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Determining Size at Maturity and Predicting Egg Extrusion from Cement Gland Development in Homarus americanus

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Abstract

In mature female Homarus, the abdominal cement glands wax and wane with ovarian development and oviposition. As the ova become mature, the glands become progressively more engorged. A simple technique for evaluating this cement gland development has been developed and related to ovarian maturity and egg extrusion. Both macroscopic and microscopic methods of assessing degree of cement gland development on the pleopod endopodites have been described. The technique enables field biologists to examine pleopods in situ to differentiate between a mature and an immature female prior to the spawning season and to determine whether a mature female will spawn in the current season. This will allow an accurate assessment of stage of maturation of any female prior to or during the egg-laying season and should greatly simplify determinations of size at maturity and numbers of mature females in the population.

Résumé

Les glandes cémentaires de femelles matures de Homarus croissent et décroissent en fonction du développement ovarien et de l'oviposition. A mesure que les ovules mûrissent, les glandes deviennent de plus en plus grosses. Les auteurs ont mis au point une technique simple d'évaluation du développement des glandes cémentaires et établi la relation avec la maturité de l'ovaire et l'extrusion des oeufs. Les méthodes, tant macroscopiques que microscopiques, permettant d'évaluer le degré de développement des glandes cémentaires sur les endopodites des pléopodes ont été décrites. Grâce à la technique présentée ici, les biologistes peuvent examiner les pléopodes in situ afin de distinguer entre femelles matures et immatures, avant la saison de ponte, et déterminer si une femelle mature pondra dans l'année. On pourra ainsi évaluer de façon précise le stade de maturation de toute femelle avant ou pendant la saison de ponte. La détermination de la taille de maturité et du nombre de femelles matures dans la population en sera d'autant facilitée.

Introduction

Size at maturity for female lobsters is generally determined from the size of egg-bearing females in the population. This presents difficulties in areas where ovigerous females are not caught in large numbers. As well, sampling must be done when the maximum number of females would be expected to be carrying eggs. This method of determining percent mature does not include those female lobsters considered to be mature because they are capable of extruding eggs, season and other factors permitting. A sizeable proportion of mature females can be found without eggs at any given time and have not been included previously in studies of size distribution of mature females as there have been no reliable external indicators of maturity other than the presence of eggs. However, maturity determinations on females can be made from the degree of development of a secondary sex characteristic - the cement glands on a pleopod endopodite. Herrick (1895) described the cement glands of Homarus and recognized a correlation between egg extrusion and cement gland development, but these glands have never been used by fisheries biologists to determine maturation and imminent extrusion except by Robinson (1979) who applied our technique to assess maturation. Cement gland staging simplifies maturity assessments in that size at maturity can be determined by examining the landed catch, and assessments can be made as much as 2 mo before the egg-laying season.

On mature female Homarus the sternal bars of the abdomen, inner surfaces of the associated pleura, and the pleopod protopodites, endopodites, and exopodites of all but the last two abdominal segments Homarus are covered with large numbers of abdominal or "cement" glands that are structurally similar to tegumental glands (Yonge 1932). Whereas tegumental glands show cyclic activity associated with molting, the abdominal (cement) glands wax and wane with ovarian development and oviposition. This correlation has been recognized in many decapods (see Aiken and Waddy 1980a, for review). As the ova undergo vitellogenesis leading to oviposition, the glands become progressively more engorged with a white opaque substance. In crayfish, the contents of the abdominal glands are expelled onto the abdominal sterna immediately before oviposition (Andrews 1906; Yonge 1937). This is assumed to occur in Homarus, also, since the glands are empty and vacuolated before oviposition is complete (Herrick 1909; Yonge 1937; Aiken and Waddy 1980 a,b). We have, however, (as did Yonge 1937) regularly observed engorged cement glands on females carrying "black" eggs during winter, several months after extrusion, so their activity may extend beyond the time of egg extrusion. Although the exact function of these glands and their role in reproduction has not been agreed upon, they are valuable indicators of maturation and imminent egg extrusion.

Cement Gland Staging Technique

The staging system described here utilizes both macroscopic and microscopic evaluation of the pleopod endopodites. The pleopod endopodites are used because they exhibit greater cement gland development than do the exopodites. Stages A through D can be assigned by gross examination of the pleopods in situ. This method is adequate to differentiate between a mature and an immature female, and to determine whether a mature female will spawn in the current season. Further refinement (substages A_1-D_2) can be obtained through examination of the severed endopodite with a compound microscope. The entire endopodite is placed posterior (concave) surface downward in a drop of seawater on a microscope slide and examined with transmitted light at 10-40x magnification.

Cement Gland Staging Criteria (Figures 1 - 3)

The following cement gland staging criteria (illustrated in Figs. 1-3) have been developed through examination of hundreds of field and laboratory specimens in all stages of reproductive development.

Stage 0: No gland development; same as male pleopod (Fig. 1, 3).

Stage A: Very slight cement gland development between the nodes (Fig. 3).

A-1 - Little gland development; seen as small dots along the sides of the endopodite (Fig. 1, 2).

A-2 - A few glands have developed the "rosettes" typical of tegumental glands, but this phenomenon is restricted to the lateral margins of the endopodite (Fig. 1, 2).

Stage B: Moderate cement gland development extending to the tip of the nodes (Fig. 3).

B-1 - Many glands have formed rosettes and development has progressed to the tip of the nodes and upper third of the pleopod (Fig. 1, 2).

Stage C: Advanced cement gland development well beyond the nodes (Fig. 3).

C-1 - Development has progressed to distal tip of the pleopod, glands are very dense along the lateral margins and extend well beyond the nodes (Fig. 1, 2).

C-2 - Gland development in the central region of the pleopod has progressed almost to the tip so that virtually all the pleopod is covered in cement glands (Fig. 1).

Correlation with Ovarian Stages and Time to Extrusion

Correlations between cement gland stage, ovary stage, and time to extrusion have been determined over the past 3 yr from autopsies on more than 500 wild-caught females and with more than a hundred females held for several years in the laboratory. This work has enabled us to predict egg extrusion as much as 2 mo in advance. Cement glands classed as stage A in the early summer are indicative of a stage 2 or 3 ovary that will not extrude for another year. This same cement gland stage in the late summer or autumn, after the egg-laying season is complete, is associated with a stage 3 or 4 ovary that will produce eggs the following year. Under natural conditions, stage B cement glands are only found in the spring-summer, as the egg-laying season approaches and indicate extrusion will occur within 2-3 mo. Stage C cement glands are found on females that are within 1 mo of extrusion.

Table 1. Correlation of cement gland stages with ovarian stage and time to extrusion.

Cement gland stage	Ovary stage[1]	Observed time to extrusion
	immature	
0	1,2	?
	developing	
A-1	2	~year
A-2	3,4	~year
B-1	3,4	same season
C-1	4,5	≤ 6 wk
C-2	5,6	≤ 1 mo
	ripe	
C-3	6A	imminent (within days)

[1]Criteria given in Table 2

This technique for determining maturation and predicting extrusion is applicable to females from all areas. Stage C cement glands (advanced development) are blatantly obvious and could not be missed by even the most inexperienced observer. Recognition and separation of stages A and B requires more practice to develop consistency of evaluation. These stages allow field biologists to examine pleopods *in situ* to differentiate between a mature and an immature female prior to the spawning season and to determine whether a mature female will spawn in the current season. This will provide an accurate assessment of stage of maturation of any female prior to or during the egg-laying season and should greatly simplify determinations of size at maturity and numbers of mature females in the population.

Literature cited

Aiken, D. E., and S. L. Waddy. 1980a. Reproductive Biology, Chapter 4, In The Biology and Management of Lobsters, Vol. 1, Physiology and Behavior, p. 215-276. Eds., J. S. Cobb and B. F. Phillips. Academic Press (in press).

1980b. Reproductive biology of *Homarus americanus*. Proc. Canada-U.S. Workshop of Status of Assessment Science of N.W. Atlantic lobster (*Homarus americanus*) stocks. Can. Tech. Rep. Fish. Aquat. Sci. 932: 59-71.

Andrews, E. A. 1906. Egg laying of crayfish. Amer. Nat. 40: 343-356.

Herrick, F. H. 1895. The reproduction of the lobster. Zool. Anz. 18: 226-228.

1909. Natural history of the American lobster. Bull. Bur. Fish. 29: 149-408.

Robinson, D. G. 1979. Consideration of the lobster (Homarus americanus) recruitment overfishing hypothesis; with special reference to the Canso Causeway. Fish. Mar. Serv. Tech. Rep. 834: 77-99.

Yonge C. M. 1932. On the nature and permeability of chitin 1. The chitin lining the foregut of decapod crustacea, and the function of the tegumental glands. Proc. Roy. Soc., London, Ser. B, 3: 298-329.

1937. The nature and significance of the membrane surrounding the developing eggs of Homarus vulgaris and other decapods. Proc. Zool. Soc., London, Ser. A., 107: 499-517.

Table 2. Stages and morphological criteria used to classify ovary development in the American lobster *Homarus americanus*.[1]

Stage 1: Immature
Ovary white
Oocytes <0.5 mm
O_f <100
Stage 2: Immature Developing
Yellow, beige, pale green
Oocytes <0.8 mm
O_f <100
Stage 3: Developing
Light to medium green
Oocytes <1.0 mm
O_f <200
Stage 4: Developing
Medium to dark green
Ooctyes 0.1-1.6 mm
O_f <325
Stage 5: Developing
Dark green
Oocytes 1.0-1.6 mm
O_f >325
Stage 6: Ripe
Dark green
Oocytes 1.4-1.6 mm
O_f >400
Stage 6A: Oocytes free
Spent or Reabsorbing
White or yellow with
dark green residual ova
Flaccid in early stages

[1]From Aiken and Waddy (1980b).

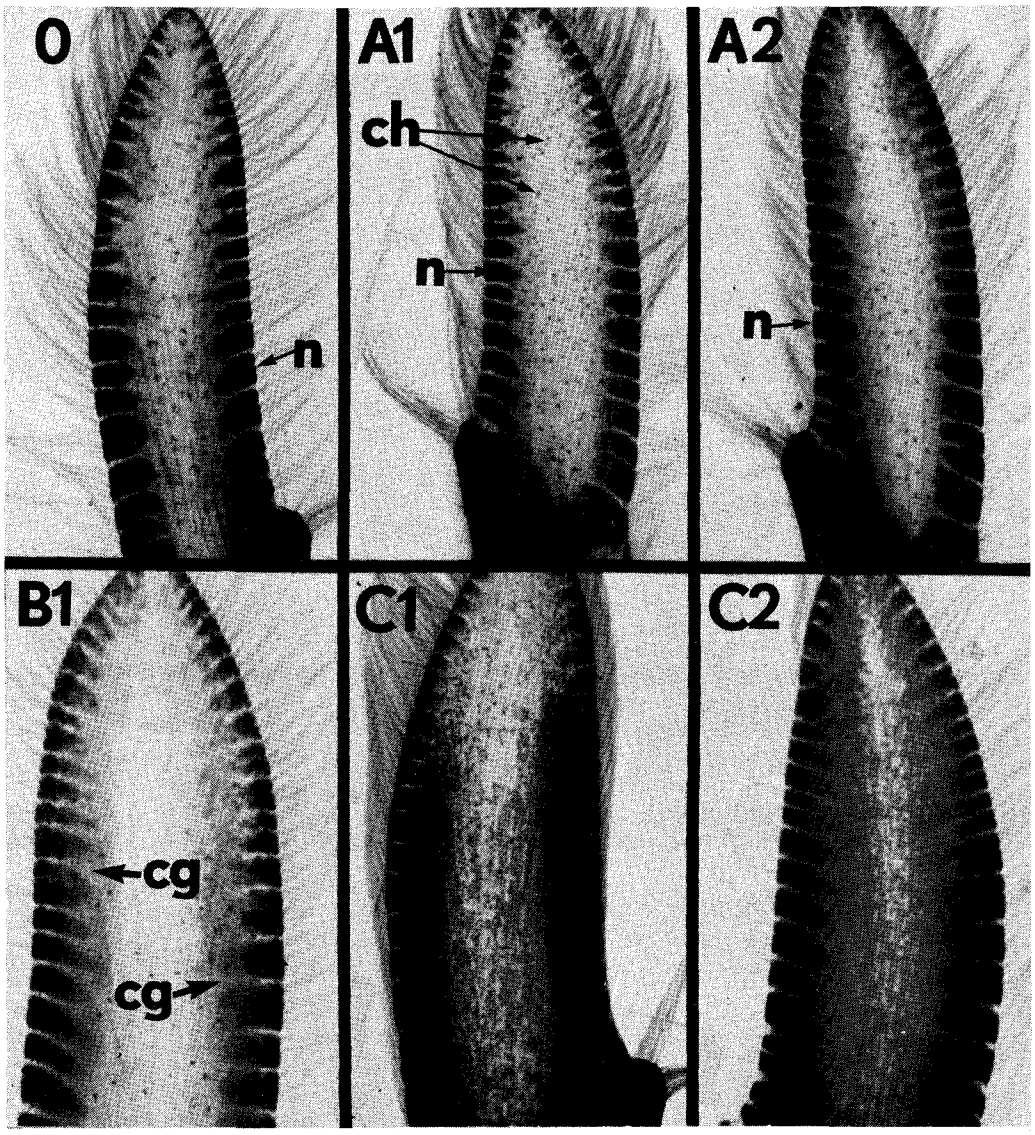

Figure 1. Cement gland staging, microscopic method. Pleopod endopodites showing development of cement glands from stage 0 (no development) through C-2 (maximum development). Cement glands (cg) develop between nodes (n) along edge of pleopod. Chromatophores (ch) are most obvious in stages 0, A-1 and A-2 as dark spots across the surface of the endopodite. For view of cement glands in stages A-1 and A-2, see Fig. 2.

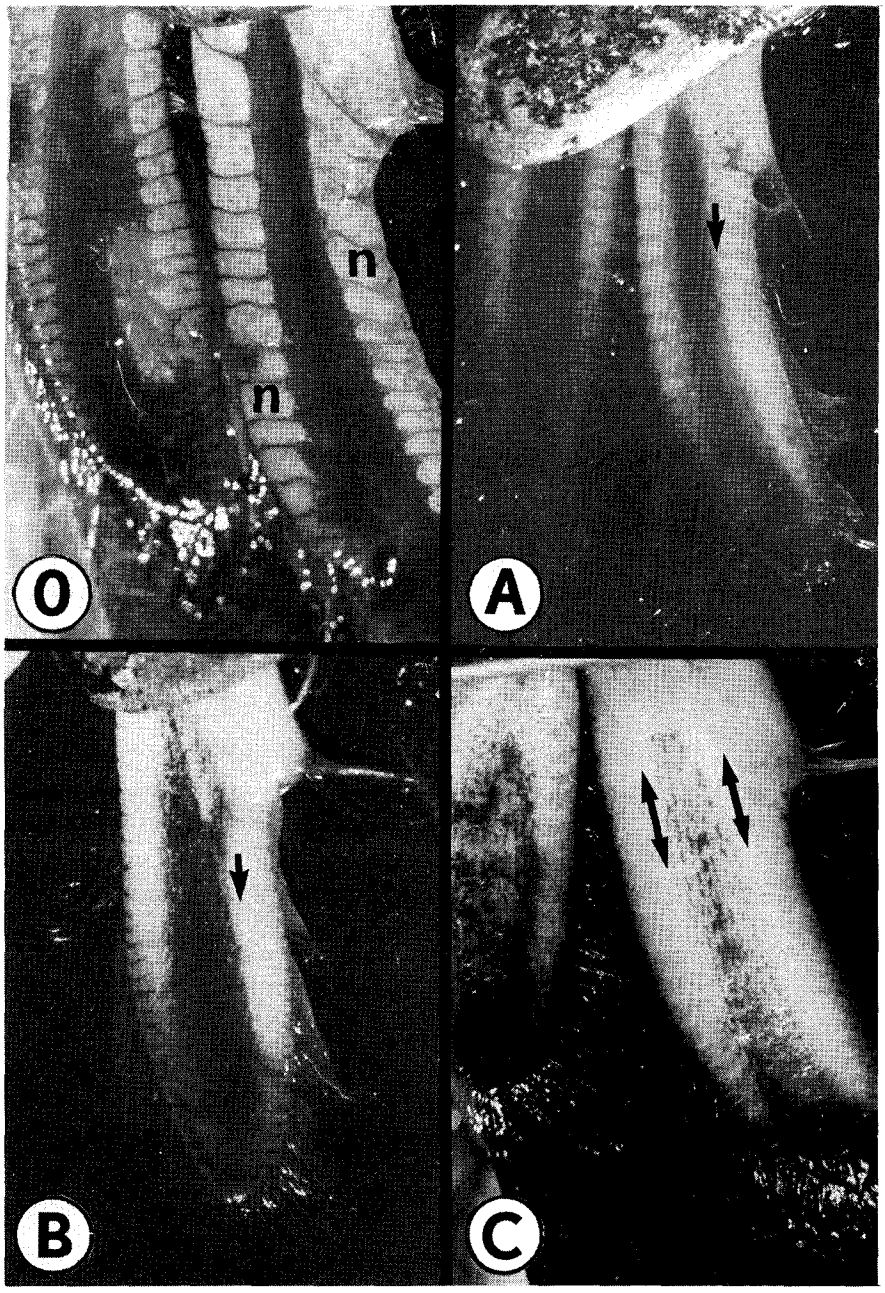

Figure 3. Cement gland staging, macroscopic method. Stages 0, A, B and C, photographed with reflected light. On the lobster, the pleopod nodes (n) appear tan or beige, the cement glands (arrows) are white. Note that cement glands progressively fill the spaces between the nodes (stages A, B) and eventually obscure the central region of the endopodite (stage C).