〈Original article〉

# Chemical composition of eggs from Deania hystricosa

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## Summary

The chemical composition of eggs from deep-sea sharks has not been thoroughly examined. We analyzed the chemical composition of eggs from *Deania hystricosa* (*D. hystricosa*), a deep-sea shark that lives 470–1900 m below sea level, for the first time. The chemical composition of protein, fat, and sodium of eggs from *D. hystricosa* (mean ± SEM, n=3) was 42.5±1.0, 55.1±4.1 and 0.086±0.002% of total organic matter, respectively. The egg did not include carbohydrate. The concentrations of docosahexanoic acid and eicosapentaenoic acid in total fat of eggs from *D. hystricosa* were 10.3% and 4.23%, respectively, which is much higher than these of chicken eggs. These results are consistent with other deep-sea sharks published previously.

**Key words:** *Deania hystricosa*, eggs, deep-sea sharks

## 1. Introduction

The deep sea represents one of the most extreme environments on Earth, imbued with high pressure, low temperatures, darkness and limited access to food[1]. Changes in membrane lipid composition responsible for adaptation to low temperatures would permit organisms to adapt to high-pressure environments. The concentration of unsaturated fatty acids in membranes often adapts to the temperature of the environment.

In viviparous elasmobranchs (sharks, skates, and rays), the embryo grows to a large size by consuming yolk throughout the gestation. Chemical contents of egg thus provide basic information for

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understanding the nutrient transfer from mother to embryo during elasmobranch reproduction. A recent study has demonstrated that in addition to nutrients from the yolk, there is additional nutrient input from the mother. For example, many stingray embryos are known to consume lipid-rich "milk" secreted by the uterine wall of the mother, increasing their weight 1680–4900 times that of the original egg or more[2]. Even for such species, yolk is still the most important nutrient source for the embryo in the earliest-stages of gestation.

In the present study, the chemical composition of *Deania hystricosa* eggs is examined for the first time. This species is known to inhabit waters 470- to 1300-m deep in the east Atlantic and northwest Pacific[3]. The reproductive mode of this species is still poorly understood; however, "mucoid histotrophy" is hypothesized to be part of the reproductive mode of the related species *D. calcea*, in which the embryonic development is mainly based on on yolk, but there is certain additional maternal nutrition[4]. So far, considering the highly limited data, the present study is a simple but noteworthy description of the chemical composition of *D. hystricosa* eggs.

## 2. Materials and methods

### 2.1 Specimens

Three deep-sea sharks specimens of *D. hystricosa* were collected from Suruga Bay, off Shizuoka prefecture, Japan. Approximately 100 g of eggs were extracted from each shark and frozen at –80°C. Just before the chemical analysis, the samples were defrosted, and 60 g of homogenized egg per shark was used for analysis.

### 2.2 Chemical characterization of eggs from D. hystricosa

The metabolizable energy in eggs from *D. hystricosa* was calculated based on Atwater factors[5]. The protein concentration was determined using the Kjeldahl method[6]. The concentration of fatty substances was determined using the acid hydrolysis method[7]. The sodium concentration was determined using the microwave digestion method[8]. The concentration of docosahexanoic acid (DHA) and eicosapentaenoic acid (EPA) were determined using gas chromatography[9]. Finally, the carbohydrate concentration was determined by subtracting the measured protein and fatty acid concentration and water from the total weight[10].

## 3. Results and discussion

In present study, the relative protein, fat and sodium contents of *D. hystricosa* were 42.5%, 55.1%, and 0.086%, respectively. Protein and fat contents of this species were within previous published range for other deep-water sharks[11] (range = 44.6 to 49.6% and 50.5 to 54.2%, in protein and fat, respectively; Table 1). Using fat and protein content values, the metabolizable energy was calculated to be 649 kcal/100 g, which is approximately four times greater than that of chicken eggs. *D. hystricosa* egg does not contain carbohydrates. This characteristic is known to be widely shared among aquatic vertebrates, and this is in contrast to the carbohydrate-rich eggs of terrestrial vertebrates[12].

Table 1. Compositon of protein, fat, and sodium of *Deania hystricosa* and other species of deep-sea sharks

| Species | Protain (%) | Fat (%) | Sodium (%) | Reference |
|---|---|---|---|---|
| *Centrophorus squamosus* | 45.8±1.8 | 54.2±9.0 | n.a. | Remme et al., 2005[11)] |
| *Centroscyllium fabricii* | 49.0±2.4 | 50.5±11.9 | n.a. | Remme et al., 2005[11)] |
| *Centroscymnus coelolepis* | 44.6±2.3 | 50.9±11.3 | n.a. | Remme et al., 2005[11)] |
| *Centroscymnus crepidater* | 45.5±2.1 | 53.7±10.4 | n.a. | Remme et al., 2005[11)] |
| *Etmopterus priceps* | 45.5±2.0 | 53.9±10.3 | n.a. | Remme et al., 2005[11)] |
| *Deania hystricosa* | 42.5±1.0 | 55.1±4.1 | 0.086±0.002 | this study |

Data are expressed as percentage of total organic contetns (total sample weight - water).
n.a.; not available

Table 2. DHA and EPA contents of eggs of *Deania hystricosa* and other species of deep-sea sharks

| Species | C22:6 n-3 (DHA) (%) | C20:5 n-3 (EPA) (%) | Reference |
|---|---|---|---|
| *Centrophorus squamosus* | 12.5 | 3.3 | Shimma and Shimma, 1968[13)] |
| *Centrophorus squamosus* | 14.5 ± 1.7 | 2.8 ± 0.3 | Remme et al., 2005[11)] |
| *Centrophorus* sp. | 19 | 4.7 | Shimma and Shimma, 1968[13)] |
| *Centroscyllium fabricii* | 13.4 ± 1.6 | 4.8 ± 0.6 | Remme et al., 2005[11)] |
| *Centroscymnus coelolepis* | 10.3 ± 1.2 | 2.1 ± 0.3 | Remme et al., 2005[11)] |
| *Centroscymnus crepidater* | 15.1 ± 1.8 | 2.6 ± 0.3 | Remme et al., 2005[11)] |
| *Centroscymnus owstoni* | 10.5 ± 1.7 | 3.4 ± 0.9 | Shimma and Shimma, 1968[13)] |
| *Centroscymnus* sp. | 9.1 | 2.7 | Shimma and Shimma, 1968[13)] |
| *Etmopterus priceps* | 12.0 ± 1.4 | 5.1 ± 0.6 | Remme et al., 2005[11)] |
| *Etmopterus unicolor* | 9.9 ± 1.8 | 3.2 ± 1.1 | Shimma and Shimma, 1968[13)] |
| *Deania calcea* | 13.9 | 3.7 | Shimma and Shimma, 1968[13)] |
| *Deania calcea* | 20.1 ± 1.5 | 4.9 ± 0.7 | Paiva et al., 2012[4)] |
| *Deania hystricosa* | 10.3± 0.6 | 4.23 ± 0.31 | This study |

Data are expressed as percentage of total fat contents.
Data of this study are presented as mean ± standard error of mean, n=3
DHA, docosahexanoic acid; EPA, eicosapentaenoic acid

DHA and EPA contents in the total fat were 10.3% and 4.23%, respectively. This value was also consistent with that reported in ten species of deep-sea sharks[4,11,13] (DHA = 9.1% to 20.1% and EPA=2.1% to 5.1%; Table 2). DHA content in deep-water sharks was much higher than in chicken eggs[14]. Such a high DHA has been considered an adaptation to the deep-sea environment. It is known that polyunsaturated fatty acids, including DHA, are important for maintaining the fluidity of cell membranes at low temperature, and fish living in cold environments tend to have higher DHA contents than those living in warmer environments[15]. High DHA content may also associated with nervous development in the embryo[4,11,15].

Comparison of the fatty acid composition, including DHA and EPA, between mother, egg, and embryo has been suggested provide information on the nutrient transfer from mother to embryo during gestation[4]. Such a comparison may clarify the poorly understood reproductive mode (presence or absence of maternal nutrient input) of *D. hystricosa*, though this is work now in progress.

## Conflicts of interest

The authors declare no conflict of interests.

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