Secondly, discharge of any wastewater should be done into shallow depth permeable layers (where hydrogeology would permit such disposal) closest to the source.

Thus in our approach, shallow underground aquifers are used: (a) as a receiving body for the treated wastewater; (b) as an active filter medium for further renovation and polishing; (c) as a means of transmission of the renovated water from the point of discharge to the point of appearance in a stream, lake or recovery through a pump and; (d) as a temporary storage of the renovated water. Thus shallow underground permeable formations/aquifers are central to our concept of wastewater disposal, renovation and recycling.

In our proposed mode of wastewater disposal, pockets of the shallow underground aquifers are likely to receive some amount of pollution load. While most of this load is of bio-degradable nature, some areas will have to be not only earmarked but also monitored for spread of the pollution plume.

One may, however, apprehend increase in the dissolved solids in the underground aquifers because of higher load of soluble salts in the wastewater. This is proposed to be off-set by recharging the low salinity storm runoff water into the shallow aquifers during monsoon season. Some of the recharged water, both of waste- and storm-water origins, will leak into deeper aquifers, undergoing further quality improvement in the process. Thus, a major part of the recharged water would either be recycled or appear as clean groundwater discharge into streams and lakes. Therefore, surface water bodies rather than receiving direct discharge of treated/untreated wastewater, will now receive renovated water resulting from soil-aquifer-treatment. This water should, in general, be clean provided the renovated water has reached the surface water body after traversal of sufficient (~500 m) distance through the aquifer.

In the foregoing, we have outlined our *Akshaydhara* strategy that is a complete water management system. The key element here is manipulation of shallow aquifers to effect renovation of storm- and waste-water through soil-aquifer-treatment and its transmission to surface water bodies, through groundwater flow, maintaining their pristine water quality perennially. In addition, the strategy will also result in (i) groundwater conservation and recharge and, (ii) increased sanitation and general improvement of the living environment. To be effective, the system has to blend with development programmes of different regions having varying hydrogeological and socio-economic conditions. This calls for appropriate research and experimentation in terms of: (i) improving technology for wastewater renovation; (ii) increased understanding of pollutant removal/retardation during movement through soil-aquifer medium and; (iii) monitoring containment and movement of subsurface pollution plumes.

We realize that this approach cannot replace the existing practice overnight or everywhere, but we do believe that a conscious effort through research and innovation will overcome the practical difficulties that may be encountered. This proposed approach will result in an environmentally sustainable integrated system of water resource development and sanitation at affordable costs.

1. Gupta, S. K. and Sharma, P., *Curr. Sci.*, 1995, **68**, 774.
2. Gupta, S. K. *Indian J. Earth Sci.*, 1993, **20**, 28–36.

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The gynandromorph of *Armigerus subalbatus* (Diptera: Culicidae)

Armigerus subalbatus (Coquillet), one of the most common mosquitoes in Kerala, is well known for its vicious man-biting habit[1]. It breeds predominantly in foul-smelling water and septic tanks in urban areas[2]. We describe here the morphological differences in mouth parts and the ratio between male, female and gynandromorph of *Armigerus subalbatus*.

The gynandromorph is a genotypic mosaic, which phenotypically appears as a combination of male and female tissue[3]. A line of demarcation between male and female organs is always apparent. The gynandromorphs are divided into three broad types[4]. (a) Anterior ♂-posterior gynander: where the anterior region is phenotypically male, head has antennae and palpi typically of a male. The posterior region is phenotypically female, with wings of the female type and abdomen with well-developed ovaries. (b) Anterior ♀-posterior gynander: where the anterior region is typically female and posterior region male. (c) Bilateral gynander: where the right side of the body resembles a male and the left side a female. Head, mouth parts and abdomen of the right side resemble those of a typical male. Head, mouth parts and abdomen of the left side resemble those of a female. Thus, one side of the body – either right or the left, is male-like and the other side is female-like.

Gynandromorphs have been found in the natural population of mosquitoes[3]. They have been described from eleven Culicine genera[3]. Most specimens have head of one sex and the abdomen of the other sex[3]. More than half of the mosquito gynandromorphs have been found in the genus Culex[4]. The gynandromorph of the genus Culex, Anopheles and Aedes have been reported earlier[3,5–7]. The genetic cascade of events resulting in gynanders has been worked out in some detail in Culicine mosquitoes. However, what role can this play in the regulation of sexual differentiation is

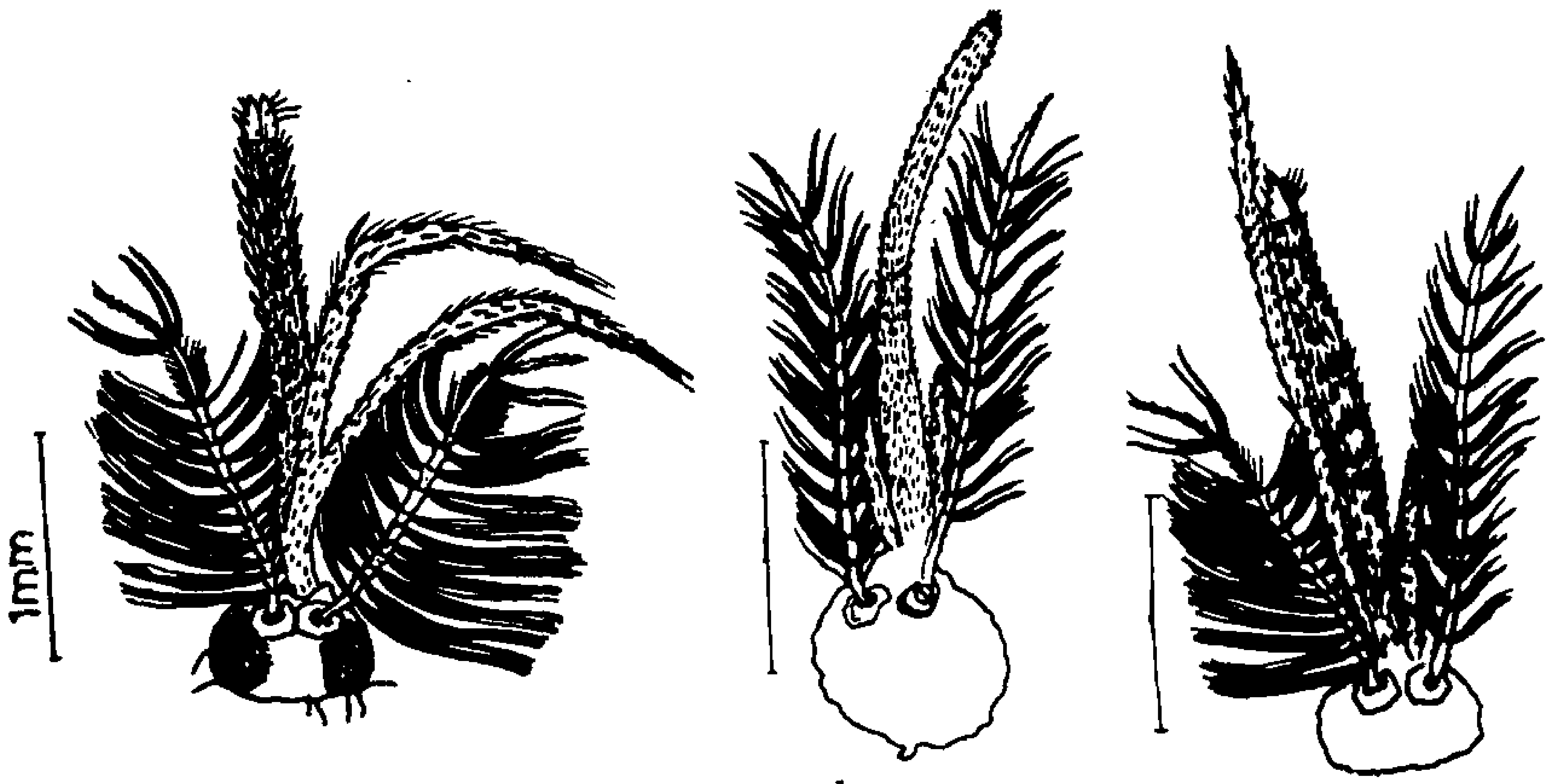

Figure 1. Head and mouth parts of *Armigerus subalbatus*. ***a***, male, ***b***, female, ***c***, gynandromorph.

poorly understood[3]. The gynandromorph of *Armigerus subalbatus* has not been reported so far. Hence an attempt has been made to record the sex ratio and morphology of the mouth parts of these mosquitoes.

The gynanders described here were collected from the Calicut University campus during the screening of *Armigerus subalbatus* for chemoreceptive studies. Outdoor as well as indoor collections of adult mosquitoes were made during dawn (5 to 7 AM) and dusk (5 to 7 PM) hours of the day. These mosquitoes were identified and a culture was maintained in the laboratory. Observations were made using a stereozoom microscope.

In order to arrive at the ratio of gynanders, one thousand eggs of *Armigerus subalbatus* were collected from the field and reared to adults in the laboratory to observe the sex ratio. Out of this, 476 were males, 430 were females and three were gynanders.

The gynander described here is a typical bilateral gynander (Figure 1). The right side of the body resembled a female and the left side that of a male. Males are easily distinguished by their conspicuous plumose antennae which contrasts with the pilose antennae of the female. The right antenna of the gynander resembled that of the female with plumose type antenna, while the left antenna resembled that of a male, have a pilose-type structure. The proboscis is the least modified mouth part, being an intermediate between male and female. The maxillary palp of the right side was short and blunt as in female and with a large number of sensilla. Palp on the left side was extremely thin, long and pointed as in the male.

The differences between normal mosquito and a gynander were conspicuous to the naked eye and could be easily detected when the mosquito was resting. Mouth parts of the male are structurally adapted for the uptake of plant juices and those of the female used both to probe flowers and to pierce the skin. The chemosensory system of these gynanders is of great interest because it may function differently when compared to typical male or female sensory system, and merits study from the viewpoint of neurogenetics.

1. Berlin, O. G. W., Dwarakanth, S. K. and Pandian, R. S., *J. Med. Ent.*, 1975, **12**, 479–480.
2. Selvaraj Pandian, R., *J. Ecobiol.*, 1990, **2**, 172–174.
3. Clements, A. N., Ph D thesis, University of Calicut, 1992.
4. Jaya Shetty, N. and Chowdaiah, B. N., *Curr. Sci.*, 1975, **44**, 702–703.
5. Leven, H., *Genetics of Insect Vectors of Disease* (eds Wright, J. W. and Pal, R.), Elsevier, Amsterdam, 1967, p. 17.
6. Craige, G. B. Jr. and Hickey, W. A., *Genetics of Insect Vectors of Disease* (eds Wright, J. W. and Pal, R.), Elsevier, Amsterdam ,1967, p. 67
7. Brust, R. A., *Can. J. Zool.*, 1966, 44, 911.

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