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ARTHROPOD-BORNE DISEASE ASSESSMENT IN
SUPPORT OF MILITARY OPERATIONS IN OMAN

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TABLE OF CONTENTS

ABSTRACT: During the summer of 1994, NAVMEDRSCHU THREE received requests from the office of the Force Surgeon, U.S. Naval Forces Central Command, Bahrain, to provide assistance in conducting arthropod-borne disease risk assessments in two separate regions of Oman. On two separate trips, NAVMEDRSCHU THREE personnel and field surveillance equipment were deployed to Oman in response to the requests. The first survey was conducted during the period 06 - 16 August, 1994, and was primarily focused on assessing the threat of chloroquine resistant *Plasmodium falciparum* malaria in the extreme southern-border area of the country. The second surveillance deployment was from 19 - 30 September, 1994, into the central-coastal region in conjunction with an amphibious landing exercise code named SEA SOLDIER IX. The major objective of the second trip was to conduct general endemic disease prevalence and threat assessment, including all fly-borne, flea-borne and/or tick-borne diseases. During both of the deployments, blood samples were collected from indigenous personnel for screening, and intensive arthropod collection and screening operations were conducted. Although minimal information was procured on the occurrence and relative threat of arthropod-borne diseases in these two areas of Oman, very valuable liaison with Omani health authorities was established and useful information on the country was obtained.

INTRODUCTION:

The Sultanate of Oman is a relatively small developing country located on the eastern edge of the Arabian Peninsula, between approximately 15° and 25° North latitude, and 50° and 60° East longitude. Oman consists of a total land area of 82,030.8 mi^2, with 854 miles of land boundaries (ca. 423 miles with Saudi Arabia, 256 miles with the United Arab Emirates, and 180 miles with Yemen) and 1,300 miles of coastline (**Figure 1**). Oman's geographic location on the Musanden Peninsula gives it a strategic foothold for controlling the transit of the Straits of Hormuz, through which more than 17% of the world's petroleum production passes from the Persian Gulf to the Arabian Sea.

Although predominately hot, dry, desert plain in the interior, Oman does possess diverse rugged mountainous terrain along its northern and southern extremes, as well as humid sub-tropical micro-environs along its southern coastline on the Arabian Sea. Oman's economy has for centuries been dependent on a strong agricultural base. Even with significant oil revenues, agriculture and animal production remain vital to its existence. Estimated annual per capita Gross National Product (GNP) is $6,308 (USD), with industry contributing 57.0%, services contributing 39.0%, and agricultural produce accounting for 4.0%. There are four major population centers in Oman; 1) Muscat with approximately 50,000 people, 2) Matrah, approximately 17,000 people, 3) Salalah, and 4) Nazwa, each with approximately 10,000

people. The vast majority of the population reside in or around these cities, which are located either in the extreme northern or extreme southern regions of the country. The expansive central region of Oman is considered virtually uninhabited, however nomadic herdsmen roam/graze their livestock throughout this region.[1] More specific information on demographic and cultural characteristics of the Sultanate of Oman are provided in various tables within **Appendix I.**

PUBLIC HEALTH

Very little information is available on incidence of disease or causes of death in Oman, particularly for the sparsely populated nomadic regions of the country. Malaria has been previously considered to be the most common disease in Oman, believed to be the cause of 47% of all reported illnesses in 1977, while gastroenteritis accounted for 29% of those treated for illnesses. A parasite screening survey of school children during 1977-78 yielded 14% positive for malaria. Numerous other diseases are present in Oman, including trachoma, glaucoma (and other eye diseases), helminthiasis, poliomyelitis and tuberculosis and various vitamin deficiency-related diseases have been reported frequently. Leprosy, cholera and smallpox have been reported as recently as 1977. Epidemics of cholera, measles and influenza occur periodically.[2]

VECTOR-BORNE DISEASE THREAT(S)

Relatively little information regarding the occurrence,

prevalence and resultant threat of arthropod-vectored diseases in Oman is available. Mosquito-vectored diseases occurring, or reported to have previously occurred in Oman include malaria (*Plasmodium falciparum, P. malariae, & P. vivax*) and dengue fever.[3] Various reports on the occurrence, distribution and prevalence of visceral and cutaneous leishmaniases suggest that the diseases are limited to endemic foci within Oman.[4,5] Flea-borne bubonic plague (*Yersinia pestis*) has been reported to occur in Oman, however little information is available on its distribution. There are no previous records of confirmed tick-borne viral diseases reported from Oman, however there are numerous reports of tick-borne diseases from neighboring countries (i.e, Saudi Arabia, Yemen and United Arab Emirates).[6,7] Specific tick-vectored/reservoired diseases of potential concern in the area of these operations include; Crimean-Congo Hemorrhagic fever virus, Quaranfil fever virus, Wanowire virus, and Boutonneuse fever (*Rickettsia conorii*). Quaranfil fever virus is normally maintained and vectored by soft ticks (*Argas arboreus*) that infest cattle herons (*Bubulcus ibis ibis*), but may be as prevalent in the camel tick (*Hyalomma dromedarii*) or (*Hyalomma impeltatum*) in some areas.[6,7]

Recently (July and August, 1994) an arthropod survey of the northern populated region of Oman was conducted. Ticks collected during this survey included four species of ixodid ticks; *H. dromedarii* (ca. 50% of total collection), *Hyalomma anatolicum*

anatolicum (ca. 44% of collection), *H. impeltatum* (ca. 5% of collection), and *Hyalomma arabica* (< 1% of total collection) (H. Y. Wassef, unpublished data).

The strategic geographic location of Oman, combined with its rapid economic and social development in recent years, suggests the importance of the country as a potential staging point in the Southwest Asia theater of operations. Due to the lack of published information on arthropod-borne disease occurrence, prevalence and potential vectors, future surveillance efforts will undoubtedly produce highly valuable results. This report presents each of the two deployments to Oman individually regarding background information and the results of the surveillance efforts. However, the discussion and summary of the information acquired is presented in an overview format.

ACTIONS:

TRIP 1 - Southern Region (06-16 August 1994).

An official request for assistance was received at NAVMEDRSCHU THREE via message traffic on 13 July, 1994 (per COMUSNAVCENTCOM msg dtd 121345Z JUL 94). NAVMEDRSCHU THREE was requested to provide personnel and equipment support in conducting a health and sanitation survey in and around a U.S. Navy Construction Battalion Team deployed to Salalah, Oman (**Figure 2**). More specifically, an assessment of the potential occurrence of chloroquine-resistant *Plasmodium falciparum* and mosquito vectors, and of the overall arthropod-borne disease threat in the area was to be conducted. The Construction Battalion Team was deployed into the area during late-March 1994, and were living in a tent compound on the outskirts of the city. A team composed of a Microbiologist and an Entomologist departed NAVMEDRSCHU THREE on 06 August 1994; travelled to COMUSNAVCENT-Bahrain to meet the rest of the survey team, and then on to Salalah, Oman. Human blood collection and mosquito surveillance operations were conducted at three specific localities during the period 10-12 August 1994. Venous blood specimens from 36 subjects residing at a refugee camp on the Oman-Yemen border were examined on thick and thin, Giemsa-stained smears. Two specimens (6.0%) were positive for malaria, both P. falciparum. Drug sensitivity testing by the WHO micro in vitro test showed both isolates to be sensitive to chloroquine. Following discussion

with the Health Superintendent, Dhofar Region, it was decided that vector/reservoir surveillance operations would be conducted at each of three sites as follows:

Construction Battalion Tent Compound, Salalah, Oman (10AUG94): The tent compound consisted of ten (10) GP-medium tents, a mobile shower/toilet trailer, and an improvised laundry facility. These accommodations served ca. 24 Construction Battalion members, however no messing or food preparation facilities were available on the site. A visual inspection of the compound to identify any potential mosquito breeding sites, and/or indicators of significant rodent populations was conducted prior to trapping operations. Limited potential mosquito breeding sites (i.e., standing water or stagnant containers of water) were found; however culicine mosquito larvae were collected from a sewage-holding pit located adjacent to the shower/toilet facility. Fifteen (15), CDC-6vDC light traps were utilized to collect host-seeking arthropods; twelve (12) configured for mosquitoes (baited with dry ice), and three (3) positioned for the collection of sand flies (without dry ice). Additionally, twenty (20) oiled-paper sticky traps were positioned to encompass the tent compound, and six (6), baited Sherman rodent traps were located in and around the tent area. Relatively low mosquito numbers were recovered from the light traps, including 116 *Culex pipiens* and two (2) *Cx. tritaeniorhynchus*. Eight (8) phlebotomine sand flies were

collected in the light traps and ten (10) were recovered from the sticky traps, and five (5) *Culicoides* spp. were collected in light traps. Sand flies collected in the light traps were cryo-preserved, dissected and screened for leishmanial promastigotes, and found to be negative.

Shihan, Oman (near Yemeni refugee camp)(11AUG94): Shihan is a village of approximately 2000 semi-permanent residents located in extreme southern Oman, approximately 350 km from Salalah. Venous blood was collected form 36 residents of the refugee camp. Blood samples consisted of 5-10 ml in red-top tubes (no anticoagulant) and an additional 1-2 ml was taken in a purple-top (EDTA) tube. The village was visually evaluated for probable arthropod and rodent breeding and nesting sites. It should be noted that strong winds (ca. 15-20 mph) blew consistently throughout our stay in Shihan. Local health officials informed us that mosquitoes did not occur in appreciable numbers in the area, but sand flies did pose a much more significant problem to the residents. Eight (8) CDC light traps were positioned to collect sand flies, and six (6) light traps were configured for mosquito collection (three of which were baited with dry ice). Twenty (20) oiled-paper sticky traps were located throughout the village in areas near likely sand fly breeding sites. Six (6) rodent traps were positioned near likely rodent nesting sites. There were no mosquito, sand fly or rodent specimens recovered from the respective traps.

Thumrait, Oman (12AUG94): Thumrait is located approximately 65 km north-northwest of Salalah, with a population of ca. 2500 permanent residents. Blood samples (5-10 ml) were collected in red-top tubes (no anticoagulant) and an additional 1-2 ml was taken in a purple-top (EDTA) tubes. It is situated in an open, flat desert plain, and is characterized by year-round constant gusty high winds of 15 - 20 mph. The local Sanitary Officer informed us that there were virtually no mosquitoes and only very low numbers of sand flies occurring within the village during any time of the year, and none at the present time. Twelve (12) CDC light traps, four (4) were baited with dry ice, to survey for mosquitoes. All traps were placed within residential gardens, or within close proximity to houses. Trap recovery included three house flies and two moths, but no mosquitoes or other anthropophilic specimens.

TRIP 2 - Central-Coastal Region (19-30 August 1994).

A request for assistance from the Force Surgeon, COMNAVCENTCOM, was received at NAVMEDRSCHU THREE on 13 September, 1994. Personnel and equipment support to conduct an entomological and serological survey for arthropod-vectored infectious diseases occurring in and around a population of Omani Bedouins during a Medical/Dental Civilian Action Program (MED/DEN-CAP) was requested. More specifically, an assessment of the potential occurrence of chloroquine-resistant malaria,

cutaneous and visceral leishmaniases, miscellaneous arboviruses, and the respective mosquito, sand fly and tick vectors of these diseases was to be conducted. Additionally, through serological survey of the indigenous population, a determination of the overall infectious and/or arthropod-borne disease exposure history within the central coastal region of Oman could be made. The MED/DEN-CAP was conducted in conjunction with a joint military amphibious assault exercise between U.S. and Omani military forces, code named Operation SEA SOLDIER IX. The military exercise, and simultaneous MED/DEN-CAP, were conducted on the eastern shore of central Oman approximately 100 km south-southwest of the city of Duqm; approximate latitude and longitude of 19°00'00"N, 57°00'00"E (± 30'00") (**Figure 3 & 4.**).

The coastal region of eastern-central Oman is characterized by low volcanic foothills, strips of sandy areas, and numerous broad, flat terraces cut by shallow wadis (gulleys). This region has very sparsely scattered oases, extremely limited vegetation, and is the least populated area of Oman (considered to be virtually uninhabited). Nomadic herdsmen live/wander throughout this region, grazing herds of camels, sheep and goats on the sparse vegetation. Average annual rainfall is only 30mm, normally falling during March, April and May. Relative humidity ranges from 23-50%, and average daily maximum temperatures vary from 25°C in January to 45°C in June.

The threat of snakebite from a venomous species during the

operation was considered to be relatively high due to the location of deployment site(s) and the activities in which personnel were involved (i.e., simulated combat situations both day and night). A request for information on, and antivenom for the various venomous snakes (particularly sea snakes) in the area of the operations was made by the CATF-Surgeon (CDR Betson, MC, USN) on 19 September, 1994. The primary venomous snakes known to be a threat in Oman include five terrestrial species, and one sea snake species that occurs in the Suqrah Bay region of the Arabian Sea[8] (**Figure 3**). Polyvalent snake antivenom was acquired from the Egyptian Serum and Vaccine Institute (Cairo, Egypt) and provided to the CATF-Surgeon. More specific information on the venomous snakes of this region are provided in **APPENDIX II.** Additionally, numerous highly toxic species of scorpions reportedly occur in this area of southwest Asia.[9] (Note: Special attention should be given to educating the troops on proper measures to avoid contact with any venomous animals.)

A team composed of an Entomologist and a Microbiologist departed NAVMEDRSCHU THREE on 19 September 1994, and reported to Force Surgeon's Office, USNAVCENTCOM, Bahrain. Following inbriefings, 782-gear issue, and deployment preparations, the team travelled via military aircraft to eastern-central Oman (**Figure 4**), and reported to OIC, MED/DEN-CAP on 21 September 1994, to begin individual specific duties consistent with deployment objectives. Specific entomological and

microbiological objectives for NAMRU-3's involvement in this operation, included: 1) Conduct intensive arthropod survey of wadis, oases and villages in and around the area of operations to determine presence, identity and abundance of potential arthropod vectors of human disease; 2) Evaluate the presence and identity of mammalian reservoirs of arthropod-borne diseases in and around the area of operations; 3) Interview the indigenous population to ascertain information on the occurrence and prevalence of arthropod-borne diseases and vectors in and around the area of operations; 4) Obtain specific medical history information, via written questionnaire, regarding the incidence, prevalence and identity of infectious diseases occurring in the indigenous Bedouin population treated at the MED/DEN-CAP site; and to 5) Collect blood (for serum) from indigenous population, in conjunction with routine MED/DEN-CAP examination and treatment procedures. Serum to be processed and screened for presence and/or antibodies to specific infectious diseases.

ARTHROPOD-BORNE DISEASE VECTOR SURVEY

Arthropod surveillance procedures included the use of CDC mosquito light traps, landing/biting counts for mosquitoes and sandflies timed exposures, and manual collection of free-living ticks. Locations at which arthropod collection procedures were performed are shown as **SITE 1**, **2**, and **3** on **Figure 4**. Collection site descriptions, and survey results at each location are as follows:

a. **SITE 1** - MED/DEN-CAP site, situated at 18°50'30"N, 57°00'30"E, approximately 4.8 km from the beach. Extremely flat, sand/gravel soil with no vegetation within 0.5 km of site. No rodent burrows or indications of animals using area, excluding domestic goats ranging through area. Shallow well and open water tank located approximately halfway between site and beach, no vegetation at well, but four ticks were collected from water tank on 24 September. Eighty-eight *Hyalomma* spp. ticks were collected from underneath and around acacia trees located approximately 5-10 km northeast of SITE 1, on 25 September. Light traps were operated within the MED/DEN-CAP camp proper during the night of 25 September, but no hematophagous arthropods were collected.

b. **SITE 2** - Shallow water well site, situated at 19°00'28"N, 57°31'52"E, approximately 50 km east-northeast of MED/DEN-CAP site. Numerous palm and acacia trees, scattered bushes, and clumps of dried grass, located on the edge of Wadi Salit. Two open water tanks fed by shallow well. Area around water tanks very heavily frequented by camels, donkeys, goats, and wildlife, as indicated by the large number of hoof prints and feces observed. Numerous large animal wallows (bedding sites) and rodent burrows located under and around trees and bushes. Light traps were operated at this site throughout the night of 23 September, yielding four *Culicoides* specimens. A total of 43 *Hyalomma* spp. ticks was collected from underneath and around palm and acacia trees at this site during the evening of 23 September,

and the early morning of 24 September.

c. **SITE 3** - Beach Support Area (BSA) located approximately 10 km west-southwest of MED/DEN-CAP site, and situated between Wadi Runit and Wadi Nakhalil. Typical sandy beach, with some scattered scrub-brush on sand dunes. Light traps were operated throughout the night of 26 September, but no hematophagous arthropods were captured; and 70 *Hyalomma* spp. ticks were collected from underneath and around acacia trees within Wadi Nakhalil during the evening of 26 September.

Rodent burrows and large animal wallows were noted underneath virtually every acacia tree examined, and where the wallows were observed, ticks were present and collected. Free-living ticks were collected from the area around acacia trees by approaching the tree from upwind, stomping the ground, and waiting for the ticks to come charging towards the bait (i.e., the collector). The CO_2 and ground vibration apparently stimulated the ticks to leave their resting site underneath the trees, and seek-out the potential blood meal. Ticks were easily collected manually during morning and late afternoon hours using this method.

VIRUS ISOLATION

Ticks collected during surveillance operations were processed for *in vitro* virus isolation attemps at NAVMEDRSCHU THREE. All ticks were processed for virus isolation, inoculated into suckling mice, and vero and BHK cell cultures. No viruses

were isolated.

BLOOD COLLECTION/SERA-SURVEY

During the period 22-25 September 1994, the MED/DEN-CAP provided treatment to 511 Omani Bedouins. All patients completed a medical questionnaire prior to treatment. Thirty-six of these patients (males; 11-68 years old) voluntarily enrolled in a serosurvey after signing an informed consent. The majority of these patients presented with gastroenteritis, lower back pain or skin rashes. An Omani military physician was present to explain the purpose of the serosurvey to all volunteers. Blood (5-10 ml) was collected via standard venipuncture (Vacutainer®) in sterile red top, nonadditive, silicone-coated blood collection tubes. Equipment to prepare and store the serum was not available at the MED/DEN-CAP field site, therefore the blood was transported to the USS Tripoli by medical/dental team personnel rotating between the site and the ship. Aboard the ship the blood was stored at 4°C. Upon completion of the operation, the blood samples were placed on cold packs and transported to NAVMEDRSCHU THREE. Serum was separated by centrifugation and frozen at -20°C. Serum antibody assays against Sandfly fever viruses, West Nile virus and Boutonneuse fever (*R. conorii*) are currently being performed at NAMRU-3 and the results will be included as an addendum to this report.

DISCUSSION:

The results of the surveillance operations conducted at the three distinctly different locations within southern Oman were consistent with the findings reported by Drs. Parvez and Kumar.[3,4] Low numbers of mosquitoes and sand flies were recovered from the Sea Bee encampment in Salalah (< 8/trap); most probably attributable to the wet, cool weather conditions during the operation. All mosquito specimens recovered were *Culex* species. Light showers occurred throughout the night, and temperatures were in the low 80's (Fahrenheit). Survey operations at both Shihan and Thumrait were significantly impeded by the high winds which blew throughout our visit, as well as by the seasonal climatic conditions (very hot and dry). Local personnel at both Shihan and Thumrait reported that mosquito populations are not a problem at these desert locations, however sand flies were reportedly abundant in Shihan during spring and early summer months. Additionally, Dr. Imadud Din informed us that all leishmaniasis cases reported from Shihan were imported cases from Yemen. Information provided in Enclosure (1) suggests that the total number of malaria cases reported in Oman is on the rise (1992 = 15 cases, 1993 = 19 cases, and 1994 (through July) = 22 cases), with a significant percentage increase in cases occurring in Omanis (1993 = 27% of cases in Omanis, 1993 = 74% of cases in Omanis, and 1994 = 64% of cases in Omanis), and all cases are believed to be imported.

Information gained during the infectious disease and arthropod vector surveys conducted during the Sea Soldier IX will be very valuable in planning preventive medicine support for potential future visits to the area. Even though various obstacles occurred that somewhat hindered, or limited the scale/scope of the surveillance efforts, significant information was gained on the potential disease threat in eastern-central Oman. The mis-coordination of the shipment, and ultimate non-arrival of critical gear and equipment for vector surveillance efforts prevented large-area trapping operations. However, back-up light trap units were operated and the results indicated that mosquito and sand fly populations were minimal in the area. The lack of equipment to properly process and store blood samples may have limited the success of pathogen isolation attempts, but did not hinder antibody detection procedures.

POTENTIAL ARTHROPOD VECTORS OF DISEASE

The relative threat of arthropod-borne infectious disease(s) to beach-deployed personnel during Operation Sea Soldier IX was minimal. Various factors contributed to this including; season, anthropophilic arthropod population occurrence, density and behavior, and most significantly, the preventive medicine strategies incorporated into bivouac/operation site location selection.

A total of 201 adult, free-living ticks was collected during the surveillance operations, including approximately 157 *H.*

dromedarii Koch, 13 *H. impeltatum* Schulze & Schlottke, and 31 *Hyalomma marginatum turanicum* Pomerantsev. The collection of numerous ixodid ticks in the exercise area (**Figure 4**) was directly related to the occurrence of domesticated livestock and wildlife in those areas. Small herds (10-15 individuals) of Arabian Oryx (*Oryx* sp.), and groups of camels, goats, and donkeys were observed on numerous occasions during the deployment. Additionally, foxes and sign of foxes (feces and tracks) were observed at both **Site 1** and **Site 2**. All *Hyalomma* spp. ticks were collected from under and/or immediately around sparsely-scattered desert trees of the genus *Acacia*, and date palm trees (Family: Palmaceae) located near water well sites within some wadis. Vegetative density and diversity was limited to approximately 3-4 trees per acre within the wadis (dry water-ways), with no trees or other vegetation occurring outside these areas. The occurrence and density of *Hyalomma* spp. tick populations at every tree examined was not unexpected, in that under every tree examined was evidence of large mammal "bedding/resting" (i.e., wallowed soil, feces, and tracks). Also numerous rodent burrows were observed under most of the trees, or within very close proximity to the trees.

Anthropophilic arthropods, other than ticks, occurring within the surveillance areas and collected during the operations were minimal. Four *Culicoides* sp. specimens were collected using CDC-light traps operated in or near *Acacia* sp. and date palm

trees, during a total of 14 trap-nights of surveillance. Omanis living near the surveillance sites were questioned regarding the occurrence and abundance of mosquitoes and/or sand flies in the area. All individuals questioned indicated that mosquitoes and sand flies did not occur to any significant degree in these areas, but that ticks were plentiful and were the major "pest/vector" species commonly encountered (second only to filth flies).

VENOMOUS ANIMALS

To our knowledge, venomous animal stings and/or bites to deployed personnel did not occur. One scorpion specimen was collected at the MED/DEN-CAP site on 25 September 1994. The scorpion was identified to be in the genus *Compsobuthus* (Scorpiones:Buthidae), but species could not be determined. Additional surveillance and collection of scorpions was not possible during this operation due to the lack of proper equipment (i.e., black light for night-searches).

RESULTANT RECOMMENDATIONS: Despite the low incidence of indigenous malaria (both *Plasmodium falciparum* and *P. vivax*), and cutaneous and visceral leishmaniasis within southern Oman, the constant possibility of imported disease argues that strict malaria chemoprophylaxis and arthropod personal protective measures (repellents and bed-nets) should be practiced by personnel deployed into this region. Vector surveillance and

control teams should be included in deployment advance teams, and should be utilized in a preventive role for any operations.

During the surveys conducted with Sea Soldier IX it was noted that many of the ground recon-forces deployed into the area were infested with excessive numbers of ticks after resting or sleeping under the only available shade/cover, the acacia trees. Particularly in this type of habitat, troops should be educated on the high probability of encountering undesirable animals inhabiting such areas. Since the trees are the only shade or cover available, they are most likely to be inhabited by a wide variety of wild animals. Rodents will seek shelter and food in such places, with ticks and fleas occurring in conjunction with the rodents. Snakes will likely visit such sites to feed on the rodents. Scorpions and various other vermin will also seek-out such a place to reside.

Excellent education of the troops prior to the operation on the proper preventive strategies against arthropod pests and vectors of disease (i.e., bednets, repellent, sanitation, and hygiene) was evident throughout this exercise. Air transportation support, particularly the services provided by Patrol Squadron 17, was outstanding and deserves special recognition for the extra efforts performed in attempting to deliver gear and equipment. Additionally, support provided by the Force Surgeon's office, USNAVCENTCOM, and the CATF-Surgeon, USS Tripoli, was of significant value to the successful

completion of the mission.

The most critical elements to the success of any disease or arthropod surveillance operation are effective and efficient logistic coordination and support. The staging and transportation of field equipment and supplies to the area of operation can be most effectively accomplished through early planning, establishment of points of contact at each "leg" of the journey, and continuous follow-up on the status of shipment(s). Particularly for arthropod surveillance efforts, assuming gear and personnel arrive intact at the site, motor vehicle availability (with or without a driver) is essential. Vehicles are necessary to evaluate the terrestrial and vegetation characteristics of the area, locate sites of likely arthropod breeding and/or occurrence, and to transport personnel, gear and specimens to and from the collection site(s) and the field laboratory or bivouacking area. To ensure vehicle and support (i.e., berthing, sustenance, communication) availability, a point of contact attached to the unit or command that will "host" the operation should be established as early in the planning phase as possible. The probable necessary points of contact when supporting US Marine Corps activities (FSSG/MEF, BSSG/MEB, or MSSG/MEU), include the Operations Officer (S-3), the Logistics/Supply Officer (S-4), the Commander Amphibious Task Force (CATF) Surgeon, Beachmaster, and the Air Officer.

Specific recommendations for future infectious disease and

arthropod vector surveillance deployments include:

a. Advance team member travelling with gear/equipment to ensure its arrival; and following arrival, its storage and/or redeployment.

b. Team members should hand-carry "back-up" gear/equipment for replacement of defective items, or in the event that primary shipment does not arrive.

c. Establishment of points of contact, and means of communication with support elements to allow for immediate replenishment of critical consumables and/or equipment.

d. Establishment of source for dry-ice and/or liquid nitrogen for use as an arthropod attractant (in the case of dry-ice), and for the processing of specimens.

More detailed information on the incidence and prevalence of arthropod-borne infectious diseases in this region of southwest Asia should be obtained. More specifically, seasonal and spatial biological studies of anthropophilic arthropods should be conducted. This information would be of significant value to planners, either contingency or training-related, when preparing for deployments into this area of the world.

Results of these surveys suggest excellent potential for future sand fly/leishmaniases (visceral and cutaneous) studies exist in Oman. Pertinent points of contact at U.S. NAVCENTCOM and in Oman are provided in **Appendix III**. Critical elements involved in executing intensive surveillance operations in this

region of Oman will be cold-chain maintenance and the significant expenses of transportation of personnel and equipment.

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Figure 1. Sultanate of Oman.

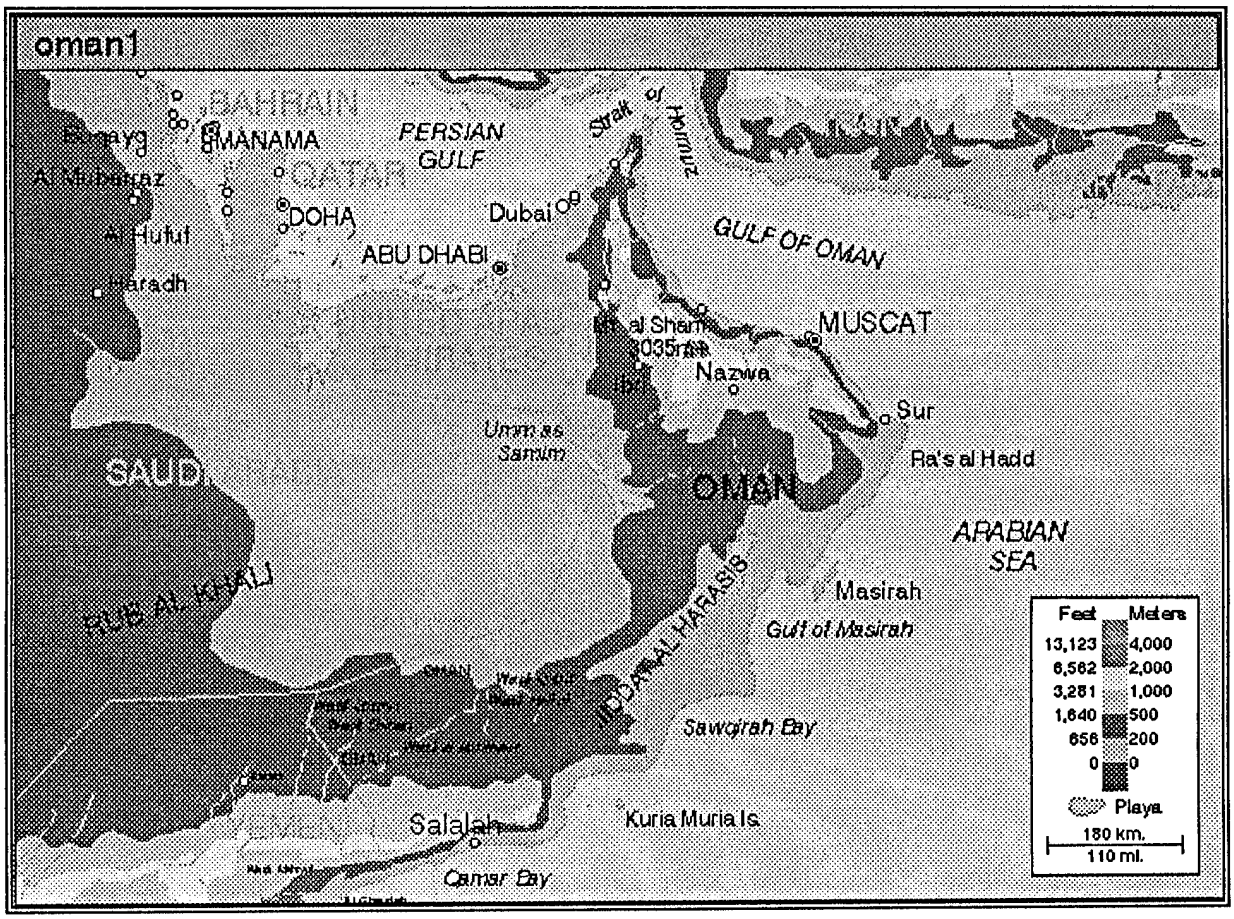

Figure 2. Southern region surveyed during period 06-16 August, 1994.

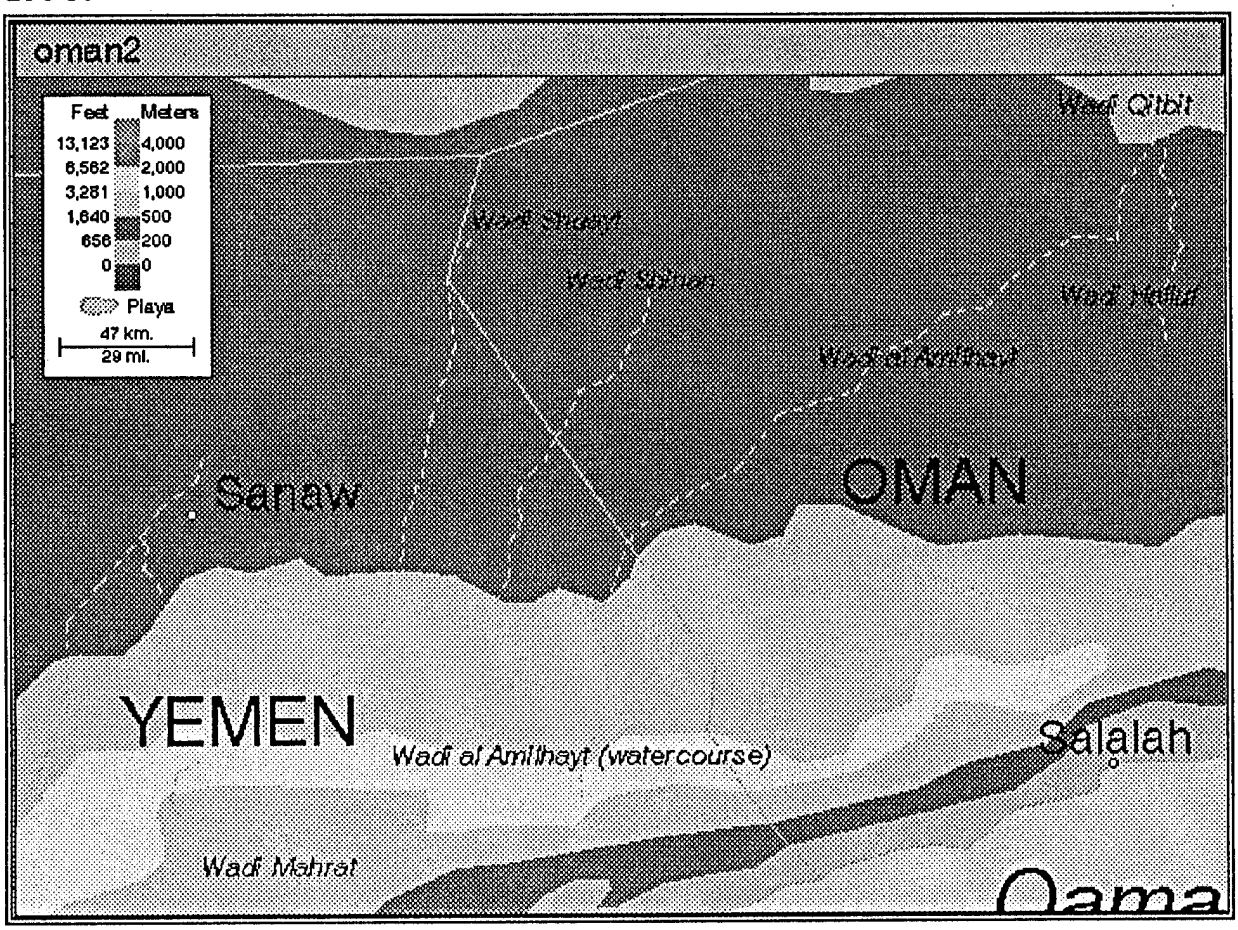

Figure 3. Central coastal region surveyed during period 16-26 September, 1994.

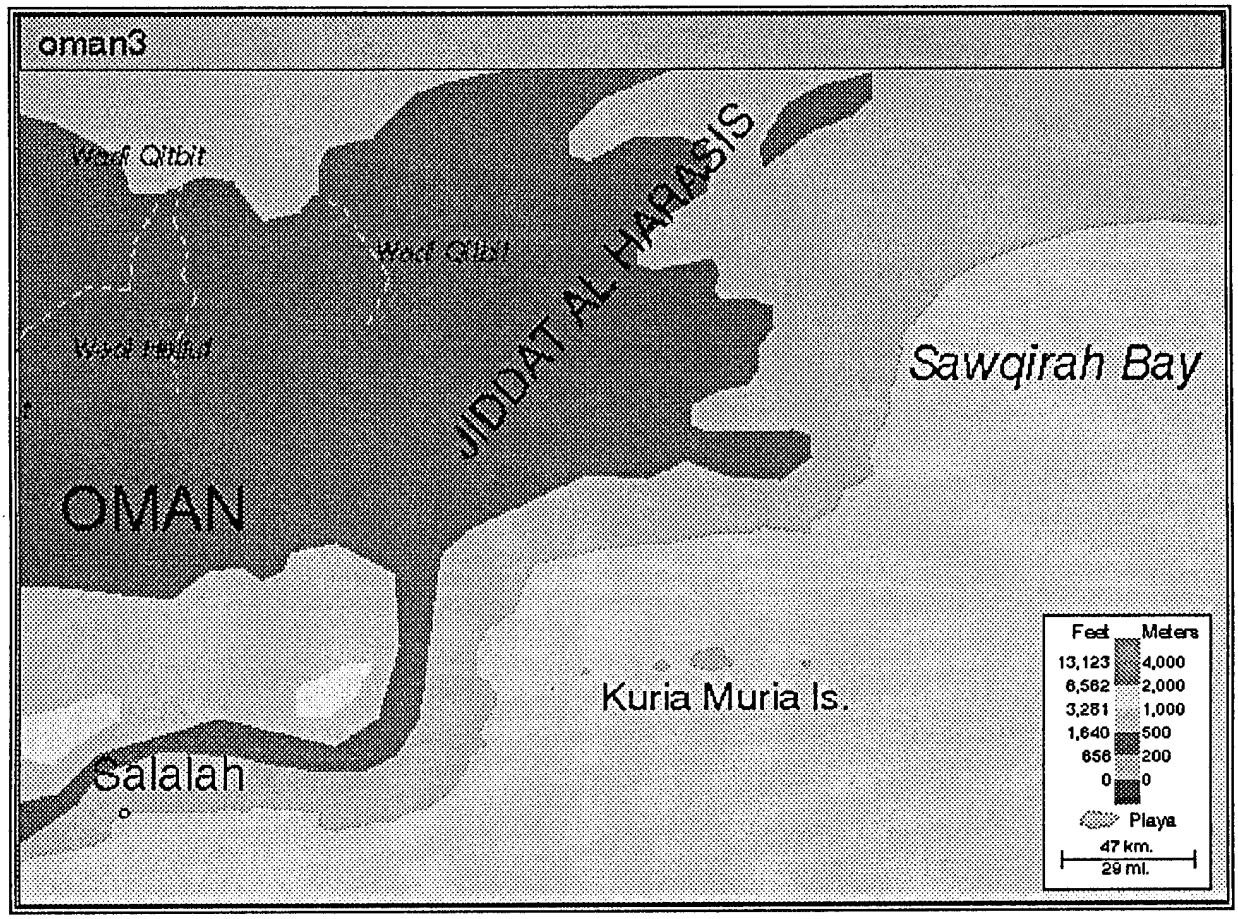

Figure 4. **ARTHROPOD-BORNE DISEASE SURVEILLANCE SITES DURING SEA SOLDIER IX.**

APPENDIX I

PERTINENT DEMOGRAPHIC AND SOCIAL INFORMATION

(Compiled from information available in *PC Globe Maps 'n' Facts*)

Table 1. **Significant population centers within the Sultanate of Oman, 1992.**

CITY	POPULATION	LATITUDE	LONGITUDE
Muscat	50,000	23.37N	58.38E
Matrah	17,000	23.37N	58.34E
Salalah	10,000	17.00N	54.04E
Nazwa	10,000	22.56N	57.33E

Table 2. **Population trends and age distribution.**

Population: 1,588,000 (**Population density:**18.70/sq.mi)
Annual growth rate: 3.5% (**Doubling time:** 23 years)
Urbanization: 9.0% (**Net migration:** 0/1000)

1980	984,000
1991	1,534,000
1992	1,588,000
2000	2,093,000
2010	2,951,000

MALES	AGE	FEMALES
Population: 836,876		**Population:** 751,124
Life expectancy: 65 years		**Life expectancy:** 68 years
0.9%	> 69	0.8%
1.2%	60-69	1.1%
3.1%	50-59	2.8%
4.7%	40-49	4.2%
6.3%	30-39	5.7%
8.7%	20-29	7.8%
12.2%	10-19	10.8%
15.6%	0-9	13.9%

Table 3. **Ethnic, linguistic and religious diversity of Omani population.**

	% of population
ETHNIC GROUPS	
Arab, Omani	77
Indian	15
Pakistani	4
Bengali	2
Other	2
LANGUAGES	
Arabic	68
Baluchi	19
Mehri	6
Farsi	3
Urdu	2
Swahili	2
RELIGIONS	
Muslim (Ibadhi)	75
Muslim, other	20
Other	5

** Nationality: *noun*--**Omani(s)**; *adjective*--**Omani**

Table 4. **Mortality and public health services data.**

Crude death rate:	6/1000 annually
Infant mortality:	40/1000 live births
Fertility rate:	7.0 children/woman
Hospitals:	174 (8,816 prsns/hospital)
Hospital beds:	4,016 (382 prsns/hospital bed)
Physicians:	1,243 (1,234 prsns/physician)
Dentists:	83 (18,482 prsns/dentist)
Pharmacists:	227 (6,758 prsns/pharmacist)
Nursing personnel:	3,497 (439 prsns/nurse)
Midwifery personnel:	33 (46,485 prsns/midwife)
Medical care expenditures:	5.1% of national budget
Access to local health care:	92.0% with access
Contraception use:	N/A of married women
Measles immunization:	46.5% infants (< 12 months)
AIDS cases reported:	1.70/100,000persons

N/A means unavailable

Table 5. **Agricultural commodity production estimates.**

AGRICULTURAL PRODUCTS	QUANTITY (metric tons)
Eggs (1989)	2,000
Meat (1988)	11,000
Milk (1989)	18,000
Potatoes (1989)	1,000
Tobacco (1989)	2,000
Wheat (1989)	1,000
Land in agriculture: 0.2%	
Total agricultural workers: 108,800	
Percent of work force in agriculture: 23.3%	

Table 6. **Annual Gross National Product (GNP).**

Gross National Product (GNP) (millions of $US)	
1989	7,756
1990	8,663
1991	9,677
GNP per capita ($US):	6,308
Annual growth:	11.7%
% for defense:	23.3%
GNP Sources:	
Agriculture	4.0%
Industry	57.0%
Services	39.0%

Table 7. **Status of education in the Sultanate of Oman, 1990.**

Level	Schools	Teachers	Students	Students/teacher
Elementary	671	12,344	304,207	24.6
Secondary	153	2,947	42,213	14.3
Third level	5	482	3,925	8.1
GNP for education:		4.0%	**Literacy rate:**	41.0%

Table 8. **Energy production and consumption estimates for the Sultanate of Oman.**

NATURAL GAS	(cubic meters)
Reserves (1990)	283,000,000,000
Production (1989)	2,790,000,000
Consumption (1988)	2,255,000,000
Consumption per capita	1,420
CRUDE PETROLEUM	**(barrels)**
Reserves (1990)	4,291,000,000
Production (1989)	226,000,000
Consumption (1988)	20,000,000
Consumption per capita	12.59

Pertinent traveller information.

Language: Arabic (official language) and Baluchi.
***Visa:** Required (Not granted to holders of passports with Israeli or Libyan visas).
Business visa: Usually valid three months, applicant must have local sponsor.
Climate: Hot, humid. Summer monsoon in Dhofar province (Summer clothing recommended year-round. Sweaters sometimes necessary in the evening. Conservative dress recommended).
Currency: Oman rial (0.39 = $1US).
Holidays:
- National Day (National Holiday), Nov. 18
- Birthday of the Sultan, Nov. 19
- End of Ramadan, variable
- Islamic New Year, variable
- Birth of the Prophet, variable

Health: Yellow fever vaccination may be required. Malaria suppressants, polio, hepatitis, and typhoid fever shots recommended. Tapwater unsafe.
Electric current: 240/415 volts; 50 cycles

NOTE: Visa and health requirements are subject to change. Please consult your travel agent or local consulate.

OFFICIAL POINT OF CONTACT:

Embassy of the United States of America
P.O. Box 50202, Medinat Qaboos
tel. 698989, telex 3785, fax 699771

APPENDIX II

VENOMOUS SNAKES OF CONCERN TO OPERATION SEA SOLDIER IX

Bitis arietans (Puff adder) - The venom of this species is very toxic, demonstrating anticoagulant activity and procoagulant properties via platelet aggregation. Venom yield is high, with fangs exceptionally long (12-18cm). Although not all bites result in envenomation, a bite by this species is serious, requiring immediate medical attention. Various polyvalent antivenoms available, including "Antirept Pasteur", "*Bitis-Echis-Naja*", and "Pasteur Isper Afrique" from Institut Pasteur Production, 3 Boulevard Raymond-Poincare, 92430-Marnes la Coquette, France, telephone:(1)47-41-79-22, Telex:PASTVAC206464F.

Cerastes cerastes (Horned asp, desert horned viper, horned sand viper, Sahara desert viper, sidewinder horned viper) - Most frequent cause of snakebite in Arabian peninsula, but venom is the least toxic (LD_{50} in Humans is 210.0 mg/kgx70). Bites common because frequency of encounter is high. Venom is hemorrhagic, affecting coagulation. Polyvalent antivenom, "Antirept Pasteur" (Institut Pasteur Production), effective.

Echis pyramidium (Egyptian saw-scale) - Venom is complex highly hemotoxic, demonstrating procoagulant, anticoagulant, defibrinolytic, and proteolytic activity (LD_{50} in Humans is 131.25 mg/kgx76). Species involved in many snakebite incidents and fatalities. Considered to be world's most dangerous snake because of venom toxicity, its abundance near cultivated areas, and its aggressive, easily excitable temperament. Antivenoms apparently effective only if prepared from venoms of same geographic taxonomic group. Numerous polyvalent antivenoms available, including "Antirept Pasteur", "*Bitis-Echis-Naja*", "Near and Middle East", and "Pasteur Isper Afrique" from Institut Pasteur Production.

Pseudocerastes persicus (Eye-horned viper, Persian desert horned viper, false horned viper, Persian horned viper, Field's horned viper, shepipon (Hebrew)) - Venom characterized as moderate to highly hemorrhagic, causing localized, followed by systemic, symptoms. Local symptoms include local pain, hematoma, and in severe cases extreme swelling and ecchymosis. Antivenom availability somewhat limited, but polyspecific Persica antivenom is available through Institut d'Etat des Serums et Vaccins Razi, P.O. Box 656, Tehran, Iran.

Naja haje (Arabian cobra) - This species has extremely long fangs, large venom glands, and is considered to be highly toxic (LD_{50} in Humans is 131.25 mg/kgx76). Large amounts of venom

may be injected in a single envenomation. A lethal envenomation by *N. haje arabicus* can kill within five hours, or as short as 15 minutes if venom injected directly into a vein. The venom primarily shuts-down the respiratory system due to its neurotoxic activity, as well as stopping the heart due to its cardiotoxic activity. Antivenoms available include "Antirept Pasteur", "*Bitis-Echis-Naja*", "Near and Middle East", and "Pasteur Ipser Afrique" from Institut Pasteur Production.

Pelamis platurus (Black and yellow sea snake, yellow-bellied sea snake, pelagic sea snake) - The most wide-ranging, most frequently encountered sea snake with highly toxic venom. Although risk of serious envenomation by this snake is higher than many other sea snakes, few, if any, deaths have been attributed to it. Specific antivenom is not available for this species. It should be noted that sea snake bites cause very minimal or no pain; any pain that is felt is like a slight pin-prick, usually with no subsequent pain, swelling, necrosis, or skin discoloration at the bite site. Therefore symptoms must be carefully monitored to determine if envenomation has occurred.

Further information regarding poisonous snakes in this region, and antivenom type and availability, can be obtained through the Armed Forces Medical Intelligence Center publication entitled **"Venomous Snakes of the Middle East"** (DST-1810S-469-91); or contact the Director, Armed Forces Medical Intelligence Center, Building 1607, Fort Detrick, Frederick, MD 21702-5004.

APPENDIX III

PERTINENT POINTS OF CONTACT

The following personnel were contacted and provided significant contributions to the successful completion of these missions.

1. CDR Betson, MC, USN, CATF-Surgeon, USS Tripoli
2. CAPT Bryce, MC, USN, Force Surgeon, USNAVCENTCOM, Bahrain, telephone: 00973-724-558
3. SSG S. E. Ellison, Special Forces Group (A), Ft. Campbell, KY
4. LtCol Finley, USMC, MEU S-3 (Operations Officer), 1ST FSSG
5. LT Nancy Franze, Medical Operations Officer, USNAVCENTCOM, Bahrain, telephone: 00973-724-033, FAX: 00973-724-556
6. Maj Gander, USMC, MEU S-4 (Logistics Officer), MSSG-15
7. LCDR Gasparovich, USN, OIC, Patrol Squadron 17, Masirah, Oman
8. Dr. Imadud Din, Medical Officer in Charge of Yemeni refugee camp (he is located at the clinic in Thumrait, Oman), telephone: 00968-279-177
9. HMC King, USN, Force Surgeons Office, USNAVCENTCOM, Bahrain
10. LtCol Koen, USMC, Landing Force Operations Officer (LFOO), USNAVCENTCOM
11. Mr. Magdy-Abd Ellazim, Sanitary Inspector, Thumrait, Oman, telephone: 00968-279-177
12. Dr. Mahmoud Shaaban, Health Superintendent, Dhofar Region, Salalah, Oman, telephone: 00968-210-130
13. Maj Minor, USMC, MEU Air Officer, 1ST FSSG
14. Maj Mitch Cook, USMC, Naval Attache and Naval Attache for Air, American Embassy, Muscat, Oman (tele:009-68-699-428)
15. Mr. Mohamed Salim, Epidemiologist for refugee camp, Shihan, Oman
16. LT Stewart Murdock, MSC, USN, OIC, MED/DEN-CAP, MSSG-15/1ST FSSG
17. 1stLt Shane Nicklaus, USMC, XO, MED/DEN-CAP, MSSG-15/1ST FSSG
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19. HM2 Ruth, USN, Force Surgeons Office, USNAVCENTCOM, Bahrain
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13. ABSTRACT *(Maximum 200 words)*

During the summer of 1994, NAVMEDRSCHU THREE received requests from the office of the Force Surgeon, U.S. Naval Forces Central Command, Bahrain, to provide assistance in conducting arthropod-borne disease risk assessments in two separate regions of Oman. On two separate trips, NAVMEDRSCHU THREE personnel and field surveillance equipment were deployed to Oman in response to the requests. The first survey was conducted during the period 06-16 August, 1994, and was primarily focused on assessing the threat of chloroquine resistant *Plasmodium falciparum* malaria in the extreme southern-border area of the country. The second surveillance deployment was from 19-30 September, 1994, into the central-coastal region in conjunction with an amphibious landing exercise code named SEA SOLDIER IX. The major objective of the second trip was to conduct general endemic disease prevalence and threat assessment, including all fly-borne, flea-borne and/or tick-borne diseases. During both of the deployments, blood samples were collected from indigenous personnel for screening, and intensive arthropod collection and screening operations were conducted. Although minimal information was procured on the occurrence and relative threat of arthropod-borne diseases in these two areas of Oman, very valuable liaison with Omani health authorities was established and useful information on the country was obtained.

14. SUBJECT TERMS
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