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Araştırma Notu / Short Note

The Larval Development of ***Penaeus semisulcatus*** (de Hann, 1850) (Decapoda: Penaeidae)

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Özet: Penaeus semisulcatus (***de Hann, 1850) (Decapoda: Penaeidae)'un larval gelişimi.*** *Penaeus semisulcatus*'un yapay üretimi üzerine olan çalışma Haziran, 2001 tarihinde Çeşme-İzmir'de bulunan Pınar Deniz Ürünleri (Balık Çiftliği)'nde gerçekleştirilmiştir. Çalışmada yumurta almak amacıyla kullanılan olgun dişi bireyler Antalya'dan getirilmiştir. Elde edilen yumurtalar laboratuar koşullarında post larval aşamaya kadar yetiştirilmiştir. Laboratuarda yetiştirilen bireylerin larval aşamaları tanımlanmış ve fotoğraflanmıştır. Larval dönemlerde *Isochrysis* sp. ve *Artemia* nauplii yem olarak kullanılmıştır. Altı naupliar, üç protozoeal, üç mysis ve ilk postlarval dönem ana hatlarıyla tanımlanmıştır. *P. semisulcatus*'un larval morfolojisi diğer *Penaeus* türleri ve bu tür ile ilgili önceki çalışmalarla karşılaştırılmıştır.

Anahtar Kelimeler: Penaeidae, *Penaeus semisulcatus*, Larval gelişim.

Abstract: The study on artificial propagation of *Penaeus semisulcatus* (de Hann, 1850), was done in captivity, at Pınar Marine Products (Fish Farm) on June, 2001 in Ceşme-İzmir. In the present study mature females were brought from Antalya for spawning. The spawned eggs reared in laboratory conditions up to the postlarval stage. The larval developments were described and imaged based on the materials hatched and reared in the laboratory. *Isochrysis* sp. and *Artemia* nauplii were used as food during the larval stages. Six naupliar, three protozoeal, three mysis and first postlarval stages were described basically. The larval morphology of *P. semisulcatus* was compared with other *Penaeus* species and preceding studies deal with *P. semisulcatus*.

Key Words: Penaeidae, *Penaeus semisulcatus*, Larval development.

Introduction

Penaeus semisulcatus (de Hann, 1850) is a commercially important species of the Mediterranean Sea. Other species such as *Metapenaeus stebbingi* Nobili, 1904, *Metapenaeus monoceros* Fabricius, 1789, and *Parapenaeus longirostris* Lucas, 1846 are caught in good numbers but are less important due to their small size. It is found in many and widespread areas of the Indo-West Pacific, from East and Southeast Africa into the Red Sea, around the Indian subcontinent, through the Malay archipelago to Japan and Northern Australia. In Recent years it has extended its range from the Red Sea through the Suez Canal into the eastern Mediterranean, where it is now fairly common (Grey and Dall, 1983; Burukovskii, 1985; Dore and Frimodt, 1987).

In Turkey, there are several studies on *P. semisulcatus*. These studies deal with gonadal maturation and spawning, relationship between body length and weight, the efficiency of salinity on larval growth, survival and development, and the efficiency of temperature and substrate on growth and survival of *P. semisulcatus* (Akataş and Kumlu, 1999; Kumlu *et al*.,. 1999a; Kumlu *et al*., 1999b; Kumlu and Erdoğan, 2000). But there is no study about larval development of *P. semisulcatus* in Turkey. This paper presents basically description of the complete larval stages of *P. semisulcatus* and comparison with preceding studies. The aim is to provide background information for further academic and aquaculture studies.

Material and Methods

Three matured females of *P. semisulcatus* were examined in turn on ovary at the dorsal. The gravid female always possessed the big ovary with a thick triangular shape at first and second abdominal segment. Five 200 l capacity plastic tanks were used as spawning and breeding tank. Tanks were washed and filled 1/3 with through 5 µm-filtered seawater. Five matured females were individually held in the tanks containing well-aerated seawater. One female in each tank spawned during the night, and the fertilized eggs in one tank were used for this study. *Isochrysis* sp. was given for protozoea, and *Artemia* nauplii for mysis and the first postlarvae. Observations were made on all larval stages and the first postlarval stage. Animals were dissected and imaged under Olympus CH 30 microscope. Measurements were made according to the definitions adopted by Motoh, 1979 and a micrometer eyepiece was used for length measurement. At nauplius stage the length of the body (BL) was measured between the apical and caudal ends excluding the furcal spines, and for the width of the body (BW), at the point of greatest width where the 2nd appendages are located. The total length (TL) of a larva was taken from the tip of rostrum, if present, to the posterior end of telson excluding the furcal spines. Carapace length (CL) was measured from the tip of rostrum, if present, to the mid-posterior end of the carapace. The measurements are expressed as mean ± SE of 20 individuals. The terminology of basic chronological pattern in the

larval stage of *P. semisulcatus* used as the studies of Kungvangij *et al*., 1972 and Hassan, 1982. At the end of present study observed body sizes at different stage of larvae were compared to former studies.

Results

Egg: The viable eggs are spherical, and the diameter was 0.301 ± 0.002 mm. Fertilized eggs divided into 2 cells within 40 minutes after spawning. It developed to 128 cells in 2 hours 50 minutes. Then appendages formed, the second appendages appeared first. The third and the first form later. The development continued and hatched out in nauplius stage. At this stage it took about 13 hours after the eggs laid.

Nauplius stage: At this stage, there are six molts. After molting, the larvae increase their growth. Each stage can identify as following. Their setae formulate are presented Table 1.

Table 1. Setae number of appendages in naupliar stage of *P. Semisulcatus*.

Stage	First Antenna	Second Antenna		Mandible	
		Endopod	Exopod	Endopod	Exopod
Nauplius I	5	4	5	3	3
Nauplius II	5	5	6	3	3
Nauplius III	6	5	7-8	3	3
Nauplius IV	6	5	8	3	3
Nauplius V	7	6	9	3	3
Nauplius VI	8	6	10-11	3	3

Nauplius I: BW= 0.196±0.001 mm.; BL= 0.324±0.002 mm.

Body is pyriform, unsegmented. Labrum and ocellus is present at the ventral side near the anterior end of body (Figure 1). The posterior portion of the body is round and has one pair of caudal spine (Kungvankij, 1972; Hassan, 1982).

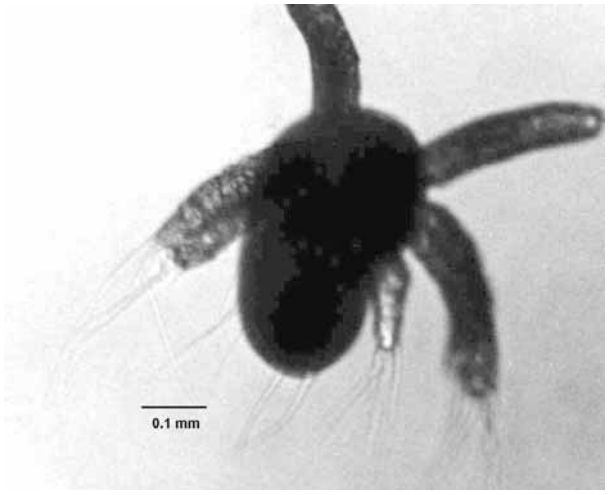

Figure 1. Nauplius I of *P. semisulcatus*

Nauplius II: BW= 0.198±0.001 mm.; BL= 0.365±0.002 mm.

The most distinguishable change from the preceding stage is that the longer setae on each appendage become plumose (Figure 2). A pair of furcal spines is straight (Kungvankij, 1972; Hassan, 1982).

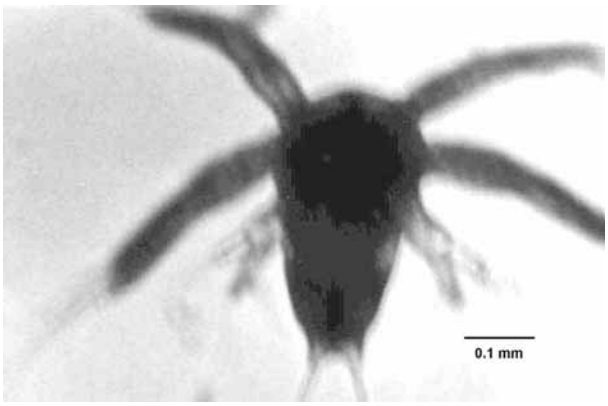

Figure 2. Nauplius II of *P. semisulcatus*

Nauplius III: BW= 0.199±0.001 mm.; BL= 0.402±0.002 mm.

Posterior portion of the body are slightly emarginated, with three pairs of caudal spine (Kungvankij, 1972) (Figure 3). Hassan, 1982 found that nauplius III bear 3-4 pairs of furcal spines.

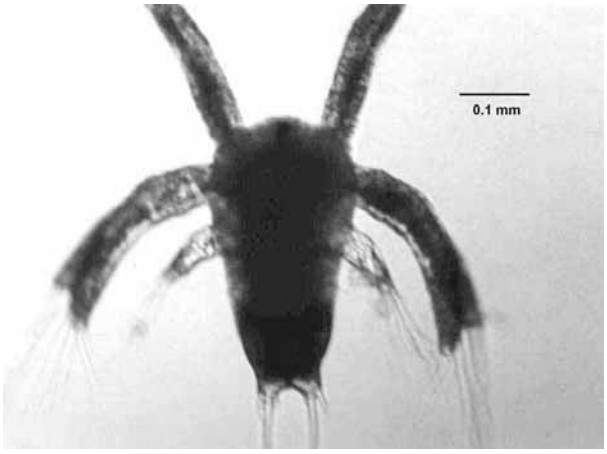

Figure 3. Nauplius III of *P. semisulcatus*

Nauplius IV: BW= 0.206±0.001 mm.; BL= 0.432±0.002 mm.

Body is more elongate, ventral appendages begin clear. The posterior portion more emarginated, there are four or five pairs of caudal spine (Kungvankij, 1972) (Figure 4). Hassan, 1982 found that nauplius IV bear 6 pairs of furcal spines.

Nauplius V: BW= 0.210±0.001 mm. ; BL= 0.452±0.002 mm.

The carapace can be seen on the dorsal surface of the body, posterior portion become bifurcate, there are 6 + 6 spines on the caudal furca (Kungvankij, 1972) (Figure 5). Hassan, 1982 found that nauplius V bear 7 pairs of furcal spines.

Nauplius VI: The maxilllae and maxillipeds are well developed, carapace more advance. Posterior portion become round bifurcate, there are seven caudal spines (Kungvankij, 1972) (Figure 6).

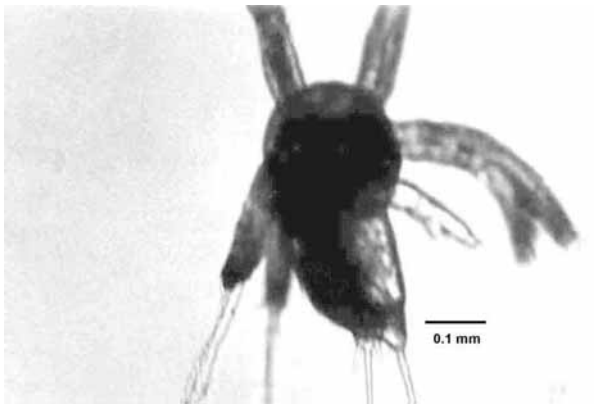

Figure 4. Nauplius IV of *P. semisulcatus*

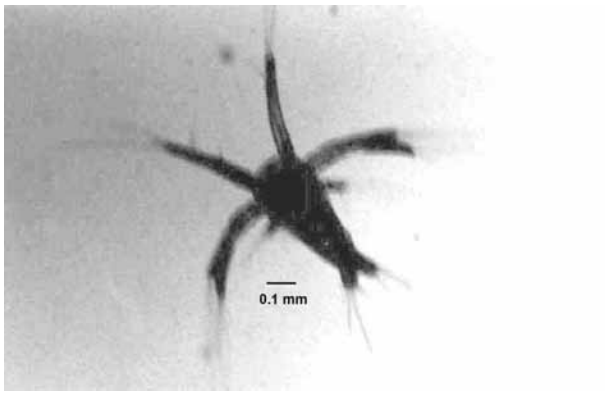

Figure 5. Nauplius V of *P. semisulcatus*

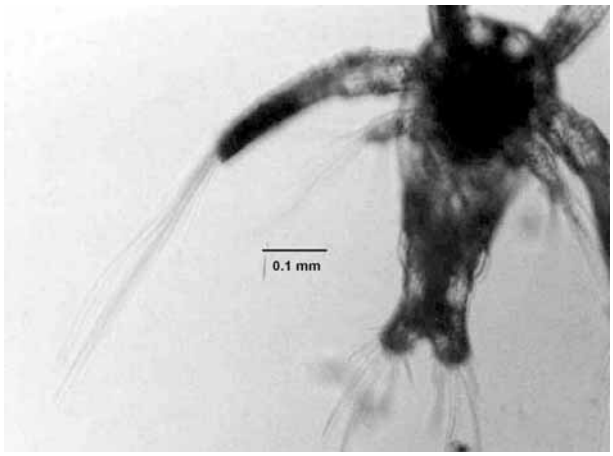

Figure 6. Nauplius VI of *P. semisulcatus*

Protozoea stage: The larvae at this stage body consist of three parts, cephalic, thoracic, and abdomen. There are three molting stages in this larval stage.

Protozoea I: CL = 0.505 ± 0.007 mm.; TL = 1.113 ± 0.024 mm.

One pair of compound eyes is present but still no stalk and cover by carapace (Figure 7). Thoracic composed of 6 segments. The abdomen is unsegmented. Caudal are bifurcate each retain seven spines (Kungvankij, 1972; Hassan, 1982).

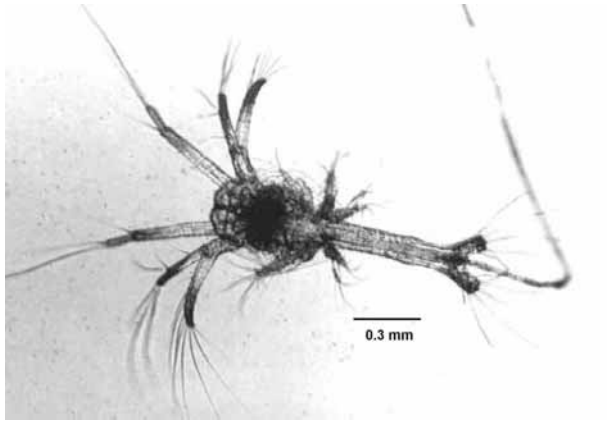

Figure 7. Protozoea I of *P. semisulcatus*

Protozoea II: CL = 0.928 ± 0.009 mm.; TL = 1.867± 0.015 mm.

The stalk of compound eyes is present. The carapace begins to cover the thorax but not yet complete. (Figure 8). The third maxilliped and five pairs of pereopod are present (Kungvankij, 1972; Hassan, 1982).

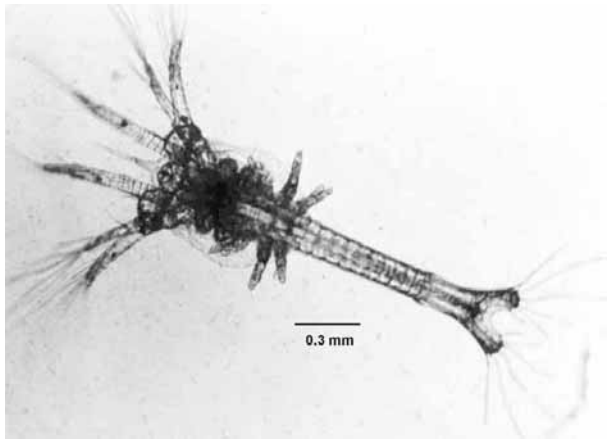

Figure 8. Protozoea II of *P. semisulcatus*

Protozoea III: CL = 1.054 ± 0.016 mm.; TL = 2.719±0.020 mm.

This stage could easily be distinguished from the previous stages in the presence of biramous uropods, and dorsomedian spines on the abdominal segments (Figure 9). The caudal furca now bears 8 + 8 setae (Hassan, 1982). Kungvankij, 1972 found that protozoea III bear 7 pairs of furcal spines.

Mysis I: CL = 1.160 ± 0.018 mm.; TL = 3.470 ±0.027 mm.

Cephalic and thoracic are joined together. At a late stage before molting to M II, rudimentary pleopods can be observed as small buds on the ventral surface of the first five abdominal segments (Figure 10). The telson now bears 9 + 9 spines (Hassan, 1982). Kungvankij, 1972 found that mysis I bear 7 pairs of telson spines.

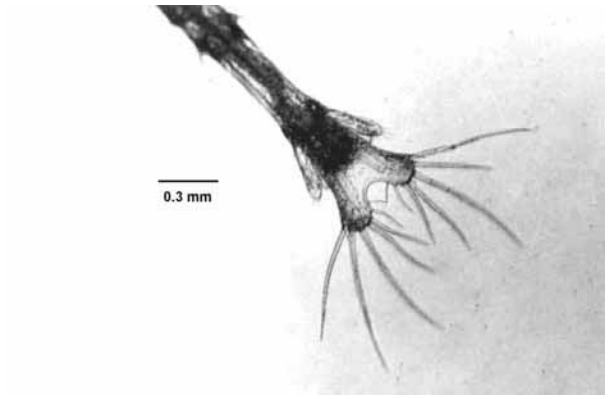

Figure 9. Telsons and Uropods, Protozoea III of *P. semisulcatus*

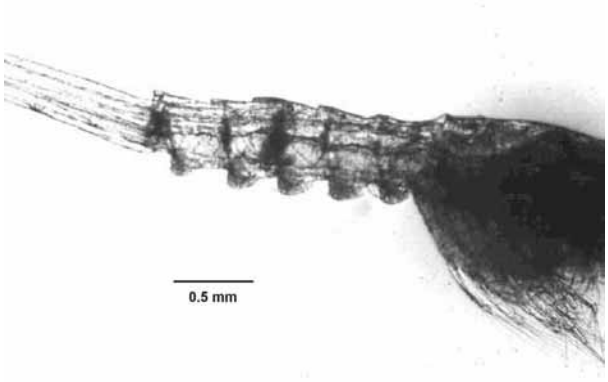

Figure 10. Pleopods, Mysis I of *P. semisulcatus*

Mysis II: CL = 1.247 ± 0.011 mm. ; TL = 4.145 ± 0.021 mm.

This stage bears unsegmented pleopods, a spine on the antennal scale and an adorsal spine on the rostrum (Figure 11). Pereopods are advance developed to be chelae (Hassan, 1982). Kungvankij, 1972 did not observe an adorsal spine on the rostrum at this stage.

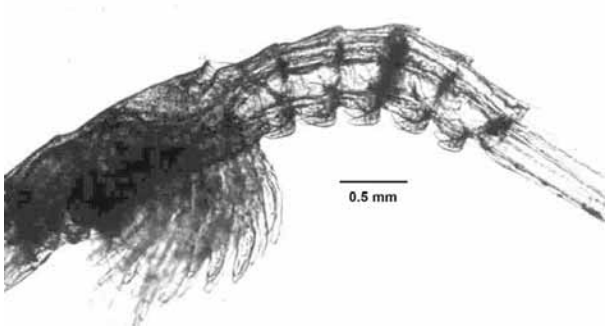

Figure 11. Pereopods and Pleopods, Mysis II of *P. semisulcatus*

Mysis III: CL = 1.386 ± 0.018 mm.; TL = 4.508 ± 0.033 mm.

This stage could be distinguished from the previous stages by the presence of well-developed 2-jointed pleopods. Spination of the carapace, abdomen and telson remains the same as in the second mysis stage; an epigastric tooth is added to the rostrum (Hassan, 1982) (Figure 12). Kungvankij, 1972 observed only one tooth spine on the rostrum at this stage.

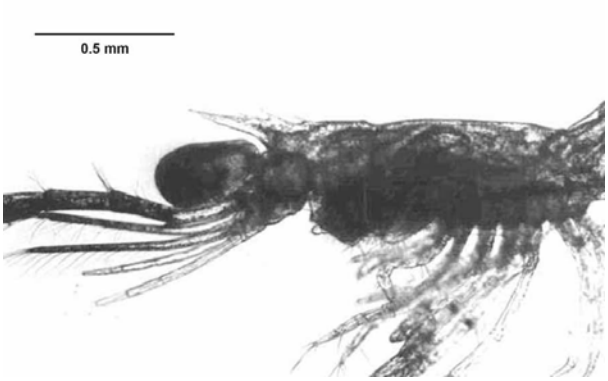

Figure 12. Carapace, Mysis III of *P. semisulcatus*

Post larva I: CL = 1.696 ± 0.017 mm.; TL = 5.570 ± 0.019 mm.

The rostrum is straight, laterally flattened and pointed, reaching hardly to tip of the antennular peduncle, and bears 3 dorsal teeth. The telson still bears 9 + 9 spines. Pleopods now well developed, and become the principal swimming organ (Hassan, 1982) (Figure 13). Kungvankij, 1972 observed 1-2 spine on the rostrum at this stage.

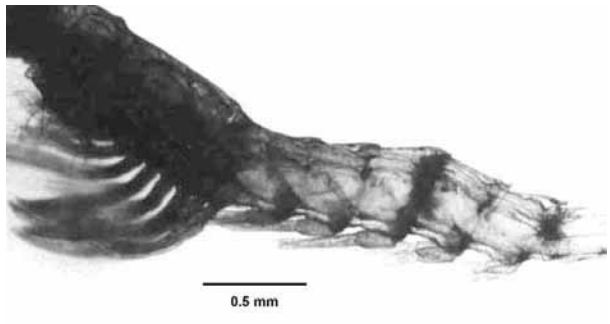

Figure 13. Pleopods, Postlarva I of *P. semisulcatus*

Discussion and Conclusion

Morphological changes during larval development of *P. semisulcatus* are basically similar to those of other penaeids studied (Hudinaga, 1942; Kungvankij, 1976; Alpbaz, 1980;, Hassan, 1982; Kitani and Alvarodo, 1982; Uçal and Hoşsucu, 1987; Özden, 1989; Leong *et al*., 1992; Kitani, 1996; Kitan,i 1997). A major difference between previous studies is in the number of naupliar instars recorded. Hassan, 1982 reports only five naupliar instars. In contrast, Kungvankij, 1976 recorded six, naupliar which is consistent with our observation. Hassan, 1982 found that nauplius I, II, III, IV and V bear 1, 1-2, 3-4, 6 and 7 pairs of furcal spines respectively. Based on this description the five instars reported in his study would be analogous to NI, NIII,

NV, and NVI described in the present study. We believe that Hassan, 1982 failed to distinguish NI and NII, probably because they both bear one pair of furcal spines. Further, the NIII described by him could include NIV in our study, as the four or five pair of newly grown furcal spines on NIV are minute and could be easily overlooked.

In this study, the similarity of the morphological characters between *P. semisulcatus* and *Penaeus monodon* was observed, which was also reported by Kungvankij, 1972 and Kungvankij, 1976. Especially in mysis and postlarval stages the number of spines on telson is 9+9 while it shows a great difference to *P. kerathurus* and *P. japonicus.* Moreover it is also interesting to note that the exopods of the pereopods do not become rudimentary as fast as in other Penaeidae in mysis and postlarval stages and remained very prominent even in the first postlarval stage.

In Table 2, recorded body sizes (BW: Body Width, BL: Body Length, CL: Carapace Length and TL: Total Length) in the present study are compared to other studies. There are some of differences between present study and the others may be due to regional variation, or to effects of differences in rearing conditions. Hassan, 1982 considered that carapace and total length from the base of the rostrum to end of the carapace and tip of the telson. Although we considered that from tip of the rostrum to end of the carapace and tip of the telson.

Table 2. A comparison of body sizes at different larval stage of *P. semisulcatus.*

Stage	Present study		Kungvankij ***et al***., 1972		Hassan, 1982	
	BW/CL	BL/TL	BW/CL	BL/TL	BW/CL	BL/TL
N I	0.196	0.324	0.200	0.324	0.160	0.320
N II	0.198	0.365	0.201	0.363	0.170	0.350
N III	0.199	0.402	0.196	0.390	0.190	0.410
N IV	0.206	0.432	0.197	0.434	0.200	0.450
N V	0.210	0.452	0.197	0.443	0.210	0.530
N VI	0.215	0.536	0.200	0.533	-	-
PZ I	0.505	1.113	0.450	0.994	0.480	1.100
PZ II	0.928	1.867	0.923	1.803	0.640	1.600
PZ III	1.054	2.719	1.105	2.755	0.750	2.400
M I	1.160	3.470	1.284	3.667	0.800	2.910
M II	1.247	4.415	1.350	4.250	0.910	3.990
M III	1.368	4.508	1.440	4.550	1.080	4.610
PL I	1.696	5.570	1.825	5.713	1.390	6.060

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