

VECTORS AND WAR - "DESERT STORM"

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The awesome technological marvels of laser-guided munitions and rocketry riveted everyone's attention during the recent Persian Gulf War. Yet, an aspect of the war that received comparatively little media attention was the constant battle waged against potential disease vectors by preventive medicine personnel from the coalition forces. The extraordinarily small number of casualties suffered in combat was no less remarkable than the low numbers of casualties due to vector-borne disease. Both statistics reflect an appreciation of thorough planning and the proper allocation of massive resources in accomplishing a mission against a well-equipped foe. A great many personnel were involved in the vector control effort from all of the uniformed services. This paper will address some of the unique vector control issues experienced before, during, and after the hostilities by the First Marine Expeditionary Force (1st MEF), a contingent of 45,000 Marines headquartered at Al Jubail, a Saudi port 140 miles south of Kuwait. Elements of the 1st MEF arrived on Saudi soil in mid-August, 1991. The 1st MEF was given the initial task of guarding the coastal road system in the Eastern Province, to prevent hostile forces from capturing the major Saudi ports and airfields located there. Combat units of the 1st Marine Division were involved in the Battle of Khafji, prior to the main campaign. In addition, 1st MEF comprised the primary force breaching the Iraqi defenses in southern Kuwait, culminating in the tank battle at the International Airport.

THE VECTOR-BORNE DISEASE THREAT

The vector control problems encountered during the five months preceding the war were far worse than those during the actual fighting. The massive buildup of personnel and equipment prior to hostilities simply overwhelmed the Saudi infrastructure. Provision of the proper storage and transportation of foodstuffs for a force of 500,000 was simply beyond their capability. This in turn produced some massive waste disposal problems. More importantly, the need to conceal the actual whereabouts of large aggregations of troops and materiel at least initially ruled out burning of the waste. Disposal by burial was difficult due to the sandy substrate and some very real religious considerations about defilement of holy soil. The situation was further complicated by the ubiquity of chemical warfare sensors specifically designed to detect organophosphate (O-P) chemicals. Thus, large-scale ULV spraying of malathion was out of the question. Notwithstanding our massive intelligence resources, we simply did not know the extent of vector-borne diseases in the area the 1st MEF was to occupy. Extensive literature searches and contacts with Saudi and World Health Organization health officials revealed large gaps in the epidemiological picture - particularly involving the risks to an immunologically-naive foreign contingent. We therefore felt it prudent to proceed as if the diseases reputed to be historically present were currently active.

Of primary concern to vector control personnel were filth flies. The disruption to established public health and sanitary services throughout the area of operations was bound to create extensive fly breeding and the potential for filth-borne disease. Trachoma was a minor source of concern due to its ubiquity in the Middle East.

Phlebotomine sand flies were another priority target because of their vectoring of cutaneous and visceral leishmaniasis in addition to Sand Fly Fever. Sand Fly Fever, in particular, had caused a great deal of morbidity to Allied Forces in the Middle East during World War Two. Its potential for explosive outbreaks caused a great deal of concern among medical planners. The disfiguring scars caused by cutaneous leishmaniasis are a common sight among the bedouin on the Arabian Peninsula. Figian units attached to the Multinational Forces and Observers in the Sinai have recently experienced severe episodes of cutaneous leishmaniasis. Rodents and feral mammals constituted a concern due to their roles as reservoirs of these leishmaniasis. Feral animals, particularly dogs, foxes, baboons, and jackals, constituted a further threat of rabies.

Venomous animals, primarily scorpions and snakes, probably generated more concern than any other group to the Marines. The prospect of living in close proximity with exotic species of venomous snakes and scorpions not only distressed the Marines but also the medical personnel charged with treating any bites or stings. The vast majority of health care personnel in theater had no experience with bite/sting treatment modalities. To rectify this, an intensive training program was instituted for both medical and non-medical personnel in the risks and treatment of venomous bites and stings in the Persian Gulf. Actually, with few exceptions, the venomous fauna of Camp Pendleton, California (the 1st MEF home base), is more of a hazard than that of the Persian Gulf. Nevertheless, the psychological threat of unfamiliar species to unit effectiveness was considered real and the training program proceeded accordingly.

Mosquito-borne disease was considered to present a negligible potential threat due to the focality of breeding habitat in the desert. Malaria is found only in the extreme southwestern part of Saudi Arabia and in the northern half of Iraq and Iraq/Iran border. However, a number of competent malaria vectors, including Anopheles stephensi, An. pulcherrimus, An. algeriensis, An. claviger, An. maculipennis, and An. hyrcanus are found on the Arabian peninsula and southern Iraq. Sindbis Virus, a dengue-like illness transmitted by Culex univittatus, is reputedly established in the saltmarshes of northeastern Saudi Arabia where the Marines were located.

The military planners foresaw the need for major sanitation and vector control capabilities prior to deployment of the main force. Accordingly, they front-loaded substantial numbers of preventive medicine personnel and equipment in the deployment scheme. Two Navy medical entomologists and two vector control technicians from the Navy Disease Vector Ecology and Control Center (NDVECC, JAX) in Jacksonville, Florida arrived in Saudi Arabia on 20 August 1990. They were augmented on 27 August by another Navy entomologist from NDVECC JAX. The equipment utilized by these personnel was also provided by NDVECC JAX and consisted of: 1 helicopter spray unit; 4 electric truck-mounted ULV units; 2 gasoline-powered ULV sprayers; 6 handheld electric ULV sprayers; 8 backpack sprayers; 2 hydraulic sprayers; 17 one gallon hand-compressed sprayers; and 3 handheld dusters. In addition, 6 CDC light traps, 10

Sherman Box Traps and 120 snap-traps for rodents were provided. This was in turn augmented by equipment from war stocks prepositioned on ships. These consisted of mostly backpacks and dusters and were used mainly for spare parts. Pesticides were supplied by NDVECC, JAX based upon threat assessments and perceived uses. Emphasis was placed upon residual and barrier emulsifiable concentrates, due to the difficulties inherent in the use of mists and fogs in the desert winds. In addition, methomyl bait formulations and synthetic pyrethroid wetttable powders were provided for fly control around latrines and garbage dumps. Given the uncertain tactical environment and the potential for chemical attack, a great deal of emphasis was placed upon personal protective measures for the avoidance of insect bites. This involved the use of permethrin uniform impregnate in conjunction with an extended duration cream formulation of DEET placed upon exposed areas. Resupply of depleted permethrin and DEET stocks became a continual problem.

The intensity of the security measures governing all aspects of the pre-war buildup cannot be overstated. The threat of terrorist attacks against hastily-constructed battlements in the desert was very real and taken seriously by the Marine security forces. There would most definitely not be another Beirut bombing. Most Marines, up to the highest echelons, had no idea of when or where they were going into combat. Rumors of an impending attack circulated nightly from August through January. The effect was to make it exceedingly dangerous to conduct what would normally be considered routine survey and control operations. It was simply not possible to utilize light traps or landing/biting counts in the survey of mosquitoes or sandflies at the forward areas. Any activity outside established perimeters at night was likely to bring immediate response from hyper-vigilant Marine guards. A few unlucky camels and goats are testimony to this. Warning shots were fired at vector control teams approaching Marine bivouacs on a number of occasions. The coalition forces were also extremely worried about a possible attack using chemical or biological agents. A sighting of piled camel carcasses near the Kuwaiti border by a reconnaissance patrol quite early in the Desert Shield operation prompted immediate fears of the use of biological agents. Death was later determined to be the result of natural causes. Indeed, any inadvertent triggering of O-P chemical sensors by misplaced ULV malathion spray could very nearly have started the war prematurely. At the very least someone might have gotten hurt. This placed a premium upon devising means of abating vector and pest problems through non-chemical means.

CONTROL OPERATIONS

The Desert Shield/Storm deployment posed some unique challenges to effective vector control. Equipment took an incredible beating during constant use in the desert environment. The ubiquitous sand, per se, had little effect on operations. A powdery, talc-like dust found in many locales, however, caused many electrical failures. It penetrated into the most carefully sealed parts and was extremely difficult to remove. This led to some rather innovative wiring schemes for equipment whose electronics had been fouled. Replacement parts were generally not available for most sprayers through local Saudi hardware outlets. Additionally, resupply of sprayer parts from stateside was of an extremely low priority compared to tanks, ammunition, etc. Thorough equipment maintenance was therefore a major priority. Most incountry land

transportation assets that could be used for survey or control operations were designated for other taskings, such as troop and equipment movement. Therefore, acquiring vehicles for spraying, when feasible, took ingenuity on the part of spray teams. Some vehicle acquisitions were of course clandestine, following a time-honored Marine tradition.

Most encampments had problems with flies (primarily *Musca domestica*, *M. sorbens*, and various sarcophagids). Most of these same bivouacs had no discernable breeding areas anywhere near. Flies would start buzzing around your face the moment you alit from a vehicle. Humiture readings of 130-140 degrees were common during August and September, and on 3 occasions readings of above 150 were recorded. Despite these temperatures, flies could be seen flying around the outside of tentage and bothering troops in the heat throughout the day. At night some flies were observed using tent flaps for harborage, but the majority seemed to disappear. To be sure, at 140 degrees, a single fly in a tent seems like several thousand - thus, claims of "hordes of flies" during many phases of the Desert Shield operation are exaggerations. However, as more troops arrived in theater, immense populations of flies attendant to the resultant trash buildup began to cause severe annoyance.

The tactical situation itself also accounted for some fly problems. On one occasion, vector control personnel were called out to assist in abating a serious fly problem at a bivouac occupied by a Marine Light Armored Infantry (LAI) battalion. Upon arriving, they discovered that the unit had billeted among the hatchery buildings of a large chicken farm far out in the desert. Tactical considerations precluded redeployment to a different site. This was one of many occasions in which simple avoidance of an infested area was overruled by the tactical commander due to the dictates of cover and concealment. Chemical spraying was out of the question due to the chickens, and organophosphate sensors. At the time, methomyl fly bait was unavailable, being enroute by ship from stateside. The infestation was finally controlled by deploying seven fly traps among the hatchery buildings. The fly trap design consisted of a 55--gallon drum half, covered with plywood into which a 10 inch diameter hole had been sawn. This was in turn covered by a wire mesh cone inserted into a 16 inch diameter capture cylinder set 1/2 inch above the plywood cover. Chicken offal or standard rations were used as bait.

Dead camels and goats were important sources of flies. A great many camel, sheep and goat carcasses were strewn about the desert. An enormous number of flies could be produced by one camel carcass in an extremely short period of time in the desert heat. This may have been partially caused by a noticeable lack of carrion feeders. Whenever carcasses were discovered they were sprayed with Dursban 4E7 and buried. Bait formulations of 1% methomyl with chemical attractant were extremely effective in controlling populations around privies and tentage, but resupply was erratic, necessitating the use of malathion/sugar bait formulations. These proved marginally effective in some areas. Camel and goat feces did not appear to be extensively used as breeding media by flies due to the widespread dung beetles and the drying effects of the sun. Dung beetles, however, produced some fly problems by boring oblique shafts into otherwise insect-proof pit latrines. These tunnels allowed flies access to breeding substrate. The tunnels were easily treated with wetttable powders.

Flies produced by domestic animals were also responsible for 10 cases of ocular myiasis caused by the Sheep Bot, Oestrus ovis. The victims reported moderate to severe conjunctival discomfort. All cases involved surgical removal of the maggots and the Marines were eventually returned to duty after a short convalescence.

A great deal of life frequented the annual and perennial halophytes and rock outcroppings out in the desert. These outcroppings, in particular, were preferred habitats of scorpions and Desert Horned Vipers (Cerastes cerastes) and were best avoided. Nevertheless, the protection the outcroppings afford made them ideal sites for marine units, whose tactical considerations usually precluded moving to a less well-protected bivouac site. Also found in these outcroppings were rodent burrows. Sticky traps placed in these burrows produced few phlebotomines - mostly Sergentiomyia christophersi and a few S. fallax. Tactical considerations prevented the use of lights, light traps, biting counts, and other standard survey methods during both Desert Shield and Desert Storm. After hostilities ended, surveys began in earnest. Small numbers of Phlebotomus spp. were captured, but the preponderance continued to be non-vector species of Sergentiomyia. Leishmaniasis did not prove to be a problem in the Marine contingents. It is presumed that the terrain occupied by the Marines didn't support the proper vector-reservoir complex required for propagation of the leishmaniasis. United States Army forces, on the other hand, suffered some cases of leishmaniasis, including at least one case of the visceral form. Army forces occupied the central portion of the combat theater during the buildup phase, when the infective bites probably occurred. This included the area surrounding Riyadh, and the oasis at Hofuf, known foci of the disease. Units experiencing leishmaniasis reported seeing "cute little mice with long tails" - probably gerbils or jerboas - running through their encampments at night. These have been incriminated as reservoirs of the cutaneous variety of leishmaniasis. Extensive rodent trapping programs were instituted and the leishmanial cases dropped off during the latter part of Desert Storm. Commensal rodents, while present, did not prove to be a severe problem in 1st MEF areas. A total of 43 rodents (Rattus norvegicus) were trapped among the boulders pierrside at Fleet Hospital Five in Al Jubail. Combings were negative for ectoparasites.

The generally high water table in the Eastern Province results in some large plant aggregations housing many birds, camels, goats, jackals and ticks. Hyalomma marginatum, a potential vector of Congo-Crimean hemorrhagic fever, was quite common in these areas. The Hyalomma stayed in the relatively cool microhabitat about 6 inches under the sand surface and appeared to spontaneously generate from the sand upon sensing footsteps. They are very long-legged for Ixodid ticks and perambulate very quickly across the sand and up pantlegs. Permethrin uniform spray and proper boot blousing afforded the only effective controls. Many Marines and Army personnel had evidently been instructed by their commands to purchase flea collars prior to deploying in the mistaken notion that this would provide protection from ticks and other arthropods in the area. Preventive medicine personnel spent a great deal of time convincing the line troops and their commanders that wearing flea collars around the ankle area was extremely ill-advised. Not only was it ineffective in stopping the fast climbing Hyalomma

ticks, it also contributed to a lowering of cholinesterase levels in a potential chemical warfare environment.

Biting insects produced some habitability problems in the forward areas, but no imminent danger of disease. Many areas in the Eastern Province consist of so-called "sabkhas", low-lying pockets of saline alluvial soil covering a very high water table. Indeed, almost the entire Eastern Province lies atop an enormous subterranean aquifer, said by some authorities to hold as much water as the entire Persian Gulf. Sabkhas, due to the high moisture content of their soil, provide an ideal breeding habitat for Leptoconops spp., mostly L. kertezi. L. kertezi accounted for intense biting activity in areas near these sabkhas. Additionally, a species of planthopper caused some severe cellulitis in unprotected troops stationed in vegetated areas forward. Troops in these areas were provided with extended duration DEET cream and fine-mesh bed netting. The combination appeared to be quite effective in reducing bite incidence.

Mosquitoes posed few problems. In some areas the water table is high enough to create saline pools. Many of these saline pools were crusted over with salt but still produced 10-20 Aedes caspius per dip at their margins. Although a nonvector, Ae. caspius was a vicious biter anywhere within 50 meters of its breeding pools, day or night. Pyrenone Tossits⁷ easily solved the problem in these pools. The winter rainy season might have been expected to result in more pools of this type and some focally intense biting, but no complaints were recorded.

Although malaria, as previously noted, was not anticipated in any areas south of Baghdad, at least eight cases of Plasmodium vivax were reported from Army units having served in the area immediately south of Basra - an area supposedly free from autochthonous malaria. Evidently, Iraqi troops from the northern provinces brought the infection southward with them and began a transmission cycle. Whether malaria is now established in the area is not known. The unit in question was one of only a few Army units that had not been prophylaxed prior to deployment. Marine units were not placed on prophylaxis specifically for the Persian Gulf theater. However, a number of units redeployed from Panama were on a chloroquine/primaquine regimen.

Feral dogs, jackals, foxes, etc. were the source of some bites, primarily in the initial stages of Desert Shield. The first bite (from a baboon) in August revealed that the Desert Shield forces had deployed without Rabies Immune Globulin (RIG). The only RIG in theater was stocked by the U.S. Embassy in Riyadh and arrangements were made for its use until RIG could be purchased elsewhere. Rabies is known to be endemic throughout the Arabian Peninsula, with up to 60% of feral dogs testing positive for the virus in some areas. The failure to stock such a vital commodity was a serious omission, but it underscores the many oversights that can occur in an operation of this size. In peacetime feral animals presenting a threat to forces would most likely be shot. However, unessential gunfire was strictly prohibited and quite dangerous during an incipient combat scenario. As a result, man/animal contact had to be reduced by strict adherence to proper waste disposal. At least one case of severe camel bite was sustained by a Marine. Camel bites are a common occurrence in the Middle East, and can result in severe trauma.

Scorpions were a major issue during the entire the Persian Gulf conflict throughout the theater. Androctonus crassicauda, a large (10cm), blackish-brown species, was the most prevalent species. Little is known about the makeup of its venom, but its close relationship to a potentially dangerous congener, A. australis, suggested due caution. Despite its size and ubiquity, it appeared to be unaggressive, and did not account for any stings. Another buthid, Buthacus yotvatensis nigroaculeatus, was particularly aggressive and was responsible for the majority of stings. Two stings by this species required hospitalization for treatment of systemic envenomation. Marine units reported 2-5 stings/battalion/week. Although, as can be expected, Marines were playing with the scorpions, all stings investigated were deemed legitimate - delivered to the extremities during night operations. Scorpion sting in the Middle East is not considered by most authorities to be potentially fatal to a healthy adult except in unusual circumstances. The vast majority of fatalities occur in infants and the elderly. Therefore, antivenin, although available in the Saudi hospitals, was not stocked. Indeed, the lethal cardiac fraction of Leiurus quinquestriatus, the most dangerous scorpion in the area, is not well neutralized by the antivenin in any event. Only one L. quinquestriatus was captured and no stings by this species were recorded. One other smallish species, Scorpio maurus, was responsible for all other stings.

Solpugids (Camel Spiders, Sun Spiders) were discovered by the Marines early on and provided hours of enjoyment in gladiatorial combat with scorpions - against our stern recommendations. The largest specimen captured possessed a legspan of more than 10 inches. They are not venomous, but their two pairs of huge independently-articulating mandibles are fearsome weapons. They run with a peculiar rapid gait that makes them appear like moving tumbleweeds as they hunt prey. They are singularly vicious predators, attacking and killing creatures much larger than themselves. Solpugids were responsible for at least one bite to the lip of a marine that required 10 stitches.

In Saudi Arabia, especially the Eastern Province where U.S. troops were stationed, the risk of serious snakebite was considered minimal - but there nonetheless. The risk to U.S. Forces in the Central Province was substantially greater due to the nature of the reptilian fauna. There are 54 species and subspecies of reptiles inhabiting the Arabian Peninsula. Of these, 26 species are known to be venomous in varying degrees. All but 3 of these are considered capable of inflicting a fatal bite on an adult human, albeit only in unusual circumstances. Many of the venomous species are relict populations, known from only one or two specimens identified from discrete localities. The most numerous reptiles in Saudi Arabia are diurnal species of rear-fanged colubrids closely allied to the racers and garter snakes of the continental U.S. They differ in that they possess enlarged, grooved teeth toward the rear of the upper mandible. These fangs are, in turn, attached via tubules to a venom gland (Duvernoy's Gland) located posterior to the orbital sinus. The venom of the two most numerous species (Psammophis shokari and Malpolon moilensis) is of low toxicity and produces little more than a transient swelling and pain at the site of the bite. Systemic symptoms were not reported in the two recorded bites from this species. Both species were active and defended themselves vigorously when molested. Malpolon, in particular, spread a hood much like a cobra and struck repeatedly during capture.

Five genera of seriously venomous terrestrial snakes are found in Saudi Arabia. Six species in these genera are known from areas that were occupied by Desert Shield Forces. All are considered potentially dangerous to humans, but nowhere in the kingdom do they fit prominently into morbidity and mortality statistics. The only potentially serious snakebite threat encountered in Desert Shield/Storm involved Cerastes cerastes, the Desert Horned Viper. Two Saudi forms of this small species (20-30 inch) were identified in the area of operations, possessing either 2 extremely short horns composed of 1 scale on top of the head a little forward of the midline of the eyes or two greatly enlarged horns. Cerastes cerastes will bury itself during both daylight and night. This makes them extremely difficult to see, and accounts for bites due to misplaced hands, etc. This viper was responsible for 17 bites in Marines for the operation's duration. Bites were painful, producing swelling, edema, and other hemotoxic effects, but produced no fatalities or prolonged hospitalization.

Conclusion

Navy vector control personnel did an outstanding job of responding to the vector control needs of their constituent Marines. Most of their efforts involved fly control and suppression of focal populations of Leptoconops and Homoptera. In addition, vector control cadre conducted extensive training for medical personnel in the biology and identification of venomous animals of the area. They were also called upon to assist in the training of all levels of medical personnel in the treatment of venomous bites and stings. One of their most effective programs involved intensive training of personal protective measures for the field troops. It is well to note that these vector control programs had to be designed and implemented within some rather severe tactical restraints. This was not an exercise. Many of the elegant survey and control methodologies historically proven to be effective were simply not available. Thus, vector control personnel had to maintain a flexible posture, taking, more or less, what the field commanders would allow in determining a control strategy. Vector-borne disease did not prove to be the cause of significant non-battle injury to the many thousands of troops participating in Desert Shield and Desert Storm because of the untiring efforts of a few select, often unheralded, professionals. Their dedication to maintaining the health of our troops in this most inhospitable of environments is one of the great untold success stories of the Persian Gulf Conflict. We should all be very proud of the excellent job these fine people did over there - I know that I am.