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Productivity of natural and artificial containers for *Aedes polynesiensis* and *Aedes aegypti* in four American Samoan villages

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Abstract. Six mosquito species were identified in a survey of containers associated with 347 households in four villages in American Samoa. *Aedes polynesiensis* Marks (Diptera: Culicidae) and *Aedes aegypti* (L) were the most abundant species, representing 57% and 29% of the mosquitoes identified. *Culex quinquefasciatus* (Say), *Culex annulirostris* (Skuse), *Aedes oceanicus* (Belkin) and *Toxorhynchites amboinensis* (Doleschall) were also found. *Aedes aegypti* and *Ae. polynesiensis* showed distinct differences in their use of containers, preferring large and small containers, respectively. By contrast with previous studies, *Ae. polynesiensis* utilized domestic and natural containers with equal frequency, whereas *Ae. aegypti* continued to be found predominantly in domestic containers. Only 15% of containers holding immature mosquitoes included pupae and fewer than 10 *Aedes* spp. pupae were found in most containers with pupae. An estimated 2289 *Ae. polynesiensis* and 1640 *Ae. aegypti* pupae were found in 2258 containers. The presence of both species in the same container did not affect the mean density of either species for larvae or pupae. Glass jars, leaf axils, tree holes and seashells produced few *Aedes* spp. pupae in any of the study villages. Overall, 75% of *Ae. polynesiensis* pupae were found in buckets, ice-cream containers and tyres, with $<7\%$ being produced in natural containers, whereas 82% of *Ae. aegypti* pupae were found in 44-gallon (US) drums (~166L), buckets and tyres. Source reduction efforts targeting these container types may yield significant reductions in both *Ae. polynesiensis* and *Ae. aegypti* populations in American Samoa.

Key words. *Aedes polynesiensis*, *Aedes aegypti*, *Wuchereria bancrofti*, dengue, lymphatic filariasis, source reduction, American Samoa.

Introduction

In 1999, the Pacific Program for the Elimination of Lymphatic Filariasis (PacELF) was established with the goal of stopping the transmission of lymphatic filariasis (LF) in the 16 Pacific island countries and territories where filariasis caused by *Wucheraria bancrofti* (Cobbold) is endemic (Burkot & Ichimori, 2002; Burkot *et al.*, 2002). From Fiji to French Polynesia, LF is subperiodic and transmitted by a number of mostly daytime-biting *Aedes* spp.; the most important of these vectors is *Aedes polynesiensis* Marks. The primary PacELF strategy for filariasis transmission elimination is annual mass drug administration

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(MDA) using the combination therapy of diethylcarbamazine (DEC) and albendazole for at least 5 years, with a minimum 80% treatment coverage.

Sustaining an 80% MDA coverage for 5 years is difficult, however, and, even if it can be achieved, recrudescence can occur. An analysis of previous MDA campaigns in Samoa and French Polynesia questioned whether MDA alone would be sufficient to achieve elimination in the absence of adjunct control measures, particularly where *Ae. polynesiensis* is the vector (Esterre *et al.*, 2001; Burkot & Ichimori, 2002; Burkot *et al.*, 2002). By contrast with most filariasis vectors, *Ae. polynesiensis* efficiently transmits LF. In this species, as microfilarial densities diminish, the proportion of ingested microfilariae that succeed in developing to infectious stage 3 larvae increases (Pichon, 2002).

In light of the difficulty of achieving and sustaining high MDA compliance and the efficiency of *Ae. polynesiensis* at transmitting LF at low microfilaraemia levels, there is an immediate need to develop and evaluate supplementary strategies to further suppress LF transmission and ensure the success of PacELF. One potential adjunct transmission suppression strategy, with good potential for implementation in the short-term, is vector control. Vector control would be compatible with either continued countrywide MDAs or focal treatment of areas with residual pockets of infections. Studies suggest that filariasis control programmes that integrate MDA with vector control can prevent the re-establishment of transmission after completion of MDA (Rueben *et al.*, 2001).

The Samoan Islands are inhabited by 13 mosquito species (Huang, 1977). The islands remain endemic for LF and suffer periodic outbreaks of dengue fever. A survey in 1998 estimated that 16% of residents in American Samoa were infected with the diurnal subperiodic form of *W. bancrofti* (Centers for Disease Control, unpublished data). The most recent dengue outbreak during 2001–02 in American Samoa resulted in the treatment of more than 3000 people at the local hospital.

Aedes aegypti is the principal dengue vector in American Samoa. *Aedes polynesiensis* is also a dengue vector, in addition to being the primary filariasis vector throughout Polynesia, including the Samoan Islands. A secondary filariasis vector is the night-biting *Aedes samoanus* (Grünberg) (Ichimori, 2001). In American Samoa this species breeds almost exclusively in leaf axils of *Freycinetia* spp. vines, so it is most abundant in villages surrounded by rainforest (Ramalingam, 1976).

Source reduction may be the most suitable vector control strategy for the day-biting, container-breeding *Ae. polynesiensis* and *Ae. aegypti*. In 1958, elimination of all containers that breed *Ae. polynesiensis* was advocated as the 'ideal' LF transmission suppression strategy (Bonnet & Chapman, 1958). Targeting for removal or mitigation those container types that produce most of the vector population has also been advocated for dengue control (Focks *et al.*, 2000). In preparation for a pilot mosquito control programme for dengue and filariasis control in American Samoa, a survey in four villages was undertaken to quantify the productivity of different container types for both *Ae. polynesiensis* and *Ae. aegypti*. Those container types responsible for producing the most dengue and filariasis vectors could then be targeted for removal or mitigation in a source reduction campaign.

Materials and methods

Study sites

The study took place in the unincorporated territory of American Samoa, from February to March 2002. Rainfall averages 3 m per year, with the highest levels of rainfall occurring from November to April (Western Regional Climate Center, 2006). The total land area amounts to 199 km^2 and consists of five volcanic islands and two coral atolls. The study area comprised four sentinel villages that had been selected for monitoring as part of the PacELF MDA programme. Residents of these villages had been characterized previously for infection with LF. The villages of Pago Pago, Fagasa and Fagaitua are located on the main island of Tutuila, and the village of Aunu'u is found on the island of the same name (located approximately 1.3 km southeast of Tutuila) (Fig. 1). Villages ranged in size from 476 people (Aunu'u) to 4278 (Pago Pago), according to the 2000 census of American Samoa (Bureau of the Census, 2004). More than 90% of residents in all villages were ethnic Samoan, with median ages between 19 and 22 years. Median incomes were lowest in Aunu'u ($14 531) and highest in Pago Pago ($19 146).

Mosquito survey

A survey of water-holding containers for mosquito larvae and pupae was undertaken in each of the four villages. After explaining to householders the purpose of the survey, the survey team inspected all potential domestic and natural breeding sites associated with that household. Potential breeding sites were classified as one of 14 container types (appliances, leaf axils, buckets, cans, coconut shells, 44-gallon drums, drum tops, glass jars, plastic ice-cream containers, seashells, polystyrene containers used as fast-food packaging, tyres, tree holes and 'others', which included a variety of plastic, metal and natural containers (e.g. rock holes). Appliances included a variety of discarded kitchen and bathroom fixtures, including stoves, refrigerators, sinks, bathtubs and toilets. Containers were also classified as being 'natural' or 'domestic' (i.e. human-made) and classified according to the volume of water held: small, medium and large containers held <0.5 L, 0.5–4 L and >4 L of water, respectively.

Containers with immature mosquitoes were recorded and samples from those with third or fourth stage instars and/or pupae were collected for identification to species. Older stage larvae were identified immediately, whereas pupae were allowed to emerge to be identified as adults. Larval and adult mosquitoes were identified using the taxonomic keys of Belkin (1962) and Huang (1977). All larvae and pupae were counted in containers with <50 larvae and/or pupae. Numbers in containers with greater numbers of immatures were estimated by counting a sample from the container and multiplying it by the proportion of the total water volume in the sample. Total numbers of pupae and larvae at the village level were estimated by extrapolating from the numbers in containers that could be sampled to include the total number of available containers. For example, where there was a stack or wall constructed of tyres, only accessible

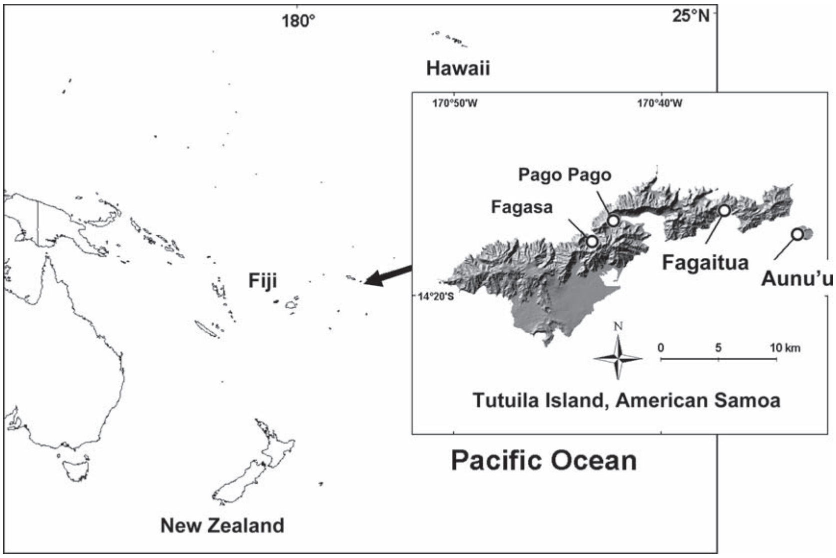

Fig. 1. Locations of the study villages in American Samoa.

tyres were sampled and the average number of immatures in the sampled tyres were multiplied by the total number of tyres to estimate the population of larvae and pupae in all the tyres.

Data analysis

The chi-square test was used to compare the proportions of artificial and natural containers with larvae and/or pupae. In order to adjust for the increased risk of at least one spuriously significant result when making multiple comparisons and to ensure that the experiment-wise risk remained ≤ 0.05, the α-level of each individual test was adjusted downward using the Bonferroni method.

Rate ratios were calculated using Poisson regression to compare (a) the mean number of *Ae. polynesiensis* and *Ae. aegypti* by container type; (b) the mean number of *Ae. aegypti* in containers with only *Ae. aegypti* vs. containers with both *Ae. aegypti* and *Ae. polynesiensis*, and (c) the mean number of *Ae. polynesiensis* in containers with only *Ae. polynesiensis* vs. containers with both *Ae. aegypti* and *Ae. polynesiensis.* The number of mosquitoes was defined as the sum of the larvae and pupae for individual species. A container type was analysed if >10 containers of that type were surveyed. All regressions utilized SAS Proc Genmod, implementing the generalized estimating equation. (GEE) procedure to adjust for correlations among multiple containers at the same house.

McNemar's test was used to investigate whether some containers were preferentially utilized by one species compared with the other species. Data were dichotomized at each breeding site as being present or absent for immatures of each species. The proportion of containers with any *Ae. polynesiensis* was compared with the proportion with any *Ae. aegypti* with only discordant cell counts contributing to the test statistic. All analyses were performed using SAS Version 9.1. Statistical significance was set at $\alpha = 0.05$.

Results

Overall, 347 households in the four study villages were inspected for mosquito breeding sites (Fig. 1). The total number of containers with water in them was 2 279, of which 110, 963, 387 and 819 were found in the villages of Aunu'u, Fagasa, Fagaitua and Pago Pago, respectively (Fig. 2a). Overall, 79% of containers in these four villages ($n = 1790$) were domestic items and 21% ($n = 483$) were natural containers. Only 48% of the 1962 containers accessible for complete inspection ($n = 944$) held mosquito larvae and/or pupae.

About half of the available containers were used as breeding sites, although this differed slightly among the villages, ranging from a low of 45% in Aunu'u, Fagasa and Fagaitua to a high of 55% in Pago Pago ($P < 0.0025$). The proportions of containers with pupae varied from 11% to 20% in the villages of Pago Pago (11%), Fagasa (16%), Fagaitua (18%) and Aunu'u (20%) ($P < 0.02$).

Overall, 2888 mosquitoes were identified from the 435 containers with third and fourth instar larvae or pupae. Six mosquito species were identified, of which *Ae. polynesiensis* and *Ae. aegypti* were the most common, accounting for 57% ($n = 1648$) and 29% ($n = 830$) of mosquitoes identified, respectively. Breteau indices for *Ae. aegypti* ranged from a low of 72 in Fagaitua to a high of 161 in Pago Pago village, whereas the Breteau index for *Ae. polynesiensis* ranged from 113 in Fagaitua to 273 in Fagasa. Mosquito species identified in containers with *Ae. polynesiensis* and *Ae. aegypti* were *Culex quinquefasciatus* ($n = 157$), *Aedes oceanicus* ($n = 118$), *Toxorhynchites amboinensis* ($n = 99$) and *Culex annulirostris* ($n = 62$). *Culex quinquefasciatus* was identified from 30 containers, including buckets and tyres ($n = 12$ and $n = 7$, respectively). *Toxorhynchites amboinensis* ($n = 99$) was found in 77 containers, including 18% of all tyres inspected ($n = 58$), as well as in 10 buckets.

Significant differences were found in the proportions of domestic and natural containers with larvae and pupae (Fig. 2b).

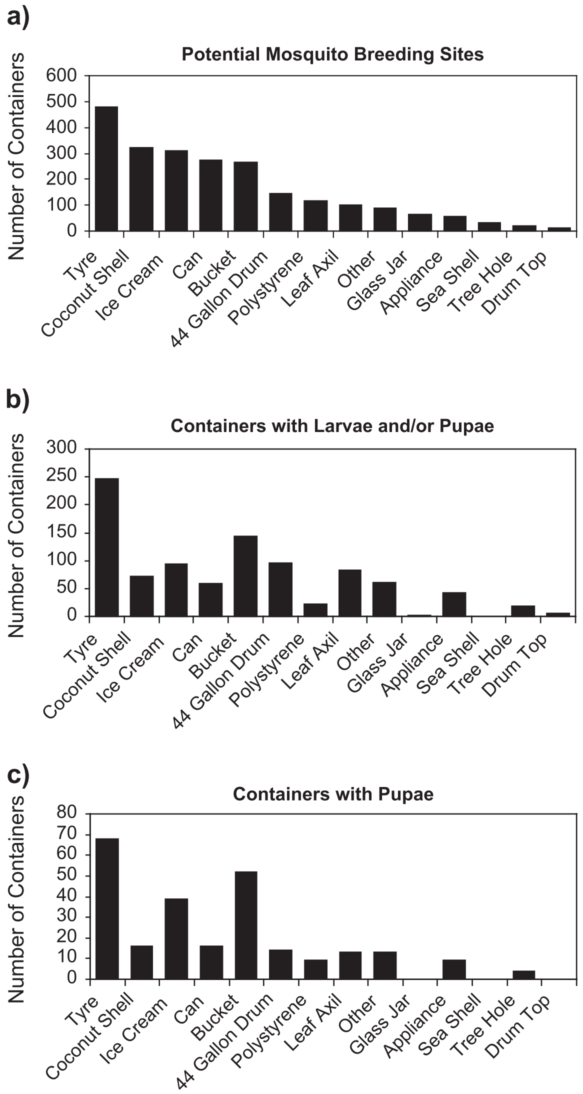

Fig. 2. Numbers of (a) potential breeding sites (containers with water); (b) containers with any mosquito larvae and/or pupae, and (c) containers with pupae associated with 347 households in four villages in American Samoa.

The most abundant domestic containers with larvae and/or pupae were tyres ($n = 247$), followed by buckets ($n = 143$), 44-gallon drums ($n = 95$) and ice-cream containers ($n = 94$). Larvae were found in 51% and 37% of domestic and natural containers, respectively ($P < 0.001$).

Pupae were found in 17% and 8.5% of domestic and natural containers ($P < 0.001$). The most abundant domestic or man-made containers with pupae were tyres ($n = 68$), buckets ($n = 52$) and ice-cream containers ($n = 39$) (Fig. 2c). Minimal water volumes in most glass containers coupled with the failure to find pupae in glass containers (jars) may have resulted in under-reporting of glass jars ($n = 63$), particularly discarded beer bottles, as potential breeding sites in villages. Among natural containers found in villages, coconut shells were most frequently found holding water ($n = 320$), but only 22% ($n = 72$) of coconut shells with water harboured larvae and/or pupae (Fig. 2c). Of the 99 water-bearing leaf axils inspected, 83% held larvae or pupae, and 86% of 22 tree holes with water harboured mosquito stages. None of the 34 water-holding seashells near houses held mosquito immatures.

Significant differences were found between *Ae. polynesiensis* and *Ae. aegypti* in their utilization of containers by larvae and pupae. Whereas no significant difference was found in the proportion of domestic and natural containers harbouring *Ae. polynesiensis* (69% and 66%, respectively; $P > 0.7$), *Ae. aegypti* was significantly more likely to be found in domestic than natural containers: 49% of domestic containers with water harboured *Ae. aegypti,* but only 5% of natural containers contained *Ae. aegypti* ($P < 0.001$). Analysis by container size also revealed differences between these species. *Aedes aegypti* was found in 29% of small containers, 48% of medium containers and 87% of large containers ($P < 0.001$). *Aedes polynesiensis* occurred more frequently in small and medium-sized containers, with 71% and 72% of such containers harbouring *Ae. polynesiensis*, respectively, compared with 35% of large containers ($P < 0.001$). *Aedes polynesiensis* was found significantly more frequently than *Ae. aegypti* in buckets, tin cans, coconut shells, tree holes and plastic ice-cream containers ($P < 0.001$), as well as in polystyrene containers ($P < 0.02$), and *Ae. aegypti* was found at a significantly higher prevalence in 44-gallon drums ($P < 0.001$) (Fig. 3).

Analysis of containers with third instar or older mosquitoes revealed significant variation among container types for the proportion harbouring *Ae. aegypti* ($P < 0.001$) (Fig. 3). Among such containers, >70% of available discarded appliances, 44-gallon drums and 'other' metal containers, but <20% of coconut shells, polystyrene containers and tree holes held *Ae. aegypti* immatures. *Aedes aegypti* larvae were not found in leaf axils. Like *Ae. aegypti, Ae. polynesiensis* exhibited significant differences in utilization of containers by third instar or older mosquitoes ($P < 0.001$). More than 70% of water-holding discarded appliances, buckets, tin cans, ice-cream containers, polystyrene trays and tree holes had *Ae. polynesiensis*. Only 10% of leaf axils contained *Ae. polynesiensis.*

Pupae were found in 15% of containers with any immature stage of mosquito. Among 178 containers in which pupae numbers were counted or estimated, 72% of containers with pupae ($n = 128$) contained <10 pupae, and 5% of containers (five buckets, two small plastic containers and two drums) had >80 pupae (Fig. 4).

There were an estimated 2289 and 1640 pupae of *Ae. polynesiensis* and *Ae. aegypti*, respectively, associated with containers in the 347 surveyed households (Fig. 5, Table 1), of which 75% of *Ae. polynesiensis* pupae were found in buckets, ice-cream containers and tyres, whereas 82% of *Ae. aegypti* pupae were found in 44-gallon drums, buckets and tyres. Buckets held the largest number of *Ae. aegypti* pupae ($n = 645$) at the time of the survey. Although buckets constituted 12% of the potential breeding sites, they produced 36% of *Ae. polynesiensis* ($n = 830$) and 39% of *Ae. aegypti* ($n = 645$) pupae. Tyres were the most abundant container ($n = 481$), and were the third and fourth most productive breeding sites for

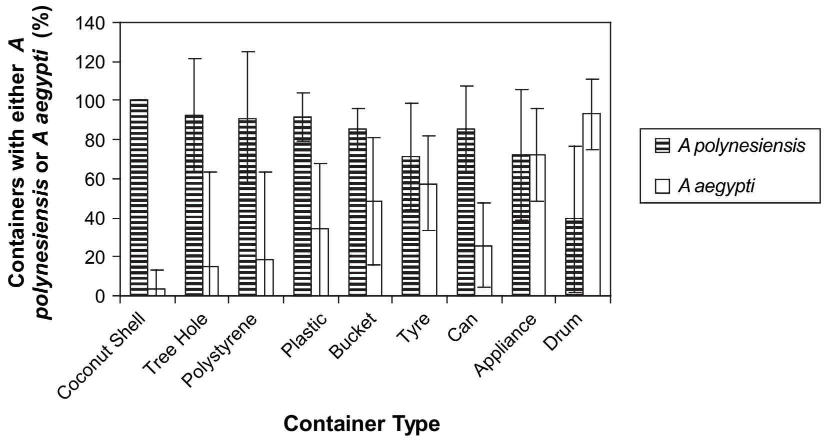

Fig. 3. Percentage of containers with *Aedes polynesiensis* (striped bars) and *Aedes aegypti* (white bars) when any mosquito species was present, by container, with 95% confidence intervals.

Ae. polynesiensis (566 pupae) and *Ae. aegypti*, (224 pupae), respectively. Tin cans produced 7% of *Ae. polynesiensis* pupae and <4% of the total *Ae. aegypti* pupae during this survey. Of even lesser importance for *Aedes* pupae were polystyrene containers, tree holes and leaf axils, accounting for <1.5% of the total number of *Ae. aegypti* and *Ae. polynesiensis* pupae seen. Mosquito pupae were not found in any of the glass jars or seashells inspected. Overall, 96% of *Ae. polynesiensis* and *Ae. aegypti* pupae were found in domestic containers in the four study villages.

Statistically significant differences in the mean number of larvae and pupae of *Ae. aegypti* and *Ae. polynesiensis* per inhabited container were found for different container types. Higher mean densities of *Ae. polynesiensis* than *Ae. aegypti* were found in coconut shells (means = 3.2 and 0.1, respectively), tyres (means = 20.1 and 8.2, respectively), ice-cream containers (means = 8.5 and 2.4, respectively) and tin cans (means = 5.7 and 2.0, respectively), whereas *Ae. aegypti* was found in higher mean numbers in drums (mean = 44.0) than was *Ae. polynesiensis* (mean = 6.5). However, the presence of *Ae. aegypti* in the same container as *Ae. polynesiensis* did not affect the number of *Ae. polynesiensis* in that container for any container type. Nor did the presence of *Ae. polynesiensis* in the same container as *Ae. aegypti* affect the number of *Ae. aegypti* in that container for any container type ($P > 0.05$).

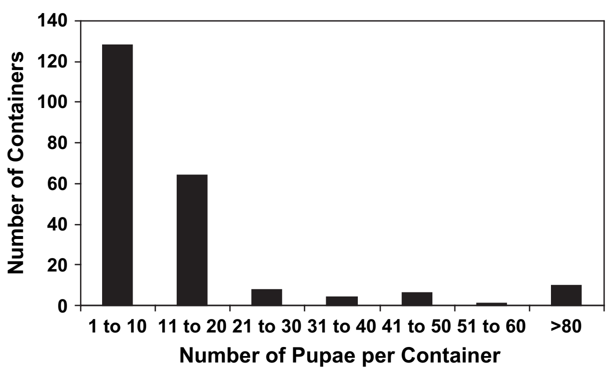

Fig. 4. Frequency distribution of *Aedes* spp. pupae by container for containers with one or more pupae.

Discussion

Attempts to eliminate LF transmission in Polynesia with MDA administration of DEC repeatedly yielded dramatic initial reductions in the prevalence and density of microfilariae (Esterre *et al.*, 2001; Ichimori, 2001), but the apparent success was followed by a gradual resurgence in the number of individuals with microfilariae. In Samoa, following a DEC-based MDA campaign in 1971, surveys in 1972, 1973 and 1974 showed that microfilariae prevalence was <0.33% but, by 1982, the microfilariae prevalence had risen to 5.2% (Ichimori, 2001). Despite 34 years of DEC chemotherapy, 0.4% of the population of Maupiti, French Polynesia were microfilariae-positive in 2000, and 1.4% of *Ae. polynesiensis* were infected with *W. bancrofti* (Esterre *et al.*, 2001).

The present PacELF strategy differs from the previous anti-LF MDA campaigns in that a combination of DEC and albendazole is being used. This MDA strategy was reported to be more effective in reducing MF prevalence and densities for a longer time period than DEC alone (Ottesen *et al.*, 1999). However, when analysed in systematic reviews using the limited number of available studies, the addition of albendazole to DEC did not appear to improve on the effectiveness of DEC alone as a microfilariacide (International Filariasis Review Group 2005; Tisch *et al.*, 2005) or as a macrofilariacide (International Filariasis Review Group, 2005). Hence, there is a need for supplemental control strategies to ensure the success of the global LF elimination campaign. The only presently available alternative to filariacide treatment (MDA-based campaigns or distribution of DEC-medicated salt) is vector control.

Insecticide-treated bednets and indoor residual wall spraying with insecticides are effective for controlling transmission of malaria and filariasis in Melanesian countries by the night-biting *Anopheles* vectors found there (Webber, 1979; Burkot *et al.*, 1990; Bockarie *et al.*, 2002), and polystyrene beads in

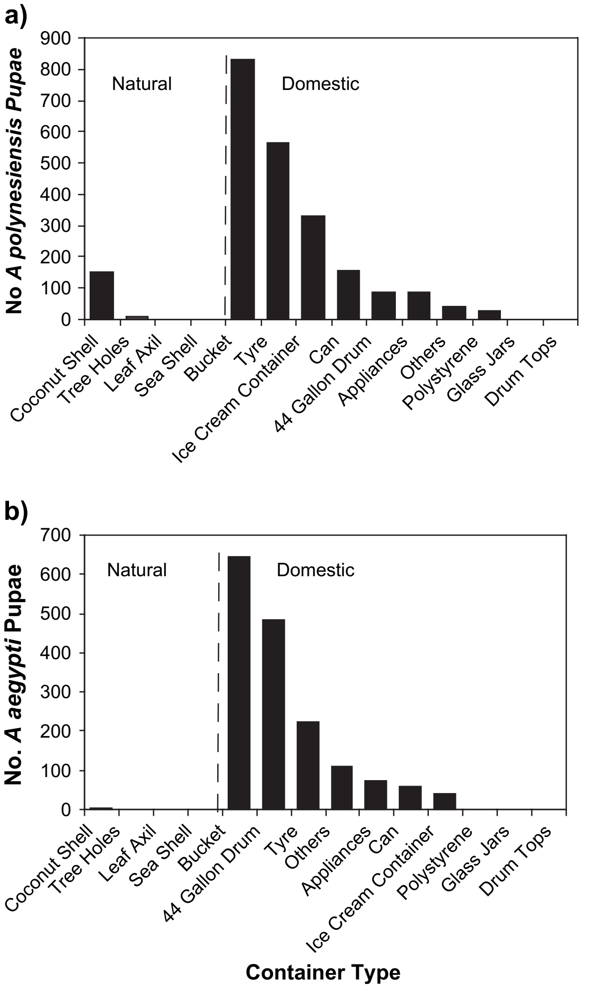

Fig. 5. Estimated numbers of (a) *Aedes polynesiensis* and (b) *Aedes aegypti* pupae found in different container types associated with 347 households in American Samoa. Numbers are grouped by natural and domestic containers and ranked within a group by number of pupae. Note: the 'Others' category contained some natural containers, but pupae were found only in the domestic containers within this category.

pit latrines act as physical barriers to both oviposition and adult emergence of *Cx quinquefasciatus* and are effective in reducing LF transmission where *Cx quinquefasciatus* is the vector (Maxwell *et al.*, 1990, 1999). By contrast with the success achieved with *Anopheles* and *Culex* vectors of LF, attempts at vector control for the *Aedes* vectors of LF and dengue have been challenged by the ecology of these species.

Both *Ae. aegypti* and *Ae. polynesiensis* are daytime-biting mosquitoes. Whereas *Ae. aegypti* prefers to feed and rest inside houses, *Ae. polynesiensis* prefers to stay outdoors. Studies suggest that both *Ae. polynesiensis* and *Ae. aegypti* have a short flight range of 100–200 m (Jachowski, 1954; Harrington *et al.*, 2005; Russell *et al.*, 2005). Both species utilize water-holding containers for oviposition. Previous studies reported that *Ae. polynesiensis* preferred natural containers (e.g. tree holes, coconut shells, crab holes), whereas *Ae. aegypti* was found much more frequently in domestic containers (Suzuki & Sone, 1978; Samarawickrema *et al.*, 1993). However, in these earlier studies, neither the numbers of available natural and artificial containers nor the densities of larvae and pupae were reported. Despite the rapidly changing ecologies of the Pacific islands, few studies on the larval ecology and control of *Ae. polynesiensis* have been published recently, except for those on French Polynesia (Lardeux *et al.*, 1992, 2002a, 2002b). Individual control strategies, including use of *Mesocyclops* spp., have yielded initially disappointing results (Lardeux *et al.*, 1992, 2002a). Although *Mesocyclops aspericornis* reduced the number of *Ae. polynesiensis* larvae in treated crab holes by 98%, the treatment of >14 000 crab holes on one French Polynesian island yielded no measurable impact on the number of biting *Ae. polynesiensis* (Lardeux *et al.*, 1992). Insecticide fogging and spraying campaigns also had minimal impacts on *Ae. polynesiensis* biting rates, with reductions of <64% in three trials (Chow, 1974; Suzuki & Sone, 1976; Wharton & Jachowski, 1980; all unpublished data).

In the absence of a dengue vaccine, source reduction campaigns to eliminate breeding sites of *Ae. aegypti* have been advocated as the only effective strategy to reduce the potential for dengue transmission (Gubler & Clark, 1996). Similarities in the larval ecologies of *Ae. aegypti* and *Ae. polynesiensis* suggest that campaigns to destroy or remove containers that serve as *Aedes* breeding sites could reduce the transmission of both dengue and filariasis in Pacific islands from Fiji to French Polynesia. The efficacy of larval source-reduction campaigns against *Ae. polynesiensis* in significantly reducing the population of biting *Ae. polynesiensis* was demonstrated in French Polynesia (Laigret *et al.*, 1965). However, the resources required for source reduction campaigns could be lessened and the efficacy of the intervention improved by targeting for mitigation or removal those types of containers that produce the greatest numbers of *Ae. polynesiensis* and *Ae. aegypti*. The short flight ranges of both these mosquitoes suggest that focal removal of the most productive breeding sites in villages could result in significant reductions in LF and dengue transmission within such villages.

By contrast with studies of *Ae. aegypti* (Focks *et al.*, 2000), application of the pupal index in *Ae. polynesiensis* studies to estimate the contribution of different container types to the total adult mosquito population has not been previously undertaken. The most abundant water-holding containers in American Samoa in the villages of Aunu'u, Fagasa, Fugaitua and Pago Pago were tyres, coconut shells and ice-cream containers. *Aedes aegypti* and *Ae. polynesiensis* showed distinct differences in their use of containers, preferring large and small containers, respectively. Surprisingly, the presence of both species in the same container did not influence the mean density of either species, suggesting that resources are available within containers to support populations of both mosquitoes. Only 15% of containers holding mosquito immatures included pupae, and most containers with *Aedes* pupae held <10 pupae. Few *Aedes* spp. pupae were found in tin cans, glass jars, leaf axils, tree holes and seashells in the study villages. However, 75% of *Ae. polynesiensis* pupae were found in buckets, ice-cream containers and tyres, and 82% of *Ae. aegypti* pupae were found in 44-gallon drums, buckets and tyres. Almost 96% of *Ae. polynesiensis* and *Ae. aegypti*

Table 1. Estimated total number of *Aedes polynesiensis* and *Aedes aegypti* larvae and pupae found in four American Samoan villages, by container type.

Container type	Containers	*Ae. polynesiensis* Larvae	*Ae. polynesiensis* Pupae	*Ae. polynesiensis* Total	*Ae. aegypti* Larvae	*Ae. aegypti* Pupae	*Ae. aegypti* Total	*Ae. polynesiensis* and *Ae. aegypti* Larvae	*Ae. polynesiensis* and *Ae. aegypti* Pupae	*Ae. polynesiensis* and *Ae. aegypti* Total
Natural containers										
Coconut shells	321	884	152	1035	13	4	17	897	156	1053
Leaf axils	99	82	0	82	0	0	0	82	0	82
Seashells	34	0	0	0	0	0	0	0	0	0
Tree holes	22	962	10	972	16	1	17	978	11	989
Totals	476	1928	162	2089	29	5	34	1957	167	2124
Domestic containers										
Tyres	481	9297	566	9863	3806	224	4030	13 103	790	13 893
Ice-cream containers	310	2331	330	2661	717	41	758	3048	371	3419
Buckets	264	12 093	830	12 923	4498	645	5143	16 591	1475	18 066
Cans	272	1428	158	1586	496	58	554	1924	216	2140
Polystyrene	118	444	28	472	42	1	43	486	29	515
44-gallon drums	143	845	88	932	5806	482	6288	6651	570	7221
Appliances	55	707	85	793	914	74	988	1621	159	1780
Drum tops	11	58	0	58	52	0	52	110	0	110
Glass jars	63	286	0	286	0	0	0	286	0	286
Others	65	1166	42	1208	1895	110	2005	3061	152	3213
Totals	1782	28 655	2127	30 782	18 226	1635	19 861	46 881	3762	50 643
Totals (all containers)	2258	30 583	2289	32 871	18 255	1640	19 895	48 838	3929	52 767

pupae were found in domestic containers, with only 156 of the 3926 pupae of the two primary vector species found in natural containers (leaf axils, tree holes and coconut shells). This contrasts with previous work suggesting that *Ae. polynesiensis* prefers natural containers. This difference may be due to increased availability of domestic containers, adaptation to the human environment or other unknown factors. The lack of crab holes in close proximity to houses in these four villages further indicates that source reduction efforts targeting artificial containers, particularly buckets, tyres, drums and ice-cream containers, should yield significant reductions in both *Ae. polynesiensis* and *Ae. aegypti* populations in American Samoa. Integration of MDA-based filariasis control activities with vector control is a logical step for continued suppression of LF transmission where *Ae. polynesiensis* is the vector. In addition, this strategy would also suppress the potential for dengue transmission by both *Ae. polynesiensis* and *Ae. aegypti*.

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