
*Patterns of disease in humans and domestic animals* is copyright by Liehne, P. F. S., E. N. Marks, B. H. Kay and P. M. Fleming. 1981.

Permission has been granted by the Queensland University of Technology Library and the executors of the estate of Dr Elizabeth Nesta Marks for display of *Patterns of disease in humans and domestic animals* on the SERF website.
PART II - PATTERNS OF DISEASE IN HUMANS AND DOMESTIC ANIMALS

(a) Introduction

Tropical regions of other continents have a well documented history of major impoundments and irrigation schemes acting as foci of epidemics of human and animal disease. (Stanley and Alpers 1975; Ackermann et al. 1973). Among the most common and threatening are schistosomiasis, trypanosomiasis, onchocerciasis, malaria, and diseases caused by arboviruses (see Stanley and Alpers, 1975 for reviews of several case histories in Africa, Asia and the Americas).

Australia is singularly fortunate in that it does not harbour the specific vectors or hosts for the majority of these diseases. Since malaria, which previously caused severe outbreaks in northern Australia has been eradicated (Black 1972), the arboviruses may present the greatest potential hazard to human health. Arboviruses include Murray Valley Encephalitis (MVE) and Kunjin viruses, responsible for the disease "Australian encephalitis" which has occurred as sporadic epidemics in Australia since 1917. A second disease, epidemic polyarthritis, caused by Ross River virus, (a group α arbovirus), is endemic in eastern Australia and occurs annually.

(b) Dams in Tropical Australia

(i) Similarities and differences between Ord and Burdekin schemes

The Ord river W.A. was one of the first of the large Australian tropical rivers to be dammed at low elevation and provides a model for future such developments north of 20°S latitude, in the annually dry tropics.

The Burdekin Project area has many features in common with the Ord. Similar annual rainfall, seasonal cyclonic influences causing periods of high rainfall intensity and runoff followed by an extended dry season, high temperatures and evaporation rates, are among the major climatic factors which make agricultural development in these areas, reliant on extensive water storage and irrigation. Vegetation communities in both areas have many features in common (R. Specht private comm.), and they provide habitats for like fauna populations. The diseases prevalent in tropical irrigation areas are frequently dependent on population of mosquitoes and suitable vertebrate hosts. Both the Ord and the Burdekin have populations of mosquitoes (especially Culex Annullirostris) and host
migratory bird species, which together enable the maintenance of endemic arbovirus populations including MVE. Mosquito and avian population in the Burdekin area are likely to increase with the extension of the irrigation areas which will provide further habitats for them. The planned expansion of the rice industry, will also supply additional feed for birds. On the other hand predacious fish in the irrigation channels assist in the control of mosquito populations in both the Ord and the Burdekin.

The two areas have several significant differences which may affect the human disease risk. Firstly the Burdekin currently has a population of 135 000 compared to 4000 in the Ord. In addition the areas under irrigation are widely variant. The Burdekin Basin irrigation schemes currently cover some 43 000 hectares. The proposed extension will result in an additional 45 000 ha and 660 new irrigated farms. The Ord River irrigation scheme supports relatively few (30) farms.

Secondly mosquito breeding in the Burdekin area may be more limited for two reasons;

- the terrain of the Burdekin damsite limits the potential for development of marginal swampland and
- there is no equivalent to the Bandicoot Bar Diversion Dam on the Ord which provides extensive mosquito habitat.

Thirdly in the Burdekin, Ross River virus is endemic whereas MVE probably is not: this contrasts with the Ord where MVE is endemic.

(ii) Arbovirus (Insect Borne Viruses) Studies in the Ord

Studies in the Ord Irrigation Area indicate that a new tropical irrigation area can become an important focus of significant insect borne viruses

The activity of arboviruses in the Ord Valley ranks as the highest in Australia and one of the highest in the world (see Lishne 1980 for a review). MVE activity has been recorded in each year of study. Whether or not these high levels of activity are the result of the development of the Ord cannot be fully ascertained, as no studies were commenced until after the completion of the main storage dam in 1972. Contributing
to the apparent high incidence of activity may be an increased awareness of MVE activity by the medical profession resulting in more accurate diagnosis. Despite these limitations the following observations as to the effects of the water impoundment and irrigation area of the Ord Basin may be made.

- The maintenance of permanent large swampy margins to the Diversion Dam has produced breeding areas which favour the development and dry season maintenance of large populations of *Culex annulirostris*, the major vector of both MVE and Kunjin viruses.
- The swamps have also produced extensive refuge areas for vertebrate populations (birds and mammals) and the widespread cultivation of grain crops has provided a ready source of additional feed. These areas are particularly favoured during the dry season when natural habitats diminish in size and carrying capacity.
- Thus, the development in the Ord has produced close associations of large populations of vertebrates and vector species throughout the year. Such associations are the basic prerequisite for continuous virus circulation.
- The patterns of succession and colonization of both Ord dams (Argyle and Kununurra) with respect to marginal and aquatic vegetation, vertebrates (birds) and insect vectors are only now becoming apparent. The effects of such ecological succession and the increasing stabilization of these new aquatic ecosystems with respect to the levels of virus circulation have yet to be adequately monitored and evaluated so that accurate conclusions as to their effects may be drawn.

(c) Mosquitoes

(i) Introduction

This discussion deals only with the probable effects of the dam on the principal man-biting mosquitoes associated with irrigation systems of the lower Burdekin and with the dam site. It is based on a small series of collections in May 1973, April and June 1980, plus miscellaneous records. We lack information on species prevalence during the summer wet
season and have no first-hand observations on flooded rice contour bays, nor on the wetlands of Bowling Green Bay.

Species with different breeding habits present different problems. Eggs of *Aedes* are laid on a moist substrate, withstand (and usually require) drying, and remain viable for many months. An enormous hatch of species breeding in temporary ground pools may occur after depressions are filled by rain, flood, irrigation water, or very high tides. Adults emerge within a week. At least partial drying, and then reflooding, must precede another large hatch. *Culex* and *Anopheles*, which oviposit on water, breed in more permanent sites with subsurface or emergent vegetation that protects larvae from predators, and also in temporary pools lasting a week or more. Larvae of *Mansonia* (and also of *Coquillettidia*) obtain air from aquatic plants; their relative immobility protects them from predation by fish (Assem 1958).

(ii) Lower Burdekin

The major pest species are *Culex annulirostris*, *Mansonia septempunctata*, *Mansonia uniformis*, *Aedes lineatopennis*; *Anopheles* and *Coquillettidia* species occur in lesser numbers.

The irrigation system provides the following potential breeding places for mosquitoes: (1) irrigation ditches; (2) drains; (3) natural channels and swamps receiving runoff from drains; (4) shallow dams on water courses; (5) lagoons and channels filled by pumping to replenish underground water; (6) natural gilgais filled or replenished by drainage swamp overflow; (7) temporary pools left by flood irrigation; (8) rice contour bays.

Examples of (1) - (7) were sampled; (1) - (5) and some gilgais supported large populations of the introduced mosquito fish, *Gambusia affinis*, undoubtedly minimising production of both mosquitoes and their natural insect predators. Reduction of insect predators in permanent sites may affect their potential as controls in temporary pools.

Very little breeding was observed in locations (1) and (2) though some *Culex* and *Anopheles* can be expected where subsurface vegetation accumulates; they were found in minor ditches. *Mansonia* are likely to colonise sites with grass and bullrushes (*Typha*); adults were resting along overgrown banks.
Locations (3) - (6) support substantial populations of mosquitoes breeding along their thickly vegetated shallow margins. *Culex annulirostris* and *Anopheles* larvae were taken; and extensive swamp areas are suitable for *Mansonia*; *Anopheles* were the commonest species breeding in gilgais.

Examples of (7) were grassy road gutters adjacent to cane fields, and depressions below flume outlets between cane rows, in which there was intensive breeding of *Culex annulirostris*, with lesser numbers of *Anopheles annulipes*. Such sites, where predators are few or absent, must contribute substantially to local mosquito populations. Larvae of *Aedes lineatopennis*, which breeds in temporary grassy pools, were not located but adults were common. If the drainage of fresh water modifies the presently transient or brackish wetlands of Bowling Green and Upstart Bays, other types of mosquito problems are likely to arise, by the creation of new habitats and breeding zones.

(iii) The dam site

*Anopheles annulipes*, *Culex annulirostris* and temporary pool *Aedes*, the common species here, could breed extensively in temporary pools resulting from fluctuations in water level. Shallow, weedy backwaters of the dam are likely to be colonised by *Culex annulirostris* and *Anopheles annulipes*.

(d) **Mosquito Transmitted Pathogens**

Four factors may contribute to increasing the vulnerability of the area to mosquito-borne disease. They are - the increased mosquito breeding habitat - an expected increase in wild birds and mammals - the expected rise in the non-immune population and - the expectation that Townsville will become an international airport.

Further irrigation from the dam will increase the extent of all the types of mosquito breeding sites discussed; associated reduction in the numbers of large domestic animals available for blood meals may increase mosquito attacks on man.

A limited amount of data, from previous clinical experiences and from a CSIRO sentinel cattle herd near Millaroo, indicate that the following medically-important pathogens have been, or are active in the Townsville-Burdekin area.
(1) Malaria

Local malaria transmission has not been reported from the lower Burdekin (Black 1972) although Anopheles capable of carrying malaria are found there and local transmission has occasionally occurred at Townsville.

An outbreak of malaria in 1943 at Sellheim on the Upper Burdekin has relevance for the dam site. Sources of infection were heavily infected New Guinea Force personnel. The first case appeared in February when the river was in flood. In April the flood subsided, considerable anopheline breeding occurred, and there were fourteen further cases. Anopheles annulipes, the only anopheline found, was the presumed vector.

Mackerras (1947) emphasized that "Anopheles annulipes shows no defined association with man, but it seems fairly clear that, if man is brought to the mosquito, for example, by placing a camp on the banks of a river where it is breeding in abundance, it will avail itself of the offered food and may transmit malaria if gametocyte carriers are presented to it".

It is recommended that possible gametocyte carriers among construction camp personnel receive appropriate treatment.

(ii) Arboviruses

Most arboviruses are zoonoses i.e., they have natural cycles between arthropod vector and domestic or wild animals. When man intrudes into their environments, human infection may occur. Dengue (man-mosquito cycle) is an exception. Definitive knowledge of the epidemiology of these viruses is, as yet, poorly known although cycles between vector and vertebrate have been suggested (Doherty 1972).

Progressive reports of studies of Australian arbovirology have been given by Doherty (1974, 1977) and St. George and French (1979).

Ross River Virus

This virus causes polyarthritis and rash in man and recently has been linked with foetal damage and abortion (Aaskov, personal communication). An explosive epidemic, involving an estimated 35 000 cases, occurred in 1979 in Fiji and has spread to other Pacific Islands.
Only incomplete records of human cases occurring in the area are available, e.g. combined records of State Health Department and Dr. J. Aaskov, Queensland Institute of Medical Research, indicate 72 cases in Townsville area between January and June 1980. At Swans Lagoon, the CSIRO sentinel cattle developed antibodies in 1975.

Murray Valley Encephalitis

This sometimes fatal disease has occurred, as "Australian X disease", in the Townsville area during 1917 (7 human cases), 1918 (2) and 1925 (11); serological evidence suggests it was also present in 1960 at least and possibility also in 1959 and 1975 (Doherty, Carley and Gorman 1964, CSIRO sentinel herd). The present major hypothesis of virus introduction into susceptible areas relates to transport by infected waterbirds (Forbes 1978).

Kunjin

This virus has not been reported from this area. It causes mild febrile illness or encephalitis in man.

Sindbis

Antibody to this virus which causes mild illness in man, was detected in fowl sera from Townsville in 1960 and 1961. The known or potential vectors of the above 4 arboviruses are species which breed in temporary or permanent pools which will increase with the implementation of the Burdekin Scheme. Species such as Culex annulirostris (freshwater) and Aedes vigilax (saltwater) are known major vectors already present in the area but several other species are capable of major epidemic involvement (Kay et al. in St. George and French, 1979).

Dengue

Large scale severe epidemics occurred periodically up until 1955 (Rowan 1956, Doherty 1957). The Burdekin scheme will have little bearing on numbers of the vector, Aedes aegypti, which breeds in artificial containers such as drums and old tyres.
(e) **Biting Midge Transmitted Pathogens**

This classification is only broadly applicable as is the premise that biting midges, mainly of the genus *Culicoides*, are responsible for the transmission of important veterinary pathogens in Australia.

The Swans Lagoon herd converted to the following viruses


Bovine onchocerciasis (skin nodules in cattle) caused by *Onchocerca gutturosa*, *Onchocerca gibsoni*, and *Onchocerca lienalis* is extremely common in cattle of the Townsville area (Copeman, personal communication).

Potential vectors of these agents, *Culicoides*, particularly *Culicoides brevitarsis*, *Culicoides bundyensis* and *Lasiohelea* sp. (Standfast and Dyce 1972, St. George et al. 1977, Standfast et al. in St. George and French 1979) have been collected in the area.

Although it is difficult to forecast the effect of increased irrigation and cropping on future prevalence, a decrease in grazing land could imply a reduction of livestock and therefore feeding on livestock. Much will depend on agricultural practices. For example, the short term introduction of livestock for fattening on stubble may increase the incidence of epizootics.

(f) **Snails and Other Alternate Hosts of Possible Disease**

(i) **Schistosomiasis**

One of the most alarming disease possibilities with respect to tropical irrigation is infection of the system with schistosomiasis. Four species of schistosome are parasitic to man, *Schistosoma haematobium* (urinary schistosomiasis), *S. mansoni*, *S. japonicum* (intestinal schistosomiasis) and *S. intercalatum*. Schistosomiasis is endemic in many tropical irrigation schemes in Asia, Africa and South America.

The life cycle of all four species mentioned above is similar and involves snails as intermediate hosts. The eggs are passed in the urine
(S. haematobium) or faeces (other species) and contain a fully developed miracidium. The miracidia must penetrate their snail intermediate host within 16–32 hours or else they will die. Schistosomes are extremely host specific in regard to their snail host. Sporocysts develop in the snail into the final larval stage, the cercariae. Cercariae released in the water actively penetrate their final host and enter the peripheral lymphatics or venous vessels and are carried to the lungs. The worms then migrate to the portal vessels where they develop into adults which mate and remain in pairs. The adult worm pairs migrate to the vesical plexus (S. haematobium) or the mesenteric veins (other species).

B. Wilson, then of Western Australian Museum, carried out a survey of Ord River snails and some other tropical Australian species for the W.A. Dept. of Health, Wilson and Stoddart (in press), and concluded that no snail investigated was a vector of human schistosomiasis. It appears likely that the Australian snail fauna will not transmit human schistosomiasis even if infected individuals discharge eggs in appropriate conditions. Therefore, although occasionally cases of schistosomiasis have been imported into Australia (Jordan 1975) the chance of local transmission is extremely remote. It is, of course possible that the introduction of appropriate snails into Australia and the establishment of a local population could result in the spread of human schistosomiasis. Live snail vectors for Schistosoma mansoni have been detected in Australia in consignments of exotic aquarium fishes, but no establishment is currently known, (B. Pratt personal communication).

It is considered that Australian standards of personal hygiene with little bathing in drainage canals and, widespread use of earth and water closets even in rural areas reduces transmission possibilities. There are well documented engineering and public health techniques for control of schistosomiasis in areas of heavy infection, e.g. McJunken (1970), World Health Organisation, (1965) and most of these measures are normal in Australian design. It is however, desirable that regular surveys of snail populations should be made in tropical irrigation areas and medical and veterinary personnel practising in such areas be properly informed as to symptoms of such exotic diseases. These are certainly, as yet unintroduced, exotic diseases of domestic stock for which Australian snails appear appropriate hosts (B. Wilson personal communication).
Probably of greater medical importance than schistosomiasis is the condition known as 'swimmers itch'. This is caused by the cercariae of avian schistosomes (genus Trichobilharzia) which penetrate the skin of man and cause hypersensitivity reactions but do not survive (see Part 8).

(ii) Leptospirosis

Leptospirosis, sometimes called Weil's Disease (see Wannon 1975), for which rats, mice and bandicoots are alternate hosts, was 50 years ago a common disease of sugarcane workers over the whole of coastal Queensland. First the practice of pre-harvest burning greatly reduced its incidence and in recent years this has been even further reduced with the almost complete mechanization of the industry.

Wannon (1975) considers rice fields as the most favoured environment for its spread which suggests the the great expansion of rice area proposed in the present development is a significant hazard. However, Australian production methods rarely expose workers to extended periods in wet paddyfields. Planting, insect and weed control and harvesting are all carried out by machinery and planting and harvest are usually carried out in dry fields.

(g) Proposal For Monitoring

In Australia at present, no data are available recording the changes that may occur as a consequence of schemes such as planned for the Burdekin. Broadly based, multidisciplinary longitudinal studies would provide a model for future national development, and could if appropriately presented be considered as an example of proper concern by the construction authorities.

The following proposal, at the pre-project stage, is seen as a definite minimal requirement which could be carried out by a research body such as the Queensland Institute of Medical Research, Brisbane, enhanced through collaboration, or at least communication, with participants in other fields e.g. James Cook University; National Parks and Wildlife Service (presently monitoring bird populations in the Burdekin wetlands); CSIRO Division of Animal Health and the Queensland Department of Primary Industries who retain a vital interest in arboviruses of veterinary importance.
With regard to human health, the following baselines should be established through intensive study over a 3 year period.

1. **The mosquito fauna of the upper and lower Burdekin**

   It is suggested that the most economical means of undertaking such a study is through sporadic collecting trips, using as many trapping methods as possible, over a full seasonal range. Such visits will facilitate a generalized assessment of the relative abundance of species and their association with different phases of the irrigation regime.

   There is no doubt that continuous study would be more desirable but at this stage, projected costs seem prohibitive.

2. **An assessment of the vector competence of the major mosquito species**

   Should an epidemic occur, knowledge of the likely vectors is necessary for control purposes. Apart from species established as vectors e.g., *Culex annulirostris* and *Aedes vigilax*, consideration of species likely to adapt to future conditions e.g., *Aedes lineatopennis*, and *Mansonia*, would be prudent.

3. **The present level of arbovirus activity**

   Serological methods are more suitable and economical than present arbovirus isolation techniques.

   Baseline data of human infection, through notification of clinical cases or routine submission of blood samples, could be achieved practically through liaison with medical practitioners in the area. Such a scheme would be successful only if residents knew of the surveillance scheme and were provided with feedback of results, again a matter of proper presentation.

   General monitoring of arbovirus activity through sequential bleeding of 2 or 3 small but strategically-placed cattle herds, would provide additional information on a much wider range of viruses. This may best be achieved through liaison with CSIRO Division of Animal Health and the Department of Primary Industries. Such a scheme may be suitable as an early-warning device for impending outbreaks of disease.

   Opportunistic bleeding of selected vertebrates when offered could provide valuable supplementary information.
Combination of these facets should provide not only an early warning scheme but also valuable baseline profiles of infection in relation to age. There is a dearth of such information in Australia.

4. **Surveys of aquatic snails**

It is recommended that regular surveys of aquatic snail fauna and aquatic vegetation be made to minimize risk of introduction of schistosomiasis. Should Townsville become an International Airport, facilities for quarantining batches of imported aquarium fish would be necessary.

Plants around the edge of the lake could harbour the lymnaeid snail which is the vector for schistosome dermatitis ('swimmers itch'). The snail infects adult waterbirds and is already common in north Queensland (D. Blair personal communication). Thus, it will be desirable to monitor the incidence of schistosome dermatitis and possibly cholera organisms in areas subject to the heaviest recreational use.

**Liaison with Water Resources Commission**

In order to minimize the creation of suitable vector breeding habitats, it is suggested that a link be established between construction personnel and entomologists.

Modification and distribution of a pamphlet such as "Mosquito Control on the Farm", (Leaflet 2850, Division of Agricultural Sciences, University of California) would aid in reducing mosquitoes.

**Conclusions**

The Burdekin dam and associated irrigation scheme will probably not cause serious health problems in view of (1) mosquito breeding habitat already available and (2) predacious mosquito fish, **Gambusia affinis** which probably have significant effect on mosquito populations at present.

However, we do recommend that (1) a monitoring system for both mosquitoes and arboviruses be set up to properly assess the risk to human health and (2) that liaison be maintained with entomologists by both construction personnel and the Queensland Water Resources Commission.