First record of a rare pelagic octopod, *Ocythoe tuberculata* (Cephalopoda: Ocythoidae), in Korea

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**ABSTRACT**

The family Ocythoidae is found throughout the temperate and subtropical waters of the world's ocean and contains a single species, *Ocythoe tuberculata*. Recently, a single female specimen of the rare pelagic species *O. tuberculata* was collected off Uljin in the East Sea/Sea of Japan of Korea by squid jigging for the first time. The appearance of this species could be considered as evidence of the changes in species distribution of sea surface. However, further studies are required to investigate whether this phenomenon is temporary or continuous.

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**Introduction**

The family Ocythoidae is a monotypic taxon, and *Ocythoe tuberculata* is the representative species of the family (Packard & Wurtz 1994). This species shows sexually dimorphism in size. The female is large, up to 350 mm in mantle length (ML), with cross points on the ventral side, whereas the male is smaller, not exceeding 30 mm in ML, with a developed hectocotylus in the sac (Roper & Sweeney 1975; Jereb et al. 2016). This species occurs from the sea surface to depths of about 200 m in subtropical and temperate waters. In North Pacific, large females with true swimbladder commonly caught in drift net in the upper 10 m of the water at night, which underpin the pelagic behavior (Packard & Wurtz 1994; Nesis 2003; Tutman et al. 2008).

This species is known to be a cosmopolitan, especially in the northern hemisphere (Roper & Sweeney 1975). Although this species is known to be distributed in the North Pacific (Jereb et al. 2016), this is the first record of the rare octopod in Korea. In this study, we describe the morphological characteristics of the species and suggest a Korean name for it.

**Materials and Methods**

**Sampling and Preservation**

A single specimen of *Ocythoe tuberculata* was captured off Uljin, in Korea, by squid jigging (Fig. 1). The specimen was stored in a freezer and afterwards in 10% formalin.

**Results and Discussion**

**Taxonomic system**

Order Octopoda Leach, 1817
Suborder Incirrata Grimpe, 1916

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Family Ocythoidae Gray, 1849
Genus Ocythoe Rafinesque, 1814
Ocythoe tuberculata Rafinesque, 1814
(Korean name: Geu-mul-mu-nui-mun-eo)
Ocythoe tuberculata Rafinesque, 1814: 29 (type locality: Mediterranean Sea)

Materials examined
Ocythoe tuberculata: ESFRI-Octo 60, female, 180 mm ML, Uljin-gun, Gyeongsangbuk-do, Korea (37°-10′ N, 130°-05′ E), 0–100 m depth, caught by squid jigging, January 3, 2017.

Description
Female. All measurements are listed in Table 1. Body is muscular. Dorsal side of mantle is smooth without warts. There is a reticular sculpture of criss-crossed skin ridges with tubercles at cross points on the ventral side of the mantle. A pair of cephalic water pores is present. Arms are long, dorsal and ventral arms are longer than lateral arms (dorsal arms are broken at the present specimen). First arms are thickest. Suckers are biserial, and suckers of the dorsal arms are larger than those of other arms. There are 8 suckers around the mouth. Web and arm fringes absent. Funnel is very long, accounting for 54% of mantle length. Locking apparatus of funnel is well developed and strongly connected to the mantle. Color is blue and violet on dorsal side and

Figure 1. Sampling location (black circle) of Ocythoe tuberculata in this study.

Figure 2. Female specimen of Ocythoe tuberculata in this study (ESFRI-Octo60, 180 mm ML). A: Dorsal side. B: ventral side. Abbreviation: CWP, cephalic water pore; DM, dorsal mantle; Ey, eye; Fu, funnel; VM, ventral mantle. Scale bar indicate 1cm
milky and red on the ventral side of the mantle. The gill is very large. Eggs are elliptical, yellowish in color, and opaque. Egg size in ovary is very small, and major axis of egg is 0.66–3.00 mm.

**Distribution**
Known from the Mediterranean Sea (Rafinesque, 1814; Tutman et al. 2008), Aegean Sea (Salman & Akalin 2012), North-east Atlantic (Caballero-Alfonso et al. 2009), eastern South Atlantic off South Africa (Voss 1967), eastern Indian Ocean off Australia (Roper & Sweeney 1976), eastern South Pacific Ocean (Cardoso 1991), North Pacific Ocean (Jereb et al. 2016), Japan (Berry 1912), and the East Sea/Sea of Japan of Korea (Jereb et al. 2016; present study).

**Remarks**
In this study, a single octopod collected in the East Sea/Sea of Japan of Korea was identified as a female of *Ocythoe tuberculata* by its muscular body tissue, absence of web between all arms, well-developed funnel locking apparatus, and the presence of tubercles on the ventral side of the mantle. In the original description by Rafinesque (1814), this species was characterized by the smooth dorsal side and the reticular sculptured ventral side of the mantle in the female, elongated arms, biserial suckers, and eight suckers around the mouth. The description of the present specimen is consistent with that of Rafinesque (1814). A molecular analysis supported our morphological results. The mtDNA *COI* sequence of the specimen was identical to *O. tuberculata* deposited in GenBank.

The occurrence of *O. tuberculata* is often explained related to sea currents and sea warming. In the Mediterranean Sea (type locality), this species is probably transported from the open waters of the Mediterranean Sea to the Aegean Sea by strong currents toward the south-east (Corsini & Lefkaditou 1994). A similar distribution trend associated with the sea currents was proposed for *O. tuberculata* in the Adriatic Sea (Tutman et al. 2008). This species enters the Adriatic, probably from the Mediterranean Sea, following a north-westward current toward the northern Adriatic Sea. Tutman et al. (2008)
suggested that sea warming affects the occurrence of *Ocythoe tuberculata* in the southern Adriatic Sea. In this area, there was considerable year-to-year variability in SST between 1950 and 2005, with a clear increase in SST in this period (+1.2 °C). As reported by Lefkaditou and Kallianiotis (2006), most females of this species collect near the coast at depths of a few meters during spring and early summer. Salman and Akalin (2012) reported that the limits of this species’ range are closely related to sea surface temperature (SST). Therefore, appearance of this species is considered as a result of mixing effect of sea currents and increased SST. On the other hand, Caballero-Alfonso et al. (2009) suggested that the appearance of this species is related with an anomalous sea warming and high abundance of jellyfish in the North-east Atlantic and populations could be displaced temporarily in higher latitudes when anomalous water warming occurs.

![Figure 4. An anatomical figure of the ventral mantel of *Ocythoe tuberculata*. Abbreviations: Fu, funnel; Gi, gill lamella; La, locking apparatus; Ov, ovary; Vm, ventral mantle. Scale bar indicate 1cm.](image)

| Specimens | Present study | Roper and Sweeney(1975) | Cardoso(1991) | Tutman et al. (2008) |
|-----------|--------------|------------------------|--------------|----------------------|
|           | ESFRI-Octo60 | 1                      | 2            | 1                    |
| Sex       | Female       | Female                 | Female       | Female               |
| TL (mm)   | 180          | 310                    | 182.2        | 330                  |
| DML (mm)  | 160.8        | -                      | 66.8         | 105                  |
| HW (mm)   | 87.6         | -                      | 34.1         | 63.8                 |
| HL (mm)   | 40.1         | -                      | 19.6         | 41.4                 |
| BW (g)    | 1234.9       | -                      | -            | -                    |
| AL L I (mm)| 226(broken)| broken                | 118          | 231.4                |
| AL L II (mm)| 260        | 360                    | 71.4         | 171.4                |
| AL L III (mm)| 258        | 335                    | 69.3         | 150.8                |
| AL L IV (mm)| 312        | 410                    | 108.7        | 199.2                |
| AL R I (mm)| 226(broken)| 500                    | 113.7        | 230                  |
| AL R II (mm)| 64(broken)| broken                | 71           | 181.6                |
| AL R III (mm)| 264        | 340                    | 61.9         | 150                  |
| AL R IV (mm)| 310        | 400                    | 98.4         | 215                  |

TL, total length; DML, dorsal mantle length; MW, mantle width; HW, head width; HL, head length; AL, arm length; R, right side; L, left side

Table 1. Comparison of actual external measurements of *Ocythoe tuberculata* with those in previous studies.
Strong currents, the Tsushima Warm Current, move toward the north-east in the East Sea/Sea of Japan from the East China Sea around Korea. (Isobe 1999). In addition, annual average of SST in the East Sea/Sea of Japan of Korea was clearly increased during 41 years from 1969 to 2008 and detected increase of +1.39 °C (Seong et al. 2010). In this way, the occurrence of *O. tuberculata* in the East Sea/Sea of Japan could be considered as evidence of the changes in species distribution of sea surface. However, a more detailed observation is required to investigate whether this phenomenon is temporary or permanent.

**Disclosure statement**

The authors declare that they have no potential conflicts of interest.

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**References**

Berry SS. 2016. A catalogue of Japanese Cephalopoda. Proc Acad Nat Sci Philadelphia. 64:380–444.

Caballero-Alfonso A, Ganzedo-Lopez U, Diez-Diez G, Castro JJ. 2009. New record of *Ocythoe tuberculata* (Cephalopoda: Ocythoidae) in the North-east Atlantic related to sea warming. Mar Biodivers Rec. no. 6153.

Cardoso F. 1991. First record of net collected *Ocythoe tuberculata* (Cephalopoda: Octopoda) from Peruvian waters. Am Malacol Bull. 8:143–144.

Corsini M, Lefkaditou E. 1994. Occurrence of *Ocythoe tuberculata* (Cephalopoda: Ocythoidae) in Greek waters. Boll Malacol. 30:304–310.

Folmer O, Black M, Hoeh W, Lutz R, Vrijenhoek R. 1994. DNA primers for amplification of mitochondrial cytochrome c oxidase subunit I from diverse metazoan invertebrates. Mol Mar Biol Biotech. 3:294–299.

Gray JE. 1849. Catalogue of the Mollusca in the Collection of the British Museum. Vol 1. order of the Trustees.

Grimpe G. 1925. Zur kenntnis der Cephalopodenfauna der Nordsee. Wissenschaftliche Meeresunksuchungen Abteilung Helgoland. 16:1–124.

Hall TA. 1999. BioEdit: a user-friendly biological sequence alignment editor and analysis program for Windows 95/98/NT. Nucl. Acids. Symp. Ser. 41:95–98.

Isobe A. 1999. On the origin of the Tsushima Warm Current and its seasonality. Cont Shelf Res. 19:117–133.

Jereb P, Roper CFE, Norman MD, Finn JK. 2016. Cephalopods of the world: an annotated and illustrated catalogue of cephalopod species known to date, volume 3. Octopods and vampire squids. FAO Species Catalogue for Fishery Purposes No. 3, Vol. 3. Food and Agriculture Organization for the United Nations, Rome.

Kim JB, Yang JH, Lee SJ. 2016. First record of *Octopus longispadicus* (Cephalopoda: Octopodidae) from Korea. Koran J. Malacol. 32:221–229.

Leach WE. 1817. Synopsis of the orders, families and genera of the class Cephalopoda. The Zoological Miscellany; being descriptions of new or interesting animals. 3:137–141.

Lefkaditou E, Kallianiotis A. 2006. New findings of female *Ocythoe tuberculata* in the northeastern Mediterranean. CIA CAbstr Book, 84.

Lindgren AR, Giribet G, Nishiguchi MK. 2004. A combined approach to the phylogeny of cephalopoda (Mollusca). Cladistics. 20:454–486.

Nesis KN. 2003. Distribution of recent Cephalopoda and implications for Plio-Pleistocene events. Berl Palaeobiol Abh. 3:199–224.

Packard A, Würtz M. 1994. An octopus, *Ocythoe*, with a swim bladder and triple jets. Phil Trans Roy Soc Lond B. 344:261–275.

Rafinesque CS. 1814. Précis des découvertes et travaux somalogiques de mr CS Rafinesque-Schmaltz entre 1800 et 1814 ou Choix raisonné de ses principales découvertes en zoologie et en botanique. Royale typographie militaire, aux dépens de l’auteur. 29

Roper CFE, Sweeney MJ. 1975. The pelagic octopod *Ocythoe tuberculata* Rafinesque,1814. Bull Am Malacol Un. 21–28.

Salman A, Akalin M. 2012. A rare pelagic cephalopod *Ocythoe tuberculata* (Octopoda: Argonautoidea): The record fecundity for Octopoda and new data on morphetry. Turk J Fish Aquat Sci. 12:339–344.

Seong KT, Hwang JD, Han IS, Go WJ, Suh YS, Lee JY. 2010. Characteristic for long-term trends of temperature in the Korean waters. J Korean Soc Mar Environ Saf. 16:353–360.

Tutman P, Sifner SK, Dulic J, Pallaoro A, Gavrilovic A, Dujakovic JJ, Glamuzina B. 2008. A note on the distribution and biology of *Ocythoe tuberculata* (Cephalopoda: Ocythoidae) in the Adriatic Sea. Vie Milieu. 58:215–221.

Voss GL. 1967. Some bathypelagic cephalopods from South African waters. Ann S Afr Mus. 50:61–88.