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Reproductive biology of the Indian scad, *Decapterus russelli* (Ruppell, 1830) from Maharashtra waters, northwest coast of India

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Original Article

Abstract

The length at which 50% of females of *Decapterus russelli* attain maturity was estimated at 153 mm. The presence of mature, ripe and spent gonads was observed from June to October and December to April indicating prolonged spawning season. The sex-ratio (male: female) varied from 1:0.43 in 140-149 mm to 1:1 in 110-119 mm length groups. Month-wise distribution of sex-ratio indicated significant predominance of male at 5% in April, May and November. The absolute fecundity ranged from 29,986 to 1,52,123 eggs. The relative condition factor value was highest in January which indicates the peak spawning month. Length-wise condition factor of males and females were maximum in the length range of 100-229 mm. In the present study size of ova diameter ranged from 0.01 to 0.97 mm.

Keywords: *Decapterus russelli, Maharashtra, length at maturity, spawning season, relative condition factor, fecundity*

Introduction

Indian scad, *Decapterus russelli* contributes substantially to the carangid fishery all along the Indian coast (Reuben *et al.*, 1992) and in Mumbai they contribute 30-40% towards the total carangid fishery by trawl in Mumbai region (CMFRI, 1985-2008). The major landing centres of Maharashtra such as New Ferry Wharf (NFW), Sasoon Docks and Versova are situated in Mumbai (Mane and Sundaram, 2011) and they account for nearly 60% of Maharashtra landings (Annam and Sindhu, 2005) hence the species from these centres can be considered as representative of Maharashtra state.

Reproductive biology of *D. russselli* has been studied by a number of workers from various coasts of India (Murty, 1991; Reuben *et al.*, 1992; Sunil and Suryanarayanan, 1994; Moiseeva and Zhuk, 1995; Tamhane, 1996; Raje, 1997;. Balasubramanian and Natrajan, 2000; Manojkumar, 2007).

Since ecological factors affect the biological and reproductive characteristics of fish population these kind of investigations need to be carried out periodically (Sasi, 2008). Therefore the present work was taken up with the objective to enhance our understanding of the reproductive biology of *D. russelli* off Mumbai coast which will be further useful in the management of the species.

Material and methods

During the period September 2005 to May 2007, weekly samples of *D. russelli* were collected from the trawlers operated at New Ferry Wharf. Out of 812 fishes, 331 were females and 481 were males. The length (L) and weight (W) were taken as described in CMFRI (1995). As mechanised trawling was suspended from 10th June to 15th August, due to southwest monsoon and restrictions imposed by the government of Maharashtra, samples could not be collected for the month of July.

Length at first maturity

Females between III and VI stages of maturity and males between III and IV stages of maturity were considered for this study. The cumulative percentage of males and females was calculated against their length groups at 20 mm and 25 mm class intervals for females and males, respectively, and maturity curve was plotted (Fig. 1).

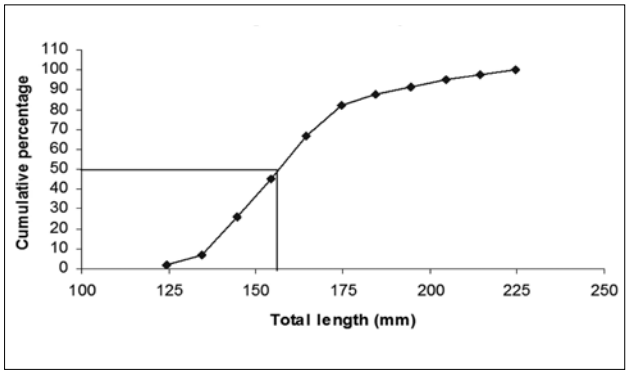

Fig. 1. Length at first maturity in *D. russelli* (males)

Spawning periodicity

Ovaries were dissected out from fresh specimens and weighed to the nearest milligram on a sensitive electronic balance. Maturity stages of *D. russelli* were noted and one lobe of the ovary was preserved in 5% formalin for ova diameter studies. Sub-samples from anterior, middle and posterior regions of the ovary were taken and mixed. Diameter of 500 ova was measured under digital microscope. Ova measuring below 0.05 mm were not considered for evaluating percentage of frequencies. The measured ova were grouped into 0.05 mm class intervals and their frequency polygons were drawn as described by Clark (1934), Palekar and Karandikar (1952) and Prabhu (1956).

For studying maturity and spawning season 328 females were examined. The maturity stages were classified exclusively depending on the stages of ovary and size of ova. Preliminary examination did not reveal much difference in the month-wise occurrence of different maturity stages between the years 2005-2006 and 2006-2007. The percentage of occurrence of various stages was pooled and represented graphically. The spawning period was ascertained from the occurrence of ripe and spent ovaries.

Relative condition factor (Kn)

This is an overall measurement of robustness or well being of the fish. For the determination of condition cycle of fish throughout the year, the condition factor was calculated for male and female separately. The relative condition factor was calculated using Le Cren (1951) formula given as, Kn = WO/WC, Where WO is the observed weight and WC is the calculated weight.

Fecundity

Fecundity was estimated by sub-sampling and examining a total of 46 mature ovaries preserved in 5% formalin for a week before counting of ova. Estimation was by gravimetric method (Mac Gregor, 1957) which involved counting the number of mature ova from a known weight of mature/ripe ovary. 0.05 g of ovary was sampled from three segments (anterior, middle and posterior) of each ovary with accuracy of 0.001g. Each portion was teased out and the ovary samples were spread evenly on a counting slide with aid of few drops of water. Number of mature ova of each portion was counted with a magnifying glass and average number of ova of the three portions was determined and the fecundity was calculated using the formula: Fecundity = Weight of paired ovary/weight of sample X Number of ova counted.

The relationship with various body parameters *i.e* total length (TL), total weight (TW) and ovary weight (OW) were established as per Least Square method. (Snedecor and Cochran, 1967).

Sex-ratio

As there are no external distinguishing characters by means of which the sexes of the species could be distinguished, the sex was recorded after dissecting the fish. Sex-ratio was estimated from the number of specimens of each sex sampled every month. Month-wise data from September 2005 to May 2007 was pooled together. Ratio of male and female in the sample was calculated month wise and lengthwise. For determining homogeneity of distribution of male and female, Chi square test (Snedecor and Cochran, 1967) was applied: Chi square = $(O-E)^2/E$. Where, O and E denote observed and expected values respectively.

Developmental stages and annual ovarian cycle

Ovaries of fresh specimens of *D. russelli* were used to study

developmental stages. Based on microscopic examination of ovaries and microscopic structure and size of ova the stages have been identified for the females and as per the International Council for Exploration of Sea (ICES) scale as immature (I), Early maturing (II), Maturing (III), Late maturing (IV), Mature (V), Ripe (VI) and spent stages (VII) were identified (Wood, 1930); and based on the morphology of the testis and oozing of milt, stages in males were identified. Male gonads were identified as Immature (Stage I), Maturing (Stage II), Mature (Stage III), Ripe (Stage IV) and Spent (Stage V)

Results and discussion

Length at first maturity

The maturity curve for males and females is given in Fig. 1 and Fig. 2 respectively. The percentage distribution of maturity stages according to different length groups are presented in Table 1. The length at which 50% of the females attain maturity was calculated as 153 mm, which is in conformity with the observations of Murty (1991) and Manojkumar (2007). However Raje (1997) reported a very high value of 189 mm as the length at first maturity for *D. russelli* from Mumbai waters. In contrast very low value of 120 mm for males and 130 mm for females was reported by Brinca *et al.* (1983) from Mozambique. Variations in maturity length of *D. russelli* from different regions as stated above may be attributed to the differences in the environmental factors.

Sex-ratio

There are no external distinguishing characters by means of which the sexes of the species could be distinguished. The sex was recorded after dissecting abdomen of the fish. Month-wise data from September 2005 to May 2007 was pooled together for this purpose. The ratio was tested by 1:1 method of chi-square. Lengthwise distribution of sex-ratio is presented in Table 3. The sex-ratio (male to female) varied from 1:0.43 in 140-149 mm length group to 1:1 in 110-119 mm length group. Lengthwise distribution of sex-ratio indicated significant predominance of males at 5% in 130-179 mm group.

Monthly and yearly percentage of males and females showed that the males dominated over the females (Table 4). The total sex-ratio was found to be 1:1.45. Month wise distribution of sex-ratio indicated significant predominance of male at 5% in April, May and November, whereas the total sex-ratio over the year was significantly male dominated at 5% level. Since the reproductive potential of many fish communities is determined by the number of females available for egg production highly male-biased sex-ratios would likely affect population structure and the viability of sensitive stocks (Ospina and Piferrer, 2008). Slightly higher ratio in the present study is not likely to affect the future population as highest numbers of females were seen in the

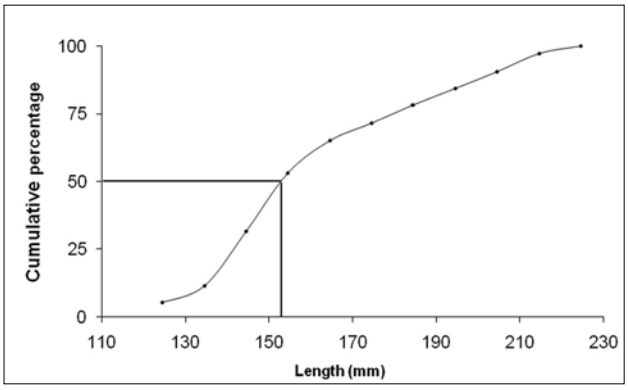

Fig. 2. Length at first maturity in *D. russelli* (females)

Table 1. Length-wise percentage distribution of maturity stages in females of D. russelli

Length group (mm)	No. of females examined	Maturity stages						
		I	II	III	IV	V	VI	VII
110-119	4	100	-	-	-	-	-	-
120-129	4	100	-	-	-	-	-	-
130-139	7	71.429	14.286	-	14.286	-	-	-
140-149	20	65	0	-	5	5	25	-
150-159	29	55.172	17.241	3.448	0.000	3.448	10.345	10.345
160-169	39	17.949	20.513	12.821	7.692	2.564	28.205	10.256
170-179	58	12.069	18.966	3.448	6.897	6.897	27.586	24.138
180-189	70	4.286	5.714	5.714	7.143	4.286	40.000	32.857
190-199	48	3.922	1.961	3.922	3.922	3.922	39.216	43.137
200-209	31	3.226	-	9.677	-	6.452	51.613	29.032
210-219	13	-	-	-	-	7.692	69.231	23.077
220-229	5	-	-	-	-	-	80	20
Total	328							

Table 2. Month-wise percentage distribution of maturity stages of females of *D. russelli*

Months	Number of females examined	Maturity stages						
		I	II	III	IV	V	VI	VII
Jan	35	2.857	-	8.571	2.857	8.571	68.571	8.571
Feb	33	-	6.061	-	6.061	6.061	57.576	24.242
Mar	64	9.375	17.188	4.688	4.688	3.125	32.813	28.125
Apr	51	13.725	13.725	1.961	5.882	3.922	31.373	29.412
May	24	37.500	20.833	8.333	-	-	12.500	20.833
Jun	3	-	-	-	-	-	66.667	33.333
Jul	-	-	-	-	-	-	-	-
Aug	-	-	-	-	-	-	-	-
Sep	8	-	-	-	-	25	25	50
Oct	44	18.182	9.091	2.273	13.636		34.091	22.727
Nov	19	68.421	10.526	-	-		5.263	15.789
Dec	50	27.451	3.922	6	6	8	46	4
Total	331							

Table 3. Length-wise sex-ratio in *D. russelli*

Length group (mm)	Males	Females	Total	Expected	% of males	% of females	Sex ratio	Chi square value
110-119	4	4	8	4	50.00	50.00	1:1.00	0
120-129	5	4	9	4.5	55.56	44.44	1:0.80	0.11
130-139	13	7	20	8.5	65.00	35.00	1:0.54	10.77*
140-149	47	20	67	33.5	70.15	29.85	1:0.43	10.88*
150-159	64	29	93	46.5	68.82	31.18	1:0.45	13.17*
160-169	71	39	110	55	64.55	35.45	1:0.55	9.31*
170-179	89	58	147	73.5	60.54	39.46	1:0.65	6.54*
180-189	84	70	154	77	54.55	45.45	1:0.83	1.27
190-199	61	48	109	54.5	55.96	44.04	1:0.79	1.55
200-209	32	31	63	31.5	50.79	49.21	1:0.97	0.01
210-219	15	13	28	14	53.57	46.43	1:0.87	0.14
220-229	7	5	12	6	58.33	41.67	1:0.71	0.33

* Significant at 5 %

length group of 140-159 mm and length at first maturity for females of the species is 153 mm

Fecundity

Absolute fecundity was determined in 46 specimens in the size range of 149 to 228 mm in total length with the corresponding total weight ranging from 28.55 to 118.47 g. The absolute fecundity ranged from 29,986 to 1,52,123 eggs for the ovary weighing between 0.601 to 4.3 g. The findings on fecundity are comparable with those of Tamhane (1996).

Linear relationship between fecundity and length of fish was established as: $F = - 2.8409 + 3.3682\ L$ ($r^2 = 0.8332$), linear relationship between fecundity and weight of fish was established as: $F = 3.0615 + 0.9797 * W$ ($r^2 = 0.8447$) and linear relationship between fecundity and weight of ovary was established as: $F = - 4.4413 + 1.0684*Wo$ ($r^2 = 0.8396$), (Where F is the fecundity, L is the total length, W is the total weight, Wo is the total weight of ovary and r^2 is the coefficient of determination). Comparatively better correlation was seen between fecundity and weight of fish. The same was also reported by Tiews *et al.* (1975); Sreenivasan (1981) and Manojkumar (2005)

Relative Condition factor (Kn)

Month wise condition factor (Kn) for males and females of *D. russelli* is given in Fig 3. Month-wise distribution of condition factor in males shows that it remains more or less stable in all months except in September when it declines to 0.91. The Kn values for males were high in January (1.06) and February

Table 4. Month-wise sex-ratio in *D. russelli*

Months	Males	Females	Total	Expected	% of males	% of females	Sex ratio	Chi square value
Jan	28	35	63	31.5	44.44	55.56	1:0.80	0.70
Feb	45	33	78	39	57.69	42.31	1:1.36	1.84
Mar	87	64	151	75.5	57.62	42.38	1:1.36	3.50
Apr	91	51	142	71	64.08	35.92	1:1.78	11.27*
May	50	24	74	37	67.57	32.43	1:2.08	9.13*
Jun	12	3	15	7.5	80.00	20.00	1:4.00	5.40
Sep	10	8	18	9	55.56	44.44	1:1.25	0.22
Oct	64	44	108	54	59.26	40.74	1:1.45	3.70
Nov	53	19	72	36	73.61	26.39	1:2.79	16.05*
Dec	41	50	91	45.5	45.05	54.95	1:0.82	0.89
Total	481	331	812	406	59.24	40.76	1:1.45	27.71*

* Significant at 5%

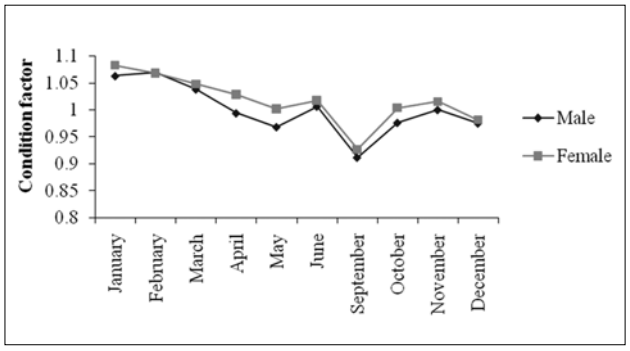

Fig. 3. Monthly condition factor of male and female

(1.07) perhaps reflecting the spawning season. In females also the condition factor was more or less stable throughout except in September with a value of 0.93. The highest value was in January (1.08) which indicates the peak spawning season.

Lengthwise condition factor of male and female in the length range of 100-229 mm was estimated and is depicted in Fig 4. Condition factor estimated for males and females does not show much variation. In males and females the highest condition factor was seen in the range of 150-159 mm with values 1.04 and 1.05 respectively. The size at first maturity also falls in this range. The lowest values in males and females fell in the range of 120-129 mm with values 0.94 and 1.00 respectively.

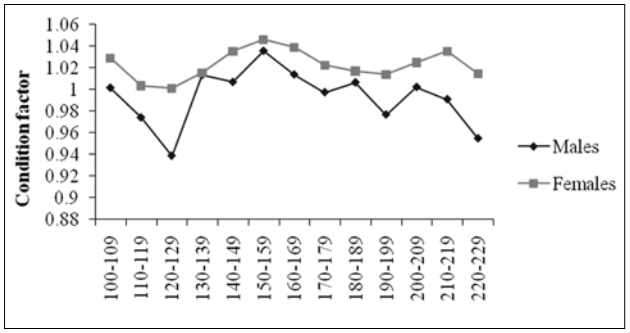

Fig. 4. Length-wise condition factor of males and females

The condition factor was high in most of the months and it fell in a narrow range of 0.92-1.07 strengthening the earlier conclusion that this species has prolonged spawning season.

Annual Ovarian Cycle

Frequencies of 8 ovaries are represented in Fig 5. Immature eggs measuring less than 0.05 mm were present in almost all stages of ovary and can be named as general egg stock. Ovary 'A' shows one distinct mode at 0.05 mm representing the immature ova. The largest egg measured was 0.18 mm in diameter. The ovary 'B' showed one mode at 'a' with egg measuring 0.36mm. These eggs belonged to the maturing stock. The largest egg measured was 0.44 mm. Ovary 'C' also belonged to the maturing group with 2 modes 'a' at 0.28 mm and the other mode 'b' at 0.41 mm which shows that some of the eggs drawn from the general stock were under the process of maturation. The largest egg measured was 0.55 mm. Ovary 'D' again showed two modes 'a' and 'b' at 0.38 mm and 0.46 mm respectively with the largest egg measuring 0.57 mm. One batch of maturing eggs from previous stock was mature as seen at mode 'b'. Similarly ovary 'E' also showed 2 modes one 'a' at 0.13 mm which represents a fresh batch of immature eggs and another mode 'b' at 0.46 mm which was a batch of mature eggs. Ovary 'F' was a ripe ovary with 2 modes 'a' and 'b' at 0.35mm and 0.55mm respectively. Here one batch was ready to spawn while the other batch was in the process of maturation. The largest egg seen was 0.68 mm. Ovary 'G' was again a ripe ovary with two modes 'a' at 0.47 mm and 'b' at 0.58 mm. The eggs measuring between 0.65 mm and 0.97 mm were few in number. The largest egg found was 0.97 mm. This ovary may be a partially spent ovary with one batch of ova released and the ova at mode 'b' ready to be spawned. Ovary 'H' showed only one mode at 0.2 mm representing a fresh batch of immature ova. Few eggs of almost every other stages

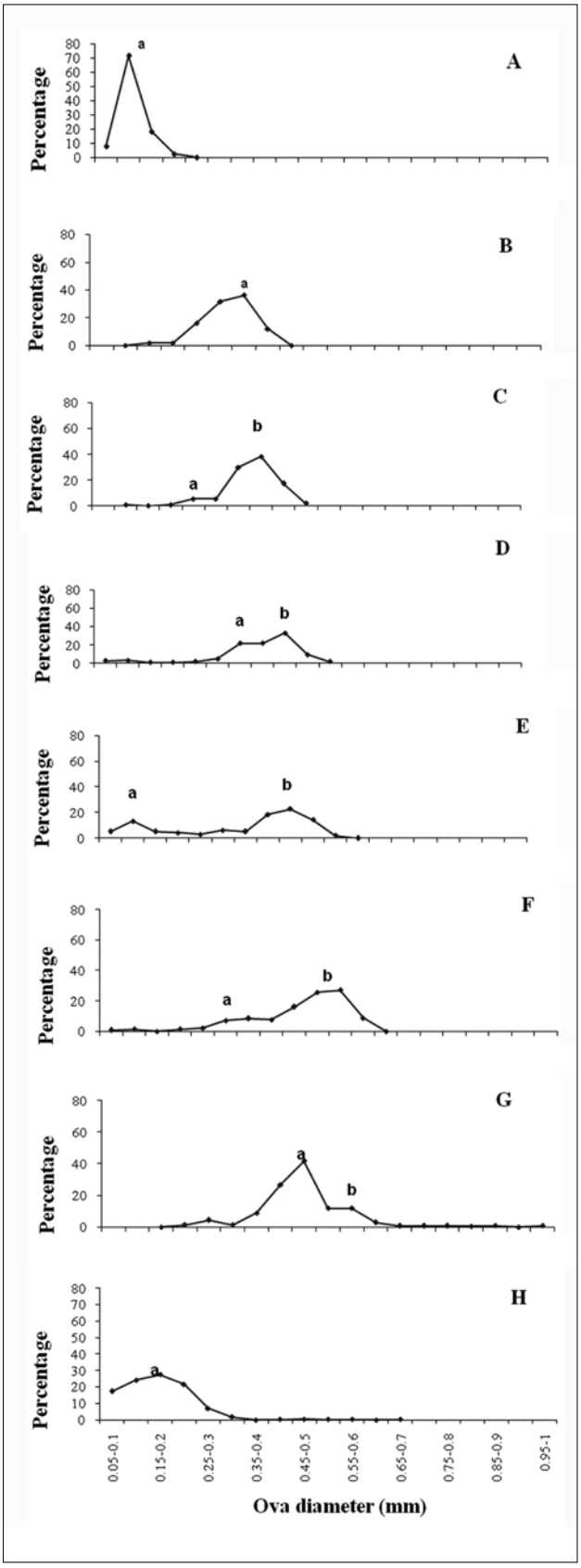

Fig. 5. Ova diameter frequency in *D. russelli* in different stages of maturity

were observed. The largest being that of 0.68 mm diameter. The observation was suggestive of it being a spent ovary.

In the present study size of ova diameter measured ranged from 0.01 to 0.97 mm. The species seems to spawn twice in a season and the period between two spawning may not be a long one.

Ova diameter studies by Murty (1991) indicate that spawning takes place in two batches during a season. Ova diameter ranging from less than 0.06 to 1.02 mm was reported by Manojkumar (2007) from Malabar Coast which is much higher than that of 0.03 to 0.55 mm reported by Tamhane (1996) from Mumbai waters. The reduced size of ova diameter in the present study may be attributed to the differences in environmental conditions including the diet.

Spawning season

Study on month-wise percentage of maturity stages of females revealed the immature gonads from October to May, maturing stages from October to January and March to May and mature females from September to March and June with a peak in September (Table 2). Ripe females were present almost throughout the year. There was no data in the months of July and August as trawling was suspended due to monsoons. Mature females were observed in June, so the ripe females are expected to be present in July. During September 50% fishes were spent which shows that in August, ripe females would be present. So it can be concluded that ripe females occurred throughout the year with a peak from December to February and another peak in June. The presence of mature, ripe and spent gonads from June to October and December to April indicates prolonged spawning season. It is also supported by the presence of spent gonads throughout the year. However, the percentage occurrence of spent gonads from November to January was very low as compared to other months with a peak in September.

Delsman (1926), Tiews (1958) and Tiews *et al.* (1975) observed prolonged spawning period for *Decapterus* sp. from Java Sea and Manila Bay. In the Indian waters, Sreenivasan (1981) reported prolonged spawning for *D. dayi* extending from February to November with peak during February and March. Raje (1997) reported November to May as the spawning season. Reuben *et al.* (1992) were of the view that December and August is the peak spawning period for this species from Northwest coast of India. Murty (1991) documented December to August as spawning period in Kakinada waters while in Vizhinjam waters it spawned during March to May. Balasubramanian and Natrajan (2000) reported November and December and Manojkumar (2007) reported March to December as the spawning period from Malabar

region. The present study showed December to March and June to October as the spawning period with peak in January and September. Different workers reported different spawning period which were overlapping. This suggests that as the species is a continuous breeder and though the ovary may be ripe, they spawn only when the conditions are favourable. However favorable conditions may vary from place to place depending upon the prevailing environmental conditions of the given area. This may be the reason for the differences in the spawning period reported by various workers

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