

LUNAR, DIURNAL AND TIDAL PERIODICITY IN RELATION TO THE PRAWN ABUNDANCE AND MIGRATION IN THE GODAVARI ESTUARINE SYSTEMS

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[Preliminary investigations to study the lunar, diurnal and tidal periodicity in abundance and migrations of prawns were made in the Bairavapalam distributary of the Goutami branch of the Godavari estuary during the period November 1961 to July 1962. The study was based on observation of the catches of a stake net (bag net) operated near the mouth of the estuary. Records of the catches were maintained tidewise daily. Comparative estimates of abundance were made on the basis of catch per hour's operation.

It was generally observed that the catches were higher during the darker half of the month than in the brighter fortnight. The landings during low tides were generally higher than those during high tides and usually heavier catches were made during nocturnal low tides than during the day low tides.

A continuous inward and outward (immigration and emigration) movement of prawns of all size groups was observed in the estuary from November to July. In general, more penaeid prawns were found to be immigrating at dawn than at dusk. Similarly, the number of emigrants was also found to be generally higher during the new moon period than during the full moon.

Metapenaeus monoceros showed an almost distinct nocturnal periodicity in migration, while no such periodicity was observed, distinctly, in other species. In the case of *Penaeus indicus* the movement of migrants was prolonged. In *M. brevicornis* the migrants were scarce till March and thereafter increased numerically. The migrant forms of *Metapenaeus dobsoni* continued to be abundant till May with peak periods in January and February. The migratory pattern of *Metapenaeus affinis* was similar to that of *Metapenaeus brevicornis*, though the migrants of the former species appeared a month earlier than the latter. Intensive studies over extended areas for longer periods are required to understand clearly the migratory pattern of the various species. The phenomenon of immigration of prawns can be clearly understood only by vital staining or tagging studies. Perhaps the emigrants might be returning with the succeeding changing tide. To verify this, laboratory experiments, by vital stains, were conducted. The marked specimens, if released during the low tides on a large scale, may be recaptured during the subsequent high tides and the duration also may be calculated. At least some percentage of the emigrants remains in the sea for maturity and breeding.]

Introduction

It is a well known fact that the estuaries and backwaters are rich in prawn fisheries. Various types of tackle are used for catching the prawns in different parts of the country. The bag net or the stake net is the commonest gear employed on both coasts of India, though the size and mode of operation differ widely in the different localities. There is a very rich stake net fishery in all the estuarine systems of the river Godavari almost throughout the year. The mode of operation of the net has been described in detail by several earlier workers and recently a profitable stake net fishery has been reported from Upputeru river (Venkataraman et al., 1955). In the Vainatheyam estuary and some shallow parts of Gautami estuary, the net is tied to permanently fixed posts. In the mouth region of the Gautami estuary the net is supported by strong ropes tied to an anchored boat, instead of poles, due to strong tidal currents and depth at the mouths. The mode of operation is similar to the description given by Menon and Raman (1961).

During floods, from July to September, when fresh water discharges are maximum, a salt-water wedge penetrates at the bottom of the estuaries, carrying with it huge populations of a palaemonid prawn, *Palaemon (Nematopalaemon) tenuipes*. All the three river mouths, namely the Gautami, Vasistha and Vainatheyam, are rich in this fishery till October, until the floods recede. From November onwards the same net is operated both at high tide and low tide to catch the migratory prawns, fishes etc., usually at nights, till about June.

The fishermen state that their catches are poorer during the full moon quarter than during the new moon quarter. They also believe that the prawns migrate to the sea in large numbers more during the night than during the day.

Knowledge about these aspects, related to the lunar, diurnal and tidal rhythms, is, however, very poor. Racek (1959) while investigating the prawn fisheries of the

estuaries and off-shore waters in New South Wales distinguished distinct lunar and diurnal abundance in prawn catches and their migrations from the inside to the offshore waters. Very recently Menon and Raman (1961) studied the fluctuations in prawn fisheries and their correlation with rainfall and strength of the tidal currents, by operating a couple of stake nets in Cochin backwaters. They, however, could not find much variation in the catches made during the full moon fortnight and new moon fortnight. Ingle et al. (1959) and Iverson and Idyll (1959) stated that the prawn catch in Tortugas, Florida, is very poor when the moon is full.

Apart from these published accounts, the lunar, diurnal and tidal periodicity in relation to the prawn abundance and migration is not perfectly known. Hence an attempt was made to verify these aspects by operating a stake net near the mouth of the Bhairavapalem distributary of the Gautami estuary.

Materials and Methods

The material was collected from a stake net operated at the mouth of the Bhairavapalem distributary of the Gautami estuary from November 1961 to July 1962. Usually the fishing intensity was noticed during the darker fortnight only. The catches for all the four tides during the full moon and new moon (two low tides and two high tides) days were approximately estimated, by taking the weight of the total catch of each tide separately. The low tides coincided with the day and night hours while the high tides coincided with the dawn and dusk hours on the full moon and new moon days. The prawns and fish in each catch were separated and their relative weights determined. The duration of operation of the net for each tide has also been recorded and the number of prawns of each species found in each catch counted and the approximate number per hour calculated. The catch per hour for each tide is also determined. The total commercial landings for the full moon and new moon fortnight have also been estimated approximately.

TABLE I

ABUNDANCE IN PENAEID PRAWNS BY THE STAKE NET IN THE
GAUTAMI ESTUARY
(low tide catches)

Months (1961 — '62)	Lunar Phase	Total catches during low tide at	
		Day (Kg)	Night (Kg.)
November	Full Moon	...	44.95
December	New Moon	...	1148.62
	Full Moon	...	499.40
January	New Moon	1153.61	5033.95
	Full Moon	786.78	961.57
February	New Moon	3995.20	5493.40
	Full Moon	...	1258.49
March	New Moon	367.29	6921.68
	Full Moon	22.70	606.99
April	New Moon	2696.76	4194.96
	Full Moon	349.58	2247.30
May	New Moon	3146.22	9788.24
	Full moon	244.71	1817.82
June	New Moon	2317.22	6082.69
	Full Moon	599.28	2756.69
July	New Moon	...	3745.50

TABLE II

ABUNDANCE IN PRAWNS BY THE STAKE NET IN THE GAUTAMI ESTUARY
(High Tide Catches)

Months (1961 — '62)	Lunar phase	Total catches during high tide at	
		Dusk (Kg)	Dawn (Kg)
November	Full Moon	27.69	4.99
December	New Moon	48.98	1448.26
	Full Moon	159.81	359.57
January	New Moon	6082.69	5243.70
	Full Moon	1048.74	437.20
February	New Moon	1498.20	3620.65
	Full Moon	769.08	734.12
March	New Moon	3032.72	2097.48
	Full Moon	11.35	179.78
April	New Moon	1207.19	2283.62
	Full Moon	707.79	599.28
May	New Moon	2272.27	2796.64
	Full Moon	384.54	489.41
June	New Moon	4055.13	3186.17
	Full Moon	1797.84	779.06
July	New Moon	3370.95	2497.00

Results

Abundance studies: It was noticed that the 'night low tide' catches were usually higher than the catches during the day low tide, while the high tide catches both during

the dawn and dusk were irregular (Tables I and II). The 'total high tide' catches, however, were more or less similar both during the dawn and dusk (Table III).

TABLE -- III.

Year	Day Low tide (M. tons)	Dusk High tide (M. tons)	Night Low tide (M. tons)	Dawn High tide (M. tons)
1961-62				
Total	15,667	27,239	52,578	26,649
Prawns	4,155	12,679	19,903	11,857
Fish	11,512	14,560	32,675	14,792

It was also noticed that the catches of the darker fortnight were more abundant than

the full moon fortnight both in case of fish and prawns (Table-IV ; Fig. 2).

TABLE — IV.

Year	Full Moon (M. tons)	New Moon (M. tons)	Total (M. tons)
1961-62			
Total	20,665	101,468	122,133
Prawns	8,992	39,614	48,606
Fish	11,674	61,854	73,528

The catch/net/hour data also confirm the above findings (Fig. 3).

The salinity is relatively low till about January and it increases gradually during the subsequent months in the mouth region of the estuary. The prawn catches were relatively rich and greater than fish in the total catches upto January. Thereafter the fishes showed an increase till about May after which the prawns again increased in their relative proportions (Fig. 2).

Migratory behaviour: The migratory behaviour of the commercial prawns, *Metapenaeus monoceros*, *Metapenaeus brevicornis*, *Metapenaeus dobsoni*, *Metapenaeus affinis*, *Penaeus indicus* and *Penaeus monodon* are considered here, based on 18,000 individuals.

There was a continuous inward and outward (immigration and emigration) movement of prawns of all size-groups in the

estuary from November to July (Fig. 4). The intensity of migration was noticed during December, February, April, May and June months (Fig. 5). In general the total number of all penaeid species immigrating was relatively higher at dawn than at dusk; similarly the total emigrants were more in numbers during the night than during the day. A few exceptions were, however, noticed in both types of migrations. The number of migrants was generally found to be greater during the new moon day than the full moon day (Fig. 5).

Metapenaeus monoceros (Fig. 4): The emigration was noticed throughout the period of observation, but the movement was almost nocturnal. The immigrants were relatively more in numbers in the dawn catches than the dusk catches. Usually the number of emigrants was greater than the immigrants. Generally the immigrants and emigrants were

seen relatively richer on the new moon days than the full moon days. The outward migration of this species was seen intense during the months of December, May and June. The size of the migrating prawns ranged between the size groups 11-15 mm. and 91-95 mm. and the mode of emigrants was at 46-55 mm. The immigrants were largely of small size.

Metapenaeus dobsoni (Fig. 6) : The emigration was noticed throughout the period of observation and there was much variation between the day and night numbers. Sometimes the day emigrants were more in numbers than the night emigrants. The immigrating prawns were usually more in numbers in the dawn catches than the dusk. Usually the number of immigrants was less than the emigrants, with few exceptions. Generally the emigrants and immigrants were found in greater numbers on the new moon days than the full moon. The period of intense emigration was observed during the months of January, February and May. The size of the migrating prawns ranged between the size groups 11-15 mm. and 86-90 mm. and the mode was observed at 46-55 mm.

Metapenaeus brevicornis (Fig. 7) : The emigration started sparsely in January and reached its peak in May. The day emigrants were sometimes noticed to be greater than the night numbers as in case of *Metapenaeus dobsoni*. Usually the dawn immigrants were found rich in numbers. Generally the number of immigrants was less than the emigrants, with few exceptions. The number of migrants was found to be greater on the new moon days than the full moon. The period of intense emigration was observed during the months of April, May and early June. The size-range of the migrating prawns was observed between the size-groups 21-25 mm. and 101-105 mm. Generally prawns between the size-groups 26-30 mm. and 61-65 mm. were common and the mode was observed at the size-group 36-40 mm.

Metapenaeus affinis (Fig. 7) : The emigration was noticed throughout the period of observation and much variation was noticed between the day and night numbers. Usually the night numbers were more than the day numbers as in case of *Metapenaeus monoceros*. The immigrating prawns were usually rich in the dawn catches. The immigrants

and emigrants were observed to be rich both on the new moon and full moon days. The period of intense emigration was noticed during the months of April, May and early June. The size of the migrants ranged between the size-groups 16-20 mm. and 121-125 mm. and the mode was observed at the size-group 46-50 mm.

Penaeus indicus (Fig. 8) : The emigrants were poor in numbers throughout the period of study and the variations during the day and night were prominent during the months of February and May only. The immigrating prawns were usually rich in the dawn catches. It is curious to note that the immigrants were generally greater in numbers than the emigrants. Though the number of emigrants was poor, the number of day emigrants was generally greater on the new moon days than the full moon days. No distinct period of intense emigration could be shown since the numbers were poor both during the day and night, except in the months of February and May. The size of the migrants usually ranged between the size-groups 31-35 mm. and 116-120 mm. and larger specimens were rarely recorded. The mode of the migrants was observed at the size-group 71-80 mm.

Penaeus monodon : The migratory pattern of this important commercial species is not clearly understood since the numbers recorded from the catches were insignificant.

From the present studies it is apparent that there is significant relationship between the prawn catches and their numbers and the lunar, diurnal and tidal rhythms. The prawn catches were generally rich during the new moon period at night low tide. Liu (1957) concluded from his studies on the lunar periodicity of some demersal fishes from Taiwan that 'the degree of variation in density in different locations is usually very great and the density of the same location varies also with the year, the season, the twenty four hours of a day, and with the phases of the moon or sequence of the tide.' Racek (1959) noticed that the school and king prawn catches fluctuates within a lunar month, 'being greatest shortly before new moon and smallest 3-4 days before full moon'. He, however, felt that the correct interpretation of this periodicity is confusing and suggested a comprehensive study of the interrelation of factors controlling diurnal and lunar periodicity in view of their im-

portance to the prawn fisheries. Ingle et. al. (1959) and Iverson and Idyll (1959) pointed out that the prawn catches in Tortugas, Florida, are poor when the moon is full. Menon and Raman (1961) could not find any variation in the catches made during the full moon fortnight and new moon fortnight though the peak catches were observed around new moon. According to them and Liu (1957) the strength of the tidal flow is probably the only factor responsible for the fluctuations in the catches.

The increase in the fish catches from February till early June was due to the incursion of marine forms into the estuary when the salinity conditions were favourable, while the prawns enter the mouth of the estuary in large numbers along with freshets in late June and July.

The experimental studies on the migration show that the migration of the penaeid prawns is usually prolonged. Kemp (1915) believed that the migration of penaeid prawns in the Gangetic Delta takes place in winter months. Menon (1951) felt that the prawn, *Metapenaeus dobsoni* moves seaward during the monsoon floods in the Cochin backwaters. Dall (1958) also reported that the young stages of *Metapenaeus mastersii* in Brisbane river are swept down-stream during floods. In general, it was observed that the intensity of migration was during the winter and summer months. The various prawn species migrating in and out of the estuary have different size-ranges, each with a prominent

mode. In some cases an intense period of migration also was observed (Table V). The migratory pattern of *Penaeus monodon* is, however, not clearly understood since the number of migrants is insignificant.

The present studies prove that migration of prawns is influenced by the tidal currents at estuarine mouths; that is, prawns moving out of the estuary with the low tide current appear to move in with the high tide current. It was consistently noticed that the night emigrants and the subsequent dawn immigrants were more in numbers. Hedgpeth (1957) indicated that motile invertebrates in estuaries move in and out of the estuary with the changing tides. Simmons and Hoese (1959) also made a similar observation of the fish movements, both bayward and gulfward, through the Cedar Bayou Pass, a natural tidal inlet, on the Texas coast. Tabb et. al. (1962) observed by tagging that some of the individuals of *Penaeus duorarum* nearest tidal channels, move Gulfward on the ebb tide and bayward on the subsequent flood tide in Florida Bay.

It is seen that parawns of all size-groups participate in the migration (Fig. 4). Simmons and Hoese (1959) also noticed prawns of all sizes moving Gulfward through the Cedar Bayou Pass on the Texas coast. On the contrary, George (1959) felt that the emigration of *Metapenaeus monoceros* — from Cochin backwaters commences after the prawns reach a length of about 100 mm.

TABLE V
MIGRATORY BEHAVIOUR OF THE COMMON PENAEOID PRAWNS IN GAUTAMI ESTUARY

Name of the species	Intense period of migration	Lunar periodicity (intense period)	Mode of Migration	Remarks
<i>Metapenaeus monoceros</i>	December, May and June	New Moon	Nocturnal	
<i>Metapenaeus dobsoni</i>	January, February and May	New Moon	Day and Night	Some times the day emigrants are rich
<i>Metapenaeus brevicornis</i>	April, May and early June	New Moon	Day and Night	Sometimes the day emigrants are rich
<i>Metapenaeus affinis</i>	April, May and early June	New Moon and Full Moon	Nocturnal	
<i>Penaeus indicus</i>	February and May	New Moon	Day and Night	

The movement of the prawns is sometimes nocturnal as observed in case of *Metapenaeus monoceros* and *Metapenaeus affinis* (Table V). Simmons and Hoese (1959) also reported distinct nocturnal movement of the prawns, *Penaeus aztecus* and *Penaeus duorarum*, Gulfward and during the daytime they observed them lying buried in the mud. Racek (1959) observed that the Eastern Australian prawn species (with one exception) run out of the estuarine grounds of New South Wales chiefly at night.

The prawns also showed distinct lunar periodicity in their movements. They were usually moving out in large numbers on the new moon days and rarely on the full moon days, with one exception of *Metapenaeus affinis* (Table V). Racek (1959) also observed good numbers of outrunning prawns at 'dark' moon phase.

Thus it is apparent from the present studies that there is conspicuous relationship between the prawn catches and their numbers and the lunar, diurnal and tidal periodicities. However, the present studies are only of a preliminary nature and similar studies for extended periods are highly desirable since the migratory pattern of the *Penaeus* species is not clearly understood.

The present studies also indicate that certain percentage of prawns (excepting *Penaeus indicus*) moving seaward seems to stay away in the sea itself and do not seem to return to the estuary at flood tide (Table VI).

The phenomenon of emigration and subsequent immigration of prawns can be verified only by either vital staining or tagging (Tabb et. al., 1962). For this purpose labo-

ratory experiments with vital stains were conducted on *Metapenaeus monoceros*. Trypan blue was found to be the best stain to mark the prawns since the retention of the stain was long and remained even after several moults. Specimens marked with this stain if released on a mass scale at low tide near the tidal inlets, the subsequent immigration can be verified.

Summary

The present studies embody the results of the observations made on the prawn abundance and migration in relation to the lunar, diurnal and tidal rhythms, by operating a stake net at the mouth of the Bhairavapalem distributary of the Gautami Godavari Estuary during the period from November 1961 to July 1962. Usually the prawn catches were more abundant in the 'night low tide' catches than in the day low tide or the high tide catches. The dawn and dusk high tide catches, however, did not show so much of variation. The prawn catches during the darker fortnight were more abundant than the same during the brighter fortnight. The increase in the fish catches from February till early June was due to the incursion of many marine forms and their fall in late June and July was due to the freshets in the estuary. The migratory behaviour of *Metapenaeus monoceros*, *M. dobsoni*, *M. brevicornis*, *M. affinis*, *Penaeus indicus* and *P. monodon* has been discussed. Generally the inward and outward movement was continuous and included all size-groups. The intensity of migration was observed during the winter and summer months only. Usually the immigrants were poorer than the emi-

TABLE VI

PERCENTAGE RATIOS OF MIGRATORY PRAWNS AT CHANGING TIDES

	Low tide (day)	High tide (dusk)	Low tide (night)	High tide (dawn)	Percentage remain- ing in the sea (difference between low and high tides)
All prawns	15.64	10.84	53.10	20.42	37.48
<i>Metapenaeus monoceros</i>	4.77	10.50	71.79	12.93	53.13
<i>Metapenaeus dobsoni</i>	36.48	7.00	29.00	27.52	30.96
<i>Metapenaeus brevicornis</i>	32.88	18.27	21.92	26.93	9.60
<i>Metapenaeus affinis</i>	7.33	1.04	82.76	8.87	80.18
<i>Penaeus indicus</i>	29.71	5.80	9.42	55.07	21.74

grants, with one exception. The total emigrants were generally observed in good numbers only in the night low tide catches, with few exceptions. The immigrants were rich in the dawn catches. The total number of migrants was more in numbers during the new moon day than the full moon day. In case of *Metapenaeus monoceros* and *M. affinis* the emigration was nocturnal. The migratory pattern of *Penaeus* species is not clearly understood. The night emigration and the subsequent dawn immigration can be verified only by releasing marked prawns at night low tide near tidal inlets.

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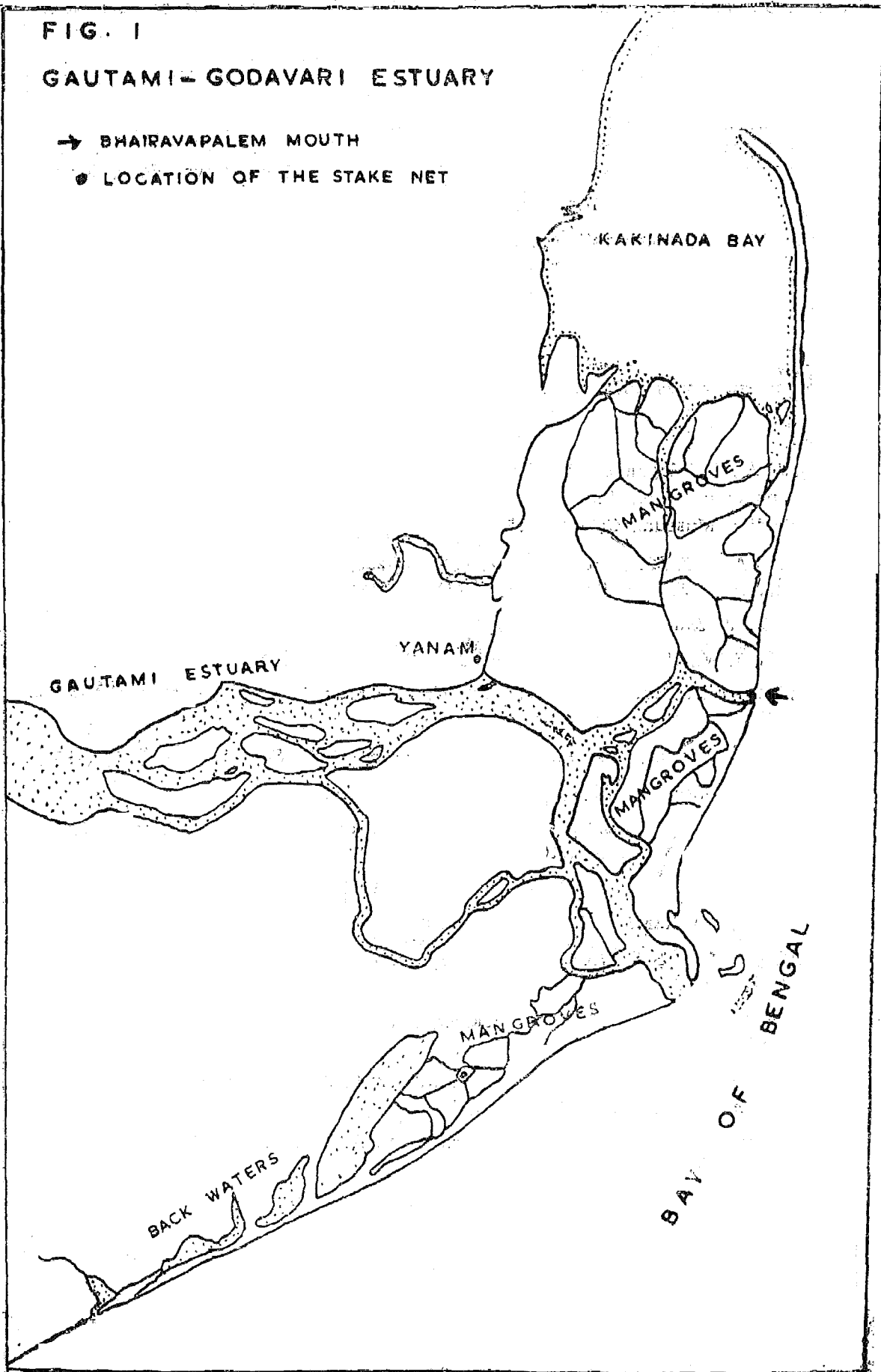
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FIG. 1

GAUTAMI-GODAVARI ESTUARY

→ BHAIRAVAPALEM MOUTH

● LOCATION OF THE STAKE NET



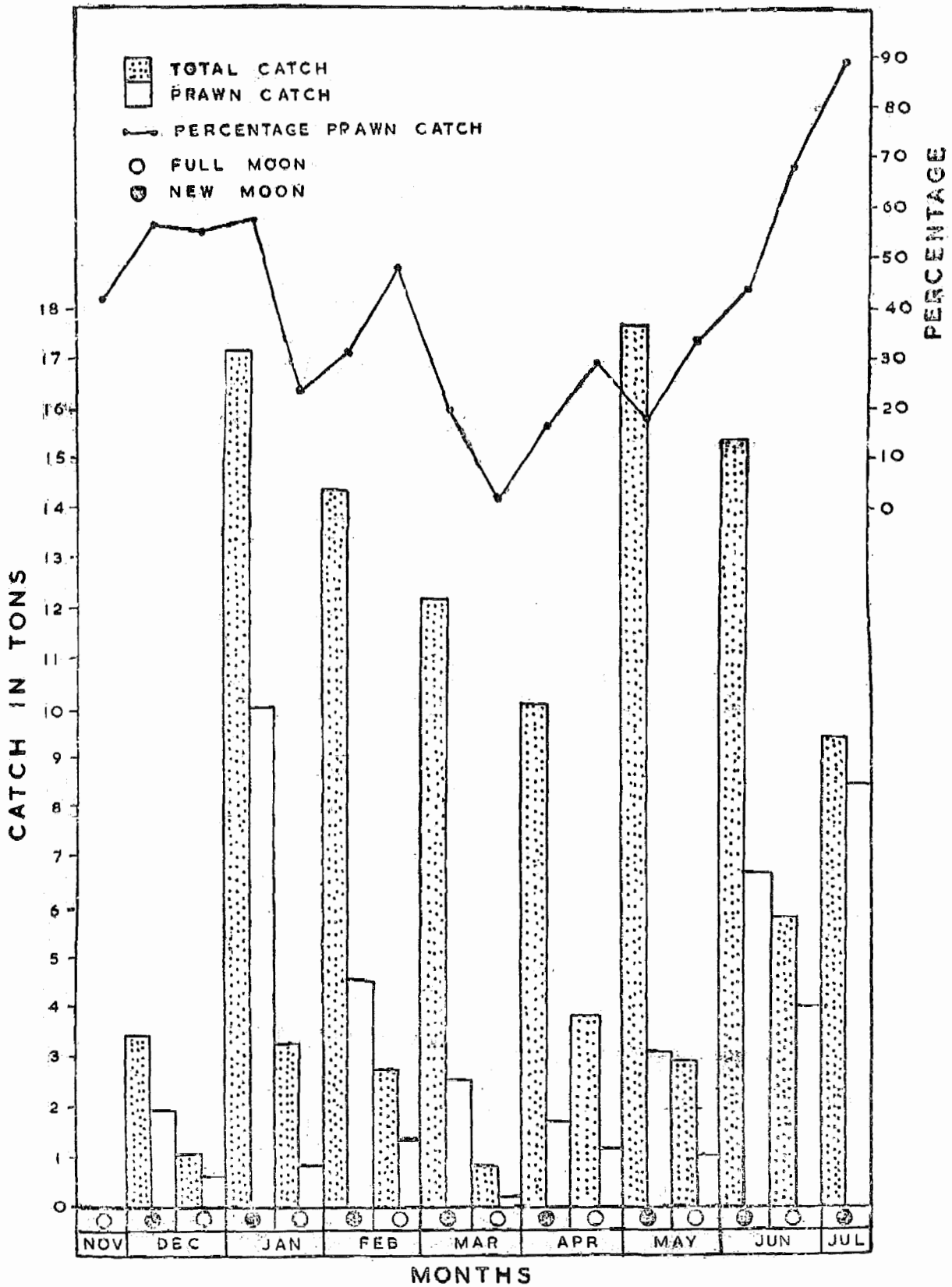


FIG 2 LUNAR PERIODICITY IN RELATION TO PRAWN ABUNDANCE BY STAKE NET 1961-62

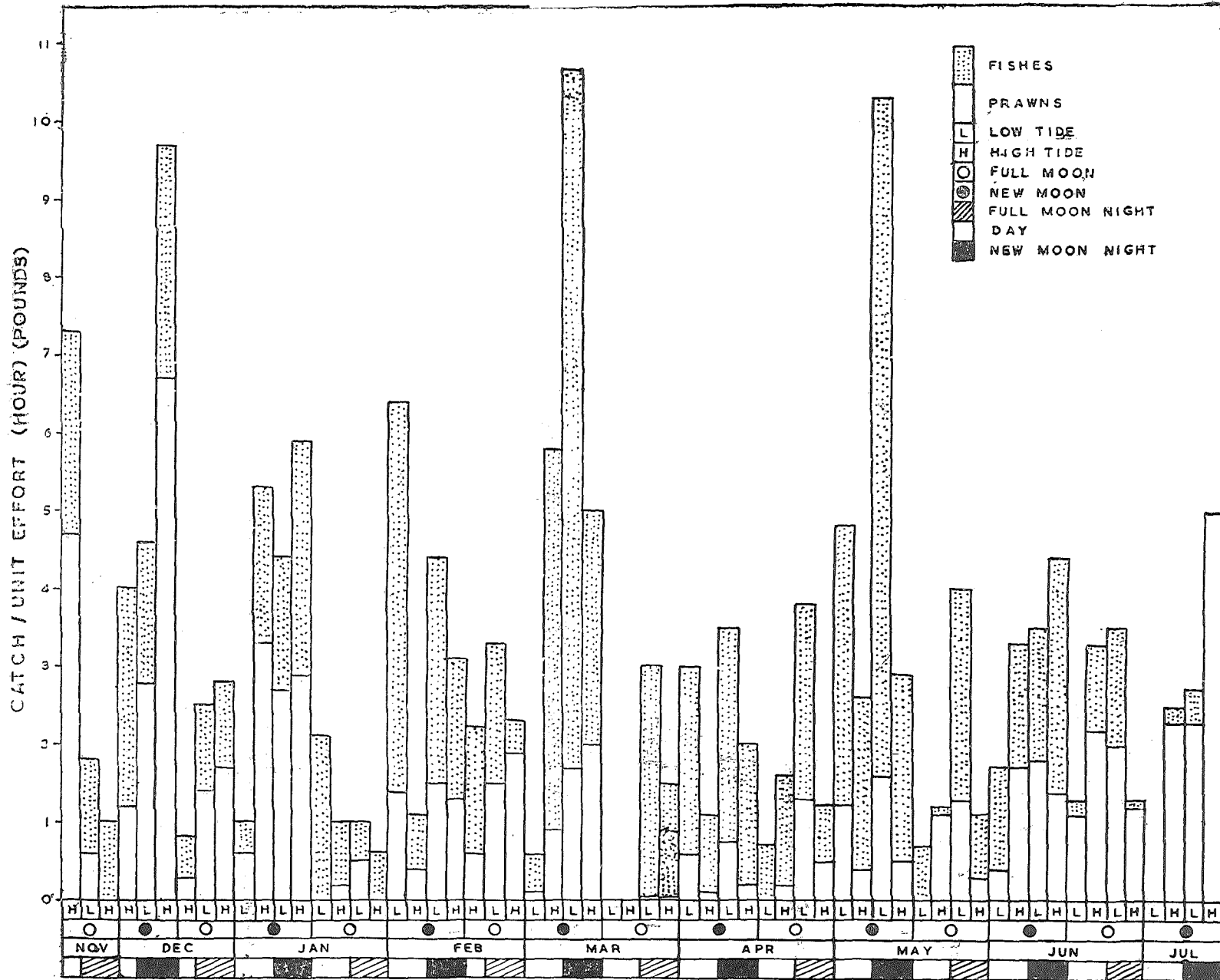


FIG. 3 LUNAR, DIURNAL AND TIDAL PERIODICITY IN RELATION TO PRAWN ABUNDANCE BY STAKE NET. CATCH/UNIT EFFORT (HOUR). 1961-62.

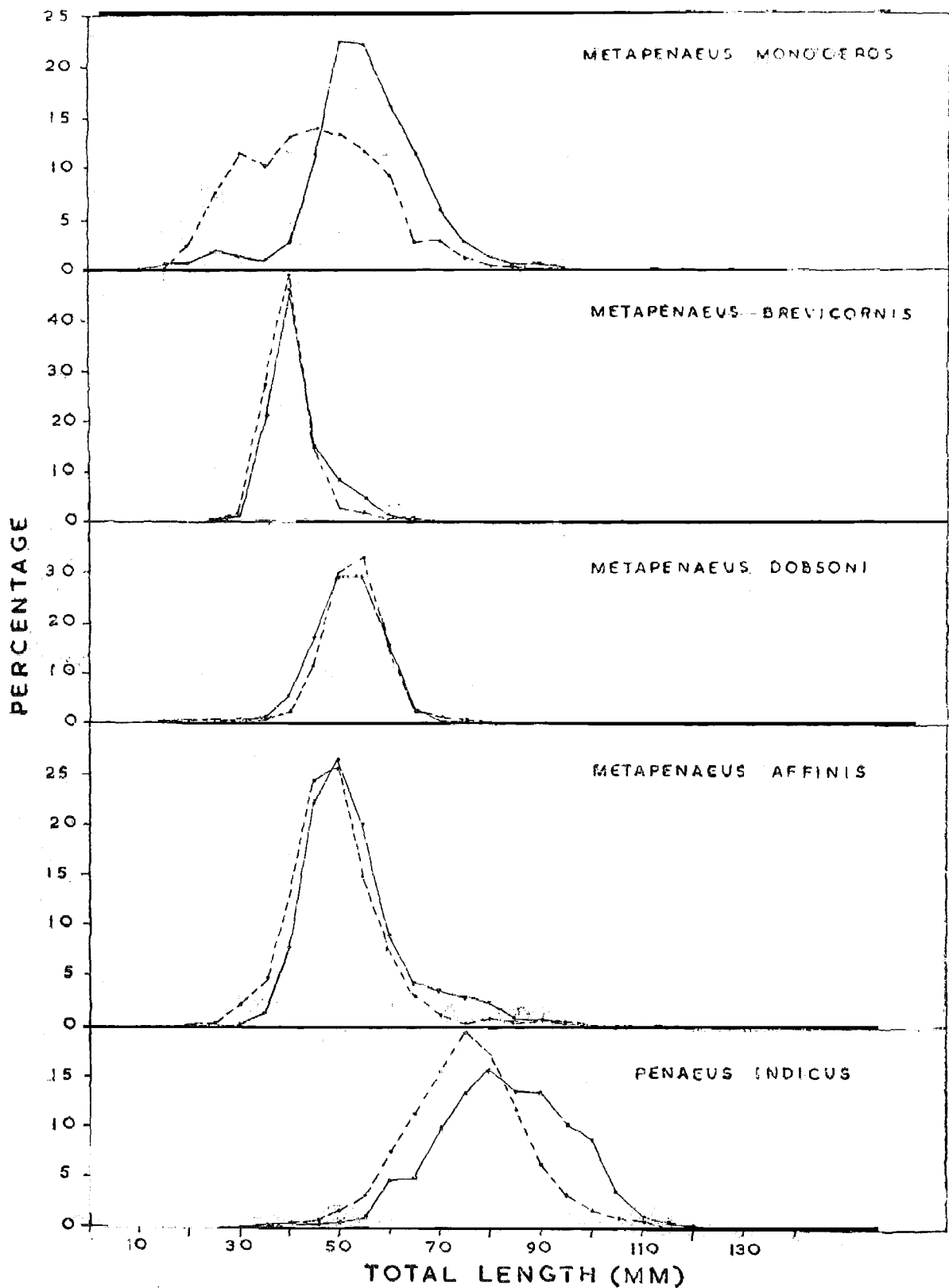


FIG. 4 MIGRATION IN PENAEID PRAWNS:
 SIZE-FREQUENCY DISTRIBUTION OF IMMIGRANTS AND EMIGRANTS.
 ——— LOW TIDE - - - HIGH TIDE

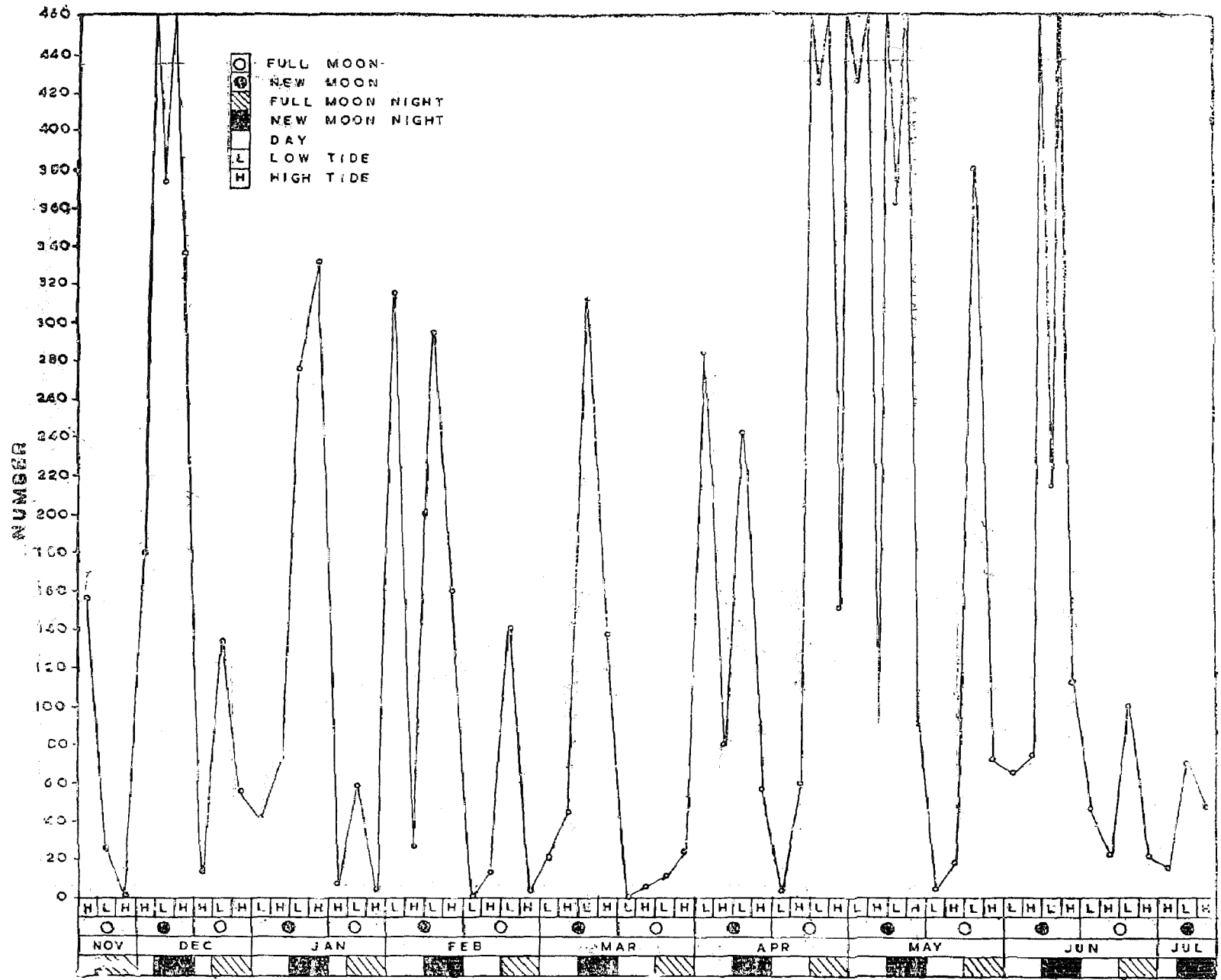


FIG. 5 MIGRATION IN PENAEID PRAWNS. ALL PRAWNS. LUNAR, DIURNAL AND TIDAL PERIODICITY.

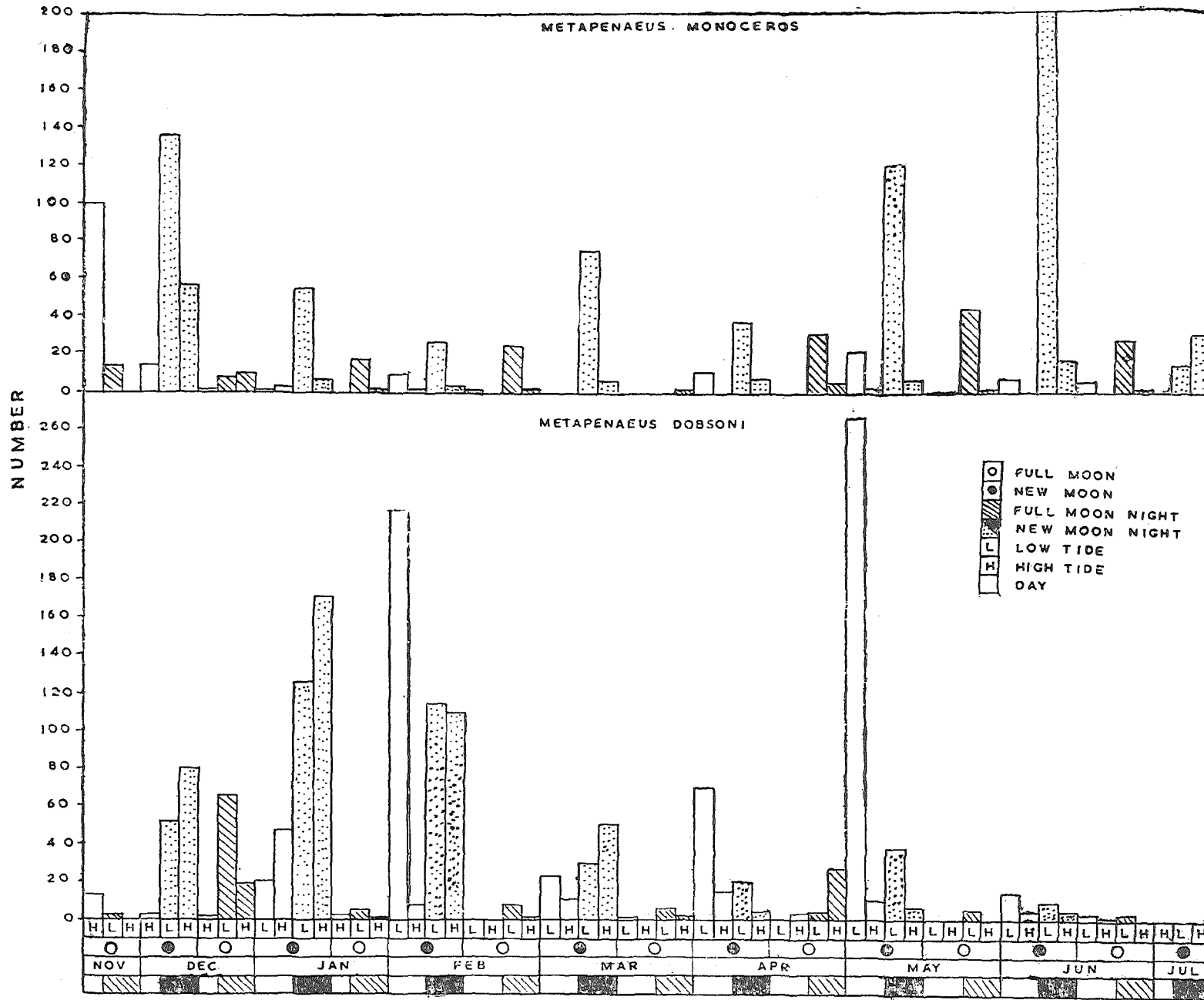


FIG. 3. MIGRATION IN PENAEID PRAWNS. METAPENAEUS MONOCEROS AND METAPENAEUS DOBSONI. LUNAR, DIURNAL AND TIDAL PERIODICITY.

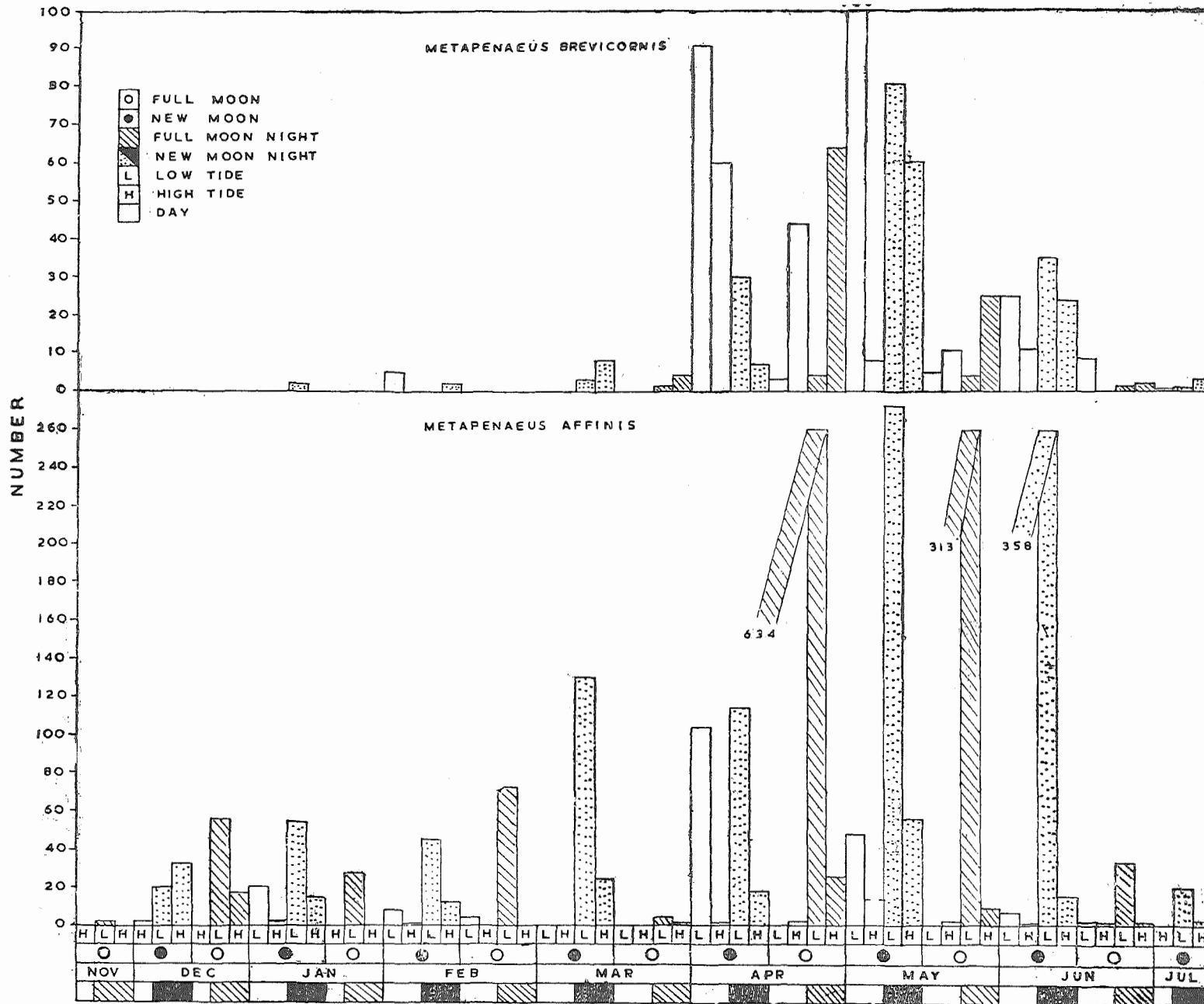


FIG. 7. MIGRATION IN PENAID PRAWNS. METAPENAEUS BREVICORNIS AND METAPENAEUS AFFINIS.

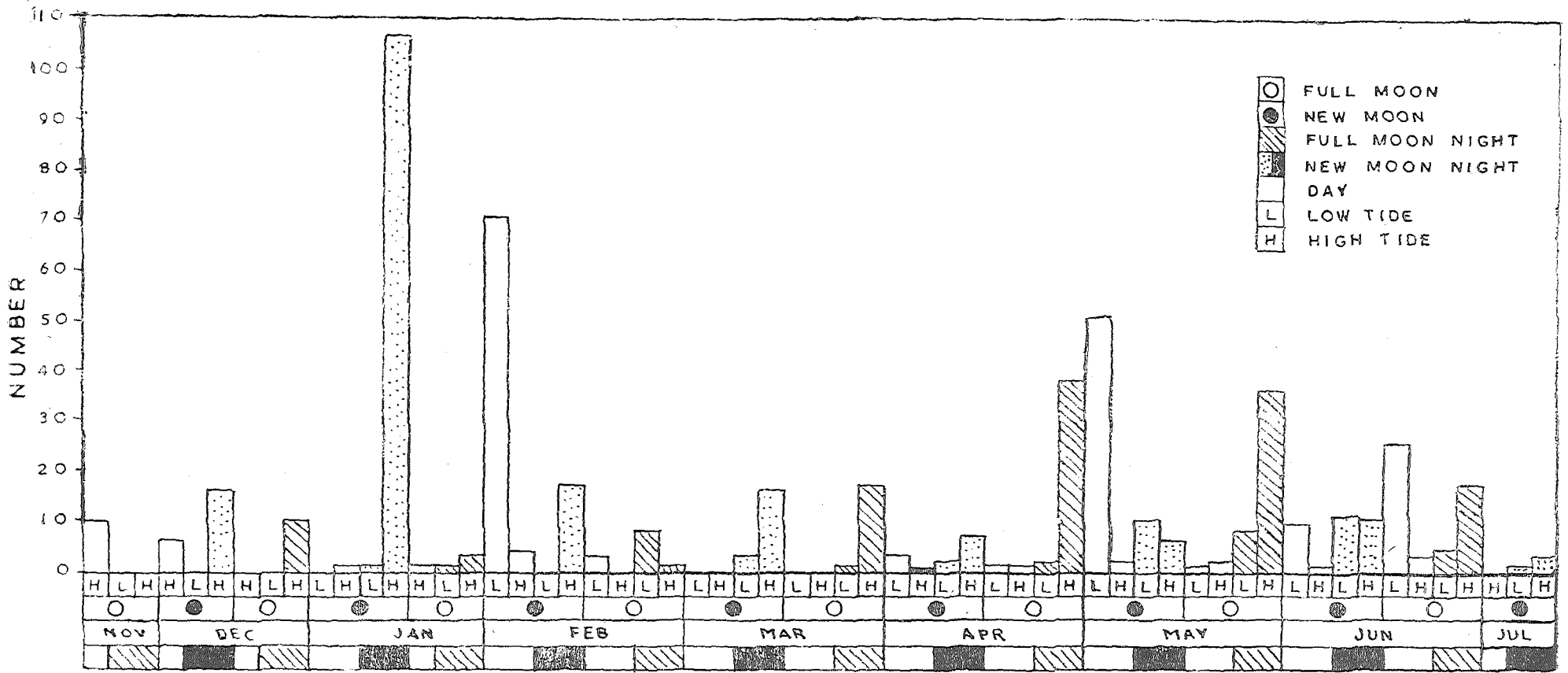


FIG. 8. MIGRATION IN PENAID PRAWNS. *PENAEUS INDICUS*. LUNAR, DIURNAL AND TIDAL PERIODICITY.