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Vector Biology
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Pakistan: Source Reduction for Malaria Control in Baluchistan Province

June 1-29, 1992

by

Michael K. Carroll, Ph.D.

VBC Report No. 82246

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'01 North Fort Myer Drive • Suite 400 • Arlington, VA 22209 • (703) 527-6500 • Telefax: (703) 243-0013 • Telex: 248812 (MSCI UR)

Author

Michael K. Carroll, Ph.D., is the Assistant Administrator of the New Orleans Mosquito Control Board, New Orleans, Louisiana, and an adjunct assistant professor of entomology at the Tulane School of Public Health and Tropical Medicine, New Orleans.

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Table of Contents

Tables

Annexes

1. Introduction

The Pakistan Malaria Eradication began in 1960 as part of the global effort to eliminate malaria. By 1968, the program included all of what was then West Pakistan.

Since the beginning of the program, malaria control in Pakistan has relied on vector control through residual insecticide spraying (currently with malathion) of walls and ceilings, and medical intervention through patient chemotherapy. Pakistan's Malaria Control Program (MCP) no longer uses DDT, dieldrin and HCH because vector resistance to these insecticides is very widespread. Some areas of Pakistan have high levels of malathion resistance in populations of *Anopheles stephensi*, with low levels detected in some populations of *An. culicifacies*.

Generally, limited larviciding is done by municipal corporations in urban areas using fenitrothion (Fenthion^{R}), temephos (Abate^{R}) and pyrimiphos-methyl (Actellic^{R}). In Baluchistan, temporary MCP employees apply Abate 500E (46% A.I. temephos) and Fenthion 2G (2% A.I. fenitrothion).

No residual wall spraying was done in Baluchistan Province in 1991 due to insecticide and budget shortages.

Generally accepted in developed countries as the most sound method of mosquito control, the integrated pest management (IPM) approach incorporates several methods of vector suppression. The components of IPM are chemical control (adulticiding and larviciding), mosquito surveillance (adults and larvae), public awareness, biological control (introduction or enhancement of larval parasites and predators), and source reduction (permanent elimination of larval breeding sites). The goal of this study was to determine the extent to which source reduction might be used in Baluchistan as part of an effort to move toward IPM, or integrated vector control, in Pakistan.

The objectives of this investigation were:

- To study the larval ecology of malaria vectors in arid rural village ecosystems in Baluchistan Province;

- To determine the main breeding habitats in malarious areas during the dry hot season (May, June, July), when larvae might be confined to small breeding sites;

- To assess the feasibility of larval control in these areas through source reduction/biological control methods; and

- To recommend to the Directorate of Malaria Control (DOMC) such alternative control strategies for malaria transmission in arid rural village ecosystems in Baluchistan Province.

Prior to and during briefings at USAID/Islamabad June 6-7, it appeared that all details of transport, personnel support and security clearances had been completed. During briefings at the Baluchistan Provincial Malaria Control Program offices in Quetta June 9, however, I learned that security clearance beyond Quetta City was not available. Persistent efforts by Dr. Rifaq and Dr. Paracha to obtain clearance were unsuccessful; thus, all study sites were limited to the "city villages" of Quetta, one of the 22 districts of Baluchistan.

2. Epidemiology

Effective vector control is based on complete, reliable epidemiological data (see Annex B flow chart). A review of MCP data and procedures in Islamabad and Quetta revealed that the epidemiologic data collected for Quetta district were not sufficient for planning specific entomological strategies, such as source reduction or biological control.

The available data are summarized in Tables A and B. No charts, graphs or data segregated by patient age, refugee status, sex, *Plasmodium* species, or village were available. This information should be recorded and analyzed to determine whether and where indigenous transmission is occurring, and the data should be shared with MCP entomologists so vector control efforts can be targeted.

A desktop computer in Quetta was not being used during this visit, apparently because of a lack of trained personnel.

Most malaria data are collected through passive case detection at clinics and hospitals. The person taking a blood smear begins filling out a standard form, EVA-M/3, which includes spaces for the patient's name, age, address, father's name, the date the slide was taken and slide result (Annex A). There is no patient follow-up and no attempt to determine whether a patient had been treated for malaria before. This is essential information for determining whether malaria infections result from indigenous transmission or *P. vivax* relapse.

Clinical Interviews of Slide-Positive Patients

On two successive mornings, Dr. Jan Rozendaal, USAID Advisor to the MCP, and I randomly interviewed 15 slide-positive patients at the Malaria Control Program/USAID office in Quetta to determine whether: a) malaria was being transmitted in their villages; b) their malaria infections were a result of relapses (*P. vivax*); or c) they had contracted malaria while traveling, particularly in or near Afghanistan, which is about 70 miles from Quetta.

Table A. Status of Malaria in Pakistan (DOMC/Islamabad)

Year	Population	Slides Taken	Slides Pos.	S.P.R.	A.P.I.
1960				15.57	Baseline survey
1961	31,535,473	25,733	936	3.64	
1962	32,510,796	83,230	754	0.91	
1963	33,516,284	272,178	4,779	2.75	0.22
1964	34,552,870	409,977	6,660	1.63	0.19
1965	35,621,515	1,078,216	15,859	1.47	0.44
1966	36,723,211	1,731,691	6,206	0.36	0.16
1967	37,858,480	2,574,664	6,465	0.25	0.17
1968	39,029,876	3,251,913	11,562	0.36	0.29
1969	40,236,985	4,705,567	45,729	0.98	1.44
1970	41,481,428	3,847,538	107,991	2.81	0.26
1971	42,764,358	3,778,934	202,496	5.36	4.73
1972	44,086,967	4,408,610	642,958	14.58	14.58
1973	45,450,481	4,252,184	599,177	14.09	13.183
1974	46,856,165	3,094,098	303,936	9.82	6.487
1975	48,865,329	3,205,689	238,315	7.43	4.930
1976	49,799,303	2,857,854	122,219	4.28	2.454
1977	51,879,670	2,667,315	47,571	1.78	0.928
1978	52,737,019	2,610,602	16,404	0.63	0.306
1979	53,929,411	2,728,648	12,572	0.46	0.220
1980	55,103,689	3,053,992	18,023	0.59	0.320
1981	56,934,577	3,018,968	37,923	1.26	0.666
1982	58,067,409	3,303,067	56,360	1.71	0.97

Table A. (continued)
Status of Malaria in Pakistan
(DOMC/Islamabad)

Year	Population	Slides Taken	Slides Pos.	S.P.R.	A.P.I.
1983	58,468,028	2,587,920	51,596	1.99	0.88
1984	60,746,320	3,255,853	73,996	2.27	1.22
1985	62,133,282	3,119,695	77,607	2.49	1.23
1986	63,997,281	2,899,020	90,393	3.12	1.44
1987	65,925,771	2,948,912	63,948	2.17	0.97
1988	67,894,715	3,094,198	57,011	1.87	0.85
1989	69,917,977	3,159,580	107,739	3.39	1.44
1990	72,272,000	2,608,398	79,689	3.05	1.106
1991	74,190,388	2,712,586	66,586	2.45	0.897

Table B. Status of Malaria in Quetta Dist., Baluch. Prov., 1991/1992 (1st Half)

Month	No. Slides	No. Pos.	Pos. P.v.	Pos. P.f.	S.P.R.	F.R. %*
1991						
January	159	43	23	20	27.0	12.6
February	184	51	37	14	27.7	7.6
March	210	37	32	5	17.6	2.4
April	323	79	38	41	24.5	12.7
May	714	162	132	30	22.7	4.2
June	876	216	129	87	24.7	9.9
July	1,666	606	265	341	36.4	20.5
August	3,011	1,511	691	920	50.2	30.6
September	4,903	3,037	558	2,479	61,9	50.6
October	3,301	1,903	247	1,656	57.7	50.2
November	1,656	762	98	664	46.0	40.1
December	1,187	463	85	378	39.0	31.8
Total	18,190	8,870	2,235	6,635	48.8	36.5

*MCP gives the falciparum rate % as: Total pos. p.f./Total no. slides

1992						
January	788	317	157	160	40.2	20.3
Febraury	752	237	168	69	31.5	9.2
March	1,072	384	338	46	35.8	4.3
April	1,408	642	593	49	45.6	3.9
May	2,662	614	562	52	23.1	2.0
June	1,097	422	366	56	38.5	5.1

The interviewed patients ranged from five to 35 years old (average 16 years, mode 13.5). Seven were female and eight were male. Thirteen were refugees from Afghanistan and two were Pakistanis. Fourteen were slide-positive for *P. vivax* and one was positive for *P. falciparum*.

Through interpreters, the 15 patients were asked the same basic questions about age, nationality, travel history for the past year, history of malaria illness, and the treatment they had received in the past. These questions often led to useful follow-up questions.

Of the 15 people interviewed, 13 had traveled to Afghanistan during the past year and most had had prior vivax infections.

3. Field Studies

Quetta City is made of many villages, or *killis*. Although many are ethnically distinct, most killis are physically contiguous. Mr. Hafiz Akhtar, assistant entomologist with the Baluchistan MCP, identified six villages from which he believed most clinic patients came. Potential mosquito breeding sites in all the villages listed below were identified and surveyed for larvae. Elder men were asked to point out standing or storage water. Villages marked with an asterisk were identified by the MCP as the most malarious.

Killi Tirkha
Killi Khroat Abad*
Killi Phoot Kili*
Killi Ghos Abad
Killi Karani
Killi Kamir Abad*
Killi Kamalo Muslim Abad*
Killi Kasi Abad (Sariab)*
Killi Nasaran (Pishin Dist.)
Killi Cashma Achozai
Killi Kharabad
Killi Samungli
Killi Tirha
Killi Dadkarim
Killi Nehsar
Killi Jungle Bagh*

All villages had some visible water. These water sources were both obvious and scarce. All sites had "gray" polluted water either in canals, roadside ditches, or seepage swales. Dipping samples from still-water areas in these water sources, we found many culicine larvae and pupae, but no anophelines. All villages had some clear, sunlit water, with or without algae. We made hundreds of standard dips, finding thousands of culicine first instar through pupae in clear and polluted water. A total of only 39 *Anopheles* first and second instar larvae were collected.

Sampling sites included wastewater canals and ditches, irrigated fields, irrigation ditches, shallow wells, exposed tunnels of karez systems (or kariz = ganat in Afghan), river beds, grassy pools, irrigation wells, talabs (small well-fed diked holding ponds < 100 feet across, < three feet deep), swales, above-ground cement water-holding tanks and rock pools, and animal water containers. Karez-supporting wells, usually about five feet in diameter and 200-300 feet deep, were not accessible for sampling.

All of the *Anopheles* larvae were collected from three separate talabs and one talab overflow ditch used to irrigate an apple orchard. Talabs are dike impoundments, fed as needed by pumping water from deep underground springs through dug wells. The water is used for crop irrigation, human bathing and livestock watering. Virtually all talabs contained mats of floating filamentous algae, emergent macrophytes and large frog tadpoles. About one-half contained small fishes. The contours of talab banks were irregular due to human and livestock activity.

Numerous village animal shelters and other buildings thought suitable for resting adult mosquitoes were thoroughly examined with flashlights and by brushing the walls and ceilings. None of these structures had screens or doors. No resting mosquitoes were collected or observed. No houses were inspected because of residents' objections.

Expected anopheline species for Baluchistan Province are: *An annularis*, *culicifacies* (A and B), *fluviatilis*, *multicolor*, *pulcherrimus*, *sergentii*, *stephensi* and *superpictus*. In descending order, the most likely to be encountered are *culicifacies*, *stephensi* and *superpictus*.

4. Field Conditions

The climate during this consultancy was very hot. Daytime high temperatures in Quetta City were almost consistently 35° C, with relative humidity ranging from single digits through about 40 percent.

The assistant malaria control entomologist in Quetta, Mr. Akhtar, initially said that it would not be difficult to find anopheline breeding in Quetta City because *Anopheles* larvae been collected in the area last June. He said that anophelines were often observed in pocketed pools along ravine streams. Sampling in such pools during this assignment produced many culicine but no anopheline larvae. Mr. Akhat noted that the spring rains had been unusually heavy in 1992 and had ended early.

The following data were prepared, upon request, by the Pakistan Meteorological Department and Geophysical Center, Quetta City.

Table C. Rainfall for Quetta City in mm

	March	April	May	June
1987	23.1	5.8	8.9	0.0
1988	0.5	4.0	0.0 (tr.)	0.0
1989	33.5	8.1	6.3	2.0
1990	16.5	2.5	4.6	0.0
1991	46.5	41.9	2.0	0.0
5 yr. avg.	24.0	12.5	4.4	0.4
1992	62.2	132.2	5.6	0.0 (6/1-6/19)

It is obvious from these data that rainfall was unusually high in March and April 1992. The area's hilly terrain probably caused rapid water runoff, washing away most mosquito larvae. *Anopheles* larvae are particularly susceptible to these conditions because they stay near the surface where the water current is strongest.

5. Observations Pertinent to Source Reduction/Biological Control

Limited funds, equipment, supplies and trained personnel may constrain the Baluchistan MCP's ability to conduct the epidemiological and entomological surveillance necessary to plan and carry out a source reduction and biological control program. Some of the limitations observed during this consultancy are listed below.

- o The MCP had no standard dippers for larval sampling and no larval collection containers, such as vials and whirlpacks (plastic collection bags).

- o No mosquito keys or specimen preservation supplies were on hand.

- o The program budget and available staff did not provide for someone to conduct in-depth patient interviews for improved epidemiology/entomology.

- o There was a critical shortage of motorized transport.

6. Recommendations

1. Malaria epidemiology needs improvement, particularly in obtaining patient case histories, analyzing data, and transferring this information to MCP entomologists. Without this crucial base, it is unlikely that the MCP will be able to expand its control program beyond patient chemotherapy. Until a sound epidemiological base has been established, source reduction and biological control in Baluchistan should be very limited.

2. Physical source reduction and biological control should be centered around villages of high rates of **indigenous** malaria.

3. The flow chart and summary in Annex B show how epidemiological and entomological surveillance and source reduction fit into an integrated malaria control program. Some simple source reduction methods requiring little labor that might be effective in Baluchistan include:

   - o removing algal mats and emergent vegetation, which help protect mosquito larvae from predators, from talabs and other small ponds;

   - o grading stream and pond aprons to eliminate water pools;

   - o in areas of relatively stable water levels, grading banks to a least 45% (1:1 slope) degrees approximately 3 feet into ponds and streams to discourage plant growth;

- o stocking water sources with larvivorous fish[1]; and

- o encouraging farmers to plant dense lines of apple trees or other shade trees along irrigation ditches to shade the water as much as possible from sunlight, which promotes *Anopheles* breeding by supporting algae and other larval food. The shade will also inhibit the growth of other aquatic plants that serve as protection from larval predators.

4. Good entomological surveillance is essential for effective source reduction and biological control. After surveying a village and noting breeding sites, MCP staff could begin a mapping and routine larval surveillance program. Village maps can be drawn freehand, and breeding/treatment records such as the one in Annex C could be used.

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[1] MCP could use "minnow" traps to collect small fishes (approximately 1-2 inches long) from talabs. If the fish prove larvivorous, they could be transferred to ponds and streams that have no fish. Minnow traps are small wire cylinders with inverted cones at either end. A trap costs about US$ 5 and could be made easily and cheaply with locally available materials. Many larvivorours fish can eat several hundred larvae a day.

7. Concluding Comments

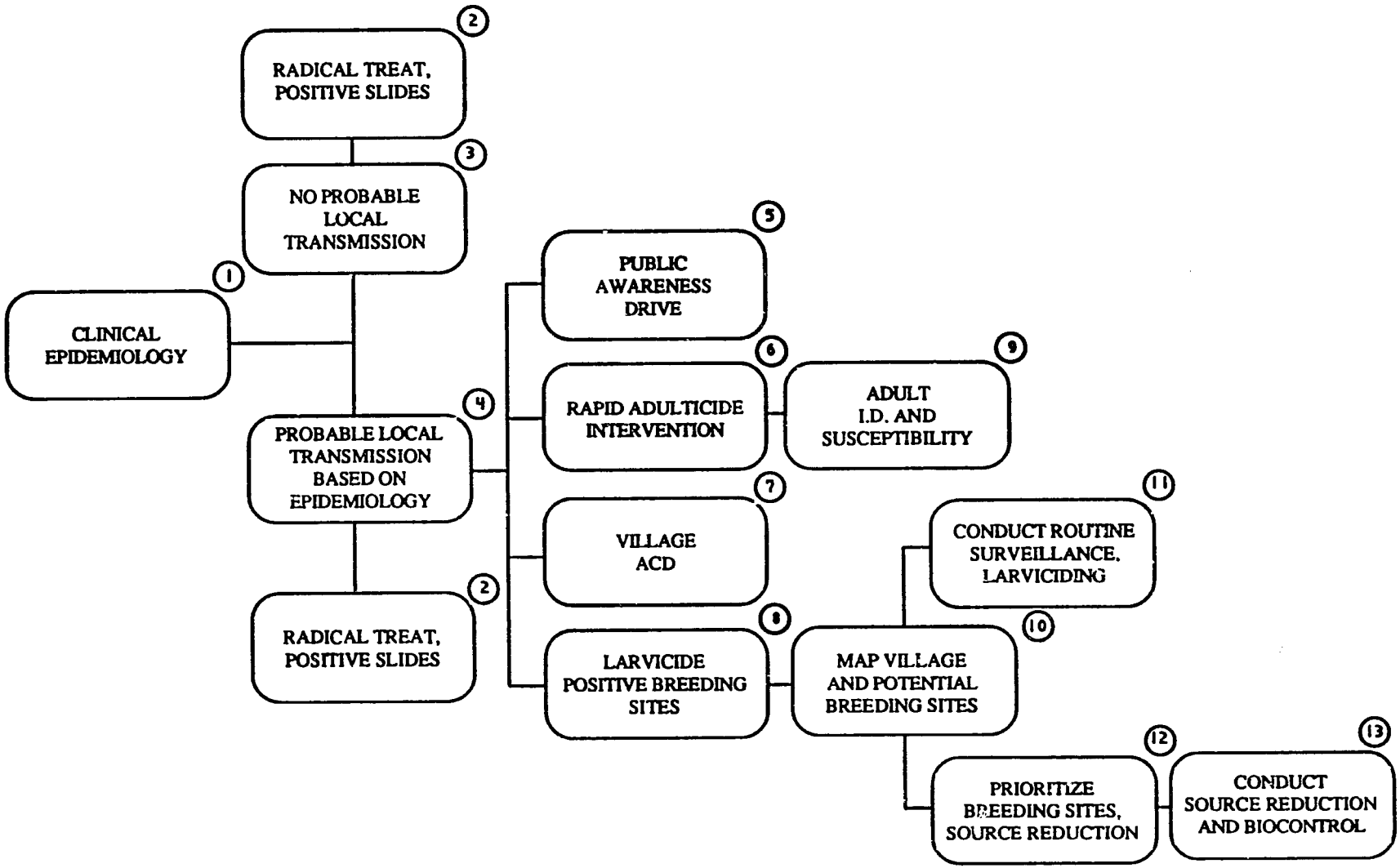
Because I could not get security clearance outside of Quetta City, I was unable to study the larval ecology of malaria vectors in the rural village ecosystems previously identified as promising sites for source reduction. The urban sites sampled during this consultancy may not be typical of the kind of breeding sites found in rural villages in Baluchistan. From the limited perspective of this investigator, however, it appears that the potential for further control of *Anopheles* breeding through source reduction/biological control in Baluchistan is very good. Container, marsh and ricefield breeding in Baluchistan are of minimum importance, water sources are easily identifiable, adult mosquito daytime resting sites are mostly confined to man-made structures, labor is inexpensive, and, compared to many other developing countries, malaria rates are relatively low.

When the epidemiological component of the MCP is strengthened and villages with high indigenous malaria are identified, focal source reduction should produce dramatic decreases in locally transmitted malaria.

Annex A

Malaria Control Sequence of Events Flow Chart

MALARIA PASSIVE CASE DETECTION AND RESPONSE



1. **Epidemiology**. Quetta District Malaria Control Program conducts a patient intake and writes subsequent laboratory (slide) results on Form EVA-M/3 (Annex B). In order that entomological response (i.e. vector control) can be effectively based on the clinic-based epidemiology, the case intake needs to be expanded to include information such as the following:

    - o Refugee or permanent resident?
    - o Travel beyond the village in past 24 mo. and where.
    - o Past history of malaria — when, where and treatment
    - o Physical reactions to past chemotherapy
    - o Family history of malaria

2. **Radical Treatment**. The program generally appears to be using commonly accepted practices. Consideration for 14-day treatment should be given to patients who have received more than one 7-day treatment. Syrup should be resupplied to the clinics for use with children unable to take the tablets.

3. **No Probable Local Transmission**. This is likely if a) a vivax patient with prior vivax infection did not obtain or complete treatment or b) a vivax patient has traveled to a malarious area in the past 24 months and has had a history of fevers.

4. **Probable Local Transmission Based on Epidemiology**. This is likely if a) the patient has no travel history to malarious areas and, if the patient had malaria before, treatment was successful or b) a high percentage of a village's infants and children with no travel history have malaria.

5. **Public Awareness Drive**. In villages with evident local transmission, posters should be placed by stores and other well-trafficked areas encouraging the use of bed nets, repellents and, if possible, house screening. Community-based source reduction should be illustrated. People with fevers should be given information on obtaining treatment.

6. **Rapid Adulticide Intervention**. House and stable wall spraying should be concentrated in areas of probable local transmission.

7. **Village ACD**. Many families should have blood smears taken to get unbiased data as to the extent of the malaria incidence.

8. **Larvicide Positive Breeding Sites**. Larvicide areas where the presence of anopheline larvae has been confirmed. In areas of very high malaria rates, all suspect breeding sights should be larvicided.

9. **Adult Mosquito Identification and Susceptibility**. Adult mosquitoes should be aspirated from dwellings and flitted or reared from late-instar larvae or pupae for identification to species. WHO kits should be used for susceptibility/resistance testing.

10. **Map Village and Potential Breeding Sites**. A free-hand line map should be drawn showing roads, dwellings (or blocks), streams, wells, ponds, irrigation systems, large water holding containers and waterlogged areas. Each "potential" breeding site should be easily identified by malaria control workers (e.g. Killi Kharabad, Sector 1, Site A).

11. **Routine Surveillance and Larviciding**. These breeding sites should be inspected regularly, particularly during traditional transmission seasons and after significant rainfall. Information should be recorded on a form such as the one in Annex C.

12. **Prioritize Breeding Sites for Source Reduction or Biocontrol**. Sites that frequently breed mosquitoes should be considered for elimination or stocking of larvivorous fish.

13. **Conduct Source Reduction and Biocontrol**. Sites closest to the village (within approximately 500 meters) that can be drained, filled or stocked with fish should be given the highest priority for action.

Annex B

Baluchistan MCP Fever Cases Report (EVA-M/3)

Malaria Control Programme (EVA-M/3)
Balochistan District..... S.No.
Fever Cases Report

Village_____ F.R. Post No.

S. No.	Name of Sick Person with Father's Name Caste & Detailed Address	Age	Date Slide's Slide	No.of Tab

Slide sent on:- ☐ ☐ ☐

Malaria Control Programme (EVA-M/3) District.....
Balochistan District..... S.No. S.No.
Fever Cases Report Village.....Tehsil..... F.R.Post No. ☐
Type_____ F.R. Post No_____ Date Slide Sent

S. No.	Name of Sick Person with Father's Name Caste & Detailed Address	Age	Date of		No.of Tab	Lab Ref No.	Result	S. No.	Results
			Fever Slide	Taken					

Slide Sent on:- ☐ ☐ ☐ Name of sandes_____ Date.....
Sig.....

12

Annex C

Sample Larval Inspection Form

1992 Larval Inspections -___ areas

Month	Day	Initials	Area	Site No.	Site Description	Address or Location	D I W	Density	Insecticide & Amount Used	Samples taken	Species	Total
							o|o	N L M H	Bti Alto Oil			
							o|o	N L M H	Bti Alto Oil			
							o|o	N L M H	Bti Alto Oil			
							o|o	N L M H	Bti Alto Oil			
							o|o	N L M H	Bti Alto Oil			
							o|o	N L M H	Bti Alto Oil			
							o|o	N L M H	Bti Alto Oil			
							o|o	N L M H	Bti Alto Oil			
							o|o	N L M H	Bti Alto Oil			
							o|o	N L M H	Bti Alto Oil			

Comments:

-23.

Annex D

General Source Reduction Methods

This annex contains the title page, table of contents and ordering information for The World Health Organization's *Manual on Environmental Management for Mosquito Control.* This well-illustrated, 283-page manual should be ordered as a general source reduction reference for Pakistan. It is much improved over the 1973 edition.

MANUAL ON ENVIRONMENTAL MANAGEMENT FOR MOSQUITO CONTROL

with special emphasis on malaria vectors

WORLD HEALTH ORGANIZATION
GENEVA
1982

25

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28

Annex E

List of People Contacted

Ms. Anne Aarnes, Chief, USAID/Islamabad, O/HPN

Ms. Barbara Spaid, Deputy Chief, USAID/Islamabad, O/HPN

Dr. Rifaq Ismail, Project Officer, USAID/Islamabad, O/HPN

Mr. Chaudhary A. A. Mujahid, Director DOMC, MOH

Dr. Ghulam Hashim, Epidemiologist, DOMC, MOH

Dr. Jan A. Rozendaal, USAID/Islamabad, Malaria Control Advisor

Dr. Mohammad Hussain, Provincial Chief, MCP/Baluchistan

Dr. Mahmood S. Paracha, Epidemiologist, MCP/Quetta

Dr. Fazal Amed, USAID/Quetta, Liaison Officer

Mr. Hafiz M. Akhtar, Assistant Entomologist, MCP/Quetta

Mr. Munir Sheikh, Director, Pakistan Meteorology Department

MAJ Ralph Harbach, Chief, Walter Reed Biosystematics Unit

CPT Jayson I. Glick, Taxonomist, Walter Reed Biosystematics Unit

Annex F

Itinerary, June 1-29, 1992

June

1 Held a short briefing with Dr. Richard Andre (VBC) in Arlington, VA. Spent the remainder of day at the Walter Reed Biosystematics Unit (WRBU) reviewing mosquito keys and keying museum specimens likely to be in Baluchistan. Worked under Captain Jayson Glick.

2 Discussed scope of work and potential study sites throughout rural Baluchistan with Dr. Andre at VBC. Conducted formal briefing for VBC staff, USAID/Washington and people from other interested agencies.

3 Continued briefings, project proposal and VBC library review. Left Washington at 10:15 pm.

4 All day flight travel.

5 Met with Dr. Rifaq (USAID/Islamabad). Discussed schedule and reviewed project.

6 Meetings with Dr. Rifaq, Mr. Mujahid (Dir. DOMC) and Dr. Ghulam Hasham (epidemiologist, DOMC). Discussed objectives and plans and reviewed epidemiology.

7 Meetings with Dr. Rifaq and Ms. Barbara Spaid [Dep, Chief of Health, Population and Nutrition (HPN)]. Reviewed and purchased maps and guides for Baluchistan.

8 Flew to Quetta City in a.m. Conducted orientation of city.

9 Meetings at Malaria Control Program in Quetta with Dr. Fazal Ahmed (USAID/Quetta Liaison Officer), Mr. Sadiq (AMS, MCP Quetta) and Mr. Hafiz Akhtar (Asst. Entomologist, MCP Quetta). Spent the evening visiting villages for larval survey.

10 Reviewed epidemiological data at MCP/Quetta and continued village larval survey.

June

11 Worked on epidemiological data.

12 Holiday

13 Holiday

14 Traveled around Quetta Valley. Stopped at several villages and questioned residents about malaria and breeding sites.

15 Traveled with Dr. Mahmood Paracha (epidemiologist, MCP/Quetta) and Mr. Akhtar and studied several villages in southern Quetta.

16 Traveled with Dr. Jan Rozendaal (USAID/Pak. Malaria Advisor) and Mr. Akhtar to several villages for study.

17 Visited several clinics with Dr. Paracha and Dr. Rozendaal. Studied more villages. In light of travel restrictions beyond Quetta, I talked to Dr. Rifaq, Dr. Paracha and Dr. Rozendaal about shortening my stay by five days. All in complete concurrence. Called Dr. Andre, who also concurred.

18 Conducted epidemiological interviews (along with Dr. Rozendaal) of 10 slide-positive patients at Quetta MCP (5 previous day). Conducted intensive study of village that many of this month's patients had come from (Jungle Bagh).

19 Returned to Islamabad in a.m. Worked on field draft.

20 Continued work on field draft.

21 Scheduled debriefing w/DOMC.

22 Scheduled debriefing with Chief HPN.

23 Continued report writing.

24 Report writing and depart Islamabad.

June

25 Holiday

26 Arrive Washington, travel day.

27 Report writing.

28 Debriefing preparation.

29 Debriefings at VBC and depart Washington.