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THE EFFECT OF TAR ON SETTLING OF THE BARNACLE *BALANUS AMPHRITRITE*

by

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CONTENTS

ABSTRACT

The present experiment was to determine the antifouling property of fresh tar on *Balanus amphritrite* (Darwin) settlement. Wood panels treated and untreated with tar were suspended at an intertidal level, similar experiment was conducted at a subtidal level. The number of *B. amphritrite* settled on these panels were counted weekly. The results showed that fresh tar covered wood surface reduced the settlement of *B. amphritrite* by 40-60% over a four-month experimental period. The experiment was conducted during the southwest and northeast monsoons. The factors of tidal level, the variation in density and the size diversity wers also tested.

I. INTRODUCTION

Bunker oil discharged offshore gradually loses its original property over time and finally becomes tar lumps being washed ashore as soft sticky fresh tar which may be deposited on beaches and the rocky shore (Dwivedi, 1974; Skekel, 1975; Eagle, 1979; Limpsaichol, 1985). Where exposure to sunlight and heat is intense the tar melts and covers the surface in patches. Such tar covering at an intertidal location could interfere with the settlement of fouling organisms. So far little information is available on the effect of tar on the settlement of barnacles. A recent study by Dharmaraj and Nair (1981) showed that fouling is a continuous process occuring throughout the year with heavy deposition in high saline water during the premonsoon and slight deposition in low saline water during the monsoon periods. Ghobashy & El Komy (1980b) also reported similar results at various seawater temperatures and Ruxing *et al.* (1981) found that current was an important factor as the rapid current favoured the settlement and growth of the barnacle larvae. Such settlement was highly dependent upon species specific attraction together with the structure of the substrate surface (Oshurkov & Oksov, 1984). Further more, when the substrate surface was treated with the barnacle extract protein, heavy settlement of barnacles was observed (Yule & Walker, 1984). By contrast field observations (Limpsaichol, unpublished data) showed that very few barnacles settled on patches of tar covered surface suggesting that fresh tar may have an antifouling property.

As it was thought that fresh tar might be used to prevent fouling of barnacles on wood, an experiment was carried out at the pier of Phuket Marine Biological Center to investigate the possible effect of tar on the settlement of the barnacle *Balanus amphritrite* (Darwin) during the south-west and north-east monsoon periods.

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II. MATERIALS AND METHODS

Ten panels of wood each having a surface area of 25×10 cm. were tied 20 cm. apart from each other with a nylon rope. The first five panels were coated with soft and sticky fresh tar (approx. 0.2 cm. thick); the other five panels were left untreated as controls. All panels were suspended horizontally at an intertidal location. For comparison, another ten panels of wood receiving the same treatment were set up, but these were suspended at a subtidal location. The number of fouling barnacles that settled on the wood surface were counted using a 4×4 cm. quadrat. The quadrat was randomly placed at 3 positions on the wood surface i.e. on the top, middle and bottom. Every organism in each 4×4 cm. was counted and the size was measured. Such observations were undertaken every week for a period of 4 months (during May-August 1981 of the north-east monsoon and November-February 1982 of the south-west monsoon periods). The results were calculated for 3-WAY ANOVA by Hewlett-Packard model 4/C Handheld calculator with an ANOVA programme.

III. RESULTS

The interaction between the numbers of *Balanus amphritrite* (Darwin) settled on the tar free and tar coated wood panels suspending at the intertidal and subtidal locations were calculated and tested by using the 3-WAY ANOVA as tabulated in Table 1–3. The location where this expertment was conducted and the size diversity of settled barnacles were presented in Fig. 1 and 2 respectively.

The effect of tar and tidal level on the settlement of barnacles on wood are great and very significant and the duration of the experiment is also important on the settling (Table 1 and 2). During the south-west monsoon, the effect on settling due to interactions between factors of tar and tidal-elvel or tar and time or tidal level and time are small and not significant. However, the overall effect turns out to be significant. In the first month (May) of the experiment the abundance of newly settled very young barnacles and some recently settled older ones were classed in the size of less than 2 mm. and 2–4 mm. respectively (Fig. 2). The most

Table 1 The 3-WAY ANOVA showing the effect of significant factors and their interaction on the settlement of barnacles during May-August (south-west monsoon) 1981.

TREATMENTS	SS	DF	MS	F
A	78,758.04	1	78,758.04	98.54**
B	109,625.14	1	109,625.14	137.16**
C	46,651.13	6	7,775.19	9.73**
AB	1,248.89	1	1,248.89	1.56NS
AC	10,207.09	6	1,701.18	2.13NS
BC	9,195.23	6	1,532.54	1.92NS
ABC	38,165.98	6	6,361.00	7.96**
ERROR	67,135.50	84	799.23	

A = Tar (tar coated-tar free)
B = Tidal level (intertidal-subtidal)
C = Time (duration of experiment)
** = Significant at 1% level
NS = Not significant

Table 2 The 3-WAY ANOVA showing the effect of significant factors and their interaction on the settlement of barnacles taken during November-February (north-east monsoon) 1982.

TREATMENT	SS	DF	MS	F
A	92,907.68	1	92,907.68	149.28**
B	65,007.08	1	65,007.08	104.45**
C	102,019.54	5	20,403.91	32.78**
AB	6,855.41	1	6,855.41	11.01**
AC	3,434.28	5	686.86	1.10NS
BC	19,299.88	5	3,859.98	6.20**
ABC	971.34	5	194.27	0.31NS
ERROR	59,748.40	96	622.38	

A = Tar (tar coated-tar free)
B = Tidal level (intertidal-subtidal)
C = Time (duration of experiment)
** = Significant at 1% level
NS = Not significant

Table 3 The average number of *B. amphritrite* settled on 4 × 4 cm. wood surface over 4 month experimentduring the two monsoons (±standard deviations)

MONSOON	Tar free		Tar coated	
	Intertidal	Subtidal	Intertidal	Subtidal
South-West	79.1	148.4	32.8	88.7
	± 19.6	± 25.0	± 20.7	± 34.2
North-East	77.1	138.8	36.6	68.0
	± 38.4	± 19.4	± 11.1	± 12.5

dominant of the 2 size classes were on the non-tar-substidal panels. In the second month (June), the settled barnacles continued growing upto 4–6 mm size with more young barnacles newly settled on all panels. The dominant size class was less than 2 mm. on the non-tar-substidal panels. In the third month (July), the settlement of new young barnacles dropped abruptly. The older barnacles of the size classes of 2–4 mm. and 4–6 mm. became abundant on the non-tar-intertidal and non-tar-subtidal panels respectively. The size diversity was significantly greater on the intertidal than on the subtidal panels. In the fourth month (August), barnacles larger than 6 mm. were dead on most panels. Smaller numbers of barnacles in all size classes were recorded on tar coated intertidal panels throughout the experiment.

During the north-east monsoon the interaction of the these factors showed some effect on the settlement of barnacles. The abundance and size composition of barnacles showed similar patterns to those of the south west monsoon experiment except that in the third month barnacles larger than 6 mm. were more abundant. In the fourth

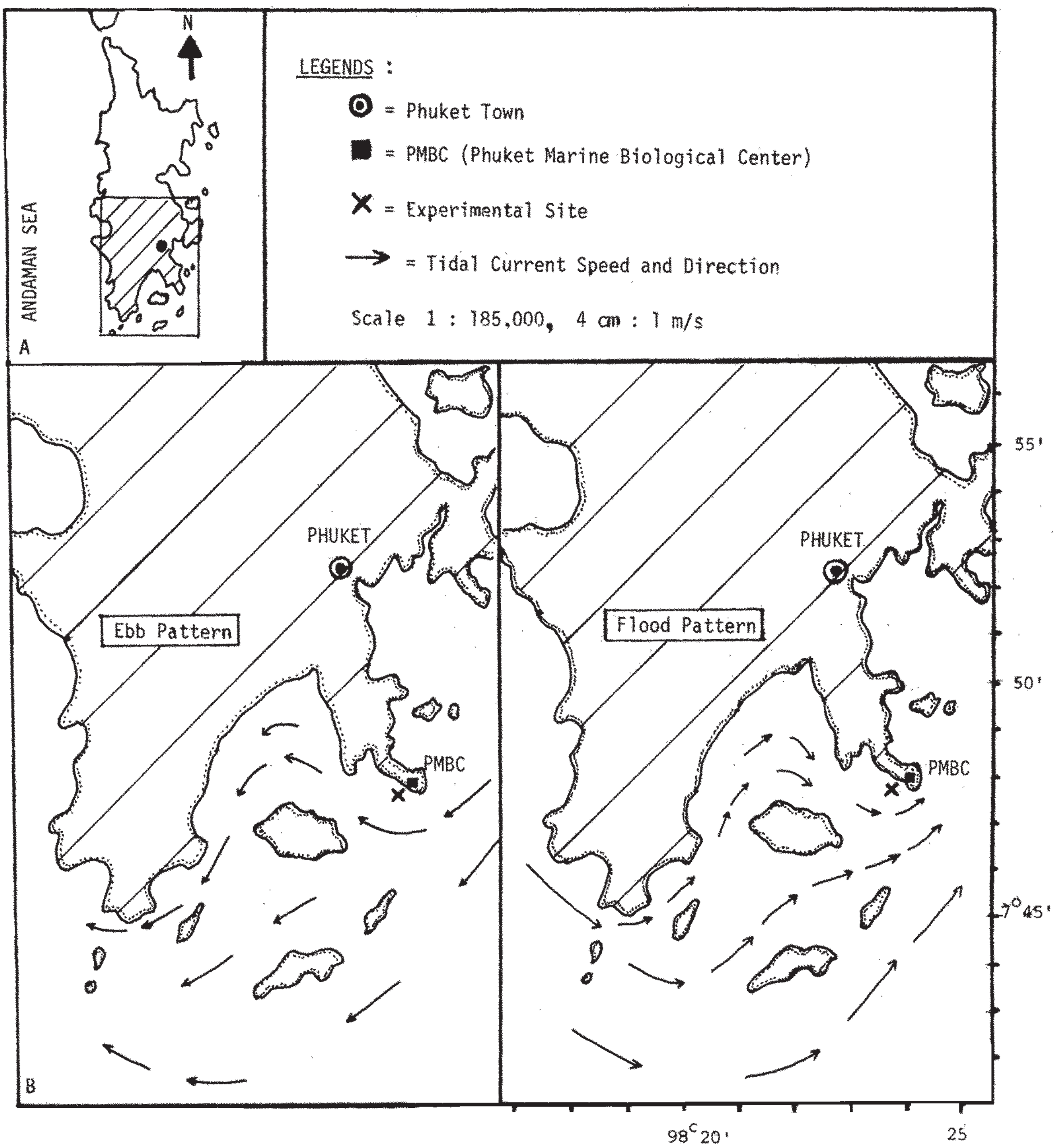

Fig. 1. A: Map of Phuket Island showing southern coast (in box).
B: Enlarged map of southern coast showing experimental site with flood and ebb tidal current patterns (Captain T. Charoenlaph R.T.N.).

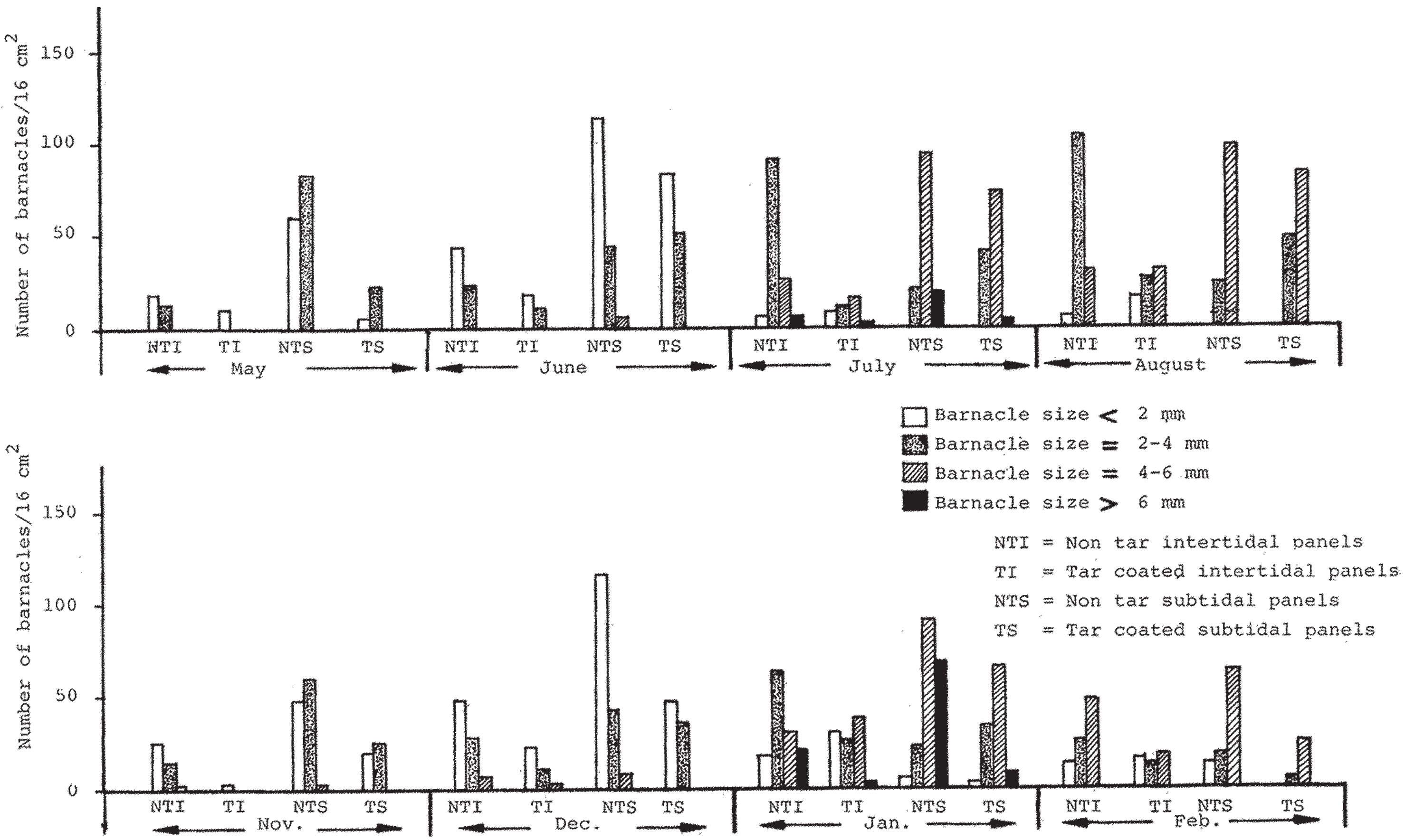

Fig. 2. The effect of tar on size diversity of barnacles (*B. amphritrite*) which settled on tar and non tar coated wood panels located at intertidal and subtidal levels. A: during south west monsoon (wet season) and B: during north east monsoon (dry season).

month, the abundance in all size classes declined and more dead barnacles larger than 6 mm. were recorded indicating that better conditions favourable for growth was in the north-east monsoon period. In addition there was no significant difference in the density of barnacles that settled between these two monsoons (Table 3). Greater density of settled barnacles was recorded at the subtidal location in comparison with the intertidal location. The density of barnacles was reduced by 40–60% on the tar coated panels during the experiments.

IV. DISCUSSION

Barnacle settlement is affected both by tidal level of site settlement and presence or absence of tar covering the substrate. The tidal effect may subsequently be due to the severe period of desiccation during low tides associated with less saline surface water which occurs during heavy rain fall preventing cyprids from settling. The effect became very significant, during the strong prevailing wind and heavy rainfall of the south-west monsoon period. It has been reported that more settlement occurred in high saline rather than low saline waters (Dharmaraj & Nair, 1981). The chemical components of fresh tar may destroy the settlement stimulating substance of barnacles. Knight-Jones (1953) found that the settlement stimulating substance consisted of a phenol component of quinonetanned protein. In a later report he showed that such a settlement stimulating property could be destroyed by a substance which attacked the phenol component of the quinonetanned protein (Knight-Jones & Crisp, 1953). However, in a preliminary experiment, the author observed that the tar reacted with phenol suggesting that tar would attact the settlement stimulating substance particularly such an effect was greater than tidal level during the calm season of the north-east monsoon period. Shi *et al.* (1981) reported a reduction of mitochondrial activities (respiration and phosphorylation) of 54% to 100% by *B. amphritrite* after treatment with the antifouling agent triphenyltin chloride, such effect was due to the cristae being damaged. The present results indicated that some barnacles were successful at settling on tar coated surfaces after one week of experiment but the cementing adhesion was not as strong as those on the control panels. The proteinaceous adhesive material involved in the settling response has been reported to be produced within one day of metamorphosis having a cementing force of up to 9.3×10^5 Newtons/m^2 in older barnacles (Yule & Walker, 1984).

There was a high density of barnacles settled on the tar coated panels by the end of the experiments. It was recorded that the suspended particles in the water were adsorbed on the tar surface as a thin layer which could have prevented the bases of barnacles from directly touching the tar and thus could lessen the effect of tar on settlement. However, such a thin layer of adsorbed particles weakened the attachment which is potentially unstable. As a result, some settled barnacles might come away. Similar results have been reported by Ghobashy & El Komy (1980b) that the silty water prevented the attachment of many fouling organisms. The factors that favoured the later settlement were associated with spatial distribution, gregariousness, neighbouring species and the degree of epibiosis together with the exposure and inclination of substrates (Gherardi *et al.*, 1981).

The gregariousness and crowding settlement were also recorded in the present study and depended largely on those previously settled barnacles and may eventually cause death. Similar results were also Reported by Barnes & Powell (1950) on crowding settlements and mortalities. Due to the considerable constant temperature of the tropical sea (Limpsaichol, 1981) resulting no significant effect of seasonal temperature variations on *B. amphritrite* in the present study although a study conducted by Ghobashy & El Komy (1980a) in the Lake Timsah (Egypt) revealed that *B. amphrttrite* and other fouling organisms settled heavily during May to September but slight settlement was recorded in the coldest month of December to February.

V. CONCLUSIONS

Fresh tar covered wood surface reduced the settlement of the barnacle *Balanus amphritrite* (Darwin) by 40-60% over a four-month experimental period during the south-west and during the north-east monsoons. The significant factors affecting the barnacle settlement were tar, tidal level and duration of the experiment. There was no significant difference in the density of barnacles settled in these two monsoons, Greater density was recorded at the subtidal location in comparison with the intertidal location. However, the size diversity was greater on the intertidal than on the subtidal locations.

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