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Water hyacinth (*Eichhornia crassipes*) as an indicator to show the absence of *Anopheles sundaicus* larvae

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Abstract: Water hyacinth, *Eichhornia crassipes*, was evaluated as to whether its appearance could be useful as an indicator to show the absence of *Anopheles sundaicus* larvae in the coastal area of the Asahan Province in North Sumatra, Indonesia. The water hyacinth was distributed along the coast in water bodies in which salinity was less than 0.2%. No *An. sundaicus* larva was found breeding in waters with hyacinths. In waters without any macrophyte vegetation, the larvae were frequently found in the range of 0.0% to 4.0% salinity. The susceptibility test revealed that the plant could not tolerate 0.32% salinity and began withering, but they were thriving at 0.24% salinity or less after 2 days exposure. It was concluded that the water hyacinth is a suitable plant for the detecting of *An. sundaicus* larval habitats and/or brackish water bodies in coastal flats.

INTRODUCTION

Accurate mapping of breeding sites of malaria vectors is essential for effective control. *Anopheles sundaicus* occurs in brackish water. This species was targeted for malaria vector control in the North Sumatra Health Promotion Project. Ike-moto (1982) reported that the larvae bred in the sunny brackish water at Perupuk village of Asahan Province in the project area. The mapping of the larval breeding sites was intensively done in Perupuk vil-

lage. This village was recorded as having the highest prevalence of malaria among six coastal villages in the project area (Kanbara, 1984). Brackish water habitats are very unstable throughout the year. The distribution and area of brackish water frequently changed with rainfall, tidal invasion into the inland area and so on. Therefore, during the survey, we required an indicator which is able to distinguish quickly *An. sundaicus* larval habitats from water bodies without this species.

The usefulness of the vegetation as a bio-

indicator to characterize larval habitats is expected to support ecological mapping for mosquito control strongly (Gabinaud, 1987). Some reports have mentioned that water plants related to *An. sundaicus* larval breeding. Sundararaman *et al.* (1957) and Collins *et al.* (1979) reported that *An. sundaicus* larvae were abundant in the blooms of fibrous floating algae. Chan (1969) also found that profuse numbers of *Culex sitiens* and *An. sundaicus* bred together with *Entomomorpha* sp. in neglected ponds left after fish rearing in Singapore. In the Perupuk area, Ikemoto (1982) reported that *Enteromorpha* sp. and *Chaetomorpha* sp. were advantageous for

An. sundaicus as shelter against predators and/or as feeding places. However, the distribution of this plant was very limited and it was seasonal in the study area.

In contrast, the water hyacinth, *Eichhornia crassipes*, is a floating plant in fresh water areas, and is common throughout Indonesia. We therefore studied whether this plant is useful as a bio-indicator of *An. sundaicus* larval habitats. We studied the following: (1) distribution of water hyacinths on the Asahan coast; (2) the relationship between distributions of water hyacinths and *An. sundaicus* larvae; (3) susceptibility of water hyacinths to saline concentrations.

Fig. 1(A).

Fig. 1-A·B. Map of study areas. (A): Environmental conditions along the coast in the Asahan Province. Names of villages are expressed in italics. Names of districts are underlined. Indrapura is the name of the town, and Kuala Tanjung is the name of the cape. (B): Survey sites in Perupuk area. Both sites of water hyacinth 1 and 2 were affected by the spring tide invasion closest in time to the equinox of April in 1986. After this, water hyacinth 1 was covered with duck weed, and water hyacinth 2 was recovered to its former state. Water hyacinth 3 was not invaded by the sea water.

Fig. 1(B).

MATERIALS AND METHODS

Study area

The whole study area consisted of 9 villages in Asahan Province facing the Malacca Strait. The distribution of water hyacinths, larval habitat and water salinity were studied in this area (Fig. 1-A). The length of the coastal line surveyed totaled about 56 km from a part of Bandar Khalipah village to Dahari Selebar village, which were located in the northwest and southeast of Asahan Province, respectively.

The distributions of water hyacinth, *An. sundaicus* larval habitat and water salinity were studied at Perupuk village and parts of Guntung and Pematang Panjang villages (Fig. 1-B). The topography and land use in a part of this area were described by Imai *et al.* (1988). There is a river, Sungai Gambus, and four tidal creeks where the sea water flows into and out of with the rising and falling of the tide, Sungai Pablik Galam, S. Alur, S. Piyai and S. Guntung, each having a free connection with the sea and a number of sub-streams. The size and water quality of these tidal creeks were strongly affected by tidal action and rainfall. In the dry season, some streams almost dried up, leaving isolated pools on the stream bed. In contrast, after heavy rainfall, these streams overflowed and large swamps were formed in the meadows.

Survey

The geographical distributions of water hyacinth and other environmental conditions in the whole study area were surveyed in January 1987. All the water samples were collected from water bodies which were accessible from the road side. The water samples collected with a dipper were quickly spread on the bottom of a white plastic tray, and the existence of *An. sundaicus* larvae was checked at every sampling point.

At Perupuk village and parts of Gun-

tung and Pematang Panjang villages, the relationship of *An. sundaicus* larval habitat, the distribution of water hyacinth vegetation and the water salinity was examined at 80 sites each of which consisted of 4 collection points. At these points the larval density was examined by 10 to 30 dippings with a dipper 18 cm in diameter and 10 cm deep. Salinity was measured at each point by a digital salinometer. The larval density and water salinity obtained from four collection points were averaged at every site and those values were counted each as one sample. This survey was repeated monthly from February to September in 1986. However, if the ground condition prevented entry to the survey site, it was put off till the following month. But even at the longest intervals, it was not put off for more than two months.

Susceptibility test of water hyacinth to salinity

Four water samples of 0.01, 0.24, 0.32 and 0.56% salinity were provided for the examination of the reactions of the water hyacinth's outward appearance to the salinity. Water hyacinths collected from the inland area of Perupuk village were used. Ten individuals were placed into a concrete pond of 1 m³ capacity containing ca. 0.5 t water in each salinity. The examination of their reactions at each salinity was done after 2 days, and 1 and 2 weeks, then the withering of the leaves and roots was carefully observed.

RESULTS

Distribution of water hyacinths in the Asahan coastal area

The area of the inland side of the road which ran parallel to the seashore, was mostly occupied by paddy fields. The water hyacinths were frequently found along both sides of the rivers and in the irrigation canals spread in the paddy fields. Such places are marked as water hyacinth areas on the water ways in Fig. 1-A. Water salinity was measured at 112

Fig. 2. Correlation of the number of *An. sundaicus* larvae/dip and water salinity in vegetation and no vegetation areas.

sampling points collected at about 0.5 km intervals from Bandar Khalipah to Dahari Selebar. But the larval collection by dipping was only done at 67 sampling points due to the configuration of the ground, *i.e.* the dipper's shaft was too short to reach the water surface or the depth of the water body was too shallow to permit dipping.

Water hyacinth was widely distributed in the direction of the land-sides of Nanasiam and Perupuk to Dahari Selebar, and in the neighborhood of the seashore of Kuala Tanjung (Fig. 1-A). The water hyacinth area occupied 34% of the whole study area. However, as stated previously, 43% of this area was at river sides and irrigation canals located in the paddy field area. Twenty-seven samples were collected from this area. No *An. sundaicus* larva was found. Water salinity was less than 0.2% in the water where water hyacinths were growing.

The paddy field area occupied 55% of the whole study area. The paddy fields were supplied with water by several irrigation canals linked to the adjacent rivers.

Durian and Medang in particular were rich in paddy fields supported by eight irrigation canals from the Si Pare Pare river. Twenty-three samples were collected. No *An. sundaicus* larva was found. Water salinity was less than 0.1%.

The tidal marsh area which was affected by periodic tidal actions occupied only 11% of the whole study area. It was distributed near the shores of Pangkalang Dodek, on the northwest side of Kuala Tanjung and between Perupuk and Tarawi. There were coves formed by slight curves in the shore. The large tidal areas were formed behind the barrier beach. Seventeen samples were collected. The mean salinity was 1.4%, and *An. sundaicus* larvae were found in 15 samples.

The distribution of water hyacinth, An. sundaicus larvae and water salinity in the Perupuk area

In the Perupuk area, water hyacinth grew in stagnant water used as ditches for coconut cultivation, fish ponds or what remained as natural flood plains (Fig. 1-B). Near the main stream of the Gambus river, although there was fresh water, water hyacinths were only found along the banks. This was due to the strong current (0.61 m/sec) of the river.

Of 80 sites in the Perupuk area (Fig. 1-B), water hyacinth was found at 32 sites before the influx of the equinoctial spring tide (EST) at the end of April 1986. Water hyacinths growing at 19 of 32 sites were then affected by the inflow of sea water coming through each tidal creek. Afterwards, water hyacinths recovered their former state at 15 sites, but died out at the other 4 sites. Instead, duck weed started to grow at these 4 sites. Duck weed distributed at 6 sites before the EST influx, afterwards the 4 sites were therefore added. No vegetation was recorded at 42 sites before the EST influx, and afterwards the 19 sites which were affected by the EST influx were temporarily added.

The relationship between *An. sundaicus* larval density and water salinity in areas

Fig. 3. Reactions of water hyacinth to water containing saline after one week's exposure.
A, 0.01 % salinity; B, 0.24%; C, 0.32%; D, 0.56%.

with water hyacinth, duck weed (*Spirodela* spp.), and/or no vegetation growth are shown in Fig. 2. Of a total of 553 samples, 174 samples were collected from the sites where there were water hyacinth growing. The salinity of the water where hyacinth grew was less than 0.2%. No *An. sundaicus* larva was found breeding in the waters with hyacinth. Fifty-seven samples were collected from the duck weed breeding waters, where salinity was measured at between 0.0% and 1.2%. *An. sundaicus* larvae were found in 12 samples. The other 322 samples were collected from waters with no vegetation. The range of salinity in those samples was 0.0% to 4.0%. The larval positive rate of 322 samples was 49% and the larval density per dip was 0.819 ± 0.175 (S.E.). In 42 samples from waters with no vegetation, though the salinity was less than 0.2%, larvae were found in 13 samples and the mean larval density per dip was recorded at 0.161 ± 0.178 (S.E.). Larvae, therefore, existed in water of <0.2% salinity.

In the fresh water ponds (thick arrow in Fig. 1-B) which are situated behind sand banks running parallel to the shore, a dense growth of water hyacinth was found. This survey site was surrounded by several *An. sundaicus* breeding sites. Although this site was located only 40 m from the seashore, larvae were not collected there from September 1985 to August 1986.

The susceptibility of water hyacinth to salinity

In the first two days after exposure to water containing saline, the hyacinths were more thriving at 0.24% salinity than those at 0.01%. A striking difference was found in the reactions of the leaf stalk forms after 2 days' exposure to 0.24% and 0.32% salinity. The water hyacinth could not tolerate 0.32% salinity and began withering. The reaction of water hyacinth to different salinities after one week is shown in Fig. 3. Almost all the leaf stalks in water with 0.32% salinity had withered

further and their roots had become wavy and shortened. Water hyacinth exposed to 0.56% salinity were more severely affected than those at 0.32% or 0.24%.

DISCUSSION

On the coastal plain area of Asahan Province there are river mouths, coastal bays, tidal marshes, and water bodies between sand banks. In this environment, the boundaries of *An. sundaicus* habitat fluctuate greatly. One consistent indicator of the presence of *An. sundaicus* is the non-existence of water hyacinth.

For *An. sundaicus* larval breeding, floating Pteridophyta, *Salvinia* sp., was mentioned by Imai *et al.* (1988). They reported that larvae were never collected in waters with this plant in Perupuk, and this plant grew in waters with 0.03–0.30% salinity and covered the entire surface of those with less than 0.1% salinity. It was speculated that floating plants including water hyacinth and duck weed may have the effect of shading the water surface for *An. sundaicus* oviposition. In malaria vector control to target "preferred" breeding sites and to distinguish "non-breeding" sites can provide a cost-effective and rational approach. The usefulness of *Salvinia* sp. in the control was limited because the distribution of this plant was very limited in the study area.

Observation of the distribution of water hyacinth vegetation in this area led us to believe that its presence might indicate an existing border between brackish water and fresh water. The salinity of *An. sundaicus* habitats was reported to be 0.4–3.0% (optimum: 1.5–2.0%) in Mid Java (Sundararaman *et al.*, 1957) and 0.5–1.0% in South Sulawesi (Collins *et al.*, 1979). In North Sumatra, it was 0.0–1.8% (Ikemoto, 1982). Imai and Panjaitan (1990) also mentioned that the optimum range was 0.5–0.8%. In our survey, *An. sundaicus* larvae were collected in waters where the range of salinity was 0.0–4.0%. The different levels of salinity in larval habitat of

An. sundaicus may be due to the instability of water conditions along coastal flats affected by tide movement. It must, therefore, be concluded that salinity is not the ultimate indicator of *An. sundaicus* breeding but it is helpful. *An. sundaicus* larvae were found in water where the salinity was at or below 0.2‰, only when water hyacinth was absent. Other anopheline mosquitoes and *Mansonia* spp., however, were commonly collected in waters with this plant. These environmental factors do not determine the existence of *An. sundaicus* larval breeding. The only noticeable difference was the existence of water hyacinth. Our observation on the distribution of water hyacinth vegetation will provide more precise information about the present condition of these malaria vector habitats.

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摘 要

An. sundaicus 幼虫生息場所の環境指標としての
ホテイアオイの有用性について

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北スマトラ州のアサハン地区の海岸部において、*An. sundaicus* 幼虫の生息場所の分布を敏速に把握するために、ホテイアオイの植生が指標として役立つかどうか調査した。ホテイアオイは塩分濃度 0.2‰ 以下の水域に広く繁茂し、これらの水域から *An. sundaicus* は採集されなかった。一方、ホテイアオイ非植生水域（塩分濃度 0.0～4.0‰）からは本幼虫が頻繁に採集された。ホテイアオイ植生水域に海水が侵入した場合を想定して、ホテイアオイの塩分耐性を調べたところ、0.32‰ 以上の塩分濃度に対してすぐに萎れ始めた。これらの結果から、ホテイアオイの植生分布とその外部形態の変化は、*An. sundaicus* 幼虫生息場所の指標として有用であると考えた。