Common names for all species and subspecies of the genus *Anguilla*

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Received: 11 March 2020 / Revised: 11 March 2020 / Accepted: 22 May 2020 / Published online: 19 June 2020
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Abstract Scientific naming rules of animals are strictly defined by the International Code of Zoological Nomenclature, while those for common names are vague and not well defined. Specifically, the common names of freshwater eels of the genus *Anguilla* have become confused among scientific papers, pictorial books, and online resources in recent years. This disordered use of common names among freshwater eels demonstrates the urgent need for the standardization of common names for these species. In addition, freshwater eel populations have drastically decreased worldwide over the past few decades, resulting in their listing as endangered species. In the present study, we defined the following five rules for the common names of freshwater eels: to (1) use a representative locality name of the geographic distribution of the species or subspecies, (2) distinguish two sympatric species or subspecies as longfin or shortfin, (3) select a name that would enable the scientific name to be easily recalled, (4) value longstanding former common names if they adhere to the above three rules, and (5) use the shortest name possible. Based on current scientific knowledge and on these rules, we proposed 22 common names for all known 19 species and sub-

species of the genus. As a result, 21, 6, 13, and 3 species and subspecies were named based on Rules (1), (2), (3), and (4), respectively.

Keywords Freshwater eel · Anguillidae · Common name · Scientific name

Introduction

Scientific names of animals are strictly defined by the International Code of Zoological Nomenclature stipulated by the International Commission on Zoological Nomenclature (<https://www.iczn.org>; Accessed 03 March 2020). However, common names are not defined by any set of rules. Although the majority of common names used are spontaneously decided on in many cases, there can be confusion when a species has two or more different common names or if a single common name is used for multiple species, e.g., among the common names of anguillid eels. Common names are considered to be effective when they are short and simple, and thus easily remembered, and organized systematically according to a certain rule.

Currently, 19 species and subspecies of Anguillid eels are recognized worldwide (Ege 1939; Castle and Williamson 1974; Watanabe et al. 2009a) (Fig. 1). These species and subspecies are all distinguishable by molecular characteristics (Watanabe et al. 2005), although there are still taxonomic issues regarding the subspecies (Dijkstra and Jellyman 1999; Watanabe

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et al. 2006, 2008a, 2014b) and populations (Minegishi et al. 2008; Watanabe et al. 2008b).

Catadromous anguillid eels occur in freshwater habitats during their growth stages and reproduce in the ocean environment. As a result, life history data on their reproduction is completely lacking and they are often referred to as ‘mysterious creatures’ (Kuroki and Tsukamoto 2012). Anguillid eels have a widespread global distribution, from tropic to subarctic zones (Fig. 1), however, they do not occur along the west coasts of the North and South American continents, the west coast of Africa, and the east coast of South America, except the north coast along the Caribbean Sea.

Anguillid eels are important food and cultural resources across the world (Kuroki et al. 2014a), but their populations have drastically decreased worldwide over the past few decades. The International Union for Conservation of Nature (IUCN) evaluated 13 species of anguillid eels and categorized *A. anguilla* as a critically endangered species, *A. japonica* and *A. rostrata* as endangered species, *A. borneensis* as a vulnerable species, and the remaining species as near threatened, least concern or data deficient species in the list (IUCN 2019). After the IUCN evaluation, the endangered status of *Anguilla* species has become a frequently broadcasted topic by the mass media and, hence, common names have also been used frequently. In addition, the shortage of temperate eel resources induced a new exploitation of tropical eels in temperate regions. Such eel resources had previously only been consumed at the local level and far less scientific research had been conducted regarding such eels compared to temperate eels. This situation resulted in the urgent need for common names.

The common names of freshwater eels of anguillid eels are now inconsistent among mass media articles, online resources, and even scientific publications (Table 1). Some lists and books do not discriminate between subspecies (IUCN 2019) and cover only some of the species in the genus *Anguilla* (Wheeler et al. 1992; Nelson et al. 2013; FishBase 2019). Furthermore, some common names do not necessarily represent their geographic distribution sufficiently, which is important to recognize the biological characteristic of the species (Yamamoto et al. 2000; FishBase 2019; IUCN 2019; Wikipedia 2020).

The objective of the study was to propose standard common names for all anguillid species and subspecies

under fixed rules based on the available scientific information, and that the frequent changing of names should strictly be avoided.

Materials and methods

Rules for common names.

We defined the following five rules in naming anguillid eels:

- (1) Use a locality name of the geographic distribution of the species or subspecies.
- (2) Distinguish two sympatric species or subspecies as longfin or shortfin.
- (3) Select a name that would enable the scientific name to be easily recalled.
- (4) Value longstanding former common names if they adhere to the above three rules.
- (5) Use the shortest name possible.

Reasons for the rule

Anguillid eels cannot be identified only by their morphological characters because of an overlapping of traits (Ege 1939; Watanabe et al. 2004). A Danish ichthyologist, Vincent Ege, faced this problem 80 years ago, and proposed a solution by using geographic distribution information of each species. He initially divided all anguillid eels into four groups using three clearly distinguishable morphological characters, i.e., the patterns of the skin (mottled or plane), width of the maxillary band (wide or narrow), and length of the dorsal fin (long or short) (Fig. 2). Ege then identified the species in each group using differences in their geographic distributions (Fig. 1). Therefore, the locality name was thus the most important characteristic in our propose rules for the common names of anguillid eels (Rule 1).

The length of the dorsal fin (longfin or shortfin) is a relatively easy external character to observe in anguillid eels (Rule 2). When the proportion of the ano-dorsal length (distance between the verticals of the origins of the dorsal and anal fins) to the total length is greater than 6%, it is classified as a longfin eel, and when the proportion is less than or equal to 6%, it is classified as a shortfin eel (Fig. 2; Watanabe et al. 2004). Body color pattern, i.e., mottled or plane, is also a distinguishable character at the immature yellow eel

Fig. 1 Ege's four groups of morphologically divided anguillid eels and the geographic distribution of each species in each group (Ege 1939), including the geographic distribution of the newly discovered *Anguilla luzonensis* (Watanabe et al. 2009a)

stage, but cannot be used at the juvenile as glass eel stage, is unclear at the pigmented elver stage, and is

even more difficult to distinguish in matured silver eels wherein patterns become vague and appear to be 'plane'

Fig. 2 Morphological characteristics of Ege's four groups of anguillid eels. (modified from Watanabe 2003)

even in species with mottled skin. Therefore, this character, which can vary among developmental stages, was not used as a rule for common names in the present study. The width of the maxillary band is also difficult to observe because of its position inside the mouth and is thus inconvenient for market use.

If the scientific name can be easily recalled from the common name, the similarity would increase simplicity and avoid confusion because scientific names are strictly defined and relatively more stable than common names (Rule 3). We considered that longstanding and widely used common names should also be valued (Rule 4). Moreover, shorter names are easier to remember (Rule 5). We applied these rules to the currently known 19 anguillid eel species and subspecies to define their common names.

Results and discussion

Based on the application of the five rules, we proposed 22 common names for the 19 species and subspecies of anguillid eels (Table 1). These names can be used to distinguish all anguillid species in the world, including 16 species and six subspecies. Specifically, 21 species and subspecies were named based on Rule (1) (locality name), 6 by Rule (2) (longfin or shortfin), 13 by Rule (3) (scientific name), and 3 by Rule (4) (longstanding common name).

We proposed 22 different common names for all 19 taxonomically classified species and subspecies of anguillid eels, including the three species that each have two subspecies (*A. bengalensis*, *A. bicolor*, *A. australis*). It is important to simultaneously give common names to

all species and subspecies, because they are all presently taxonomically authorized and thus both require common names. It is also important to use fixed rules when allocating common names to species, to give users a systematic understanding and ensure that they are easy to remember.

The geographic distribution of species was important in Ege's taxonomic classification of anguillid eels. All proposed common names, except one (Bicolor eel) have locality information in their names. This information reminds users of the geographic distribution of the species and subspecies and thus makes the common names easier to remember. However, the geographic distributions of *A. interioris* and *A. luzonensis* are not yet fully defined. Especially, *A. luzonensis* is a newly discovered cryptic species (Watanabe et al. 2009a) and its distribution is reported only in the Philippines and Taiwan (Teng et al. 2009; Watanabe et al. 2009a; Kuroki et al. 2012; Aoyama et al. 2015; Shinoda et al. 2015; Shirotori et al. 2016). Further investigations are needed to define the exact geographic distribution limits of these species.

Taxonomic confusion of scientific names (Watanabe et al. 2014a) may cause issues regarding the common names of anguillid species. Three species in the genus *Anguilla* (*A. bengalensis*, *A. bicolor*, and *A. australis*) each have two subspecies, which has caused taxonomic discussion (Dijkstra and Jellyman 1999; Watanabe et al. 2005, 2006, 2008a, 2014b; Minegishi et al. 2012). Issues regarding subspecies can be resolved in the future by avoiding classification into subspecies or by elevating the rank of subspecies to species. For future taxonomic reorganization, and to reduce confusion from taxonomic changes, we allocated these three

Table 1 Common names used for anguillid eels in the world

Eel's Group	Scientific Name	IUCN ^{*1}	FishBase ^{*2}	Wikipedia ^{*3}	Australian Fish Names Database ^{*4}	Kuroki et al. 2014b ^{*5}	This Study
1	<i>Anguilla celebesensis</i> Kaup, 1856	Celebes longfin eel	Celebes longfin eel	Celebes longfin eel	<i>nm</i>	Celebes longfin eel	Celebes eel
1	<i>Anguilla interioris</i> Whitley, 1938	Highlands long-finned eel	Highlands long-finned eel	Highlands long-finned eel	<i>nm</i>	New Guinea eel	New Guinea eel
1	<i>Anguilla megastoma</i> Kaup, 1856	Pacific long-finned eel	Polynesian long-finned eel	Polynesian long-finned eel	<i>nm</i>	Polynesian longfin eel	Polynesian longfin eel
1	<i>Anguilla izonensis</i> Watanabe, Aoyama & Tsukamoto, 2009	Philippine mottled eel	<i>nm</i>	Philippine mottled eel	<i>nm</i>	Luzon eel	Luzon eel
2	<i>Anguilla bengalensis</i> (Gray, 1831)	Indian mottled eel	Indian mottled eel	Mottled eel	<i>nm</i>	<i>nm</i>	Bengal eel
2	<i>Anguilla bengalensis bengalensis</i> (Gray, 1831)	<i>nm</i>	Indian mottled eel	Indian mottled eel	<i>nm</i>	Indian mottled eel	Indian Bengal eel
2	<i>Anguilla bengalensis labiata</i> (Peters, 1852)	<i>nm</i>	African mottled eel	African mottled eel	<i>nm</i>	African mottled eel	African Bengal eel
2	<i>Anguilla marmorata</i> Quoy & Gaimard, 1824	Marbled eel	Giant mottled eel	Giant mottled eel	<i>nm</i>	Giant mottled eel	Indo-Pacific eel
2	<i>Anguilla reinhardtii</i> Steindachner, 1867	<i>nm</i>	Speckled longfin eel	Speckled longfin eel	Longfin eel	Australian longfin eel	Australian longfin eel
3	<i>Anguilla borneensis</i> Popia, 1924	Indonesian longfinned eel	<i>nm</i>	Borneo eel	<i>nm</i>	Borneo eel	Borneo eel
3	<i>Anguilla japonica</i> Temminck & Schlegel, 1846	Japanese eel	Japanese eel	Japanese eel	<i>nm</i>	Japanese eel	Japanese eel
3	<i>Anguilla rostrata</i> (Lesueur, 1817)	American eel	American eel	American eel	<i>nm</i>	American eel	American eel
3	<i>Anguilla anguilla</i> (Linnaeus, 1758)	European eel	European eel	European eel	<i>nm</i>	European eel	European eel
3	<i>Anguilla dieffenbachii</i> Gray, 1842	<i>nm</i>	New Zealand longfin eel	New Zealand longfin eel	<i>nm</i>	New Zealand longfin eel	New Zealand longfin eel
3	<i>Anguilla mossambica</i> (Peters, 1852)	African longfin eel	African longfin eel	African longfin eel	<i>nm</i>	African longfin eel	Mozambique eel
4	<i>Anguilla bicolor</i> McClelland, 1844	Shortfin eel	Indonesian shortfin eel	<i>nm</i>	Indonesian shortfin eel	<i>nm</i>	Bicolor eel
4	<i>Anguilla bicolor bicolor</i> McClelland, 1844	<i>nm</i>	Indonesian shortfin eel	Indonesian shortfin eel	<i>nm</i>	Indian shortfin eel	Indian bicolor eel
4	<i>Anguilla bicolor pacifica</i> Schmidt, 1928	<i>nm</i>	Indonesian shortfin eel	Indian shortfin eel	<i>nm</i>	Pacific shortfin eel	Pacific bicolor eel
4	<i>Anguilla obscura</i> Günther, 1872	Pacific shortfin eel	Pacific shortfinned eel	Pacific shortfinned eel	Pacific shortfin eel	Polynesian shortfin eel	Polynesian shortfin eel
4	<i>Anguilla australis</i> Richardson, 1841	<i>nm</i>	Short-finned eel	Short-finned eel	Southern shortfin eel	<i>nm</i>	Australian eel
4	<i>Anguilla australis australis</i> Richardson, 1841	<i>nm</i>	Short-finned eel	Short-finned eel	<i>nm</i>	Australian shortfin eel	Australian shortfin eel
4	<i>Anguilla australis schmidii</i> Phillips, 1925	<i>nm</i>	Short-finned eel	Short-finned eel	<i>nm</i>	New Zealand shortfin eel	New Zealand shortfin eel

nm: no name has been defined^{*1} <http://www.iucnredlist.org>^{*2} <http://fishbase.org>^{*3} <https://en.wikipedia.org/wiki/Anguillidae>^{*4} <http://www.fishnames.com.au>^{*5} Canadian Journal of Zoology, 92(9), 749–770

species, as well as their six subspecies, common names.

There are problems when allocating common names to species, e.g., regarding the populations and geographic distributions of the species. For example, we name *A. marmorata* as the “Indo-Pacific eel” considering their wide geographic distribution from the western Indian Ocean to the eastern Pacific. This species has the widest geographic distribution of all anguillid species in the world, with at least four populations (Ishikawa et al. 2004; Minegishi et al. 2008; Watanabe et al. 2008b, 2009b; Gagnaire et al. 2011), i.e., in the North Pacific, South Pacific, in the waters surrounding Guam, and in the Indian Ocean. If these populations are recognized as separate species, additional common names will be needed to distinguish them. In addition, the possibility of segregating other species, such as *A. celebesensis*, *A. bengalensis*, and even the well-studied *A. anguilla* and *A. japonica*, into different populations have been discussed. The progression of science and advancement of classification techniques can change the taxonomic status of a species and thus the common names will also need alteration.

Hybridization may pose another problem in naming. The occurrence of eel hybrids was first reported in the Atlantic eels, *A. anguilla* and *A. rostrata* in Iceland (Avise et al. 1990; Avise 2003; Albert et al. 2006). Recently, the existence of hybrids has been discussed in tropical eels (Schabetsberger et al. 2015; Barth et al. 2020). The reproductive isolation mechanism that closely relates to the occurrence of natural hybrids is not well understood in anguillid eels because their spawning areas are located far offshore and thus are not easy to investigate. The spawning areas of the two Atlantic eel species are considered to overlap in the Sargasso Sea (McCleave et al. 1987), and *A. marmorata* and *A. japonica* also breed sympatrically in areas west of the Mariana Islands (Chow et al. 2009; Kuroki et al. 2009). These cases could lead to hybridization and raise other taxonomic problems.

The location of the spawning area in the ocean is important to consider with regards to the geographic distribution of catadromous anguillid eels. Ocean current systems connect the offshore breeding locations and the continental growth habitats, and as a result, the geographic distribution of species can be passively determined. Future investigations regarding the locations of the spawning areas of each anguillid species may promote a better

understanding of the geographic distributions of species, and such information may be useful for the allocation of common names.

Acknowledgements This study was partially supported by JSPS KAKENHI Grant Number 6252030, 17K19300 to K.T., 25450270, 17H03859 to K.M., and 26450268, 17K07921 to S.W., and a Grant for Scientific Research from the Faculty of Agriculture, Kindai University to S.W.

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