KOREAN JOURNAL OF ICHTHYOLOGY, Vol. 32, No. 4, 245-250, December 2020
ISSN: 1225-8598 (Print), 2288-3371 (Online). DOI: https://doi.org/10.35399/ISK.32.4.6

Received: July 9, 2020
Revised: September 7, 2020
Accepted: October 31, 2020

First Occurrence of a Pleuronectid *Atheresthes evermanni* (Pleuronectiformes) from the Middle East Sea, Korea

By Jeong-Ho Park, Yo-Soon Jang[1] and Jin-Koo Kim[2,]*

Research Planning Division, National Institute of Fisheries Science, Busan 46083, Republic of Korea
[1]East Sea Research Institute, Korea Institute of Ocean Science & Technology, Gyeongbuk 36315, Republic of Korea
[2]Department of Marine Biology, Pukyong National University, Busan 48513, Republic of Korea

ABSTRACT Two specimens (407～438 mm in standard length) of a pleuronectid *Atheresthes evermanni* were collected by a gill-net from the coastal waters off Goseong-gun, middle East Sea of Korea. These specimens are characterized by a large mouth, narrow interorbital space, invisible eye at blind side, long and slender gill rakers, emarginated caudal fin, and almost straight lateral line. This is the first record of *A. evermanni* in Korean waters; we therefore add it to the Korean fish fauna and propose new Korean name, "Hwa-sal-chi-ga-ja-mi-sog" for the genus and "Hwa-sal-chi-ga-ja-mi" for the species, respectively.

Key words: Pleuronectidae, *Atheresthes*, *Atheresthes evermanni*, first occurrence, East Sea

INTRODUCTION

The subfamily Hippoglossinae (family Pleuronectidae) composes five genera and eight species (Nelson *et al*., 2016). Among them, the genus *Atheresthes* Jordan and Gilbert, 1880 includes two large (over 84 cm) species, *A. evermanni* Jordan and Starks, 1904, and *A. stomias* (Jordan and Gilbert, 1880), which are distributed in the North Pacific and Bering Sea (Mukhametov and Orlov, 2002). Because of their commercial importance and morphological similarities, many studies on the above mentioned genus have been conducted on external morphology (Yang, 1988; Mukhametov and Orlov, 2002), molecular phylogenetics (Ranck *et al*., 1986; Suzuki *et al*., 2001), food habits (Yang and Livingston, 1986), early life (Tsukamoto *et al*., 1995; Forest *et al*., 2014), and biology and distribution (Zimmermann and Goddard, 1996). These two species briefly described by Lee *et al*. (1999), e.g., the Korean name, distribution, and morphological characteristics using distant water samples.

During a fisheries resources survey in the middle East Sea, we collected two unique and large pleuronectid specimens by gill-net of commercial vessel at 550～650 m depth from coastal waters off Goseong-gun, Korea. They were identified as *A. evermanni*, on the basis of morphological characters such as mouth size, gill raker shape, width of interorbital space, and shape of caudal fin. This species has not yet found in Korean waters. Therefore, we describe the morphological and additional genetic characteristics of *A. evermanni* in detail as the first record from Korea.

MATERIALS AND METHODS

Counts and measurements follow those of Hubbs and Lagler (2004). Each body part, except for standard length, body depth, dorsal, and anal fin base length, was measured to the nearest 0.1 mm using digital Vernier calipers. The specimens were deposited at the East Sea Fisheries Research Institute of National Institute of Fisheries Science (NIFS), Korea.

Molecular identification of these specimens was performed using the COI barcode. The PCR amplifications for the COI gene were conducted in 20 μL reaction mixtures containing 2.0 μL of a 10X reaction buffer, 0.25 mM of dNTP, 0.2 μM each primer, 1 U of Top DNA polymerase (Bioneer Co., KOREA), and 2 μL of Template DNA. Ther-

저자 직위: 박정호(해양수산연구사), 장요순(책임기술원), 김진구(교수)
*Corresponding author: Jin-Koo Kim Tel: 82-51-629-5927,
Fax: 82-51-629-5931, E-mail: taengko@hanmail.net

Fig. 1. *Atheresthes evermanni*, NFRDI-FI-IS-0008430, 438 mm SL, Goseong-gun, East Sea, Korea (A; ocular, B; blind side).

mocycling conditions were as follows: initial denaturation for 5 min at 94°C, followed by 35 cycles of denaturation for 30 s at 94°C, annealing for 30 s at 51°C, and extension for 1 min at 72°C, followed by a final extension for 10 min at 72°C. The PCR product was electrophoresed on a 1.5% agarose gel to check integrity, and then it was purified by using the Universal DNA purification Kit (TIANGEN, China). The purified fragments were sequenced using the ABI 3730xL DNA Analyzer (Applied Biosystem, Foster City, USA). DNA sequences were analyzed using BioEdit (Version.7.0.5). Identification of DNA sequences at species level was accomplished using both the BOLDSYSTEMS (http://www.boldsystems.org) selecting 'species level barcode records' database and the BLAST on the NCBI (http://www.blast.ncbi.nlm.nih.gov/Blast.cgi). The evolutionary history was inferred using the Neighbor-Joining method (Saitou and Nei, 1987). Evolutionary analyses were conducted in MEGA X (Kumar *et al*., 2018). The COI sequence of *A. evermanni* used in this study was assigned the registration number from NCBI (MW036486 and MW036487).

TAXONOMIC ACCOUNTS

Genus *Atheresthes* Jordan and Gilbert, 1880

(New Korean name: Hwa-sal-chi-ga-ja-mi-sog)

Atheresthes Jordan and Gilbert, 1880: 51 (type species: *Platysomatichthys stomias*).

Description. Mouth very large, maxillary extending beyond eye; both jaw with sharp teeth; interorbital space narrow; caudal fin emarginated; lateral line almost straight (Jordan and Gilbert, 1880).

Atheresthes evermanni Jordan and Starks, 1904

(New Korean name: Hwa-sal-chi-ga-ja-mi)

(Fig. 1; Table 1)

Atheresthes evermanni Jordan and Starks, 1904: 621, pl. 5,

Table 1. Comparison of meristic and morphometric characters of *Atheresthes evermanni* (O, ocular; B, blind side)

	Present study	Jordan and Starks (1904)	Mukahametov and Orlov (2002)	Amaoka (2016)
Number of specimens	2	1	35	–
Standard length (mm)	407~438	270	283~520	–
Counts				
Dorsal fin rays	104~106	114	98~117	100~106
Anal fin rays	85	94	81~93	78~85
Pectoral fin rays (O)	14~15	–	13~16	14~15
Pectoral fin rays (B)	14 (n=1)	–	13~16	14~15
Pelvic fin rays (O)	6	–	–	–
Pelvic fin rays (B)	6	–	–	–
Total Gill rakers (upper+lower)	12~14 (2~3+10~11)	14 (3+10)	10~13 (2~3+7~11)	– (2~4+8~10)
In % of Standard length				
Body depth	38.8~39.1	33.3	28.2~33.6	33.3~38.5
Body width	8.7~9.0	–	–	–
Head length	21.8~28.5	30.3	22.8~26.8	26.3~28.6
Caudal peduncle length	11.2~11.5	–	9.1~11.4	–
Caudal peduncle depth	9.4~9.5	–	–	–
Predorsal length	9.3~9.7	–	6.7~9.4	–
Prepectoral length	28.2	–	–	–
Preanal length	28.2~37.0	–	26.7~33.3	–
Prepelvic length	27.4~28.6	–	21.2~24.8	–
Preanus length	31.1~31.4	–	–	–
Pectoral fin length (O)	9.9~13.0	14.4	11.2~14.6	–
Pectoral fin length (B)	10.1 (n=1)	9.3	7.8~12.0	–
Pelvic fin length (O)	5.9 (n=1)	–	–	–
Pelvic fin length (B)	5.7~6.0	–	–	–
Dorsal fin length	8.8~11.5	–	–	–
Dorsal fin base length	80.6~82.8	–	–	–
Anal fin length	10.1~11.1	–	–	–
Anal fin base length	59.6~60.2	–	–	–
In % of Head length				
Snout length	31.6~32.2	25.0	21.9~27.5	22.2~31.3
Eye diameter	23.7~24.7	21.1	13.0~17.1	–
Postorbital length	76.1~79.4	–	52.8~59.2	–
Upper jaw length (O)	67.2~71.1	52.6	51.2~57.3	52.6~83.3
Upper jaw length (B)	71.0~75.8	–	54.6~60.7	55.6~58.8
Interorbital width	9.3~10.6	–	4.4~8.8	5.9~8.4
Suborbital length	2.3~2.6	–	–	–

fig. 1 (type locality: Matsushima Bay, Japan); Sakamoto in Masuda *et al*., 1984: 351, pl. 314-A (Japan); Yang, 1988: 608, fig. 2B (Bering Sea, USA); Mukhametov and Orlov, 2002: 178 (Kuril Islands and Kamchatka, Russia); Evseenko, 2004: 3 (North Pacific); Nakabo and Doiuchi in Nakabo, 2013: 1678 (key, description, Japan); Lea, 2013: 244, fig. 1 (California); Amaoka, 2016: 141, fig. 4-4-1 (Japan).

Material examined. NFRDI-FI-IS-0008430, one specimen, 438 mm in standard length (SL), 38°29.50′N, 128°33.15′E, Daejin, Goseong-gun, Gangwon-do, East Sea, Korea, 600~650 m depth, 29 January 2015, F/V Munchang-ho, red snow crab gill-net, collected by B.S. Yoon; NFRDI-FI-IS-0008708, one specimen, 407 mm in SL, 38°29.00′N, 128°32.70′E, Hawjinpo, Goseong-gun, Gangwon-do, East Sea, Korea, 550~600 m depth, 26 May 2015, F/V Mun-

chang-ho, red snow crab gill-net, collected by B.S. Yoon.

Description. Meristic and morphometric characters are shown in Table 1. Body deep and compressed; snout short; mouth very large and oblique, posterior end of upper jaw exceeding far beyond eye; upper eye bigger than lower eye, the former does not interrupt the profile of head; interorbital space narrow and convex; two pairs of nostrils, anterior them at ocular side tube-type; upper jaw at blind side longer than it at ocular side; single row of long canine at anterior upper jaw and several rows of small teeth at posterior it of ocular side; medium-sized canine sparsely at upper jaw of blind side; two rows of long canine at lower jaw both sides, the exterior small; dorsal fin start at middle of the upper eye; dorsal and anal fin bases long; middle part of dorsal and anal fin rays the longest; pectoral fin located to just above anus; pelvic fin inserted anterior to pectoral fin; pectoral fin at ocular side larger than it at opposite side; posterior margin of pectoral fin at ocular and blind sited truncated and rounded, respectively; anus located between pelvic and anal fin; gill rakers long; lateral line almost straight; posterior margin of caudal fin emarginated.

Color of specimens. When fresh, body and all fins overall blackish on ocular side, with several black blotch and scaly markings; body on blind side somewhat pale blackish, with scaly. After fixation, body coloration almost similar to fresh them.

Distribution. Goseong-gun, Gangwon-do, middle East Sea, Korea at 550~650 m depth (present study), Japan at 60~900 m (Amaoka, 2016), Russia (Mukhametov and Orlov, 2002), and North Pacific (Evseenko, 2004).

Remarks. The present specimens were identified as belonging to the genus *Atheresthes*, based on the following characteristics: mouth very large, maxillary extending beyond eye; both jaw with sharp teeth; interorbital space narrow; caudal fin emarginated; lateral line almost straight (Jordan and Gilbert, 1880). And then, based on comparisons with *Atheresthes* from the Pacific Ocean, the specimens was identified *A. evermanni* Jordan and Starks, 1904 on the basis of a narrow interorbital space, invisible eye at blind side, and long slender gill rakers (Jordan and Starks, 1904; Yang, 1988; Mukahametov and Orlov, 2002).

Meristic characters of present specimens agree well with those of previous descriptions of *A. evermanni*. However, some of morphometric characters, especially cephalic parts, were different from those of both Mukahametv and Orlov (2002) and Amaoka (2016) in snout length (31.6~32.2 vs. 21.9~27.5 and 22.2~31.3), eye diameter (23.7~24.7 vs. 13.0~17.1), postorbital length (76.1~79.4 vs. 52.8~59.2), and upper jaw length (blind) (71.0~75.8 vs. 54.6~60.7 and 55.6~58.8). Therefore, in order to clarify the exact species and difference in some above mentioned characters, additional molecular genetic studies were conducted. We analyzed the cytochrome c oxidase subunit I (COI) barcode region. As a result, COI barcode sequences of our specimens corresponded to them of *Atheresthes evermanni*. These COI barcode sequences showed 97.95% similarity with them of *Atheresthes stomias* (Fig. 2). Therefore, this is considered a geographic variation or allometric growth in the same species. However, it is necessary to follow-up study more specimen of the species from various localities in order to clarify geographic variation.

This species is readily distinguished from congener *A. stomias* (Jordan and Gilbert, 1880), by the eye on blind side (visible in the former vs. invisible in the latter) and number of gill rakers on ocular side (10~13 in the former vs. 14~18 in the latter). In addition, this species is easily distinguished from *Hippoglossoides dubius* in Korean waters by the shape of caudal fin (emarginated vs. double truncated) and mouth size (far beyond the eye vs. just beyond it).

This species' Korean name and brief description were previously reported by Lee *et al.* (1999), using Pacific Ocean samples instead of Korean's them. This species has

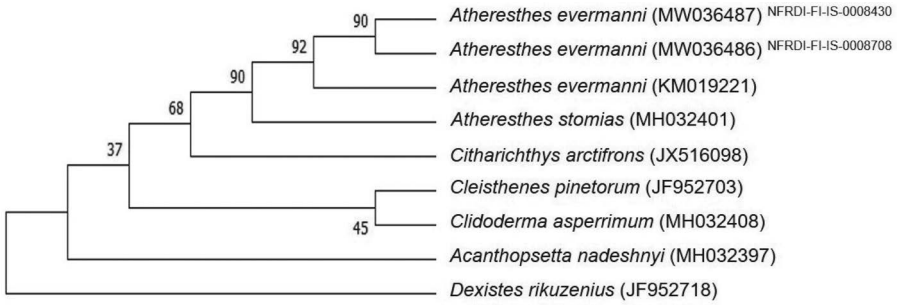

Fig. 2. Neighbor-Joining (NJ) tree based on the COI barcode sequences of two specimens, ingroups (*Atheresthes evermanni*, *A. stomias*) and outgroups.

not yet found in Korean waters. Therefore, we describe morphological characters of *A. evermanni* in order to register on the Korean fish fauna. We follow 'Hwa-sal-chi-ga-ja-mi' previously provided by Lee *et al.* (1999) for the Korean name of *A. evermanni*.

ACKNOWLEDGEMENTS

We would like to deeply thank B.S. Yoon for help with collecting samples. This work was supported by a grant from the National Institute of Fisheries Science (R2020 026).

REFERENCES

Amaoka, K. 2016. Flatfishes of Japan (Citharidae, Paralicthyidae, Bothidae, Pleuronectidae, Poecilopsettidae, Samaridae). Tokai Univ. Press, Kanagawa, Japan, 229pp.

Evseenko, S.A. 2004. Family Pleuronectidae Cuvier 1816-righteye flounders. Calif. Acad. Sci. Annotated Checklists of Fishes, 37: 1-37.

Forest, L.D., J.T. Duffy-Anderson, R.A. Heintz, A.C. Matarese, E.C. Siddon, T.I. Smart and I.B. Spies. 2014. Taxonomy of the early life stages of arrowtooth flounder (*Atheresthes stomias*) and Kamchatka flounder (*A. evermanni*) in the eastern Bering Sea, with notes on distribution and condition. Deep-Sea Res. II, 109: 181-189. https://doi.org/10.1016/j.dsr2.2014.05.005.

Hubbs, C.L. and K.F. Lagler. 2004. Fishes of the Great Lakes Region, revised ed. Michigan Univ. Press, Ann Arbor, U.S.A., 332pp.

Jordan, D.S. and C.H. Gilbert. 1880. Description of a new flounder (*Pleuronichthys verticalis*) from the coast of California, with notes on other species. Proc. U.S. Natl. Mus., 3: 49-51.

Jordan, D.S. and E.C. Starks. 1904. List of fishes dredged by the steamer Albatross off the coast of Japan in the summer of 1900, with descriptions of new species and a review of the Japanese Macrouridae. Bull. U.S. Fish Comm., 22: 577-630, pls. 1-8.

Kumar, S., G. Stecher, M. Li., C. Knyaz and K. Tamura. 2018. MEGA X: Molecular Evolutionary Genetics Analysis across computing platforms. Mol. Biol. Evol., 35: 1547-1549. https://doi.org/10.1093/molbev/msy096.

Lea, R.N. 2013. Record of the Kamchatka flounder, *Atheresthes evermanni*, in California waters. Northwest Nat., 94: 244-246.

Lee, J.U., Y.U. Kim, Y.C. Park, D.Y. Moon, J.B. Kim and J.K. Kim. 1999. Fishes of the Pacific Ocean, 1st ed. Hanguel-graphics, Busan, Korea, 512pp.

Mukhanmetov, I.N. and A.M. Orlov. 2002. On the morphology of arrowhead flounders of the genus *Atheresthes* in the Pacific waters of the northern Kuril Islands and southeastern Kamchatka. Rus. J. Mar. Biol., 28: 178-185.

Nakabo, T. and R. Doiuchi. 2013. Family Pleuronectidae. In: Nakabo, T. (ed.), Fishes of Japan with pictorial keys to the species, 3rd ed. Tokai Univ. Press, Kanagawa, Japan, pp. 1675-1683.

Nelson, J.S., T.C. Grande and M.V.H. Wilson. 2016. Fishes of the world, 5th ed. John Wiley & Sons Inc., New Jersey, U.S.A., 707pp.

Ranck, C.L., F.M. Utter, G.B. Milner and G.B. Smith. 1986. Genetic confirmation of specific distinction of arrowtooth, *Atheresthes stomias*, and Kamchatka flounder, *A. evermanni*. Fish. Bull., 84: 222-226.

Saitou, N. and M. Nei. 1987. The neighbor-joining method: A new method for reconstructing phylogenetic trees. Mol. Biol. Evol., 4: 406-425. https://doi.org/10.1093/oxfordjournals.molbev.a040454.

Sakamoto, K. 1984. Family Pleuronectidae. In: Masuda, H., K. Amaoka, C. Araga, T. Uyeno and T. Yoshino (eds.), The fishes of the Japanese archipelago. Tokai Univ. Press, Tokyo, Japan, pp. 351-355.

Suzuki, N., M. Nishida and K. Amaoka. 2001. The phylogenetic position of the genus *Atheresthes* (Pleuronectidae) and its classification: a molecular phylogenetic approach using mitochondrial sequence data. Bull. Fish. Sci. Hokkaido Univ., 52: 39-46.

Tsukamoto, Y., Y. Ueno, T. Minami and M. Okiyama. 1995. Transforming specimens of two righteye flounders, *Atheresthes evermanni* and *Reinhardtius hippoglossoides*. Jap. J. Ichthyol., 41: 469-473.

Yang, M.S. 1988. Morphological differences between two congeneric species of pleuronectid flatfishes: arrowtooth flounder, *Atheresthes stomias*, and Kamchatka flounder, *A. evermanni*. Fish. Bull., 86: 608-611.

Yang, M.S. and P.A. Livingston. 1986. Food habits and diet overlap of two congeneric species, *Atheresthes stomias* and *Atheresthes evermanni*, in the eastern Bering Sea. Fish. Bull., 82: 615-623.

Zimmermann, M. and P. Goddard. 1996. Biology and distribution of arrowtooth, *Atheresthes stomias* and Kamchatka, *Atheresthes evermanni*, flounders in Alaskan waters. Fish. Bull., 94: 358-370.

한국 동해 중부 해역에서 채집된 가자미과(Pleuronectidae) 어류 첫기록종, *Atheresthes evermanni*

박정호 · 장요순[1] · 김진구[2]

국립수산과학원 연구기획과, [1]한국해양과학기술원 동해연구소, [2]국립부경대학교 자원생물학과

요 약 : 가자미목 가자미과에 속하는 *Atheresthes evermanni* 2개체(표준체장 407~438 mm)가 동해 중부 고성군 연안에서 자망으로 채집되었다. 본 개체는 입이 크고 양안간격이 좁으며, 무안측에서 눈이 보이지 않고 새파는 가늘고 길며, 꼬리지느러미는 만입형이고 측선은 거의 직선인 특징을 가지고 있다. 우리나라 해역에서 *A. evermanni*는 처음 기록되고, 본 종을 우리나라 어류상에 포함시키며 새로운 속명과 국명으로 각각 '화살치가자미속' 및 '화살치가자미'를 제안한다.

찾아보기 낱말 : 가자미과, 화살치가자미속, 화살치가자미, 한국 첫기록종, 동해