UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

AD-A272 137

REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER / 2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE: Three Simple Devices for Preventing Development of Aedes Aegypti Larvae in Water Jars	5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Pattamaporn Kittayapong and Daniel Strickman	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Division of Communicable Disease and Immunology, Walter Reed Army Institute of Research, Washington, DC 20307-5100	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS: U.S. Army Medical Research & Development Command, Ft. Detrick, MD 21701-5012	12. REPORT DATE 13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office): Walter Reed Army Institute of Research, Washington, DC 20307-5100	15. SECURITY CLASS. (of this report) 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

THIS DOCUMENT HAS BEEN APPROVED FOR PUBLIC RELEASE AND SALE: ITS DISTRIBUTION IS UNLIMITED.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

DTIC
S ELECTE
NOV 09 1993
A

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Aedes aegypti

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

We developed three types of covers that are easily fabricated from plastic screen locally manufactured in Thailand. The covers were designed to permit normal use of water jars for drinking, utility water uses, and water storage. Tests of the covers in the laboratory and field demonstrated that they could completely prevent successful development of Aedes aegypti(L) inwater jars. Initial experience in a village setting demonstrated that these devices were readily manufactured and used in a community-based program. Village residents adapted the covers to local patterns of water use, collecting rainwater through

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. ABSTRACT (continued)

the screen and adjusting cover use to water depth.

Am J Trop Med Hyg, 49(2), 1993, pp. 158–165

THREE SIMPLE DEVICES FOR PREVENTING DEVELOPMENT OF *AEDES AEGYPTI* LARVAE IN WATER JARS

PATTAMAPORN KITTAYAPONG AND DANIEL STRICKMAN
Department of Biology, Faculty of Science, Mahidol University, Bangkok, Thailand; Department of Medical Entomology, U.S. Army Medical Component, Armed Forces Research Institute of Medical Sciences, Bangkok, Thailand

Abstract. We developed three types of covers that are easily fabricated from plastic screen locally manufactured in Thailand. The covers were designed to permit normal use of water jars for drinking, utility water uses, and water storage. Tests of the covers in the laboratory and field demonstrated that they could completely prevent successful development of *Aedes aegypti* (L.) in water jars. Initial experience in a village setting demonstrated that these devices were readily manufactured and used in a community-based program. Village residents adapted the covers to local patterns of water use, collecting rainwater through the screen and adjusting cover use to water depth.

Dengue virus infection is prevalent in Thailand. In 1990 alone, 111,897 cases of dengue hemorrhagic fever (DHF) were reported through the public health system.[1] Since DHF accounts for only about 7% of all dengue virus infections,[2] cases of DHF in 1990 probably indicated more than one million dengue virus infections. The vector responsible for most of this transmission in Thailand is *Aedes aegypti* (L.),[3] which typically develops in domestic water containers.

Rural Thai residents use water containers extensively in their homes, placing them in a number of locations, according to convenience of water use. Water use can be classified into three broad categories: drinking, utility, and storage. Drinking water is usually the cleanest water in the house, and may also be used for food preparation. Utility uses include washing (bathing, laundry, dishes, feet, hands), watering plants, water for animals, flushing toilets, etc. Storage is usually for a long period to assure adequate drinking water for the dry season. Water jars (hand-thrown, roughly glazed ceramic containers with 135–200-liter capacity) are commonly used for all three categories of water use. Such jars have long been recognized as an important habitat for *Ae. aegypti*.[4–6]

This paper describes the fabrication and effectiveness of three types of covers that prevent the successful development of *Ae. aegypti* in water jars. The three types of covers correspond to the three categories of water use in rural Thai households. Initial experience demonstrated that local villagers could implement the use of the devices in an integrated, community-based control program.

MATERIALS AND METHODS

Descriptions of the covers

The basic material for all of the covers was a blue plastic screen, which is used throughout Thailand for a wide variety of purposes. The screen is manufactured by a number of companies (e.g., Thai Plastic Products Co., Bangkok, Thailand) and sold at a retail price of about \$0.48/m^2. The finest mesh available (9×11 mesh/cm; 24×27 mesh/in) was necessary to block movement of adult *Ae. aegypti*.

Fabrication of the covers can be accomplished in a village setting, sewing by hand or on sewing machines. In the descriptions below, some measurements are provided in terms of the exact size of the water jar to be covered. Such measurements would be useful for a small number of containers, but in practice the covers can be produced in a few size classes that will fit most water jars in a community.

The cap cover (Figure 1) was designed for covering water jars used for long-term storage. The cover is a disk of screen with a band of elastic sewn into a circumference hem of square-weave, cotton cloth. The finished cover resembles a large shower cap and is easily secured over the lip of a jar. To construct the cover, a disk of screen is cut with diameter equal to the distance across the top of the jar, from the base of the jar lip to the base of the lip on the opposite side plus 1 cm (Figure 1a). Next, 2-cm wide strips of cotton cloth are cut diagonally to the weave (Figure 1b). The orientation of the cut is important so that the strip can be shaped around the circumference of the screen disk. Strips are sewn together in diagonal joins (Figure 1c) to make a strip as long as the circumference of the screen disk (Figure 1d). Elastic (6-mm wide) is cut 10 cm longer than half the distance of the circumference (Figure 1e). The next step is to sew the elastic band into a hem around the disk. The elastic is sewn into the hem without stitching the elastic down at any point (Figure 1f). A small excess of elastic must be used so that elastic protrudes from both ends of the completed hem (Figure 1g). The excess end of the elastic is pulled from the end of the hem while holding the opposite end of the elastic in place. In this way, the edges of the screen disk are gathered together and the cover assumes a shower-cap shape. The ends of the elastic are sewn together (Figure 1h) so that the length of unstretched elastic is approximately half the circumference of the screen disk. The final step is to sew together the open ends of the hem.

The flap cover (Figure 2) was designed to allow access to clean water in the jars. This cover is similar to the cap cover, but with a hole cut in the top and a screen flap placed over the hole. Since local people typically use a flat-bottomed bowl to dip out drinking water, the hole should be wide enough to allow the bowl and a person's hand to enter (usually 15–20 cm). In use, the flap is held securely in place either by a water bowl or by a commercial aluminum water-jar lid. To get water, the user lifts off the bowl or lid, raises the flap, and dips out water, being careful to replace the flap on top of the cover rather than pushing it into the jar. Construction of the flap cover is similar to construction of the cap cover, with the hole and flap constructed before hemming elastic around the screen disk. The hole is cut slightly wider than a water bowl (Figure 2a). The flap should be cut 3 cm wider in diameter (Figure 2b) than the hole to allow overlap. The circumference of the hole (Figure 2c) is simply stitched to prevent the screen from unraveling at the edge. The flap is hemmed (Figure 2d) with 1.5 cm–wide bands of cotton cloth, cut diagonally to the weave. To form a hinge, the flap is sewn along 3 cm of its circumference to the side of the hole (Figure 2e), centering the flap over the hole.

The bag cover (Figure 3) is designed to be used with utility water that is not consumed by humans because it involves placing screen directly in the water. The bag has the advantage for utility uses of allowing free access, so that water may be liberally scooped out according to typical water use. This cover consists of a bag of screen inserted into the jar and secured around the jar lip by a string. At night or when not in use, the bag is reversed or everted so that any larvae that had been inside the bag are killed by drying. Such frequent drying also prevents algal growth on the screen. Larvae that pass through the screen into the space between the bag and the wall of the jar may develop to adults, but the adults are unable to escape past the screen, and eventually die. Construction of the bag begins by measuring off screen from a 1 m–wide roll so that the length is equal to at least 2 cm longer than the circumference of the outer edge of the jar lip (Figure 3a). This length of screen must be oriented so that the selvage (i.e., specially woven to prevent unraveling) edges will be located at the top and bottom of the bag (Figure 3b). The cut sides of the screen are sewn together (Figure 3c) so that a cylinder is formed with the selvage edges at top and bottom. One end of the cylinder is then sewn together, forming a straight seam (Figure 3d). The ends of the seam are folded toward the center (Figure 3e) and sewn down (Figure 3f). This expands the sealed end of the cylinder into a roughly rectangular, flat bottom. The next step is to use a nail to spread individual meshes of the screen, creating an even number of holes (approximately 20) around the open end of the cylinder, 1–2 cm from the selvage edge (Figure 3g). A nylon drawstring 2.5 times the circumference of the bag is threaded through the holes so that the ends of the string protrude toward the center of the bag (Figure 3h). To install the cover, the bag is inserted into the jar and the open end folded over the lip of the jar (Figure 3i). The drawstring is pulled tight and knotted, and the ends of the string are wrapped around the lip and knotted tightly to make a secure seal between the jar and the bag.

Testing efficacy of the covers

A series of tests were performed to establish that properly used covers prevented mosquito development. The cap and flap covers were evaluated in a village environment (Village Two, Hua Sam Rong Subdistrict, Chachoengsao Province)

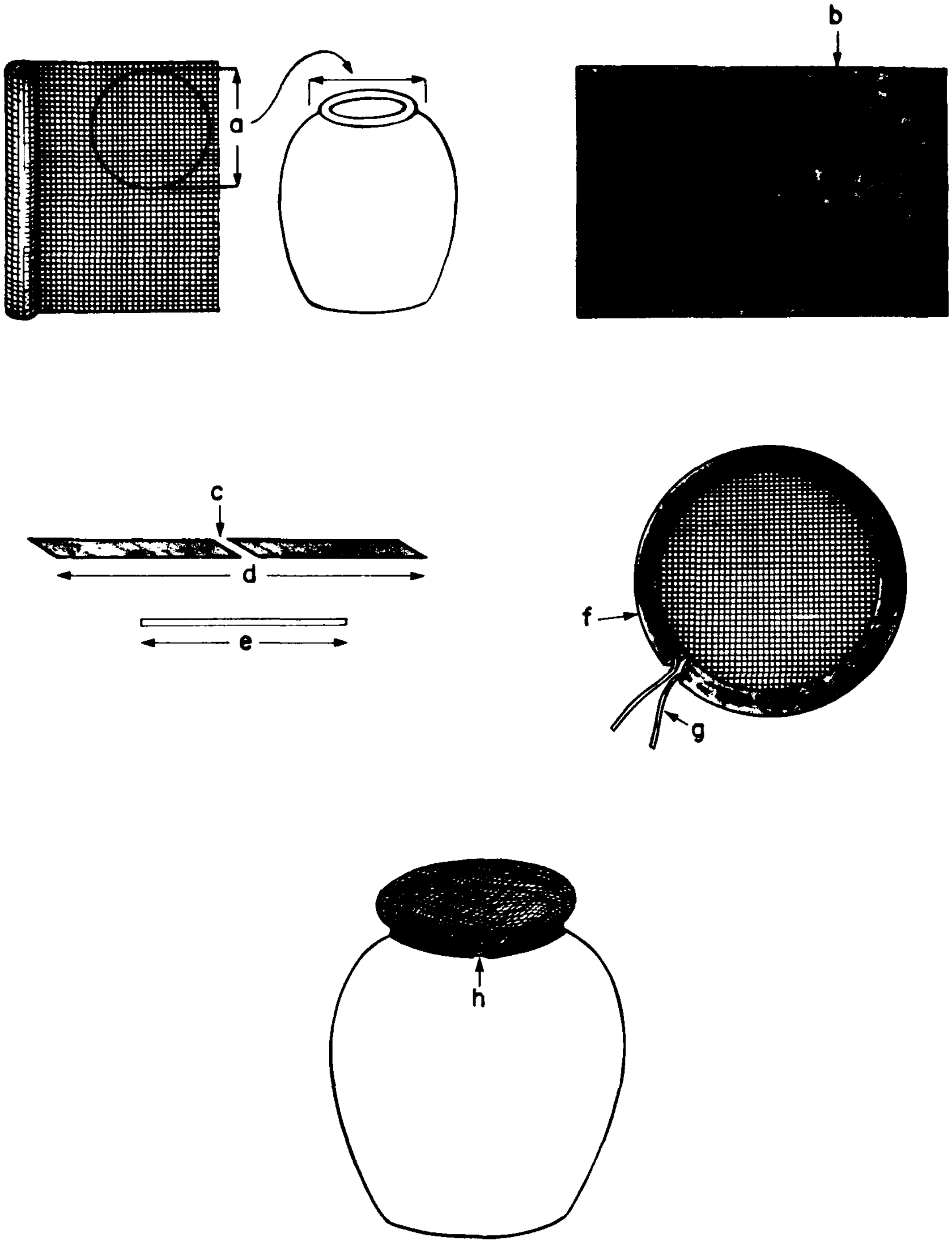

FIGURE 1. Details of construction of the cap cover. **a**, distance across the top of the jar. **b**, diagonal orientation of the cuts, **c**, strips sewn together in diagonal joins. **d**, strip with a length equal to the circumference of the screen disk. **e**, elastic cut 10 cm longer than half of the circumference of the screen disk. **f**, arrangement of the elastic band and the hem. **g**, excess elastic protruding from the completed hem. **h**, completed cap cover across the top of the jar.

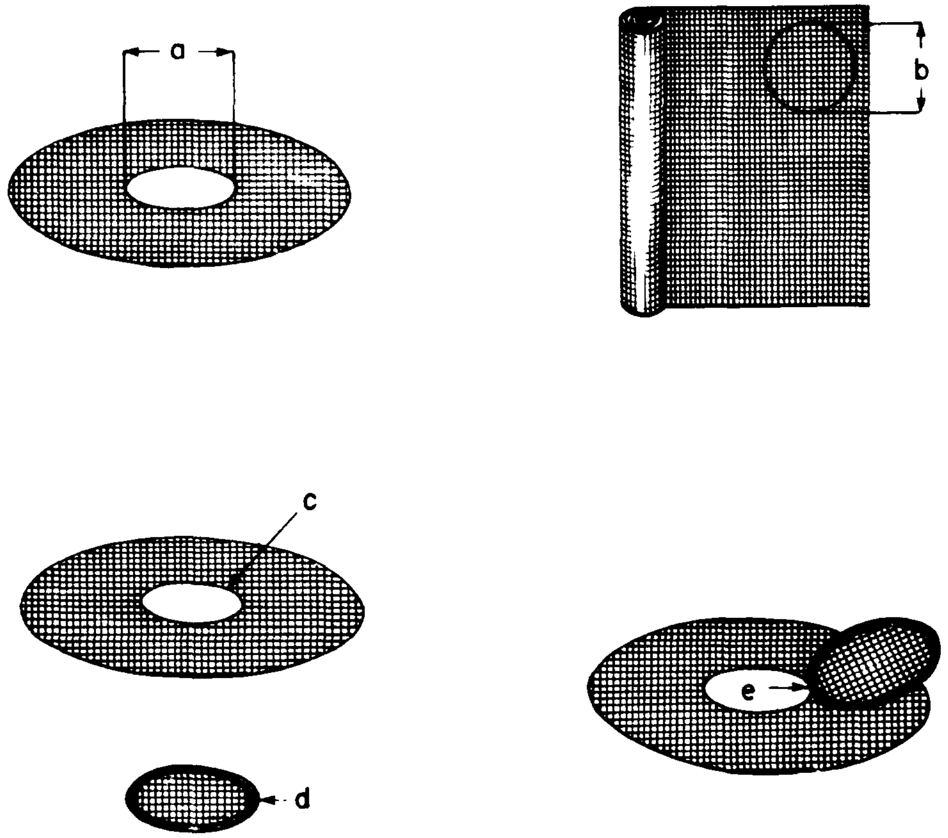

FIGURE 2. Details of construction of the flap cover. **a**, hole in the flap cover. **b**, flap cut 3 cm greater than the diameter of the hole. **c**, stitched circumference of the hole to prevent unraveling. **d**, hemmed flap cover. **e**, hinged arrangement of the flap cover over the hole.

by testing of four covered jars in two houses and four uncovered jars in two other houses. Treatments were assigned to separate houses to avoid the possibility that open jars would attract ovipositing *Ae. aegypti* away from covered jars. At the end of seven days, all larvae were removed from the jars with a fine-mesh fish net. *Aedes* larvae were counted, taken to the laboratory, reared to fourth instar or adult, and identified to species. Other genera of mosquitoes were not identified to species. In four trials with cap covers, one jar was covered with a cap cover and the other jar was covered with a commercial aluminum lid. The flap covers were tested for one week with a bowl on the flap and for one week with an aluminum lid over the cover. Results were analyzed by one-way analysis of variance followed by Fisher's least significant difference test to distinguish differences between means (cap cover tests) or by unpaired Student's t-tests (flap cover tests).[7]

The bag cover was tested in the laboratory to determine what proportion of larvae would become trapped in the space between the bag and the wall of the jar. Fifty newly hatched *Ae. aegypti* larvae (eggs collected from females reared from field-caught larvae) were added to each of seven jars with bag covers held at ambient temperature (water temperature 31–32.5°C). Larvae in each jar were fed 0.1 g of ground fish food twice during the six days of development. On the sixth day, all larvae and pupae were removed with a fish net, and those from inside the bag were counted separately from those between the bag and the wall of the jar.

To determine whether adults could escape from the space between the bag and the water jar, a water jar with the bag cover installed was placed

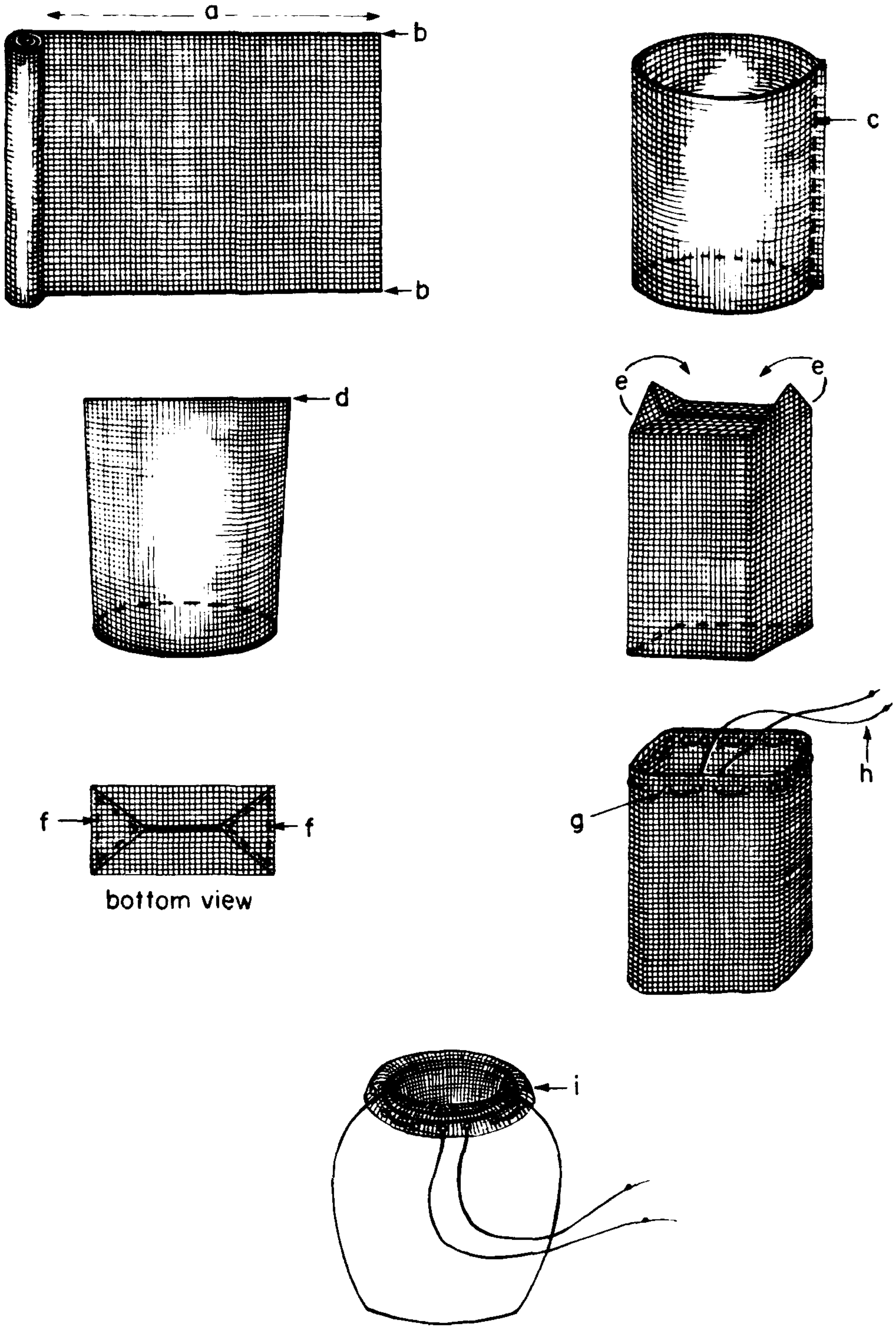

FIGURE 3. Details of construction of the bag cover. **a**, screen used to construct the bag cover cut to a length 2 cm greater than the circumference of the outer edge of the jar lip. **b**, selvage of the screen at the top and bottom of the bag. **c**, cut sides of the screen sewn together to form a cylinder. **d**, one end of the cylinder sewn together to form a straight seam. **e**, ends of the seam folded together toward the center. **f**, ends of the seam sewn together. **g**, individual holes made in meshes of the screen with a nail around the open end of the cylinder. **h**, nylon drawstring. **i**, completed bag inserted over the lip of the jar.

TABLE 1

Comparison of numbers of Aedes aegypti *juveniles found in water jars with cap covers or commercial aluminum lids*

Cover	Total no. of jars	No. (%) of jars positive	Mean ± SD no. of juveniles/jar
None	16	16 (100)	39 ± 51
Aluminum lid	8	5 (62)	6 ± 8*
Cap cover	8	0 (0)	0 ± 0*

* $P < 0.05$, $F = 3.85$ versus no cover.

TABLE 2

Comparison of number of Aedes aegypti *larvae in water jars either with flap covers or uncovered*

Cover	No. (%) of jars with larvae	Mean ± SD no. of larvae/jar
Flap with bowl	0 (0)	0 ± 0
None	4 (100)	25 ± 6*
Flap with lid	0 (0)	0 ± 0
None	4 (100)	46 ± 24†

* $P < 0.01$, $t = 8.15$.
† $P < 0.01$, $t = 3.86$.

in a cage (1 × 1.5 × 2 m high) in a room at ambient temperature in Bangkok (water temperature 29–31.5°C). Two hundred newly hatched larvae of *Ae. aegypti* (collected from females reared from field-caught larvae) were added to the jar and fed 0.1 g of ground fish food three times during development. The cage was examined for escaped adults for four days after emergence began.

Experience with use of the covers

During 1990, the three covers were used in a community-based dengue control program. The covers were integrated with other techniques that also only required local materials. These other techniques included cleanup of waste containers, biweekly house-to-house trash pick-up, placing salt or oil in water-filled ant traps that would otherwise support larval development, and guppy fish (*Poecilia reticulata*) in large containers.

The program was organized through the Thai Ministry of Public Health, and received authority through the provincial center and active cooperation from the subdistrict-level health office. Some 3,000 covers were fabricated by 10 local residents who were trained in a workshop. Other residents were recruited as dengue control volunteers, with one volunteer for every 10–20 houses. The volunteers were trained in group sessions and given the role of inspecting and counselling households every 2–4 weeks. In practice, the volunteers reinforced the program through daily contact with their neighbors. Although data from this pilot program are still being compiled, we provide here accounts of experience with the covers.

RESULTS AND DISCUSSION

Jars covered with cap covers (Table 1) and flap covers (Table 2) contained no mosquito larvae after seven days of exposure in the field. In contrast, 100% of the uncovered jars exposed at the same time contained larvae of *Ae. aegypti*, 37% (nine jars) contained *Culex* larvae, and 4% (one jar) contained *Anopheles* larvae. Although five of eight jars with aluminum lids were infested with *Ae. aegypti*, the number of larvae was reduced by 87% compared with uncovered jars (Table 1).

In laboratory tests of the bag cover, 45% of the larvae passed through the bag to the area between the bag and the wall of the jar (Table 3). In a separate test, larvae between the bag and the wall of the jar completed development, but adults were unable to escape past the bag during a four-day period. In actual use, the larvae on the insides of the bags would have been eliminated by everting the bag daily.

Previous publications on the use of covers to prevent *Aedes* infestation mainly consist of general advocation of the method.[8] For Thai water jars, various public health leaflets and popular publications[9] have suggested the use of commercial aluminum lids or plastic sheet tied to the jar with string. Although commercial lids are convenient and widely used, their efficacy is questionable. A larval survey in Thailand reported that jars with such covers were infested less often than uncovered jars;[6] however, another

TABLE 3

Juvenile stages of Aedes aegypti *inside and outside (i.e., between bag and wall of water jar) seven bag covers following six days of development*

Stage	Mean ± SD		Percentage	
	In bag	Outside bag	In bag	Outside bag
Larva	16 ± 6	9 ± 4	65	35
Pupa	8 ± 3	11 ± 4	42	58
Total	24 ± 4	20 ± 4	55	45

survey[10] found covered jars infested more often than uncovered jars when located outdoors. In the laboratory, only about 20% of ovipositing *Ae. aegypti* were found to be able to enter a jar with a commercial lid,[11] corresponding to the reduction in number of larvae in jars with commercial lids tested in the field (Table 1).

During the pilot control program, residents were able to use the three types of covers to prevent development of *Ae. aegypti* in water jars. Household use of the covers revealed several unanticipated benefits. The blue screen was convenient for inspection purposes because it was very easy to see from a distance. As a result, dengue control volunteers going about their daily business had a good idea of whether a household was generally compliant, even though a formal inspection was not in progress. Also, the screen did not interfere with filling jars and was perceived by local residents as allowing healthy air exchange.

The bag cover was used in an innovative way by some residents who depressed the bag to a level just above the water. This allowed access to water by depressing the bag only slightly further. Withdrawing the bag a short distance took the screen out of contact with the water, avoiding the necessity of reversing the bag each night.

The flap cover was effective when used properly, which was usually the case in an individual home. In the school, where many children used the drinking water jars, the flap was often pressed down into the hole, allowing mosquitoes access to the interior of the jar. Replacement of the flap cover with some other device may be necessary in situations where people are not careful to be sure the flap remains on top of the hole. Possibilities include sealed containers with taps in public places or a metal lid with a foam rubber ring that seals the lid to the jar.[11]

Although the screen covers are not the complete solution to dengue vector control in Thailand, they can form an important component of community-based programs. Further indication of the general suitability of the covers was observed in 1992, when screen covers similar to those described here were observed in southern Thailand, where local public health workers who had heard of preliminary use of the covers had advocated the method in their own area (Linthicum K, Armed Forces Research Institute of Medical Sciences, Bangkok, Thailand, unpublished data). With some modification, screen covers could probably be an effective part of dengue vector control programs in other parts of the world where water is intentionally stored in open containers.

Acknowledgments: Our special thanks are given to Pensri Kittayarak, who generously contributed sewing skills to design the fabrication of the three kinds of covers. We also thank Dr. John Edman for design of the field tests, Pongpen Tanomjit and Pirom Sanguansab (Hua Sam Rong Public Health Office) for support in the field, Prachong Panthusiri for preparation of the figures, and Thaweep Saraburin, Sekhsan Samran, Phittaya Chuailua, and Somlim Vanthana for technical assistance.

Financial support: This work was supported by funds from the U.S. Army Medical Research and Development Command.

Disclaimer: The views of the authors do not purport to reflect the position of the Department of the Army or the Department of Defense (para 4-3, AR 360-5).

Authors' addresses: Pattamaporn Kittayapong, Department of Biology, Faculty of Science, Mahidol University, Rama VI Road, Bangkok 10400, Thailand. Daniel Strickman, Department of Entomology, Walter Reed Army Institute of Research, Washington, DC 20307-5100.

Reprint requests: Daniel Strickman, Department of Entomology, Walter Reed Army Institute of Research, Washington, DC 20307-5100.

REFERENCES

1. Anonymous, 1991. Diseases under surveillance. *Wkly Epidemiol Surv Rep (Thailand) 22:* 299.
2. Burke DS, Nisalak A, Johnson DE, Scott RM, 1988. A prospective study of dengue infections in Bangkok. *Am J Trop Med Hyg 38:* 172–180.
3. Halstead SB, 1984. Selective primary health care: strategies for control of disease in the developing world. XI. Dengue. *Rev Infect Dis* 6: 251–264.
4. Bang YH, Pant CP, 1972. A field trial of Abate larvicide for the control of Aedes aegypti in Bangkok, Thailand. *Bull World Health Organ 46:* 416–425.
5. Tonn RJ, Sheppard PM, Macdonald WW, Bang YH, 1969. Replicate surveys of larval habitats of Aedes aegypti in relation to dengue hemorrhagic fever in Bangkok, Thailand. *Bull World Health Organ 40:* 819–829.
6. Chareonsook O, Thanprasertsuk S, Singklang K, Yawwa T, Purahong S, Kunasol P, 1990. Seasonal surveillance on dengue vectors in rural areas. *Special Epidemiol Surv Rep (Thailand)* 2: 1–21. (English summary.)
7. Steel RGD, Torrie JH, 1960. *Principles and Procedures of Statistics.* New York: McGraw-Hill, 73–75, 99–131.
8. World Health Organization, 1986. *Dengue Haemorrhagic Fever: Diagnosis, Treatment and*

Control. Geneva: World Health Organization, 31.

9. Prugsaphong K, 1990. Dengue. *Close to the Doctor 14:* 24–32. (In Thai.)
10. Kittayapong P, Strickman D. 1993. Distribution of container-inhabiting Aedes (Diptera:Culicidae) larvae at a dengue focus in Thailand. *J Med Entomol 30:* 601–606.
11. Strickman D, Kittayapong P. 1993. Laboratory demonstration of oviposition by Aedes aegypti (Diptera:Culicidae) in covered water jars. *J Med Entomol 30* (in press).