relationship between eels and humans. Since then, the relationship between humans and eels has been maintained, largely because of the long-standing human tradition of exploiting eels as food. At first, eels were caught by hands and feet, but as time passed, many different types of fishing gear and methods of catching eels were developed. Eels were caught using a variety of contrivances including spears, scythes, pots, nets, weirs, rock piles, and hook and line. Their unique habits, body form, behaviour and life history gave rise, however, to some common features of fishing gear and methods around the world, and these were put to use in catching glass eels, yellow eels and silver eels, i.e. every stage in the life cycle of eels except for the earliest (eggs and leptocephalus larvae), wherever they were found.

In historical times, all the eels caught from a river would be consumed locally in the village where the people lived, but later, as catches increased, part of the catch not needed for immediate consumption would be preserved and used for trade. This was the beginning of eel marketing and economics. Then, the increasing social demand for eels as food gave rise to eel aquaculture, as a means of maintaining a stable supply of eels to the market. The increased eel consumption in many countries also produced a variety of recipes for eel dishes around the world, including kabayaki, smoked eel, eel pie, jellied eels, angulas, eel stew, eel curry and matelote d'anguille. Cooking knives themselves have been designed specifically for filleting eels according to local needs, and tableware has been invented to handle eel dishes only. These features are all representative of the food culture that has developed around eels.

However, the overexploitation of eel resources and the degradation of many river environments triggered a huge decrease in eel resources worldwide that became notably evident in the 1970s. Now scientists working on eels have to pay close attention to the problems of the decimated resources as well as the need for their conservation. Research aimed at developing the technology to produce glass eels artificially began with European and Japanese eels in the 1960s, with the motivation in both cases being to achieve a stable supply of glass eel seedlings for aquaculture ponds and to reduce the impact of fishing on wild glass eels with a view to their conservation. This research challenge has recently been expanded to other eel species, e.g. the Australian and American species. However, although promising, such efforts have yet to achieve definitive success, meaning the production of large numbers of offspring, in any species of eel.

The Cultural Science of Eels

The traditional exploitation of eels as food spawned a feeling of familiarity with eels in the human mind, and this relationship naturally yielded various cultural references to the species. Eels now appear in idioms, metaphors and proverbs in many languages, e.g. "as slippery as an eel" in English, "il y a anguille sous roche" in French ("there's an eel under the rock," referring to a fishy or dubious situation), and "unagi nobori" in Japanese ("eel climbing," or a phenomenon that continues to rise with no apparent end). In addition, people have expressed eels in various forms of art and daily items, such as poems, paintings, carvings, handicrafts, accessories,

books, films, storytelling and fables, children's stories, cartoons, comic songs and even cookies. All of these reflect a human interest and perhaps even affection for eels, proving that this unique fish has always fascinated people.

At the same time as being objects of affection, however, eels are also regarded as objects of fear and respect. This is because they resemble snakes or dragons as well as exhibiting strange behaviour and incredible power. Old sayings, legends and myths about eels survive in various parts of the world, and in these, eels are sometimes portrayed as monsters or gods related to floods and droughts, or as spirits of water. A well-known example is the tragic romance of the eel-god Tuna (who also has other names in mythology, e.g. Tunaroa) and the beautiful village girl Hina. This myth is related widely among the tropical islands of the Pacific, combined with a legend on the origin of the coconut tree (see the similar story outlined in the French chapter 5).

Memorial services are still held for eels in some parts of East Asia, to thank the eels that have been sacrificed by humans and to pray for their souls. Eel mounds or memorial towers have been erected in places where these services are held; solemn, respectful ceremonies to pray for the eels' souls are held in front of them, after which yellow eels are released into the wild. Scientific evaluation of these events has recently started in the hope of finding ways to improve release techniques and thereby enhance eel resources.

Eels are also bound up in taboos or spirituality. The indigenous peoples of Canada and New Zealand treat eels with awe and respect. Further, some people or districts in Japan respect eels as messengers of Buddha, so shun the idea of eating them, as do the folk of some parts of Polynesia and Melanesia where eating eels is considered taboo. In the latter case, this is because people believe that their ancestors eight generations back were eels, so worship them as sacred creatures. This leads to a belief that, if sacred eels are killed or eaten, precious spring water will dry up or people will be afflicted by terrible disease. Many beliefs, totemism and taboos in Pacific islands are linked to eels, because they are important, key animals for local people. It is also of note that the routes by which this culture has been propagated and diffused are closely related to those of human migration and interaction in the South Pacific. At the same time, they overlap with the image of eel migration from spawning areas offshore to freshwater rivers on small tropical islands in the South Pacific, resulting from the dispersal of the tiny leptocephalus larvae in oceanic currents.

Where Does This Lead?

We know that eels have been shrouded in mystery since the earliest days of human thought. At the same time, they are popular in world cuisine and are a familiar part of everyday language and of arts and crafts, revealing a long-lasting and close relationship with humans. In recent decades, however, with global populations of eels in sharp decline, some species face the real threat of extinction, and effective conservation strategies and measures are needed urgently to protect them.

As shown in Fig. 1, this book attempts to explain much of what is known currently about eels, focusing on social and cultural aspects as well as eel science. Lateral comparisons across these issues between various countries should provide an overall image of the relationship between eels and humans, and as such, our ultimate aim is to encourage a more comprehensive and detailed understanding of eels from the perspectives of social, cultural and natural science. By promoting an understanding of this close relationship between eels and humans, we hope to engage the broader public and increase public awareness of the importance of eels, helping hopefully to conserve these unique endangered fish. By so doing, we hope to ensure the survival on earth of these mysterious yet often loveable creatures.

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