Brief Communication

Methods for identifying maturity and spawning season in commercial crustaceans: an overview

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Understanding the spawning peaks/spawning seasons of commercial crustaceans is crucial for informing policy decisions related to their management. Maintaining a healthy spawner biomass during the breeding season is a fundamental requirement to ensure the success of the fishery in subsequent years. A field-oriented methodology for identification of the maturity of different crustaceans can aid in determining the spawning season for each species and proposing protective measures for spawners. The identification of spawning seasons for each species can also contribute to making policy decisions regarding the appropriate timing for fishing closures to safeguard the reproductive stock. The recruitment of new individuals into the population ensures a continuous supply of resources for harvesting. Preserving the reproductive stock and preventing overfishing are essential for the sustainability and long-term viability of the fishery.

Coastal penaeid shrimps

The inshore penaeid shrimps are dioecious, and different species have distinct sizes at which they attain maturity. Maturity in inshore penaeid shrimps is classified generally into five stages – Immature (IM), early maturing (EM), late maturing (LM), maturing or ripe (M) and spent (SP) and can be ascertained externally. The ovary extends from the base of the rostrum to the end of the abdomen and consists of the anterior, middle and posterior lobes.

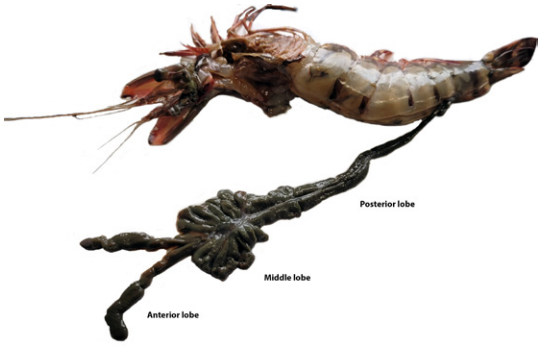
Maturity stages

1. Immature (IM): The ovaries are thin, thread-like, and colourless, and lobes do not appear to be differentiated.

2. Early maturing (EM): The ovary starts showing pigmentation as the lobes of the ovary begin to develop.

3. Late maturing (LM): The anterior and middle lobes expand and acquire a diamond shape; the colour is dark green.

4. Mature (M): In this stage, the anterior and middle portions of the ovary fill up the cephalothorax and the posterior lobe, too, is well formed and occupies all of the abdomen; they are visible as dark green through the exoskeleton.



Ripe ovary in penaeid shrimp ready for spawning

Late maturing and early maturing stages

5. Spent (SP): The appearance of the ovary is similar to that in the immature stage of shrimp, being colourless and, in some cases, with slight pigmentation in the posterior lobe. They are distinguished based on size, those above the size at maturity being spent.

Immature (IM), mature (M) and spent (SP) stages

The late maturing and mature/ripe stages are considered for determining the spawning season in coastal penaeid shrimp. The monthly percentage of these two stages in the total four stages (excluding the immature stage) is estimated, and the months having the highest percentage are the species' peak spawning month/months.

$$\text{Mature \%} = \frac{LM+M}{EM+LM+M+SP} \times 100$$

Where LM – late maturing, M – mature, EM – early maturing, SP – spent stages

Penaeid shrimps spawn throughout the year and may have a secondary spawning peak in addition to the primary spawning peak.

Portunid crabs

In India, the commercial crab fishery is composed of portunid crabs. The majority of these species breed throughout the year along the east and west coasts of India. Male and female crabs can be identified easily from the shape of their abdomen i.e., ventral side of the carapace. In both sexes, the abdomen becomes freely open once the crab attains maturity. If the abdomen is open, one can see two paired pleopods in males and 4 paired pleopods in females. Matured females store sperms in their spermatheca and once the matured ovary releases ova, simultaneously sperms are released and fertilization takes place. The fertilized eggs are released during spawning and they get attached to the setae of the abdominal pleopods, this egg mass is known as 'berry' and the crab with a berry is called a 'berried crab'. A good berry will be compact and rounded in shape and it is attached to the mother till hatching. Newly spawned eggs are bright orange or yellow. The colour of the eggs gradually changes to dull yellow/light brown, then to deep grey, at this stage, eggs are ready for hatching. This duration is the embryonic development period or the incubation period and depending on the size of the berry and water temperature the number of days taken also varies. In Indian waters, it is observed that the developmental period required for portunid species varied between 8-12 days.

Crab with berry on the 1st day of spawning

Same crab on the 10th day of spawning

For identifying the spawning period of a commercial crab, the best method is to monitor the occurrence of berried crabs in the landings. Record the number of berried crabs (irrespective of the colour of the egg mass) during the sampling and analyse the month-wise percentage for each species. This is the easiest and most reliable method to record the spawning season of a crab. If we assume the spawning time based on the ovarian stages, there are chances of misidentification of the stages and that may lead

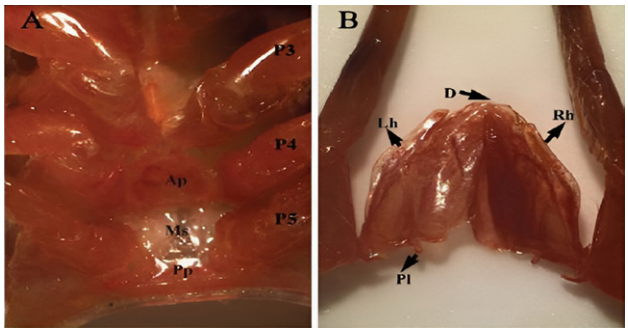
to erroneous estimation. Moreover, it is not certain that all the matured ovaries may lead to successful spawning which is dependent on many direct and indirect factors. Hence, the best method to study the spawning period is to monitor the berried females in the landings. This methodology will also help in keeping uniformity in the reporting. This data will give a clear picture of the spawning period of a species in a region. Earlier studies clearly showed that in most of the species, there are major and minor peaks of spawning. The formula to be followed for estimating the percentage of berried crabs is:

$$\text{Berried \%} = \frac{B}{IM+MNB} \times 100 \quad \text{where}$$

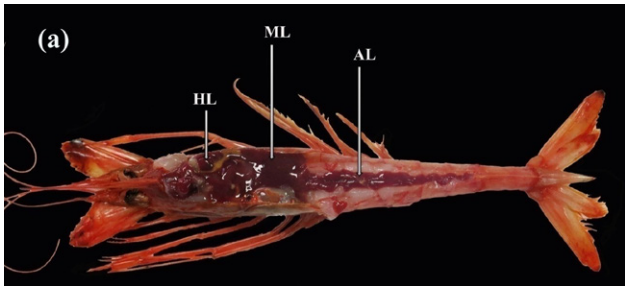
B – berried, IM – immature, MNB – mature not berried.

Deepsea penaeid shrimps– *Aristeus alcocki*

The developmental stages of the ovary are determined by both macroscopic and microscopic analysis. Macroscopic analysis was used to categorize the developmental stages based on the shape, structural dimensions, and colour of the gonads. Five stages were distinguished in females of *Aristeus alcocki.*



Reproductive morphology of *Aristeus alcocki*: ventral view of thelycum (A); P3, third pereopods; P4, fourth pereopods; P5, fifth pereopod; Ap,anterior portion; Pp, posterior portion; Ms, median surface; petasma (B): Lh, left half; Rh, right half; D, distal end; Pl, papilla;



Reproductive organelles: (a) Female (HL-Head lobules, ML-middle lobules, AL-abdomen lobules)

Stage I (Immature-IM)

The ovary is thin, translucent, colorless, tubular, and located postero-dorsally from the carapace to the fifth abdominal segment in two parallel, empty branches.

Stage II (Early Mature-EM)

The ovary size increases, extending antero-posteriorly with light pinkish coloration.

Stage III (Late Mature-LM)

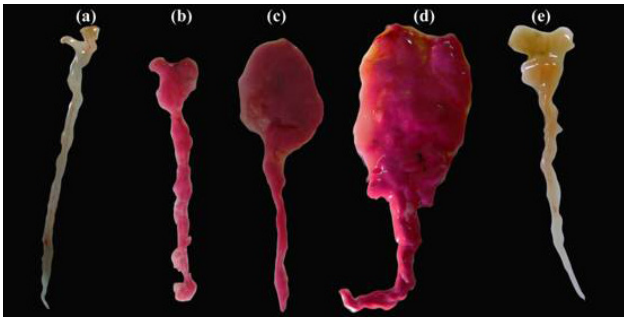
The two lobes of the ovary expand towards the cephalothoracic, hepatopancreatic, and abdominal regions above the gut; pinkish; clearly visible through exoskeleton.

Stage IV (Mature-M)

Ovary dark pink or violet, distinctly visible through exoskeleton from cephalothorax to sixth abdominal segment. The ovary expands, with anterior and middle lobes occupying 50% of cephalothorax.

Stage V (Spent-SP)

After maturation, eggs were extruded and ovary was found to be flaccid and pale white.



Macroscopic view of the ovary in *A. alcocki* during maturation process a) Stage I: IM; b) Stage II: EM; c) Stage III: Late Mature; d) Stage IV: Mature; and e) Stage V: Spent.

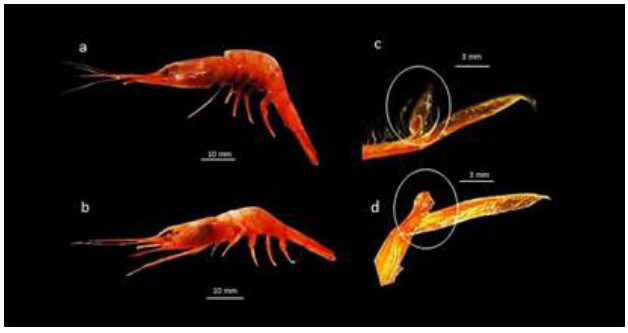
Based on the ovarian development the Mature includes stages III and IV (LM+M) and the peak represents the spawning peak which varies from species to species and with time in deepsea penaeid shrimps. Females are classified into five groups based on ovarian maturation: Stage I: Immature (IM); Stage II: Early maturing (EM); Stage III: Late Mature (LM); Stage IV: Mature (M); and Stage V: Spent (SP).

$$\text{Maturity \%} = \frac{LM+M}{EM+LM+M+SP}$$

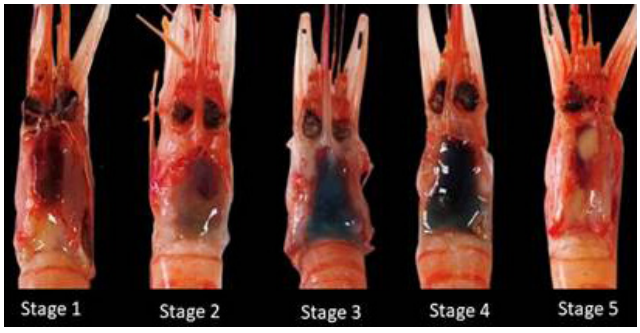
The month(s) having the highest maturity % is considered as peak spawning period.

The Immature (IM) is not included in the calculation of maturity % and spawning peak. The Spent (SP) stage is also not included to calculate the proportion of maturity as the shrimps have already released the eggs and thus not contributing to the spawning peak.

Deepsea non-penaeid prawn– *Plesionika semilaevis*



Ovigerous (a) and non-ovigerous (b) females of *Plesionika semilaevis*, (c) leaf-shaped endopod of first pleopod in females (c) and blunt-shaped endopod of first pleopod in males (d).



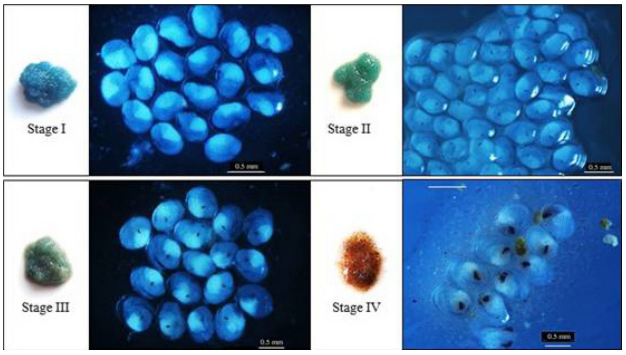
Macroscopic variation in different stages of ovarian development: Stage 1: IM (Immature); Stage 2: EM (Early Mature), Stage 3: LM (Late Mature); Stage 4: M (Mature); Stage 5: SP (Spent)

Calculation of maturity % based on the ovarian development:

$$\text{Maturity \%} = \frac{LM+M}{EM+LM+M+SP}$$

Calculation of maturity % based on the on the berried and non-berried shrimps:

We can classify all the females into three groups
IM=immature= size below the LM50
MNB=Matured but non berried



Macroscopic and microscopic variation in different stages (I-IV) of berried shrimp, *P. semilaevis*. (color of the berry varies from species to species)

B=Berried= all the colours of the berry

$$\text{Maturity \%} = \frac{B}{MNB+B}$$

The month/s having highest maturity % is considered as peak spawning period

Inshore lobster– *Panulirus polyphagus*

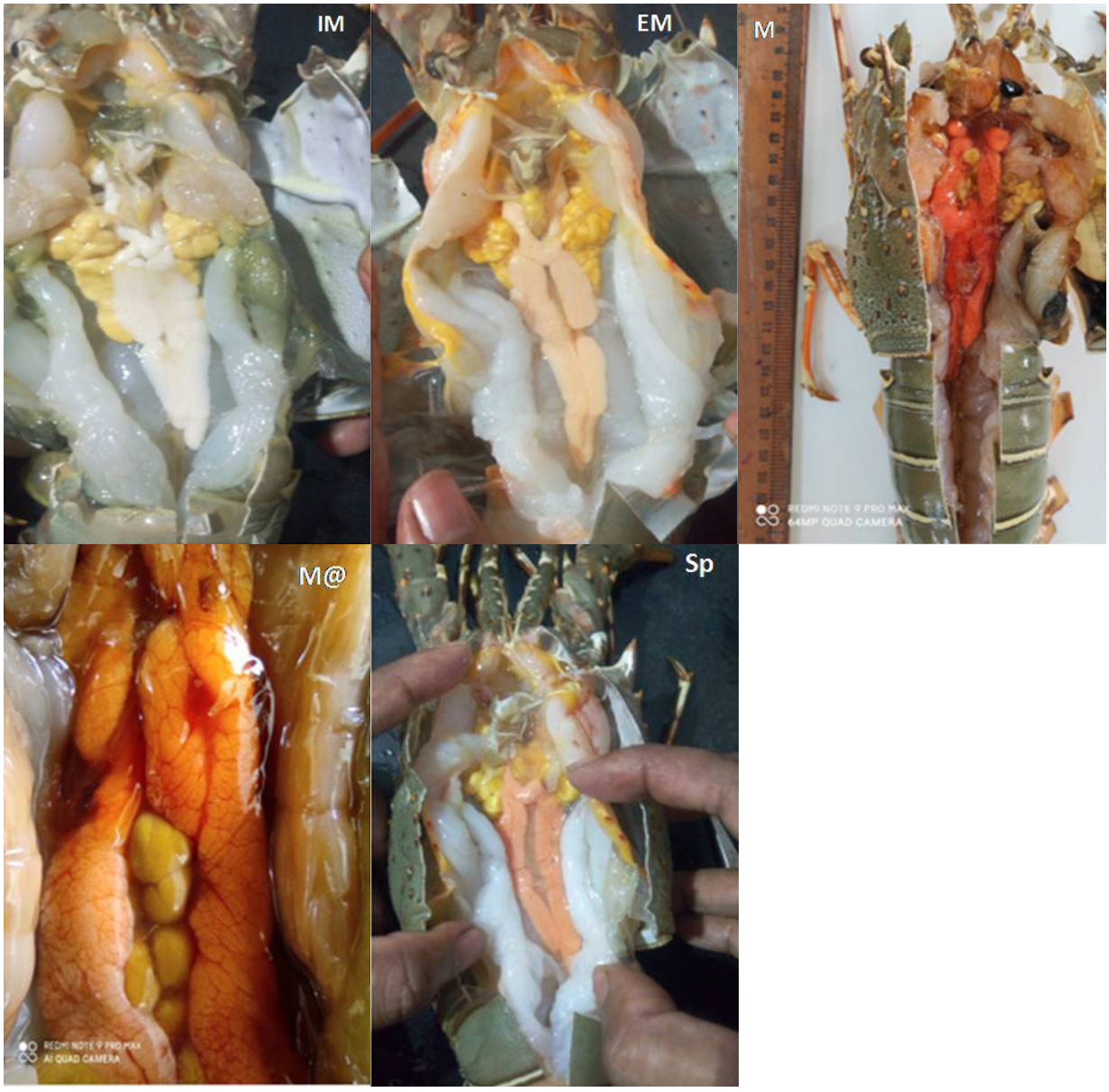
According to Silva and Landim (2006), the developmental stages of ovaries are:

1. Immature stage (IM): Ovaries with slender anterior and posterior lobes restricted to the body cavity. Ovaries are whitish and difficult to distinguish from surrounding muscles.

2. Early maturation stage (EM): Ovaries have grown in volume and extension with pinkish or light yellowish in color, the organ appears distended and firm to touch indicating multiplication of germ cells (early stage vitellogenesis).

3. Mature stage (M): The ovary is fully developed and occupies all available space in the body cavity; it becomes more sinuous and may extend onto the second abdominal segment. The color of the ovary is orange or reddish and the nodes or cysts give the surface a nubbly look.

4. Spawning or resorption stage (SP): After spawning, oocytes and other cells may be resorbed by the ovaries. The gonad becomes transparent and flaccid with pigmented areas and empty spaces internally. The color and size of the ovary are more or less similar to the immature or pre-mature stage.



Ovarian development (IM,SP); immature ovary (IM), early maturation stage (EM), matured stage (M,M@), resorption stage (SP)

Calculation of maturity % based on the ovarian development:

$$\frac{M}{M+SP}$$

Calculation of maturity % based on the development of berry:
Females can be classified into three groups
IM=immature= size below the LM50
MNB=Matured but non-berried
B=Berried= all the colours of the berry

$$\text{Mature \%} = \frac{MNB+B}{IM+MNB+B}$$

Berry- of all colours, (yellow, orange, bright orange, brown/ black) is considered for calculating the spawning peak. Immature specimens are excluded for the calculation of spawning peak. The month/s having highest maturity % is considered as peak spawning period

The methodology reported above may be suitably adopted for all species occurring in the various groups such as deep sea penaeid and non-penaeids and lobsters.

References

Rao, P.V. 1964. *Fish.Fish.Rep.*,57: 285-302.

Silva and Cruz Landim. 2006. *Braz.J.Morphol.Sci.*, 23(3-4): 479-486.