The Size and The Shape of Sagittal Otolith of Redtail Scad, *Decapterus kurroides* Bleeker 1855 from Kema Bay, North Minahasa Regency, North Sulawesi, Indonesia

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**ABSTRACT**

This study aimed to examine the difference in the otolith size and otolith shape of redtail scad *Decapterus kurroides* between sex in North Sulawesi. The otoliths of *D. kurroides* were studied for sagitta otolith pair samples of 34 juveniles, 58 females and 75 males from Kema Bay. These pairs sagitta otolith images were interpreted using ImageJ tool to describe the otolith size (length, width, perimeter, and area), then we calculated the shape index (form factor, roundness, circularity, rectangularity, ellipticity and aspect ratio or length-width ratio). No significant difference was found in otolith length between left and right otoliths of juveniles of *D. kurroides* or called also symmetrical but significant differences or asymmetrical were found in all sample, females and males. The regressions of total length against otolith sizes (otolith length, otolith width, otolith perimeter and otolith area of *D. kurroides*) follow a power function. The growth patterns showed dominant allometric growth in total length–otolith sizes relationships of *D. kurroides* from Kema Bay.

**Keywords**: size, shape index, otolith, *Decapterus kurroides*, Kema Bay.

**ABSTRAK**

Penelitian ini bertujuan untuk mengetahui perbedaan ukuran dan bentuk otolit ikan layang anggur, *Decapterus kurroides* antar jenis kelamin di Sulawesi Utara. Otolit dari *D. kurroides* dipelajari untuk sampel pasangan sagitta otolit dari juvenil sebanyak 34 individu, betina sebanyak 58 individu dan jantan sebanyak 75 individu dari Teluk Kema. Citra pasangan otolit sagitta ini diinterpretasikan menggunakan fasilitas gambar untuk mendeskripsikan ukuran otolit (panjang, lebar, keliling, dan luas), kemudian dihitung indeks bentuk otolitnya (faktor bentuk, kebulatan, sirkularitas, persegi panjang, elips dan rasio aspek atau rasio panjang-lebar). Tidak ditemukan perbedaan yang signifikan pada ukuran dan indeks bentuk otolit antara otolit kiri dan kanan dari juvenil, *D. kurroides* atau disebut juga simetris. Sebaliknya signifikannya atau asimetris ditemukan pada semua sampel otolit betina dan jantan. Regresi panjang total terhadap ukuran otolit (panjang otolit, lebar otolith perimeter, dan luas otolit) *D. kurroides* mengikuti fungsi perpangkatan (multiplikatif). Pola pertumbuhan menunjukkan pertumbuhan alometrik dominan dalam hubungan panjang total dengan ukuran otolit *D. Kurroides* dari Teluk Kema.

**Kata kunci**: size, Bentuk Indeks, otolith, *Decapterus kurroides*, Teluk Kema.

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1. Introduction

Fish is one of the world resources contributing protein to human life, this commodity can be eaten by various levels of human life and so all religions do not forbid him to eat. Redtail scad, Decapterus kurroides as a small pelagic fish known locally as ‘malalugis anggur’, this fish is not only consumed by humans but are useful as bait fish in catching tuna and skipjack. Scad fish production in Indonesia is high and with a wide market share, including in this area. The economic value is generally in the medium price category (Sumaila et al. 2007). Redtail scad is a fish which has prominent red colour on the tail and is in one genus with other red-tailed scads, such as D. akaadsi, D. tabi and D. smithvanizi n. sp. (Kimura et al. 2013) It is called Decapterus that comes from the word deca = ten and pteron = finlet (Rumero 2002). The fish is categorized in class Actinopterygii, order Perciformes, sub-order Perciformes and family Carangidae (Masuda et al., 1975, 1984; World Registered Marine SpeciesWORMS: http://www.marinespecies.org/aphia.php?p=sourcedetails&id=234250 and fishbase (https://www.fishbase.se/search.php).

Biologically in fish found ear stones (otolith), functions as a hearing aid and regulates body balance. In its development, otolith is also used as a very useful tool for determining fish age and growth. Even Begg and Brown (2000) can also be used to identify stocks. Otolith is part of the inner ear of fish including scad fish.

The otolith study on various marine fishes in tropical regions, especially Indonesia, has not been significantly conducted. Wright et al (1990) have firstly reported it on Stolephorus heterolobus in Java Sea, then on several species of eels (Anguilla spp.) around Sulawesi waters and others (Arai et al. 2000, 2003; Sugetha et al 2001; Kuroki et al. 2005; Lee et al 2008; Chino & Arai 2010), bluefin tuna (Thunnus maccocyii) around Bali waters (Shiao et al. 2009; William et al. 2013; Farley et al. 2014), Chinese herring (Tenualosa toil) around Sumatera waters (Milton & Cheney 2001), red snapper (Lutjanus erythropterus) around Nusa Tenggara waters (Fry & Milton 2009), Bali sardinella (Sardinella lemuru) around Bali waters (Wuji et al. 2016), skipjack tuna (Katsuonus pelamis) in the southern waters of Java and the Sulawesi Sea (Wuji et al. 2017, 2018; Mogea et al. 2019), and Selar crumenophthalmus in Manado Bay (Bahri et al. 2018). Otolith study does not merely aim to get information on fish aging and fish growth but also to identify or discriminate the fish stock. According to Campana & Casselman (1993), the size and the shape of otolith are also beneficial to use as stock identity indicator for varied growth rate among fish stocks. This study aimed to characterized otolith and examine the difference in the otolith size and otolith shape of retdail scad Decapterus kurrodes between juvenile, male dan female from Kema Bay, North Sulawesi.

2. Materials And Methods

Figure 1. Research location of Kema Bay, North Sulawesi
Figure 2. Redtail scad *Decapterus kurroides*, head place of otolith, otolith image and otolith size $OL =$ length, $OW =$ width, $OP =$ perimeter and $OA =$ Area.

This study was carried out from September 2017 to September 2019. Redtail scads *D. kurroides* were obtained from fishermen’s catches in Kema Bay (Geographical 1°15' -1°22' North / 125°05'-125°15' East) (Figure 1). The fish were caught with vertical multiple hook-handline and mini purse seine. They were proportionally taken to represent the exploited fish body size. Data collected included sex and total length (TL). The redtail scad that were used as the research sample consisted of 167 individuals, measuring a total length with an average of 159 mm with total length an interval of 97 mm-203 mm. Redtail scad are then taken to the Laboratory of Fish Health and Fish Health, Environment, and Toxicology of FPIK UNSRAT. Redtail scad ascertaining their sexes by observing their gonads. The head is then separated and the otolith will then be taken out from just below the skull near the spine. Otolith is cleaned with H$_2$O$_2$ to dissolve the blood, and then washed with deionized water (WaterOne) then air dried using 70 % alcohol. The otoliths to be observed under a stereo microscope Olympus SZX7-DP21 microscope camera, the pair of left and right otoliths documented into photographic image. The image of an otolith is used by the imageJ facility to obtain the size of the otolith, in 4 parameters, length (OL), width (OW), perimeter (OP) and area/breadth (OA), here in after shall be referred to as otolith size as presented in Figure 2. The shape index calculation includes the roundness index and the aspect ratio.

There were 6 parameters of the shape indices calculated from the size of the otolith ([Wujdi et al 2016; Ladorit et al 2017]), form-factor (FF) = $(4\pi AO)/OP^2$, roundness (RO) = $(4OA)/(\pi OL^2)$, circularity (CI) = $OP^2/OA$, rectangularity (RE) = $OA/(OL*OW)$, ellipticity (EL) = $OL - OW/OL + OW$ and aspect ratio (AR) = $OL/OW$. Difference in otolith size and shape index between the left and the right ones was analyzed using pair t-test, while the difference in the otolith size and shape between sex was tested with t-test. The relationship of otolith size against the fish TL was estimated using equation $Y = a X^b$, where $Y$ is otolith size (OL and OW) and $X$ is fish total length (TL), $a$ is intercept, and $b$ is slope. Parameters $a$ and $b$ were calculated using Least Squares method after the data had been transformed to natural logarithm as $\ln Y = \ln a + b \ln X$. The linearity and the goodness of fit were analyzed using ANOVA, whereas the regression line comparison used analysis of covariance (ANCOVA) (Scherrer 1984; Draper & Smith 1998). To examine whether $b$ equals to the theoretical value of $b = 1$ (for the relationship of OL and OW), t-test was applied. If $t_{calc}$ is bigger than $t_{tab}$, the growth pattern is allometric or the otolith growth increment does not go along with the body length increment whereas if it is the opposite, the growth pattern is isometric or the otolith size increment is in line with the body.
Table 1. T-test comparison of mean pairs (left-right) of size and shape index of total pairs sample otolith redtail scad, Decapterus kurroides from Kema Bay.

| Otolith size and shape index | Total Sample (n = 167) |          |          |        |          |          |          |
|------------------------------|------------------------|----------|----------|--------|----------|----------|----------|
|                              | Left       | Right     | t_{cal}  | t_{tab}(0.05, 165) |
| Otolith Size                 |            |           |          |        |          |          |          |
| Otolith length OL (mm)       | 4.146      | 4.137     | 2.308*   | 1.967  |
| Otolith width OW (mm)        | 1.758      | 1.742     | 5.257*   | 1.967  |
| Otolith perimeter OL (mm)    | 11.232     | 11.207    | 0.912    | 1.967  |
| Otolith area OA (mm^2)       | 4.990      | 4.965     | 4.842*   | 1.967  |
| Otolith shape index          |            |           |          |        |          |          |          |
| Form Factor FF               | 0.490      | 0.489     | 0.449*ns | 1.967  |
| Roundness RS                 | 0.362      | 0.363     | -0.531*ns| 1.967  |
| Circularity CI               | 25.777     | 25.828    | 0.445*ns | 1.967  |
| Rectangularity RE            | 0.668      | 0.672     | -3.152*  | 1.967  |
| Ellipticity EL               | 0.403      | 0.405     | -2.148*  | 1.967  |
| Aspek Nisbah AR              | 2.352      | 2.365     | -2.102*  | 1.967  |

Note: *ns = not significant, * = significant

Table 2. T-test comparison of the average left-right paired samples of size and shape index of juveniles, females and males redtail scad otoliths, Decapterus kurroides

| Otolith size and shape index | Juvenile n = 34 | Female n = 58 | Male n = 75 |
|------------------------------|-----------------|---------------|-------------|
|                              | Left       | Right        | t_{cal}    | Left       | Right        | t_{cal}    | Left       | Right        | t_{cal}    |
| Otolith size                 |            |              |           |            |              |           |            |              |           |
| OL (mm)                      | 2.932      | 2.927        | 0.663*ns  | 4.554      | 4.514        | 2.431       | 4.383      | 4.376        | 0.661*ns  |
| OW (mm)                      | 1.328      | 1.321        | 1.389*ns  | 1.896      | 1.877        | 4.400       | 1.841      | 1.824        | 3.312*    |
| OP (mm)                      | 7.998      | 7.967        | 1.001*ns  | 12.294     | 12.236       | 0.980       | 11.829     | 11.832       | -0.077*ns |
| OA (mm^2)                    | 2.596      | 2.586        | 1.647*ns  | 5.774      | 5.707        | 5.105       | 5.436      | 5.414        | 1.861*ns  |
| Otolith shape index          |            |              |           |            |              |           |            |              |           |
| FF                           | 0.511      | 0.513        | 0.550*ns  | 0.482      | 0.480        | 0.232       | 0.487      | 0.485        | 0.619*ns  |
| RS                           | 0.384      | 0.384        | 0.004*ns  | 0.355      | 0.357        | 0.856       | 0.359      | 0.359        | 0.959*ns  |
| CI                           | 24.699     | 24.60        | 0.614*ns  | 26.270     | 26.270       | 0.262       | 25.917     | 24.719       | 0.693*    |
| RE                           | 0.665      | 0.668        | 0.929*ns  | 0.669      | 0.673        | 2.272       | 0.669      | 0.675        | -2.162*   |
| EL                           | 0.376      | 0.377        | 0.869*ns  | 0.412      | 0.412        | 0.267       | 0.407      | 0.411        | -2.632*   |
| AR                           | 2.207      | 2.214        | 0.815*ns  | 2.403      | 2.406        | 0.220*      | 2.379      | 2.399        | -2.632*   |

Note: *ns = Not significant, * = significant
total length 30 cm and can reach a maximum size of 45 cm. In the Masuda et al. (1975, 1984) report, it was mentioned that there were male fish capable of reaching a maximum TL of 300 mm even 400 mm. Information on the size of this mature sex fish is not yet available in fishbase but Maulita et al. (2013) reported that the male scad maturity is at 32 cm and 33 cm on female. This research was able to distinguish females and males by checking at their gonads. Females at the smallest size were 175 mm while males at the smallest size were 151 mm. Thus, were smaller than the size of the first mature gonads that have been reported.

3.2 The otolith size and shape index of redtail scad

The total number of intact otolith samples collected was 167 pairs. Range of otolith length left: right: 2.523 mm – 5.259 mm and 2.517 mm - 5.173 mm, mean of otolith length left- right: 4.146 mm and 4.137 mm are small otolith (Furlani et al., 2007). Range of otolith width left and right: 1.150 mm – 2.078 mm and 1.153 mm – 2.089 mm, otolith perimeter (OP): left and right: 6.910 mm-13.926 mm and 6.108 mm - 14.312 mm and left otolith (OA) area 2.170 mm - 6.954 mm and right 2.215 mm – 6.966 mm. The analysis of the shape index of the otolith form factor has been calculated that were the form factor (FF) left and right : 0.401 - 0.567 and 0.385-0.50 or FF < 1 which shows scad otolith is circular, roundness (RS) left the right : 0.304 - 0.420 and 0.318-0.422 or RS < 1 indicates that the otolith is not round, circularity (CS), Rectangularity (RE) left and right : 0.634 - 0.703 and 0.619 - 0.796 : and Ellipticity (EL) left and right : 0.334 - 0.45 and 0.347 - 0.46 and the aspect ratio of left AR : 2.004-2.808 and right AR 2.065 – 2.816 or AR > 1 indicates the otolith is not square (AR = 1) but is elongated. All otolith size and shape indices show no real difference between left and right side (tcal < tlab (0.05, 165)) (Table 1). Comparison of size and shape index of otolith pairs redtail scad otoliths to characterize or differentiate otolith. Table 1. Calculation of t-test for the mean comparison of all left-right paired otolith samples redtail scad turned out to be not significantly different (tcal < t0.05, n-2)) on otolith perimeter, form factor, roundness and circularity or there was difference between the left and right otolith (tcal < t0.05, n-2)) on otolith length, otolith width and otolith area, thus it could be said that left otolith and right otoliths were asymmetrical.

The comparison of otolith pairs (left and right side) is also done by doing the same grouping of juveniles (34 ind), females (58 ind) and males (75 ind) as presented in Table 2. Calculation of t-test for the average comparison of all left-right paired otolith samples redtail scad both on the size and on the shape index turned out to be not significant (t < t0.05, n-2)) on juvenils otolith pairs was symmetrical. But there was

Table 3. T-test comparison of mean male-female of the otolith size and shape index of the redtail scad Decapterus kurroides

| Otolith Size and Shape Index | Females n = 58 | Males n = 75 | tcal | t0.05, n-2 |
|-----------------------------|---------------|--------------|------|-----------|
| Size                        | Min | Max | Var | Mean | Min | Max | Var | Mean |       |       |
| Otolith Length (OL) mm      | 4.040 | 5.259 | 0.064 | 4.554 | 3.134 | 5.173 | 0.193 | 4.383 | 2.613 | 1.979 |
| Otolith Width (OW) mm       | 1.669 | 2.023 | 1.005 | 1.896 | 1.373 | 2.078 | 0.023 | 1.841 | 2.543 | 1.979 |
| Otolith Perimeter (OP) mm   | 10.906 | 13.926 | 0.620 | 12.294 | 8.798 | 13.882 | 1.430 | 11.829 | 2.564 | 1.979 |
| Otolith Area (OA) mm        | 4.555 | 6.799 | 0.187 | 5.774 | 3.051 | 6.954 | 0.761 | 5.436 | 2.710 | 1.979 |
| Shape Index                 |         |      |     |      |         |      |     |      |       |       |
| Form Factor (FF)            | 0.411 | 0.558 | 0.001 | 0.482 | 0.401 | 0.567 | 0.001 | 0.487 | -0.879 | 1.979 |
| Roundness (RS)              | 0.304 | 0.408 | 0.000 | 0.355 | 0.314 | 0.407 | 0.000 | 0.359 | 1.134 | 1.979 |
| Circularity (CS)            | 22.529 | 30.594 | 3.598 | 26.209 | 22.174 | 31.321 | 3.206 | 25.91 | 0.909 | 1.979 |
| Rectangularity RE           | 0.304 | 0.408 | 0.000 | 0.355 | 0.634 | 0.703 | 0.000 | 0.669 | 0.267 | 1.979 |
| Ellipticity EL              | 0.362 | 0.464 | 0.000 | 0.412 | 0.363 | 0.453 | 0.000 | 0.407 | 1.149 | 1.979 |
| Aspect Ratio (AR)           | 2.134 | 2.808 | 0.014 | 2.403 | 2.141 | 2.101 | 0.015 | 1.129 | 1.126 | 1.979 |
Otolith pairs of juvenile redtail scad was symmetrical. Wujdi et al. (2016) stated there was no real difference between the size of the left and right otolith or symmetrical of lemuru fish (*Sardinela lemuru*) in the Bali Strait, as well as for anchovy (*Engraulis encrasicolus*) in Black and Marmara Sea (Zengin et al. 2015). Otherwise, otolith pairs of female and male difference size or asymmetrical like otolith of plaice *Pleuronectes platessa* and turbot, *Psetta maxima* (Helling et al. 2005).

**Table 4.** Relationship of total length (TL) and Otolith size (OL = Otolith Length, OW = Otolith Width, OP = Otolith Perimeter and OA = Otolith Area) of of the redtail scad *Decapterus kurroides*

| Model          | n  | r   | R² | F ratio | nilai P | s_b | t    | t-tab | Pattern         |
|----------------|----|-----|----|---------|---------|-----|------|-------|-----------------|
| ln(OL) = 3.261 + 0.923*ln(k TL) | 167 | 0.96 | 92.305 | 1979.36 | 0.000 | 0.021 | 3.667* | 1.974 | Allometri       |
| ln(OW) = 3.22 + 0.746*ln(k TL)  | 167 | 0.96 | 92.950 | 2175.35 | 0.000 | 0.081 | 3.136* | 1.974 | Allometri       |
| ln(OP) = -2.194 + 0.909*ln(k TL) | 167 | 0.96 | 91.484 | 1772.70 | 0.000 | 0.022 | 2.252* | 1.974 | Allometri       |
| ln(OA) = 6.927 + 1.678*ln(k TL) | 167 | 0.97 | 94.951 | 3102.70 | 0.000 | 0.152 | 4.134* | 1.974 | Allometri       |

Note: *b=1 at OL, OW and OP; “b=2 at OA; s_b = standar error b; * = significant; # = no significant

Figure 3. Box and Whisker plot of comparison female and male otolith size of redtail scad *Decapterus kurroides* from Kema Bay
There was a significant difference in ratio between the left otolith and right otolith, therefore the analysis was carried out using only the left side consistently in the t-test of male and female samples on otolith size and shape index in male and female fish. The results that differed from the results of the t-test comparison mean of male and female presented in Table 3 turned out to be the size of the otolith OL, OW, OP and OA all significantly different are presented in Figure 3 (t > t(0.05, 167)). In contrast, the shape index CS, RS and AR were not significantly different (t < t(0.05, 165)). It can be said that between males and females, there were no differences in the shape index between males and females.

Table 5. Total length (TL) regression relationships - sagitta otolith measurements (OL = Otolith Length, OW = Otolith Width, OP = Otolith Perimeter and OA = Otolith Area) of juveniles, females and male redtail scad *Decapterus kurroides*.

| Model | n  | r  | ln(TL) - ln(OL) | Intercept (a) | Slope (b) |
|-------|----|----|----------------|--------------|-----------|
| Juvenile | | | | | |
| In OL = -3.114 + 0.891*ln(TL) | 34 | 0.80 | ln(TL) - ln(OL) | 0.80 | 0.117 | 9.32 | 2.037 |
| ln(OW) = -2.239 + 0.536*ln(TL) | 34 | 0.66 | ln(TL) - ln(OW) | 0.66 | 0.108 | 4.296 | 2.037 |
| ln(OP) = -2.743 + 1.025*ln(TL) | 34 | 0.84 | ln(TL) - ln(OP) | 0.84 | 0.118 | 0.212 | 2.037 |
| ln(OA) = -5.438 + 1.358*ln(TL) | 34 | 0.77 | ln(TL) - ln(OA) | 0.77 | 0.199 | 3.226 | 2.037 |

| Model | n  | r  | ln(TL) - ln(OW) | Intercept (a) | Slope (b) |
|-------|----|----|----------------|--------------|-----------|
| Juvenile | | | | | |
| ln(OL) = -1.943 + 0.669*ln(TL) | 58 | 0.58 | ln(TL) - ln(OL) | 0.58 | 0.124 | 2.669 | 2.003 |
| ln(OW) = -1.483 + 0.410*ln(TL) | 58 | 0.54 | ln(TL) - ln(OW) | 0.54 | 0.085 | 6.929 | 2.003 |
| ln(OP) = -1.231 + 0.723*ln(TL) | 58 | 0.54 | ln(TL) - ln(OP) | 0.54 | 0.149 | 1.872 | 2.003 |
| ln(OA) = -3.629 + 1.041*ln(TL) | 58 | 0.67 | ln(TL) - ln(OA) | 0.67 | 0.154 | 6.227 | 2.003 |

| Model | n  | r  | ln(TL) - ln(OP) | Intercept (a) | Slope (b) |
|-------|----|----|----------------|--------------|-----------|
| Juvenile | | | | | |
| ln(OL) = -2.887 + 0.850*ln(TL) | 75 | 0.82 | ln(TL) - ln(OL) | 0.82 | 0.067 | 2.239 | 1.993 |
| ln(OW) = -3.139 + 0.731*ln(TL) | 75 | 0.87 | ln(TL) - ln(OW) | 0.87 | 0.049 | 5.490 | 1.993 |
| ln(OP) = -1.900 + 0.851*ln(kTL) | 75 | 0.83 | ln(TL) - ln(OP) | 0.83 | 0.066 | 2.258 | 1.993 |
| ln(OA) = -6.439 + 1.583*ln(kTL) | 75 | 0.89 | ln(TL) - ln(OA) | 0.89 | 0.093 | 4.484 | 1.993 |

| Pattern | | | |
|---------|----|----|---|
| Isometri | | | |
| Allometri | | | |

Note: sb = standard error b

Table 6. ANOVA of regression line of ln(TL)-ln (Otolith size) of *D. kurroides* from Kema Bay

| Size | Sample | F-ratio | P-value | F-ratio | P-value |
|------|--------|---------|---------|---------|---------|
| ln(TL) - ln(OL) | Female and Males of *D. kurroides* from Kema Bay | 1.030 | 0.311 ns | 2.230 | 0.137 ns |
| ln(TL) - ln(OW) | Female and Males of *D. kurroides* from Kema Bay | 0.340 | 0.561 ng | 7.79 | 0.006 ** |
| ln(TL) - ln(OP) | Female and Males of *D. kurroides* from Kema Bay | 0.610 | 0.434 ng | 0.570 | 0.450 ns |
| ln(TL) - ln(OA) | Female and Males of *D. kurroides* from Kema Bay | 0.790 | 0.377 ng | 6.250 | 0.014 * |

Notes: TL = Total Length, OL = Otolith Length, OW = Otolith Width OP = Otolith Perimeter, OA = Otolith Area, ns = not significant, * = significant; ** = highly significant.
Both the average CS female = 0.482 and the average CS male = 0.487; CS <1 showed that the scad otolith is not round. Likewise, the mean female RS (0.355) and the average female RS (0.359), both RS <1 shown that the otolith scad are not round. While the gene and regulative protein responsible for the peripheral biomineralisation process have been identified, it remains unclear how the symmetry between the right and left otoliths in fish species is
Average male AR = 2.134) and female AR mean = 1.129 are both AR > 1 shown elongated otolith scad. The form of otolith was specific to each species was given a name. Specifically, redtail scad otolith that are not round, not circular, and are elongated. Redtail scad has a unique form are called fusiform shape (Furlani, et al. 2008 and Tuset et al. 2003).

3.3. Relationship of total length and otolith size

Figure 5. Regression line comparison of Ln TL- Ln OL, Ln TL- Ln OW, Ln TL- Ln OP and Ln TL- Ln OA of *D. kurroides* from Kema Bay.
Regression between TL and OL, TL and OW, TL and OP, and TL and OA of D. kurroides from Kema Bay follows a power (multiplicative) function (Figure 4) or linear function after transformation to natural logarithm (Table 4). Regression of the TL–Size (OL, OW, OP and OA) (Table 4) of D. kurroides of Kema Bay indicated variations in slopes (b) and correlations (r) in which D. kurroides from Kema Bay had higher (r>96 %). Similarly, b values characterizing the growth pattern show allometric growth in TL-OL, the TL-OW, the TL-OP and the TL-OA relationship.

Regression of the TL–Otolith Size (OL, OW, OP and OA) of juveniles, female, and males D. kurroides of Kema Bay indicated variations in slopes (b) and correlations (r). Males D. kurroides from Kema Bay had highest correlation (r > 82 %). The b values characterizing the growth pattern show dominant allometric growth of TL-OL, the TL-OW, the TL-OP and the TL-OA relationship of juveniles, females and males. To compare the linear regression lines of ln(TL)–ln (Otolith size) as presented in Figure 5.

To compare the linear regression lines of ln (TL)–ln (Otolith size), ANOVA was employed (Table 5). For the regression of ln(TL) – ln(OL), because the p-value for the intercept and the slopes is greater or equal than 0.05 (a : F-ratio = 1.030; P = 0.311 and b : F-ratio = 2.230; p = 0.137), there are not statistically significant differences between for the intercept and the slopes for the various values of female and male at the 95% confidence level. Similarly with the regression of ln(TL) – ln(OP), there are not statistically significant differences between for the intercept and the slopes for the various values of female and male at the 95% confidence level.

The comparison of linear regression of ln(TL)–ln(OW) and ln(TL)–ln(OP) there are statistically not significant differences between the intercepts for the various values of females and males. Because the p-value for the slope of ln(TL)–ln(OW) and ln(TL)–ln(OP) are less than 0.05 (F-ratio = 7.79; P = 0.006 and F-ratio = 6.250; P = 0.014), there are statistically significant differences between the intercepts for the various values of females and males at the 95% confidence level.

4. Conclusion

The otolith size and the shape index of D. kurroides from Kema Bay were successfully characterized. Significant differences was found in otolith size and shape index except otolith perimeter, rectangularity, ellipticity, and aspect ratio otolith between of D. kurroides. Therefore, the otolith size and shape of left-right sides of redtail scad from Kema Bay were asymmetrical. No significant differences were found in otolith size and shape index between left and right otoliths of juveniles or symmetrical, but significant differences between left and right otoliths of male and female D. kurroides from Kema Bay. The regressions between total length and otolith sizes (otolith length, width, perimeter and area) of D. kurroides follows a power function. The growth patterns showed dominant allometric growth in total length-otolith length, total length-otolith width total length-otolith perimeter, total length-otolith area relationships of D. kurroides from Kema Bay.

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