Distribution of Macrobenthic Polychaete Families in Relation to Environmental Parameters in North West Penang, Malaysia

Mohammad Gholizadeh, Khairun Yahya, Anita Talib and Omar Ahmad

***Abstract*—**The distribution of macrobenthic polychaetes along the coastal waters of Penang National Park was surveyed to estimate the effect of various environmental parameters at three stations (200m, 600m and 1200m) from the shoreline, during six sampling months, from June 2010 to April 2011.The use of polychaetes in descriptive ecology is surveyed in the light of a recent investigation particularly concerning the soft bottom biota environments. Polychaetes, often connected in the former to the notion of opportunistic species able to proliferate after an enhancement in organic matter, had performed a momentous role particularly with regard to effected soft-bottom habitats. The objective of this survey was to investigate different environment stress over soft bottom polychaete community along Teluk Ketapang and Pantai Acheh (Penang National Park) over a year period. Variations in the polychaete community were evaluated using univariate and multivariate methods. The results of PCA analysis displayed a positive relation between macrobenthic community structures and environmental parameters such as sediment particle size and organic matter in the coastal water. A total of 604 individuals were examined which was grouped into 23 families. Family Nereidae was the most abundant (22.68%), followed by Spionidae (22.02%), Hesionidae (12.58%), Nephtylidae (9.27%) and Orbiniidae (8.61%). It is noticeable that good results can only be obtained on the basis of good taxonomic resolution. We proposed that, in monitoring surveys, operative time could be optimized not only by working at a higher-taxonomic level on the entire macrobenthic data set, but by also choosing an especially indicative group and working at lower taxonomic and good level.

***Keywords*—**Polychaete families, environment parameters, Bioindicators, Pantai Acheh, Teluk Ketapang.

I. Introduction

THE assemblage structure of existing organisms differs in space and time in response to many physical and biotic parameters. Ecology is the integrated survey of the relation of living organisms, comprising human beings, to their environment. Polychaetes occupy almost all marine and estuarine sediments [5] and are often the predominant constituent of the macrobenthic communities both in terms of individuals and number of species [10-16].

Though bottom macrobenthic communities have numerous advantages as indicators, they are exceedingly complicated, including a great variety of organisms and generally a large number of species. In this case, analysis of some taxonomic structures appears to be more appropriate [2].

One of the valuable marine organisms to tolerate contamination is the Polychaete for the reason that they live at the interface of water-sediment. This layer is biologically reactive and chemically active [13].

Polychaetes perform an important role in ecosystem processes of macrofauna assemblages such as recycling, pollutant metabolism and in the interment of organic matter [10].

In marine macrobenthic organisms, Polychaetes is one of the most momentous groups. They are often the predominant macrobenthic taxon in these sediments in terms of numbers, both numerically of species and abundance, and may make up more than half of the organisms in soft bottom habitats. Polychaetes could hence be good indicators of species richness and assemblage models in macrobenthic assemblages [6]. The aim of this study was distribution and abundance of polychaetes and its relationships with environmental parameter in North West Penang, Malaysia.

II. Material and Method

The study was performed at two locations in Penang coastal water bimonthly for period of one year.

Two sites (Teluk Ketapang and Pantai Acheh), which are located at the North West coastal waters of Penang National Park were selected as the sampling sites.

Pantai Acheh was chosen due to near to mangrove forest and Teluk Ketapang was assumed be minimally altered by anthropogenic activities of stress. At each sites, 6 sampling stations was chosen.

The coverage area of each sample was be recorded by using a Garmin Global Positioning System (GPS) model 12X. The selection of sampling sites was determined after considering different factors. Samples were collected during one year (June 2010 to April 2011).

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International Journal of Earth, Energy and Environmental Sciences
ISSN: 2517-942X
Vol:6, No:12, 2012

Fig .1 Sampling locations at North West of Penang, Malaysia

Three replicate samples were taken at each sampling site by means of a Ponar grab (6"x6"). Macrobentho's samples were sieved over 0.5 mm mesh. The residues retained on the sieves were fixed in 5% formalin with the addition of Rose Bengal to stain the animals in the samples.

Physical parameters (temperature, salinity, dissolved oxygen in situ, pH and Total Suspended Solid (TSS)) and chemical parameter (chlorophyll-a level) of sea water around the sampling sites were collected and measured at proper depth to determine the effects of exogenous environmental factors on the bimonthly distribution and abundance of macrobenthic community in the sampling sites in the coastal waters of Penang.

A measurement of salinity, dissolved oxygen, pH and temperature was recorded in-situ by using a model YSI 30 SCT meter meanwhile the rest of the parameters was analyzed in the laboratory.

III. Data Analysis

To test the differences in abundance, richness, evenness and diversity in the polychaete community, four fixed parameters were considered: (i) bimonthly (from June 2010 until April 2011), (ii) with 3 stations (200m,600m, 1200m), (iii) with two sampling sites levels (A, B) and (iv)depth, with three levels (3,6,9 m) was utilized.

If the variances were significantly different (P =0.05), data were transformed into $\sqrt{X} + 1$ and $\ln(X + 1)$ if variance was still heterogeneous. Shannon-Wiener diversity (H′), Margalef's species richness (d), Peilou's evenness (J′) and Abundance was studied.

Graphical presentation of multivariate models of polychaete community was acquired by non-metric multidimensional scaling (nMDS). To understand which environmental factors had the greatest influence on macrobenthos characteristics for stations sampled, Principal Components Analysis was implemented to a correlation matrix of environmental variables for all sampling stations, and then plotted in two-dimensional space.

IV. Results

Polychaete was the second group of the macrofauna assemblage comprising 12.31% of the total abundance.Due to the macrofaunal assemblage, a total of 604 specimens were gathered, and distributed into 20 various taxonomic groups.

A total of 604 individuals were examined which was grouped into 23 families. Family Nereidae was the most abundant (22.68%), followed by Spionidae (22.02%), Hesionidae (12.58%), Nephtylidae (9.27%) and Orbiniidae (8.61%).

The maximum Shannon-Wiener diversity (H′=2.16) was recorded at distance 200m and 1200m (August) in Teluk Ketapang and lowest value of diversity was found at distance 1200m (December) in Teluk Ketapang (Fig. 3).

Low in evenness was observed at station 200m (October) in Pantai Acheh and highest evenness was found at Pantai Acheh in 600m in February.

The highest richness (3.47) was recorded at distance 200m and 1200m (August) in Teluk Ketapang and lowest richness (1.67) was observed in Teluk Ketapang at 1200m (December).

The pH values ranged between 8.16 and 8.6. Percentages of organic matter ranged between 1.01% and 4.48%. The highest values were shown in the shallow stations.

Salinity ranged 28.43% and 30.03‰ at all stations. Temperature range at all sampling stations was observed between 29.27°C and 31.6°C.

The survey region is described by the heterogeneity of sediments particle size.

Silt and clay dominated at all sampling stations. The 200 m distance in Pantai Acheh was described by the presence of lowest percentage of silt and clay compared to other stations.

TABLE I
NUMBER OF ORGANISMS PER METER SQUARE AT DIFFERENT STATIONS AND MONTHS IN TELUKKETAPANG AND PANTAI ACHEH, PENANG, MALAYSIA

Station	200m P.Aceh		600m P.Aceh		1200m P.Aceh		200m T.Ketapang		600m T.Ketapang		1200m T.Ketapang	
Polychaete	**Ab.ab**	**Rel.ab**	**Ab.ab**	**Rel.ab**	**Ab.ab**	**Rel.ab**	**Ab.ab**	**Rel.ab**	**Ab.ab**	**Rel.ab**	**Ab.ab**	**Rel.ab**
Amphinomidae	6	6.32	1	2.27	0	0.00	1	1.89	0	0.00	2	4.00
Cossuridae	5	5.26	0	0.00	2	4.00	1	1.89	0	0.00	0	0.00
Lumbrinereidae	4	4.21	3	6.82	3	6.00	0	0.00	0	0.00	0	0.00
Scalibregmidae	1	1.05	0	0.00	0	0.00	0	0.00	0	0.00	2	4.00
Cirratulidae	1	1.05	0	0.00	0	0.00	0	0.00	1	1.92	0	0.00
Magelonidae	2	2.11	0	0.00	0	0.00	1	1.89	0	0.00	2	4.00
Spionidae	22	23.16	6	13.64	7	14.00	10	18.87	10	19.23	7	14.00
Nephtylidae	6	6.32	5	11.36	4	8.00	5	9.43	6	11.54	5	10.00
Orbiniidae	4	4.21	4	9.09	5	10.00	6	11.32	4	7.69	5	10.00
Glyceridae	5	5.26	4	9.09	4	8.00	3	5.66	3	5.77	2	4.00
Nereidae	21	22.11	9	20.45	9	18.00	11	20.75	8	15.38	6	12.00
Pilargiidae	1	1.05	1	2.27	2	4.00	0	0.00	1	1.92	3	6.00
Hesionidae	6	6.32	6	13.64	6	12.00	4	7.55	12	23.08	6	12.00
Goniadidae	3	3.16	2	4.55	2	4.00	2	3.77	2	3.85	3	6.00
Syllidae	0	0.00	1	2.27	0	0.00	0	0.00	0	0.00	0	0.00
Sigalionidae	0	0.00	0	0.00	0	0.00	1	1.89	1	1.92	0	0.00
Phyllodocidae	2	2.11	0	0.00	1	2.00	0	0.00	0	0.00	0	0.00
Pectinariidae	0	0.00	0	0.00	2	4.00	1	1.89	0	0.00	1	2.00
Terebellidae	1	1.05	1	2.27	0	0.00	2	3.77	0	0.00	1	2.00
Ampharetidae	0	0.00	0	0.00	0	0.00	3	5.66	1	1.92	1	2.00
Sabellidae	1	1.05	0	0.00	0	0.00	1	1.89	1	1.92	2	4.00
Sternaspidae	3	3.16	0	0.00	1	2.00	1	1.89	1	1.92	1	2.00
Flabelligeridae	1	1.05	1	2.27	2	4.00	0	0.00	1	1.92	1	2.00
Total	95	100.00	44	100.00	50	100.00	53	100.00	52	100.00	50	100.00

Analyzing the MDS plot (Fig. 2), variations are detected in the structure of polychaete community. A highly homogenous group (group1) was recorded, that comprises most of the sampling stations during the various sampling periods. This group is described by the domination of the families Spionidae, Nereidae, Orbiniidae, Nephtylidae and Hesionidae. The results of n-MDS revealed a separation of the sampling station near the coast (200m) in Pantai Acheh and 1200 m in Teluk Ketapang, with regard the sampling stations comprised in group 1 (Fig. 2). Spionidae and Nereidae were the families responsible for the dissimilarities between sampling stations at Teluk Ketapang, (1200m) during December 2010 and group 1. The differences between sampling stations at Pantai Acheh 200m (in August and October) and group 1 are because of variations in the some families Separation from group 1 was also observed in sampling stations at Teluk Ketapang, at 1200m, in December and Pantai Acheh, at 200m, in August and October during the investigation.

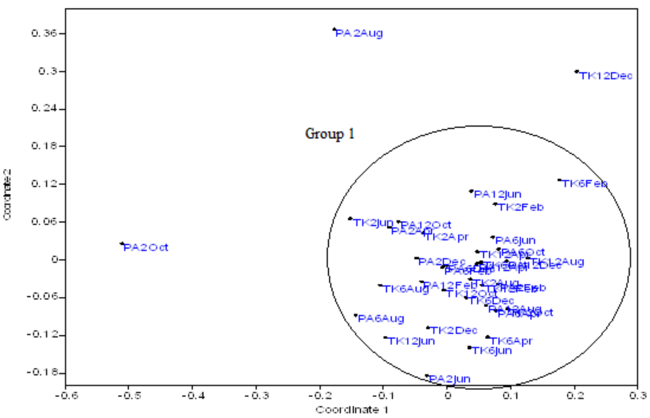
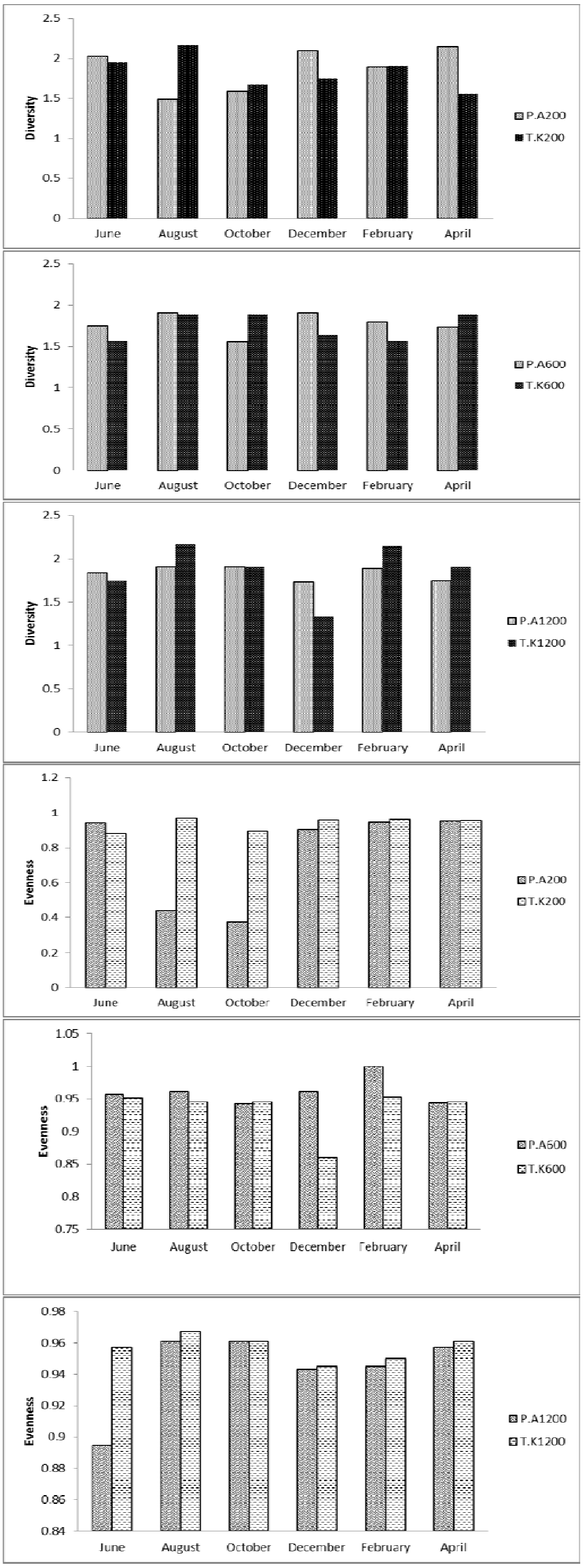


Fig. 2 Non-metric multidimensional scaling plot using Bary-Curtis similarities for Polychaete abundance data



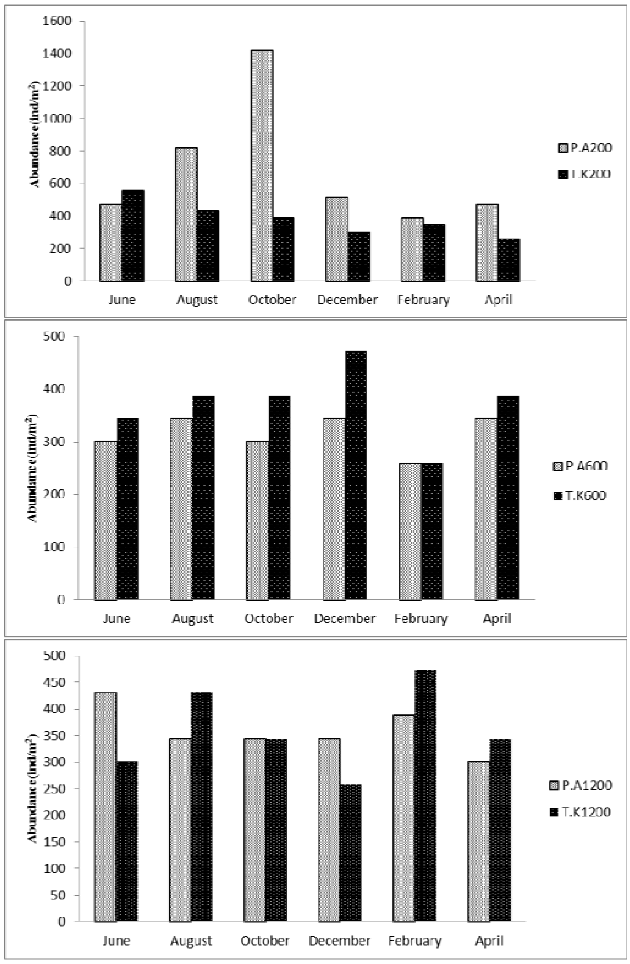


Fig. 3 Mean diversity, evenness and abundance of Polychaete assemblage at sampling months, for each station (200m, 600m and 1200m) and for two locations (Teluk Ketapang and Pantai Acheh)

Based on Chatfield and Collins, (1980), the components with eigenvalues more than one would be considered when analyzing a correlation matrix.

From the PCA result evaluated using Statistica 8 and the first four components were calculated with eigenvalues, it can be seen that from Table III, out of the 14 components studied these four principal components accounted for 63.54% of the total variance of the original data.

TABLE II
PRINCIPAL COMPONENTS ANALYSIS EIGEN VALUES, NUMBER OF COMPONENTS IS 4 PRINCIPAL COMPONENTS ANALYSIS

	Eigenvalues	% Total variance	Cumulative eigenvalue	Cumulative %
1	4.083946	21.49445	4.08395	21.49445
2	3.472348	18.27552	7.55629	39.76997
3	2.599645	13.68234	10.15594	53.45231
4	1.917705	10.09319	12.07365	63.54550

Scree plot plotted for this set of data also revealed a dramatic fall of eigenvalues from the first to the fourth eigenvalue. As a result, the first four components can be considered significant in the analysis (Fig. 4).

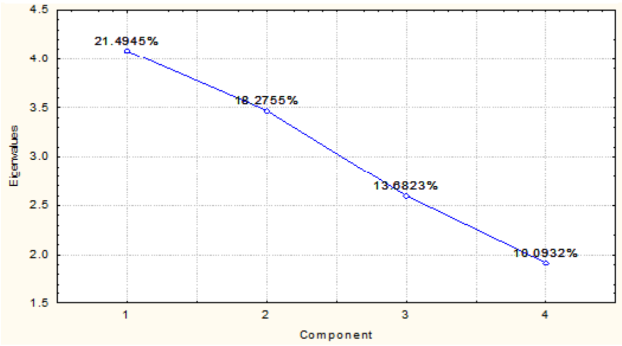


Fig. 4 Eigenvalue scree plot for macrobenrthos abundant and environmental parameters in Teluk Ketapang and Pantai Acheh, Penang, Malaysia

TABLE III
ROTATED PRINCIPAL COMPONENT LOADINGS FOR 15 STANDARDIZED SEDIMENT PARAMETERS AND ENVIRONMENTAL FACTORS. THE FOUR PCA FACTORS HAD EIGENVALUES MORE THAN 1

Variable	PC 1	PC 2	PC 3	PC 4
Depth	0.092	0.266	-0.410	-0.019
Temperature	-0.046	0.441	0.235	0.067
DO	0.202	-0.341	-0.176	0.071
EC	-0.083	0.309	0.167	-0.297
pH	0.000	0.104	-0.137	0.432
Chlorophyll. A	-0.213	-0.226	0.254	-0.021
Salinity	-0.072	0.418	0.180	0.175
TSS	0.041	-0.204	0.309	-0.178
Organic matter	-0.002	0.018	0.428	0.234
Fine sand	-0.211	0.123	-0.286	-0.136
Very Fine sand	-0.344	0.048	-0.108	-0.106
silt	-0.411	-0.226	0.099	0.091
Silt. Clay	-0.418	-0.141	0.024	0.171
clay	0.446	0.145	-0.016	-0.135

The First component (PC1) is the component that well characterizes the connection between macrobenthos abundance and the other few important variables as shown in Table IV (silt, Silt Clay and Clay).

These three factors can be grouped as the sediment particle size. In the context of macrobenthos community, sediment particle size has influence on macrobenthos abundance due to the lives of their in the sediment. Temperature and Salinity was found in the second component (PC2).

These two parameters can be grouped as the physical properties of water. The third component (PC3) is the component that clear describes on the variable namely, depth and organic matter.

The component loadings of depth and organic matter are good parameters from macrobenthos abundance and this suggests that depth and organic matter have influence on macrobenthos abundance.

Organic matter has the component loading that is closest to macrobenthos abundance which several researchers show that they are closely connected.

In the fourth component (PC4), the component loadings were low and moreover, the percentage of total variance elucidated accounted for PC4 is only 10%.

Although important, pH value observed no connection between these parameters and macrobenthos community abundance.

V. DISCUSSION

The term community is broadly utilized and most definitions of assemblages include the idea of a group of organisms observed in a special place (physical environment); some ecologists detected that these families must interact in some significant way to be considered assemblage members [11]. One of the basic surveys on the assemblage conception in marine biology is by [12]. He compared some definitions both in animal and plant biology and the discussion resulted in a final definition: ‘‘an assemblage is a collection of organisms taking place in a specific habitat, probably interacting with each other and with the habitat and detachable from other groups by using of an ecological examination. ’’

This study displayed a clear spatial change in macrobenthic community structures in relation to environmental parameters such as sediment particle size, organic matter and depth in the coastal water (Fig. 2). Additionally, the three stations with a distance of 200m until 1200 m in two locations are exposed to various abundance and depth. Pantai Acheh shoreline of 200m is shallow is exposed to high loads of organic matter compared with Teluk Ketapang, which is less affected by pollution. The increment of organic contaminants possibly enlarged the nutrient load leading to high oxygen consumption rates. A the distance is further from the shore at Station 600m with 6m deep and station 1200m possibly considered a clean with no apparent source of anthropogenic activities. Variations in the polychaete community composition found at distances 600m and 1200m are presumably due to other parameters, unrelated to sediment composition since the particle size at these sampling station is more silt, although it probably could effect on macrobenthic polychaetes. In spite of the heterogeneity of the region, most sampling stations and sampling months are grouped in MDS. Hence, the most obvious impact of sediment composition and organic matter is the consistent variation in the polychaete assemblage at station 200m which is near the shore. This can be observed in the MDS in Fig. 2, where the distance between station 200m and the rest consistently enlarges with spatial and depth.

Many investigations have revealed the spatial distribution of macrobenthic community along a subtidal gradient is related to sediment particle size and/or organic matter [1-4-7].The high percentage of organic matter observed in station 200m in Pantai Acheh and 1200m in Teluk Ketapang showed a positive relation with abundance, diversity and richness of macrobenthic polychaetes. High percentages of sediment with grain size ≥125 µm revealed to have an increased in macrobenthic abundance. This may aid in expounding the higher abundance of macrobenthic organisms detected at station 200m, particularly for the deposit feeders. It had been reported that the sediment type (sand vs. mud) is one of the parameters responsible for the spatial distribution of macrobenthic families according to feeding behavior [9-13].

Polychaete community variations at the sampling stations adjacent to the coast displayed the existence of change in sensitivity levels in polychaete families to pollution impact. It is useful to investigate the behavior of these families for early discovery of new disturbance. Spionidae, Nereidae and Nephtylidae were predominant organisms in station 200m at Pantai Acheh and Spionidae, Hesionidae, Nereidae, Orbinidae and Nephtylidae was observed in Teluk Ketapang. Grassle and Grassle (1974) observed that some polychaete species were greatly opportunistic and responded quickly to environmental disturbances [8]. However, the choice of bioindicators organisms could vary with time and space (particularly when they comprise indicative species) [14]. For this, it would be essential to keep on analyzing the impact of various environmental conditions with respect to time and space. Changes observed in the polychaete assemblages demonstrate that analysis of the impact of high taxonomic levels show interesting results. Changes in assemblages have been discovered in other investigations where fauna has been assembled to higher taxonomic levels, family or even phylum [17-3].

Acknowledgment

The authors are thankful to the officers and crew of Center of Marine and Coastal Study (CEMCS) research vessel for help on board during sample collection. This project was funded by Research University Grant, Universiti Sains Malaysia (Account number: 1001/PPANTAS/815052).

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