PRELIMINARY RESULTS ON THE REPRODUCTIVE BIOLOGY OF THE WHITE MARLIN, *TETRAPTURUS ALBIDUS* POEY 1960, IN THE WESTERN EQUATORIAL ATLANTIC OCEAN

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SUMMARY

The tuna longline fishery in the Atlantic Ocean catches a considerable amount of white marlin Tetrapturus albidus*, as by-catch. Aiming at studying the reproductive biology of the species, biological samples and fisheries data were collected by observers on board of the chartered Brazilian tuna longline fleet, based in northeast Brazil, which operates mainly in the equatorial Atlantic, between the latitudes of 5°N and 5°S. Data on gonad development, monthly variation of gonad index, size at first maturity and fecundity were analyzed. Size at first sexual maturity (L_{50}) was estimated as 139 cm (low jaw- fork length/ LJFL), for males, and 147 cm, for females. The monthly mean gonad index of the white marlin was highest, for both sexes, in May and June. Fecundity of two mature females was equal to 771.000 and 877.150 t oocytes.*

RÉSUMÉ

La pêcherie palangrière de thonidés dans l'Océan Atlantique capture un volume considérable de makaire blanc (Tetrapturus albidus)*, en tant que prise accessoire. Afin d'étudier la biologie de la reproduction de cette espèce, des échantillons biologiques et des données sur les pêcheries ont été collectés par les observateurs embarqués à bord de la flottille palangrière thonière brésilienne affrétée, basée dans le Nord-Est du Brésil et opérant surtout dans l'Atlantique équatorial entre les latitudes 5°N et 5°S. Les données sur le développement des gonades, la variation mensuelle de l'indice gonadique, la taille à la première maturité et la fécondité ont été analysées. La taille à la première maturité sexuelle (L_{50}) a été estimée à 139 cm (longueur maxillaire inférieur-fourche / LJFL) pour les mâles et à 147 cm pour les femelles. L'indice gonadique moyen mensuel du makaire blanc était le plus élevé, pour les deux sexes, aux mois de mai et de juin. La fécondité des deux femelles matures était de 771,000 et 877,150 t d'ovocytes.*

RESUMEN

*La pesquería atunera de palangre del Atlántico captura una cantidad considerable de aguja blanca (*Tetrapturus albidus*) como captura fortuita. Para estudiar la biología reproductiva de esta especie, se recopilaron muestras biológicas y datos de pesquerías a través de observadores embarcados en la flota atunera fletada de palangre brasileño, con base en el noreste de Brasil, y que opera fundamentalmente en el Atlántico ecuatorial, entre 5ºN y 5ºS. Se analizaron los datos sobre el desarrollo gonadal, la variación mensual del índice gonadal, la talla de primera madurez y la fecundidad. La talla de primera madurez sexual (L_{50}) se estimó en 139 cm (mandíbula inferior-horquilla/LJFL) para los machos y 147 cm para las hembras. El índice gonadal medio mensual de la aguja blanca era mayor, para ambos sexos, en mayo y junio. La fecundidad de dos hembras maduras era igual a 771.000 y 877.150 t oocitos.*

KEYWORDS

White marlin, reproductive biology, fecundity

1. Introduction

The white marlin, *Tetrapturus albidus*, is an oceanic, pelagic and highly migratory species, found mainly in the mixed layer of equatorial and tropical waters of the Atlantic Ocean. The species is fished by both sport and commercial fisheries, being often caught, as a by-catch, in the longline fishery targeting tunas and swordfish. Due to its highly migratory nature, it is fished by several nations, in different areas of the Atlantic Ocean, being thus exposed to a significant fishing pressure, which has resulted in an important decline of its stock. Due to its relatively low commercial value, if compared to tunas and swordfish, and to the fact that a great part of its catches happens as by-catch, many specimens are discarded at sea, further hindering accurate catch estimates and studies on its biology. The last stock assessment on the species done by ICCAT was in 2001. Although the last assessment effort, conducted in 2002, could not provide an estimate of stock status with certainty, previous results have indicated that the stock has been over-fished for many years (ICCAT, 2005). Due to a continuing lack of biological information on the species, the ICCAT Standing Committee of Research and Statistics has recommended that research on white marlin biology be conducted in order to provide better information for future stock assessment. The present paper was thus conducted, with the purpose of contributing new data on the reproductive biology of white marlin in the equatorial western Atlantic, based on specimens collected from commercial longliners operating from northeast Brazil.

2. Material and methods

The data and samples examined in the present study were collected by observers, of the National Observer Program, on board of chartered tuna longliners based in the Ports of Recife (PE), Cabedelo (PB) and Natal (RN), located in northeast Brazil, from November 2004 to November 2005. All specimens were measured for low jaw-fork length (LJFL), immediately after boarding. Length-frequency distributions were calculated based on 10 cm intervals. After measured, they were dissected for the collection of gonads, which were then frozen and stored in freezers, up to the time of landing. In the laboratory, they were thawed, weighted and examined for macroscopic characteristics, being then immersed in 10% formalin solution, for fixation, and later on transferred to alcohol 70%. The sexual stages were classified after Ovchinnikov (1971) (**Table 1).**

A total of 493 gonads, 113 males and 380 females, were examined. The monthly number of males and females sampled was compared by Chi-square. The gonosomatic index was calculated by Schaefer and Orange (1956), as follows: $GI = GW \times 10^5 / LJFL^3$, where GI is the gonosomatic index, GW is the gonad weight and LJFL is the Low Jaw-Fork Length. The monthly mean gonosomatic index for both males and females, excluding juveniles, was calculated in order to evaluate the seasonal variation of reproductive activity. The size at first sexual maturity was estimated by a logistic curve (Arocha, 1997).

In order to estimate fecundity, the gonads of 2 mature females were examined fresh. Batch fecundity (B_f) was estimated as the product of the counts of hydrated oocytes per unit of weight (*Hyd*) and the ovary weight (O_w) (Arocha *et al*, 2005). The diameter of 300 oocytes were measured to assess oocyte development.

3. Results and discussion

The 113 males examined ranged from 105 to 220cm LJFL, being more frequent from 140 to 150 cm. Females ranged from 110 to 236 cm, with a mode between 150 to 160 cm (**Figure 1**). Mean LJFL was 153.9 cm, for males, and 154.7 cm, for females. The mean length of white marlin specimens caught by Brazilian longline fleet, from 1971 to 1985, estimated by Goodyear *et al.* (2003) ranged from 162 to 172cm, which is a little larger than the values presently found. Considering the high level of fishing pressure exerted on this stock, it is possible that the apparent reduction of the mean length be a result of over-exploitation. Several authors have reported that female white marlins attain a larger maximum size than males, being also heavier for similar sizes (De Sylva and Davis, 1963; Ueyanagi *et al*., 1970; Lenarz and Nakamura, 1972; Goodyear and Arocha, 2001). This may account for the relatively larger size of females in the present sample.

Females were more frequently sampled than males in all months (χ^2; $P < 0.01$). The number of fish sampled from January to March was much lower than in other months, for both sexes. Males in stage II were predominant from October to February, and in June, while the highest proportion of males in Stage IV happened in May (over 60%). Males in stage V, in turn, were predominant in July (**Figure 2**). Females in stage II predominated in all months, ranging from a little less than 40% in May to 100% in March. The highest frequency of females in stages IV and V happened in May, while females in stage VI were more frequent in June (**Figure 3**). The

monthly mean gonosomatic index for males showed the highest value in May (**Figure 4**), while for females there were two peaks: one in June and other in December (**Figure 5**). These results suggest that spawning happens mainly in May-June, although the high proportion of immature females in all months clearly indicates that the sampled area (5°N to 5°S) is not an important spawning ground. A similar result was also found by Souza *et al.* (1994), working in the same area. According to Arocha *et al*. (2004), the GI of white marlins caught in the equatorial North Atlantic (to the north of 5°N), from January to March, similarly to the present results, was low. Based on the variation of the GI along the year, together with the frequency of spawning specimens, those authors concluded that in the northeast Atlantic, from about 18° to 24°N, spawning occurs mainly from April to June, concurring with the present results.

Several authors have reported that white marlin, in the South Atlantic, spawns mainly off south of Brazil, during summer (Ueyanagi *et al*., 1970; Mather *et al*., 1975; Nakamura, 1985; Arfelli *et al*., 1986). Hazin (1993) postulated that white marlins migrate from the third to the first quarter of the year, from off northeast Brazil, southward, following the displacement of 25°C surface isotherm, to spawn during summer, off southern Brazil. At the end of the first quarter, most females caught in that area have ripe ova (Uyenagi *et al*., 1970).

The size at first sexual maturity (L_{50}) estimated by the logistic curve was equal to 139.4 cm, for males (**Figure 6**), and 147.8 cm, for females (**Figure 7**). This size is about 40 cm shorter than the one found by Arocha *et al.* (2004). Such a difference may result from the relatively smaller size of the fish sampled off northeast Brazil, as well as to the higher proportion of immature females. A higher number of immature females in the sample tend to result in underestimation of the size at first sexual maturity (Braccini *et al*., 2006).

The frequency distribution of oocyte diameter showed a mode at 0.8 mm (Figure 8), in the female measuring 160 cm LJFL, and at 1.2 mm, in the female measuring 175 cm LJFL. Batch fecundity was equal to 771.000 and 877.150 oocytes, respectively. These figures are significantly larger than the mean batch fecundity of 418,675 oocytes, found by Arocha *et al*. (2004), for 4 females sampled off Venezuela.

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Table 1. Classification of sexual stages.

Stage	*Females*	*Males*
I - Juvenile	Gonads in the form of thin, unpaired strands. Externally similar in males and females	
II - early maturation	Gonad in the form of paired round sacs; dense, surrounded by a thick dermal membrane of multi-layered epithelium. Blood vessels weakly developed	Gonads paired, in the form of thin, granular strands of a dark shade. Cross section in the form of a polygon, more rarely a triangle.
III - advanced maturation	Gonads in the form of large yellowish sacs with differentiated opaque eggs which are difficult to detach from the ovary	Gonads thicker. The rounded pinkish granules are closely packed. In cross section there is a weak secretion the color of diluted milk.
IV - mature	Parts of the ripe, opaque eggs show through the transparent membrane, The gonads take up more than half of the body cavity.	External appearance of testes as in stage III. Secretion thick and white.
V - spawned	Gonads running	Gonads running
VI - recovering	Signs of inflammation visible in the gonads. Ovaries flaccid with traces of hemorrhage.	

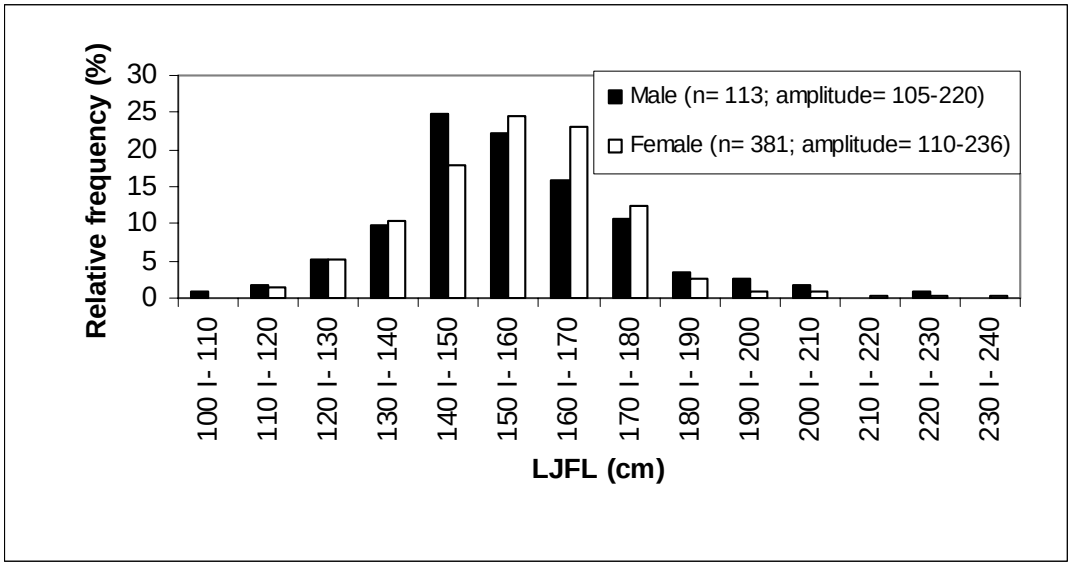

Figure 1. Low-jaw fork length frequency distribution of white marlins sampled by sex.

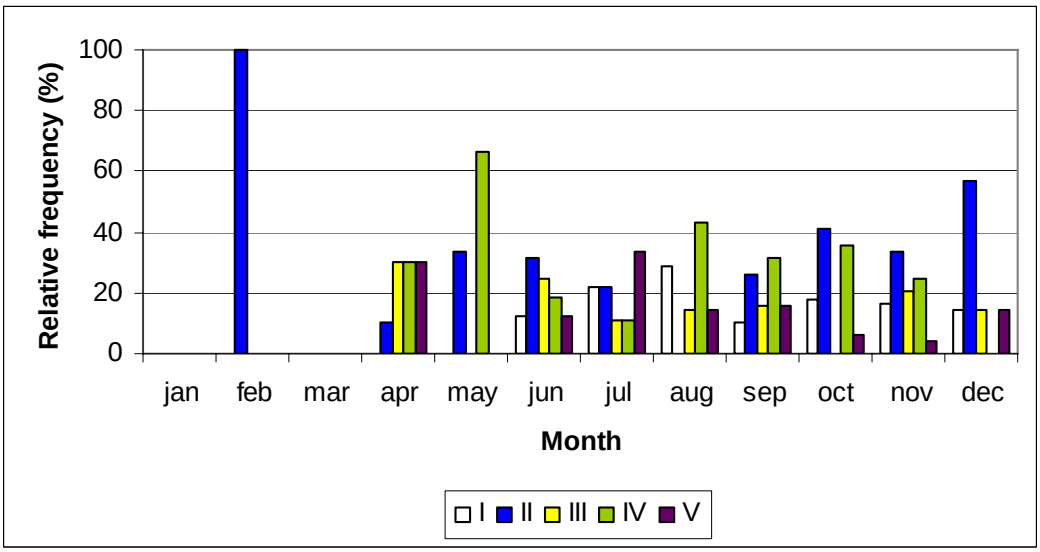

Figure 2. Monthly frequency distribution of sexual stages of male white marlins sampled from the western equatorial Atlantic Ocean.

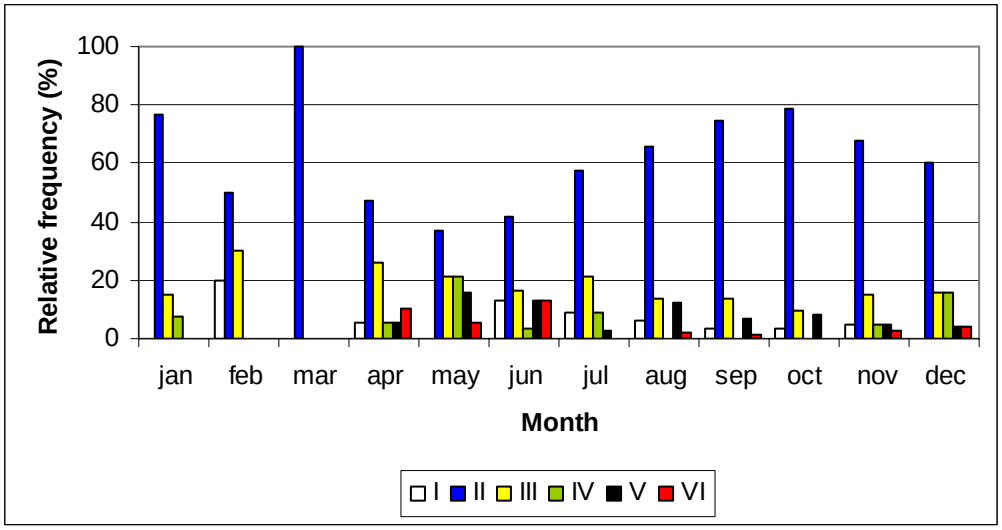

Figure 3. Monthly frequency distribution of sexual stages of female white marlins sampled from the western equatorial Atlantic Ocean.

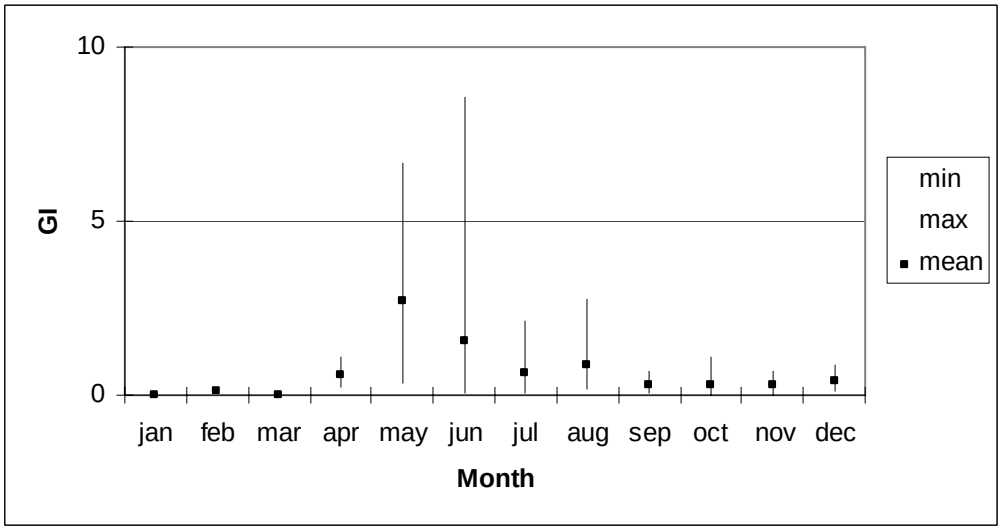

Figure 4. Monthly mean gonosomatic index of male white marlins from the western equatorial Atlantic Ocean.

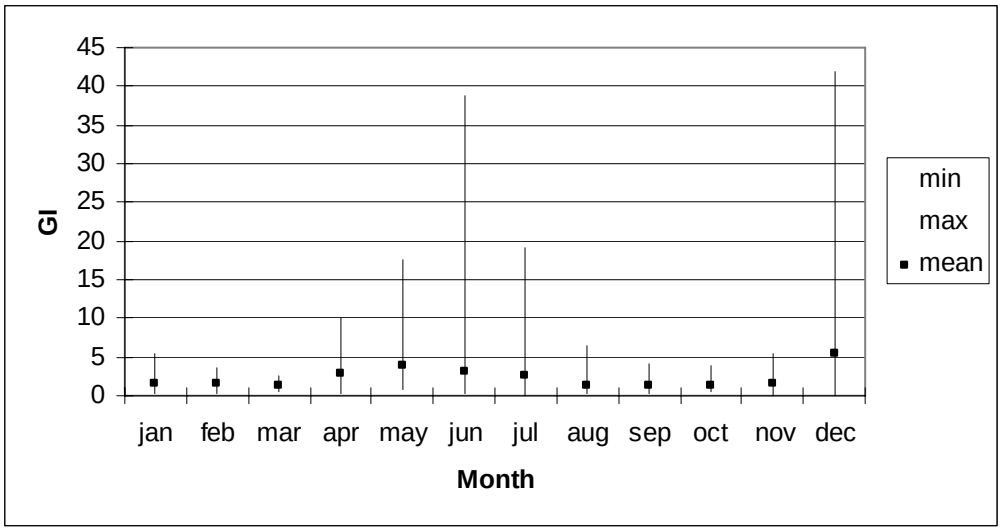

Figure 5. Monthly mean gonosomatic index of female white marlins from the western equatorial Atlantic Ocean.

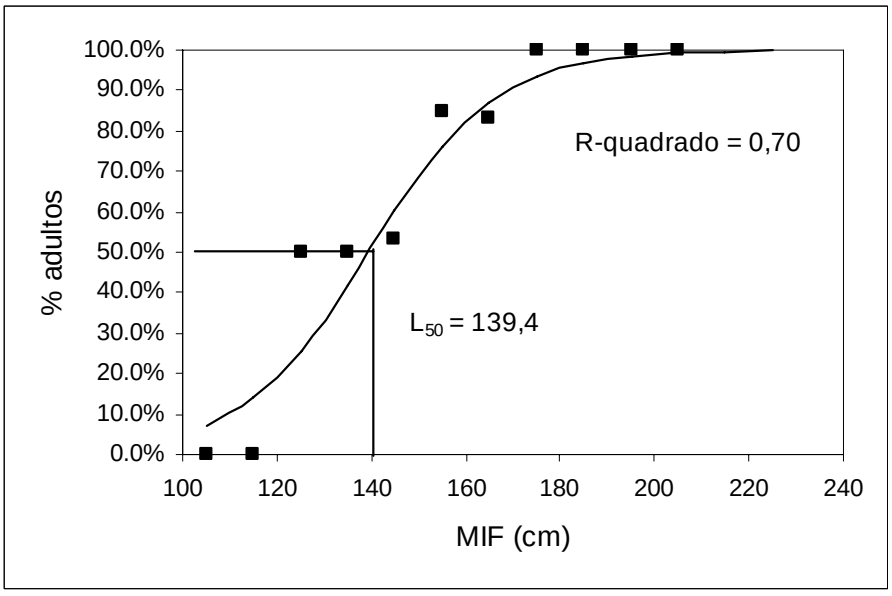

Figure 6. Size at first sexual maturity (L_{50}) of male white marlin estimated by the logistic curve.

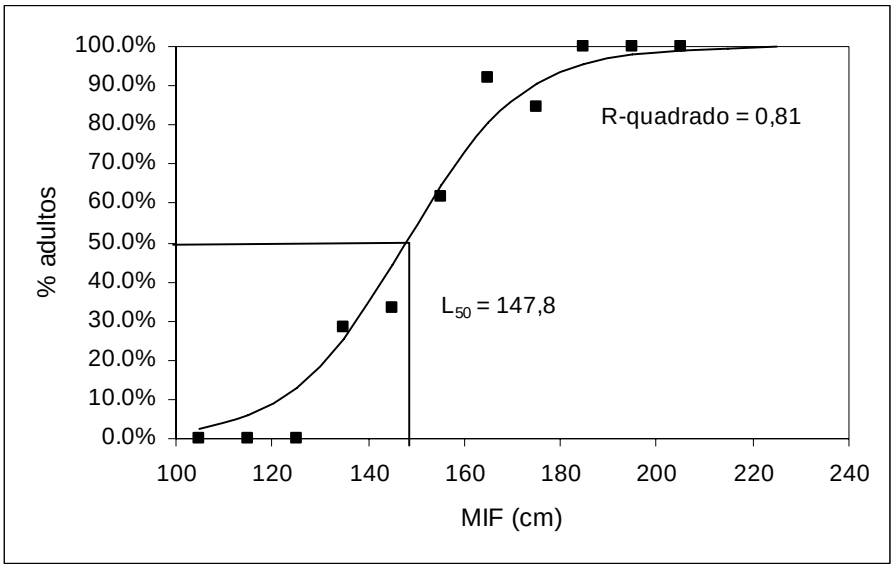

Figure 7. Size at first sexual maturity (L_{50}) of male white marlin estimated by the logistic curve.

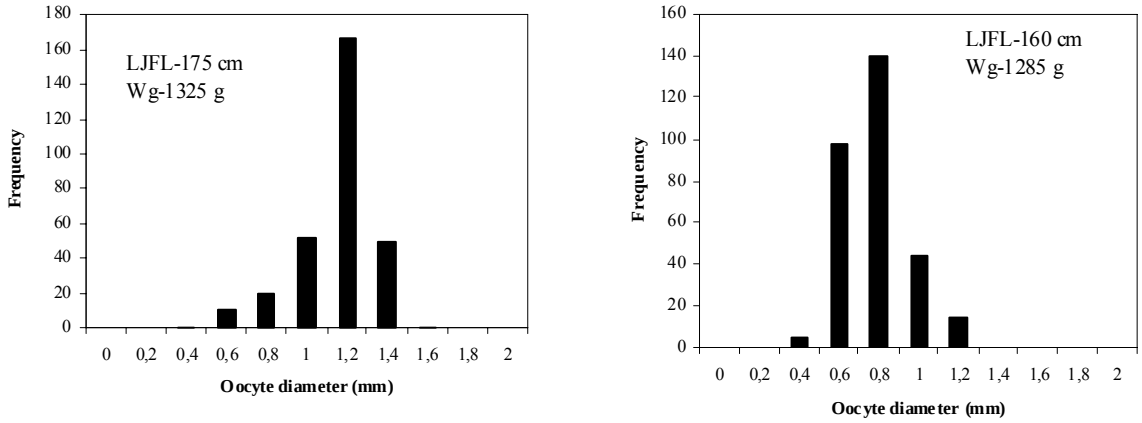

Figure 8. Diameter frequency distribution of hydrated oocytes.