PLEOPODAL EGG PRODUCTION OF THE WHITE-CLAWED CRAYFISH *AUSTROPOTAMOBIUS PALLIPES* LEREBOULLET UNDER LABORATORY CONDITIONS: RELATIONSHIP BETWEEN EGG NUMBER, EGG DIAMETER AND FEMALE SIZE

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ABSTRACT

Reproductive data from a total number of 1296 adult white-clawed crayfish (864 females mean carapace length size 3.36 ± 0.49 cm and 432 males mean carapace length size 3.66 ± 0.38 cm) are reported. In a 10-year period, crayfish from wild populations caught in mid September were kept under indoor laboratory conditions where mating and spawning took place. Broodstock mortality was low: 5% in females and 1.1% in males. From the initial number of females, 771 mated (89.2%) and 721 spawned (83.4%). Pleopodal eggs were counted without removal between 3 and 20 days after spawning and mean number was 73.5 ± 34.1 (range 14-220). Egg diameter of 94 females was measured giving a mean value of 2.39 ± 0.015 mm (range 2.08-2.79 mm). Correlations between female size (carapace length CL), number of pleopodal eggs and egg diameter were made.

Key-words: white-clawed crayfish, reproduction, fecundity.

PRODUCTION DES ŒUFS PLÉOPODAUX DE L'ÉCREVISSE À PIEDS BLANCS *AUSTROPOTAMOBIUS PALLIPES* LEREBOULLET DANS LES CONDITIONS DE LABORATOIRE : RELATION ENTRE LE NOMBRE D'ŒUFS, LE DIAMÈTRE DES ŒUFS ET LA TAILLE DE LA FEMELLE

RÉSUMÉ

Les données reproductrices d'un nombre total de 1296 écrevisses à pieds blancs adultes (864 femelles avec une carapace de longueur moyenne de 3,36 ± 0,49 cm et 432 mâles avec une carapace de longueur moyenne de 3,66 ± 0,38 cm) sont incluses. Sur une période de 10 ans, des écrevisses de populations sauvages ont été capturées à la mi septembre et gardées en laboratoire où elles se sont accouplées et reproduites. La mortalité du stock de reproduction était faible: 5 % pour les femelles et 1,1 % pour les mâles. Sur le nombre initial de femelles, 771 se sont accouplées (89,2 %) et 721 ont frayé (83,4 %). Les œufs pléopodaux ont été comptés sans élimination entre 3 et 20 jours après la fraie et le nombre moyen d'œufs par femelle était de 73,5 ± 34,1 (intervalle de 14 à 220). Le diamètre des œufs de 94 femelles a été mesuré, donnant une valeur moyenne de 2,39 ± 0,015 millimètre (intervalle de 2,08 à 2,79 millimètres). Les corrélations entre la taille de la femelle (CL, longueur de la carapace), le nombre d'œufs pléopodaux et le diamètre des œufs pléopodaux ont été calculées.

Mots-clés : écrevisse à pattes blanches, reproduction, fécondité.

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INTRODUCTION

In the different cultured crustaceans the number of spawned eggs has great variability. According to LEE and WICKINS (1992), penaeid shrimps have the highest fecundity with mean values between 200,000 and 1,000,0000 followed by the freshwater prawn (*Machrobrachium rosenbergii*) with an egg production ranging between 20,000 and 80,000 and the lobster (*Homarus* spp) with a range between 5,000 and 80,000. Freshwater crayfishes, especially astacids, have the lowest fecundity, with values usually fewer than 250 eggs (MOMOT, 1991; REYNOLDS, 2002).

Among European astacids, the white-clawed crayfish (*Austropotamobius pallipes* Lereboullet) has the lowest fecundity as reported in different studies on wild populations (BROWN and BOWLER, 1977) and under laboratory conditions (MATTHEWS, 1992; CARRAL *et al*., 1994, 2000; CELADA *et al*., 2001).

It has been proved that female size and pleopodal egg number are positively correlated (RHODES and HOLDICH, 1982; BREWIS and BOWLER, 1985; CARRAL *et al*., 1994). This relationship is under a strong environmental influence and factors such as trophic conditions or year to year differences can determine marked differences in fecundity (REYNOLDS, 2002).

Egg size also has an influence on the number of pleopodal eggs, as has been described in different crustacean species (LEE and WICKINS, 1992). In freshwater crayfishes, ABRAHAMSSON (1973) stated that species with higher pleopodal fecundity spawned small eggs. Thus, the egg production of *Pacifastacus leniusculus* is approximately 90% higher than in *Astacus astacus* and the diameter of signal crayfish eggs is 27.3% smaller than that of noble crayfish eggs.

The egg number decreases throughout the embryonic development (MASON, 1977; CELADA *et al*., 1988; WOODLOCK and REYNOLDS, 1988; TAUGBØL and SKURDAL, 1990a, 1990b; REYNOLDS *et al*., 1992) and thus the period lapsed from spawning should be considered when data obtained by different authors are compared.

To sum up, the number of pleopodal eggs shows a great variability due to several factors such as population, year of breeding, female size and stage of embryonic development. In order to minimize some of the factors affecting this variability, the aim of this paper is to record the reproductive parameters in *A. pallipes* obtained under laboratory conditions during ten consecutive years.

MATERIAL AND METHODS

A total number of 864 females and 432 males of white-clawed crayfish from 13 populations located in the province of León (Spain) were caught in mid-September over a period of ten consecutive years. Crayfish were transferred to laboratory facilities where the last part of gonadal development, mating, and spawning and egg development took place.

During the reproductive process, the animals were kept in 1 m^2 fibre-glass tanks provided with shelters. Water was supplied in a flow-through system at a rate of 1.5 l/min at temperatures between 8°C and 13°C.

Mean carapace length (CL) of egg bearing females included in the study (n = 721) was 3.36 ± 0.49 cm (range: 2.05-4.75 cm). Mean size (CL) of males was 3.66 ± 0.38 cm (range: 3.41-4.32 cm). Male: female ratio was 1: 2.

Broodstock mortality, mating and spawning percentage were recorded. Number of pleopodal eggs was counted without removal between 3 and 20 days after spawning,

during the first phases of embryonic development, corresponding to the first cell divisions, according to CELADA *et al*. (1985, 1991).

To establish the relationships between female size and number and average diameter of pleopodal eggs, a group of 94 females was used (mean CL = 3.42 ± 0.35 cm, range 2.81-4.46 cm). Eggs were counted without removal and a sample of three eggs per female was removed in order to measure their diameters. In all cases, twenty five days had elapsed from spawning (phase III: the blastosphere).

Data were analysed using the software Statistica 6.0. (Statsoft, Inc., Tulsa, Oklahoma, USA). Raw and logarithmic transformed data were analysed by the Pearse Product-Moment correlation method. The significance level was $P < 0.05$.

RESULTS

Percentage of mortality was 5% (females) and 1.1% (males). From the surviving females, 93.9% were mated and 87.8% spawned. The mean number of pleopodal eggs was 76.2 ± 35.8 (range: 14-220). Figure 1 shows the plot of linear regression between female size and egg number (Number of pleopodal eggs = – 96.96 + 51.216*CL; r = 0.71). As shown in Figure 2, the relationship between log transformed data gives a value of the constant b of 2.432 (Log number of pleopodal eggs = 0.556 + 2.432∗log CL).

The mean egg diameter was 2.39 ± 0.015 mm (range: 2.08-2.79 mm). Figure 3 shows the plot of linear regression between female size and egg diameter. The correlation coefficient was positive but low (r = 0.14) and non significant. The formula of regression analysis of log transformed data was: Log diameter of pleopodal eggs = – 0.081 + 0.629∗log CL, r = 0.63).

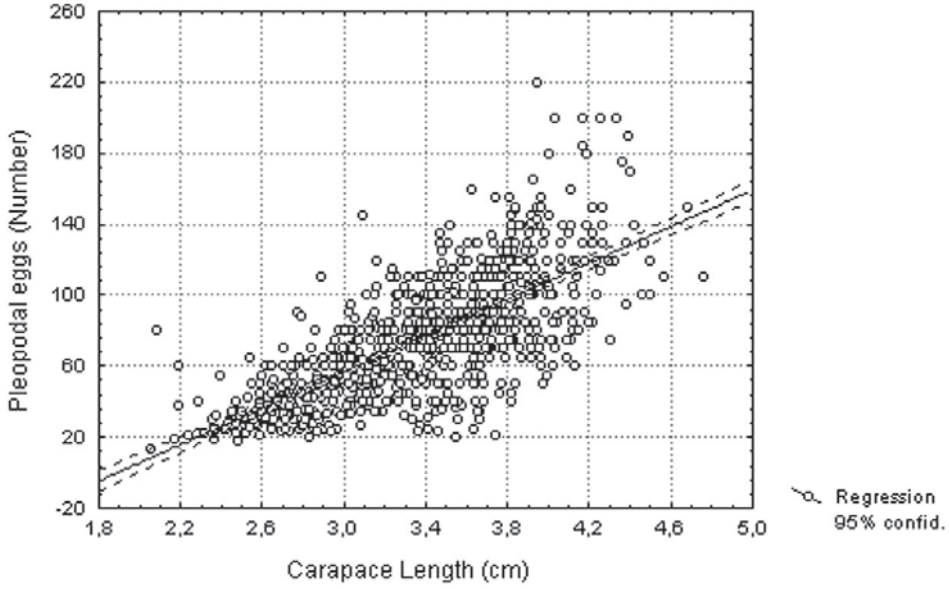

Figure 1
The relationship between female size (CL) and pleopodal egg number.

Figure 1
Relation entre la taille de la femelle (CL) et le nombre d'œufs pléopodaux.

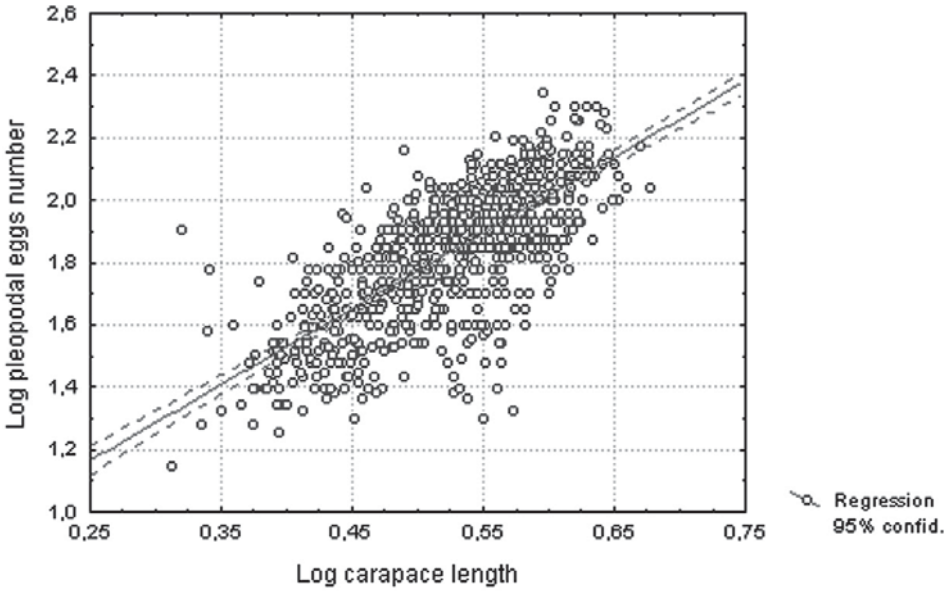

Figure 2

The relationship between log of female size (CL) and log of pleopodal egg number.

Figure 2

Relation entre le logarithme de la taille de la femelle (CL) et le logarithme du nombre d'œufs pléopodaux.

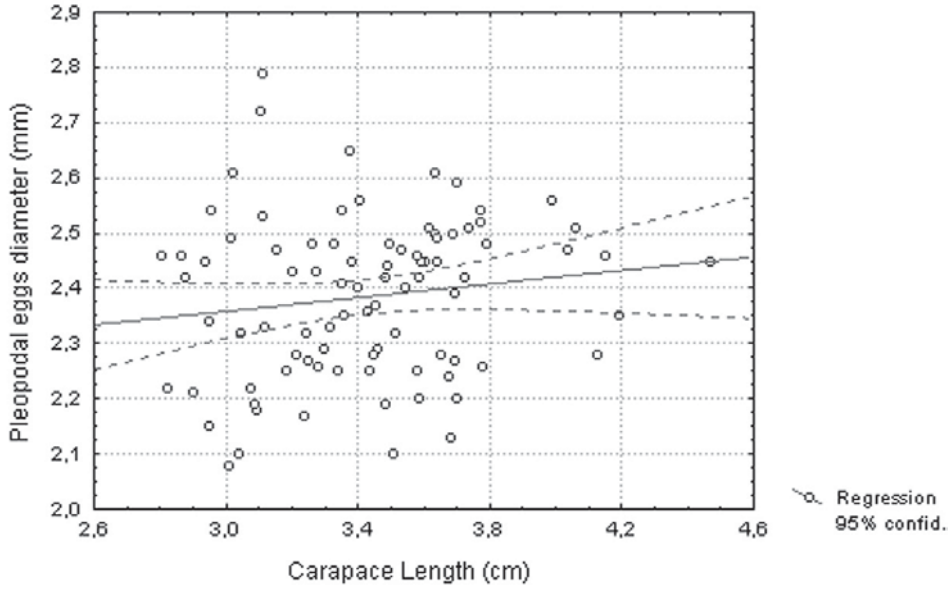

Figure 3

The relationship between female size (CL) and pleopodal egg diameter.

Figure 3.

Relation entre la taille de la femelle (CL) et le diamètre des œufs pléopodaux.

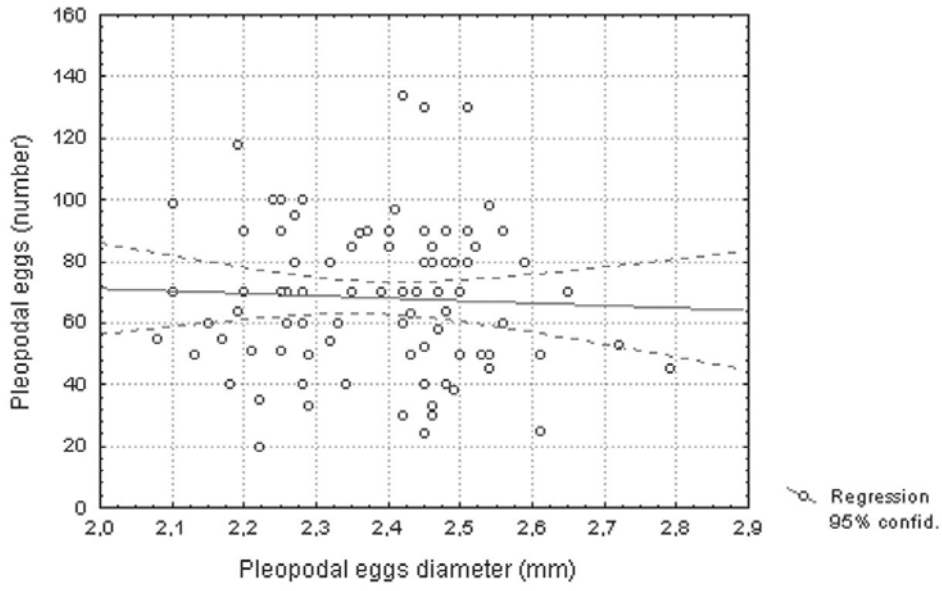

Figure 4
The relationship between number of eggs and average diameter of the egg.

Figure 4.
Relation entre le nombre d'œufs et le diamètre moyen de l'œuf.

The relationship between egg number and diameter is shown in Figure 4. The correlation coefficient was negative (r = – 0.05) and non significant. The formula of regression analysis of log transformed data was: Log number of pleopodal eggs = 0.794 + 3.973∗log egg diameter, r = 0.99).

DISCUSSION

The mating and spawning percentages obtained were high (93.9% and 87.8%, respectively) and similar to those obtained in *A. astacus* and *A. pallipes* under laboratory conditions (TAUGBØL and SKURDAL, 1989, 1990a,b; CARRAL *et al*., 1994, 2000, CELADA *et al*., 2001).

As in previous studies, the number of pleopodal eggs was positively correlated with female size. Correlation coefficients reported by different authors have shown a high variability. So, RHODES and HOLDICH (1982), BREWIS and BOWLER (1985), O'KEEFFE (1986) and CARRAL *et al*. (1994) obtained in *A. pallipes* the following coefficients: 0.53, 0.93, 0.51 and 0.72, using data from 123, 59, 50 and 304 egg-bearing females, respectively. These differences are probably related to the different numbers of animals, different populations, reproductive seasons and the phase of embryonic development. In our study, these possible causes of variability were reduced using a high number of animals coming from 13 populations, during ten consecutive breeding seasons and recording egg number a few days after spawning.

The relationship between log pleopodal egg number and log size has been recommended to stabilize the variance in fecundity in crustaceans. SOMERS (1991), stated that this relationship based on an allometric model (log y = log (a) + b log x) differs by a factor of 3. In agreement with the data obtained by HARLIOĞLU *et al*. (2004) for

Astacus leptodactylus, the value of the slope (Figure 2) was lower than 3 (2.4318) showing the absence of a simple volumetric relationship.

In general terms, larger females usually produce more eggs but for long-lived crayfish species, as *A. pallipes*, old females can show a reduced fecundity (MOMOT, 1984). According to this statement, we found a relatively low pleopodal egg production (less than 60) in big females (see Figure 1). But more important variability on fecundity has been recorded for a given female-size. This fact, previously reported by CARRAL *et al*. (1994) and HARLIOĞLU *et al*. (2004), was also observed in this study (i.e. females of 3.45 cm CL had 100, 87, 83, 70, 35 and 23 eggs).

In accordance with our results, LAHTI and LINDQVIST (1983) did not find a significant correlation between female size and egg diameter in *A. astacus*. However, and in agreement with WOODLOCK and REYNOLDS (1988), larger females usually have bigger eggs, although variability in egg size of the spawn is high. Other factors, such as the feeding regime during ovarian development, should also be considered.

The correlation between egg number and diameter was negative but low (Figure 4). However, this correlation is more evident among different species as those with higher fecundity spawn smaller eggs. Thus, although white-clawed crayfish carry fewer eggs than *A. lepyodactylus* and *P. leniusculus* they are larger (LOWERY, 1988).

Log transformation led to a marked increase of correlation coefficient between female size and egg diameter (0.63) and between egg number and diameter (0.99) and thus can be recommended for prediction purposes.

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