AN OUTBREAK OF GRAIN ITCH MITE DERMATITIS IN SINGAPORE

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SYNOPSIS

An outbreak of dermatitis caused by the grain itch mite, *Pyemotes ventricosus* (Newport), occurred during the period September 1977 to January 1978 at the Maternal & Child Health Clinic of the Institute of Health, Outram Road, and affected 17 people, all workers of the Clinic. Initial spraying of the floors, walls, and chairs of the Clinic to control suspected cat fleas, did not control the menace until the mites were traced to its source inside the furniture beetle, *Anobium punctatum* (DeGeer), which was infesting the old wooden chairs used in the Clinic. The outbreak was controlled when the wooden chairs were replaced by new metal ones.

INTRODUCTION

Pyemotes ventricosus (Newport), previously called *Pediculoides ventricosus,* is a mite belonging to the family Pyemotidae which is characterised by a clubshaped organ between coxae 1 and 2 in the adult females. It is a parasite of various insect larvae infesting grain, straw, hay, cottonseed and other stored products such as dried peas, barley and tobacco. It has been variously called the "grain itch mite", the "straw itch mite", the "hay itch mite" and the "barley itch mite". The first name seems the most widely used and acceptable.

Epidemics of dermatitis caused by the mite have been reported in the United States (Booth & Jones, 1952), Europe and Australia (Swan, 1934). In these countries, agricultural workers had been chiefly affected but industrial workers and others had also been attacked through occupational or incidental exposure to infested materials (Sheals, 1973). As far as is known, epidemics of dermatitis due to this mite, has never been reported in Singapore in the medical literature.

DESCRIPTION OF THE OUTBREAK

On 17 Oct 1977, a complaint of intense pruritus with insomnia in some patients was lodged by the Medical Officer in charge of

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the M & CH Clinic at the Institute of Health (IOH) to the Ministry of the Environment (MOE). Upon investigation by MOE staff over a period of almost one month, no biting insects such as mosquitoes, bed bugs, cat fleas and biting midges, nor their breedings, could be found in the immediate vicinity although IOH staff nurses had suspected cat fleas, ***Ctenocephalides felis felis*** (Bouche), to be the cause as a number of stray cats were seen.

On 3 Nov 77, when the itch nuisance had continued unabated and become unbearable, the walls and floors of the Clinic were sprayed with 1.3% malathion. From then on, and until the end of 1977, MOE staff carried out one fogging and four more spraying operations in order to abate the nuisance (Table 1). But all through this while, the workers in the Clinic continued to suffer intense itch, the insecticides sprayed and fogged had apparently made no impact.

Further investigation revealed that the lesions inflicted were confined mainly to parts of the clothed body where movements of insects would be restricted. Hence mites instead of insects were suspected to be the cause. It was also observed that the majority of the workers complained of the first bites as occurring on the buttocks and thighs. The search for the nuisance was thus narrowed to seating furniture. When the seating furniture were examined, metal chairs with wooden seats and back supports (Fig 1) were found perforated with tiny (1 mm diameter) holes from which frass could be seen extruding (Fig 2), signs typical of infestation by wood-boring beetles. Upon closer examination of the holes under the zoom binocular microscope, beetles, most of them immobile or dead, were seen. The beetles were identified as the funiture beetle ***Anobium punctatum*** (DeGeer) (Fig 3). Since this beetle does not normally bite man although it has biting mouthparts, it was suspected to be the host of mites. The suspicion

Fig 1 A room in the Institute of Health, Outram Road, with old beetle-infested wooden chairs.

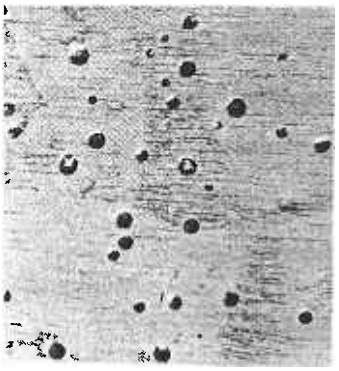

Fig. 2 Tiny holes, some with frass protruding, on the underside of the seat of a chair infested with the furniture beetle.

Fig. 3 *Anobium punctatum*.(DeGeer), the wood-boring furniture beetle.

TABLE 1: Anti-pest measures taken to abate itch nuisance at IOH

Date	Insecticide Used			Areas Treated
	Name	Dosage	Amount (litres)	
3 Nov 77	Malathion	1.3%	36	Spraying on room walls, floors and chairs.
12 Nov 77	DDT	1.0%	36	Spraying on room walls and floors.
19 Nov 77	Malathion	2.0%	14	Fogging within IOH building.
	Malathion	1.6%	72	Spraying on walls and garden outdoors.
24 Dec 77	Malathion	1.6%	72	Spraying on walls, floors and furniture.
31 Dec 77	Permethrin ("Coopex")	0.2%	10	Spraying on all chairs and furniture.

TABLE 2: Time distribution of cases based on first attacks by mites, age distribution and occupation of cases.

Age	No. Cases	Occupation						Time Distribution			
		MO	MW	NO	FPA	CO	MHS	Sep	Oct	Nov	Dec
25-30	2	—	—	—	—	2	—	1	—	—	1
31-35	4	—	—	3	—	—	1	—	4	—	—
36-40	5	—	1	3	1	—	—	—	4	1	—
41-45	3	1	—	—	—	1	1	1	1	—	1
46-50	2	—	1	1	—	—	—	—	1	1	—
51-55	1	—	—	—	—	—	1	—	1	—	—
Total	17	1	2	7	1	3	3	2	11	2	2

MO = Medical Officer; MW = Mid-wife; NO = Nursing Officer; FPA = Family Planning Assistant; CO = Clerical Officer; MHS = Medical Health Servant

was confirmed upon dissection of some of the beetles. Numerous mites were seen inside the abdomen under the elytra and wings. They were then keyed down to *Pyemotes ventricosus* (Newport).

The role of the mite in causing dermatitis was confirmed in January 1978. the control of the outbreak was speedily effected through replacement of the wooden chairs with metal ones.

ANALYSIS OF CASES

1. Time distribution of cases

This was based on dates of first attack by the mites.

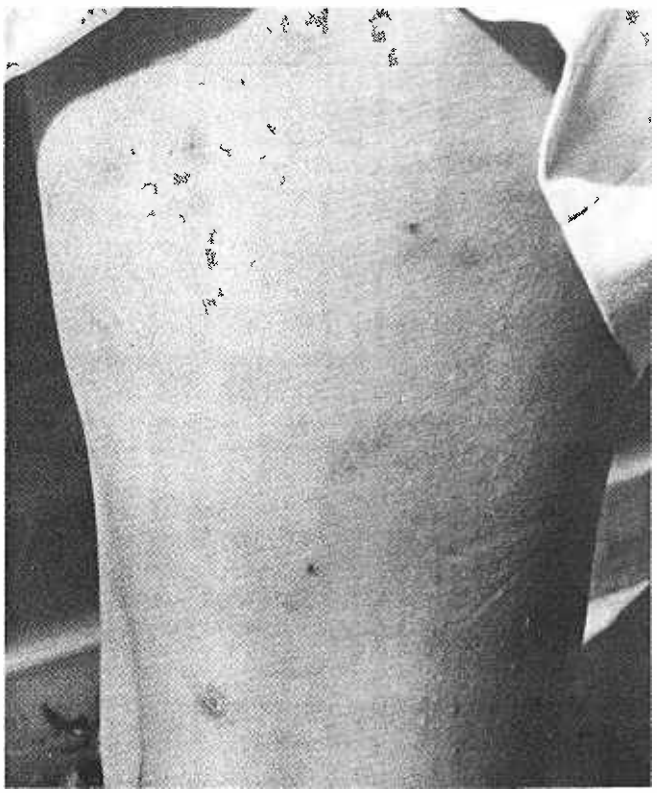

Fig 4 Weals on underside of thigh caused by the grain itch mite.

The outbreak spanned over a period of 4 months, from September to December 1977, with a peak occurring in October (Table 2).

2. Age, sex and ethnic distribution

All the workers at the Clinic were Chinese females and all were attacked by the mites. Their ages ranged from 28 to 50, with a mean of 38. The majority (5 cases) were in the 36-40 age group (Table 2).

3. Distribution of bites on body

The distribution of bites on the body was based on the replies to a fact-finding questionnaire sent to the Clinic. From the returns, it was observed that all parts of the body, except the head, palms and feet, were attacked by the mites. The majority (16 cases or 94.1%) were attacked in the buttocks, groin and thighs (Fig 4) while 15 cases or 88.2% were attacked in the neck (Table 3).

CLINICAL MANIFESTATIONS AND PATHOLOGY

From personal observations and from the literature,

TABLE 3: Distribution of bites on the body according to age groups of the 17 workers, arranged by decreasing numerical order and percentage

Body part attacked	No. of cases by age group						Total no. of cases	%
	25-30	31-35	36-40	41-45	46-50	50-51		
Thighs	2	3	3	4	—	—	12	70.6
Buttock	2	2	4	—	1	1	10	58.8
Groin	—	—	1	1	—	—	2	11.8
Thighs, buttock and groin	2	3	5	4	1	1	16	94.1
Neck	2	4	4	3	1	1	15	88.2
Abdomen	—	3	4	1	1	—	9	52.9
Arms	—	2	4	1	1	—	8	47.1
Chest	2	—	1	1	1	—	5	29.4
Legs	—	2	2	—	1	—	5	29.4
Hands	1	1	1	1	—	—	4	23.5
Back	—	—	1	1	—	1	3	17.6
Breasts	—	1	1	1	—	—	3	17.6

the following clincial picture of the skin condition is obtained. The eruption, a cutaneous lesion (Fig 5), is characterised by a rosy-red weal surmounted by a whitish central vesicle (Fig 5b, c) which marks the site of bite. The vesicle rapidly becomes a pustule (Fig 5c). The weals normally appear 10 to 16 hours after a bite (said by one nurse to be painful like a sting) and reach their maximum development in about 24 hours. At this time pruritus becomes intense, and some edema of the surrounding area may occur. The lesion becomes blanched on rubbing but the surrounding area is erythematous. The central vesicle is readily destroyed by rubbing or scratching and serum exudes from the site. Because of the intense pruritus, scratching often leads to excoriation of the lesions (Fig 5d) and to secondary infection and septicaemia. The weal and pruritus subside spontaneously after 48 to 72 hours, but both may recur for several days if the lesions are rubbed or scratched. After the pruritus has subsided, a scar is left (Fig 5d).

Each weal measures about 5mm in diameter on the average (Fig 5d) but may be as large as 10mm (Fig 5c). Variation in size of the weal may occur in the same and different persons.

According to Booth & Jones (1952), local complications are pyoderma, eczematous reactions, and regional lymphadenopathy. Systemic symptoms that may accompany the eruption are fever, chills, malaise, headache, nausea, vomiting, and asthma. Altered laboratory findings recorded include leukocytosis, eosinophilia, and albuminuria.

The histopathology of a typical urticarial lesion surmounted by a vesicopustule, biopsied 18 hours after a bite, was described in Booth & Jones (1952). The pathological changes in the skin are characteristic of the lesions of urticaria.

The eruption had been confused with urticaria, chickenpox, scabies and even with smallpox (Swan, 1934).

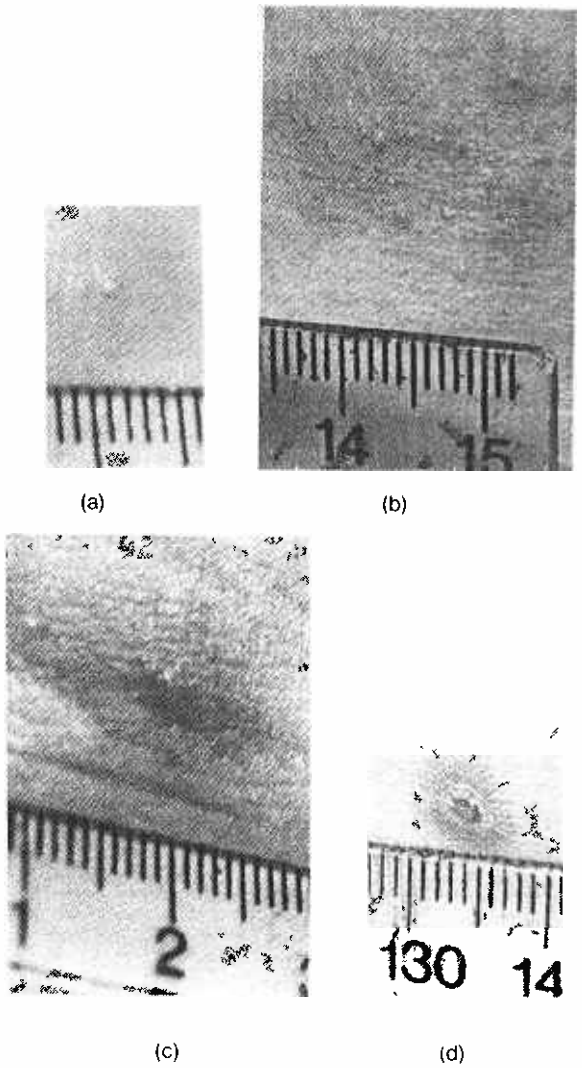

Fig 5 Stages in the development of dermatitis caused by the grain itch mite:

a - few hours after bite, a raised vesicle marks site of bite;
b - several hours after bite, weal with central vesicle surrounded by erythematous area;
c - about 24 hours after bite, pustule with whitish central vesicle and erythematous surrounding area;
d - 2-3 days after bite, scab with inner pale exocriated ring and outer erythematous area.

THERAPY AND PROPHYLAXIS

Based on returns of a questionnaire, 11 of the 17 workers sought medical treatment while the other 6, including the doctor, applied self medication. One midwife indicated that she sought treatment at the Middle Road Hospital, a specialist centre for skin diseases. Excluding the doctor, the other 5 who did not seek medical treatment were 2 nurses, 1 clerk and 2 medical health servants.

The drugs used for treatment included antihistamines such as Anthisan, Chlor-Trimeton, Longifene, and corticosteroids such as Betnovate, Eurax (= Crotamiton) and Hydrocortisone cream.

Before seeking medical treatment, most of the patients applied soothing agents with germicidal and antiseptic properties such as "Mopiko" which contains 3.92% menthol, 5.83% camphor, and 3.75% methyl salicylate in an ointment base; "Medicated Oil (Axe Brand)" which contains 20% menthol, 15% eucalyptus oil, 0.9% chloroform B.P., 15% methyl salicylate, 5% camphor and 12% of an essential oil with a base added; "Dettol Cream" which contains 0.3% w/w chloroxylenol (4-chloro-3,5 xylenol), 0.3% w/w irgasan DP 300 (2,4,4-trichloro-2'-

hydroxydiphenyl ether), and 0.2% w/w edetic acid (K salt); and "Asepso Soap" which contains a 2% 'binary germ killer' and a 4% 'activator'. These are drugs which can be purchased on-the-counter without prescription, from pharmaceuticals.

Besides applying self medication, some patients also changed their clothes, washed and bathed themselves thoroughly.

BIOLOGY OF *PYEMOTES VENTRICOSUS*

1. Hosts of the mite

P. ventricosus is normally ectoparasitic on the larvae of a number of insects particularly those existing in stored products. Its stylets or needle-like mouthparts (Fig 6a) which are modified chelicerae, pierce the insect cuticle, and sucks out body fluids from the host. Its salivary secretion injected into the host during feeding, immobilizes the host (Swan, 1934).

Among its hosts are the Angoumois grain moth, *Sitotroga cerealella* (Olivier), the wheat joinworm, *Harmolita tritici* (Fitch), a chalcid hymenopteran, and Anobiid beetles. The Angoumois grain moth occurs widely in America, Europe and Australia, particularly in the cereal-growing belts, i.e. mid-west USA and South Australia. Its larvae feed on cereal grains both in haystacks and in the store.

P. ventricosus cannot thrive on human blood (Chandler, 1955). Man is an incidental and transient host and comes into contact with the mite during chaff-cutting operations, and loading of chaff cargo (Swan, 1934), and handling of infested foodstuff (Busvine, 1966). Serious infestations therefore occur commonly among grain thrashers, millers and granary workers.

2. Distribution

P. ventricosus is probably cosmopolitan. It has been reported from West Africa, Morocco, Algeria, and Egypt, in addition to Europe, America and Australia.

3. Life cycle

P. ventricosus has an unusual life cycle. The adults are normal-looking (Fig 6) although somewhat modified for a parasitic life on insects. The young fertilized females, about 0.2 mm long and barely visible to the naked eye (Fig 6a), seeks out a suitable host to which she becomes permanently attached. As she feeds, the opisthosoma (the abdominal region behind the

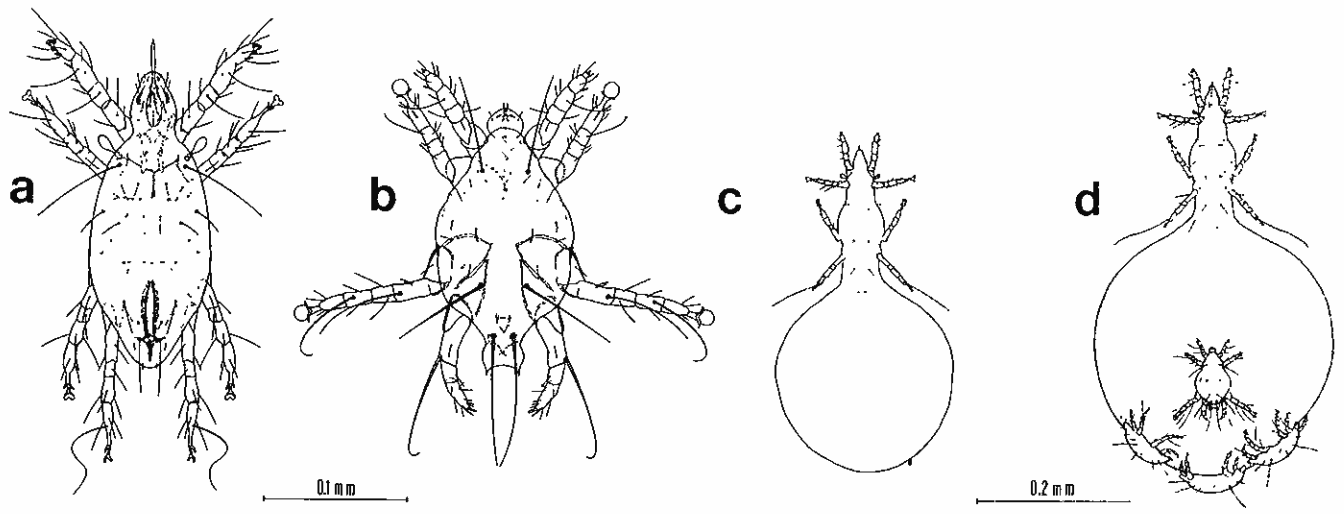

Fig 6 Grain itch mite, *Pyemotes ventricosus* (Newport): a — young female; b — male; c — ovigerous female with brood sac; d — males grouping around genital aperture of gravid parent.

Note: All figures were drawn under camera lucida by senior author after clearing in lactophenol. Figures were retraced for photographic reproduction by Miss Chew Lai Ming.

legs) becomes enormously distended (Fig 6c) and the eggs develop and hatch within this grotesquely enlarged brood sac which may reach a diameter of 1.5 mm. The young mites complete their development within the parent and do not emerge until they are sexually mature, about 1-2 weeks under tropical conditions. Reproduction is thus viviparous. The progeny numbering 200 - 300 continue to be produced over a period of 9 to 33 days, so that as many as 36 births may take place on a single day.

Males are first produced by the fertilized females but they account for only 3 - 4% of the offspring. The males remain attached to the parent brood sac for 20-30 days, living apparently parasitically on her, and would die in 20 hours if removed from the mother (Busvine, 1966). They remain close to the mother's genital opening.

Females are produced later and they move towards the genital aperture for emergence. The males, outside the parent, seize the emerging females with their clasper-like hind legs (Fig 6b), help them out, and immediately fertilize them. Each male mates with about 30 females (Busvine, 1966). It is said that the males would never assist the birth of young males (Munro, 1966). If all the males are removed before young females emerge, the latter would give birth to progeny pathenogenetically, and all the offspring would be males.

The fertilized females, unlike the males, scatter to seek and parasitize new hosts and the life cycle begins all over again. If they are unsuccessful, they die after about 48 hours.

CONTROL

Treatment of the infested chairs with insecticides as fogs or as residual sprays could not effectively destroy the beetles inside the chairs although both beetles and mites existing near the wood surface and outside were killed.

Complete control was effected only after the beetle-infested chairs were replaced with non-infested ones. The accurate diagnosis of the problem was thus of primary importance in the control of the disease.

DISCUSSION

1. Mite biology

The biology and bionomics of *P. ventricosus* are not fully understood. Much remains to be studied and unravelled. There is no mention in literature, for example, of the distinct differences between the male and female mite and of the relationship between their different structures and their functions. There is also no mention of their morphological differences in relation to their medical importance. These are therefore presented below.

The prognathous condition of the head with mouthparts facing forwards, suggests that the mite is as much an endoparasite of insects as it is an ectoparasite as reported in literature. In our observation, the mite was seen parasitising inside the body of the adult furniture beetle, under the wings and in the abdomen rather than on the insect. Ectoparasites would normally have heads in the hypognathous or opisthorhynchous condition or a gnathosoma in the ventral position with mouthparts directed ventralwards so that feeding on the host can be constantly, if not continuously, maintained. No doubt *P. ventricosus* can also lead a permanent ectoparasitic existence on the insect host but in this case, it must attack the soft parts of the insect body, e.g. intersegmental membranes, or the soft body of insect larvae which in turn must remain more or less motionless or be protected (e.g. inside wood) in order that the ectoparasite might survive.

In the female mite, the extensible stylets are obviously modified for piercing the insect body and sucking out fluids. The strong pharyngeal (salivary? cibarial?) pump appears to be connected posteriorly to strong endophragmal skeletal structures presumably involved, by muscle attachments, in the protraction and retraction of the stylets. The opposable claw-thumb complex in the first pair of legs and the claws with disk or pulvilli-like pretarsi of the remaining pairs of legs are obviously structured for clinging firmly onto the insect host. The pair of club-shaped organs between the 1st and 2nd pairs of legs are absent in the males, an observation not previously mentioned in literature, as far as we know. The function of these organs is not known, but we suspect that they could be poison glands. The salivary secretion of the mite is said to immobilize the insect host (Swan, 1934). The venom, once injected into the insect body, would no doubt circulate in the insect haemolymph and paralyse the musculature of the body wall, likely by a neuromuscular block. The effect would be that the heart and alimentary canal of the insect host would continue rhythmic activity and the nervous system would remain active, but degenerative changes would set in and the insect would eventually die. In our observation, all the furniture beetles which were attacked by the mite eventually died. Dead beetles with almost empty bodies, on dissection, had large numbers of mites, some with brood sacs containing

eggs, some with transparent brood sacs, and some with males and young females. In the dead beetles just emptied of their body contents, large numbers of young female mites could be seen actively searching for new hosts. It is likely that only when the insect host has died and when the mites have depleted their source of food and are in search of new hosts, that they will attack man when man comes into contact with the contactant material.

In the male, the stylets are rudimentary and probably incapable of piercing the insect body or even that of its parent from which it is said to get its sustenance. It may be that the male does not feed at all but exists solely for the fertilization of the young virgin females as they emerge. The claws in the first pair of legs are also rudimentary and minute. Obviously they are not adapted for clinging onto the insect host body. The pulvilli-like pretarsi of the 2nd and 3rd pairs of legs are considerably larger than those in the female, suggesting greater mobility requiring grip in locomotion as would be necessary on the spherical brood sac of its parent. The clasper-like hind pair of legs with spatula-like claws are obviously highly modified for pulling the virgin females out of the brood sac in order to fertilize them as they emerge. The genitalia are large and conspicuous (Fig 6b), a clear indication of the male's important role in reproduction. The terminal pair of sclerotized hooks in the genitalia are obviously structured for hooking securely onto the female genital opening during insemination. Thus, unlike the female, the entire morphology of the male is modified for adaptation to a temporary existence on its parent body and for the sole purpose of mating. Busvine (1966) stated that the male would die in 20 hours if removed from its parent. It is likely, therefore, that the males do not leave the parent brood sac at all but die soon after mating the emerging females. If so, they would not likely be involved in biting man and causing dermatitis, especially since they have rudimentary mouthparts and do not possess the club-shaped poison glands.

2. Medical and economic importance

Besides causing allergic and eczematous dermatitis, *P. ventricosus* has been reported to be associated with an epidemic of asthma among workers in grain mills in Florence, Italy (Ancona, 1923). The workers suffered dermatitis of the usual type produced by the mite, but subsequently, through continual exposure to the conditions at the mills, ultimately developed asthma. Ancona (1923) considered that the symptoms might be due to inhalation of the mite or its action on the nasal mucous membrane. According to Wharton (1976), Newport in 1850 also reported *P. ventricosus* to be associated with an epidemic of asthma among grain workers. It is now known that asthma is more commonly associated with house dust mites and is one of 3 common syndromes associated with house dust allergy,the other two syndromes being perennial rhinitis and childhood eczema (Wharton, 1976). No doubt, like house dust mites, *P. ventricosus* is an agent or producer of the house dust allergen which causes the respiratory and skin disorders among atopic individuals.

P. ventricosus is otherwise beneficial to man in its parasitic role on a variety of pest insects, particularly insect pests of stored products.

3. Diagnosis of grain itch

The diagnosis of grain itch caused by *P. ventricosus* is not an easy matter. Firstly, *P. ventricosus* is extremely difficult to detect on the human skin because of its small size and transparent body and its transient stay. Secondly, the skin eruption may be confused with urticaria, and even chickenpox and smallpox (Swan, 1934). It may also be attributed to bites by other acarines such as the rat mite *Ornithonyssus bacoti* (Hirst), the human itch mite (or scabies) *Sarcoptes scabiei* (L.), or other dermatitis-causing mites, and insects such as biting midges and fleas. A Middle Road Hospital dermatologist had in fact mistaken it for flea bites and treated it as such. Thirdly, the insects on which *P. ventricosus* parasitizes may themselves be the suspect agents of dermatitis because of their closer association with man through occupation or industry, and because of possession in some of them (e.g. anobiid beetles) of biting mouthparts although essentially they are non-biters of man. It is unlikely for an investigator, even if he should be a trained entomologist or parasitologist, to suspect a parasite of insects rather than the insects themselves to be involved, especially when the insect hosts of the mite are readily found in numbers to be closely associated with man through contact of the infested material (e.g. chairs, grain and chaff). Fourthly, the normal onset of pruritus usually takes place 10 hours or more, by which time the association between the pruritus and the contact with the infested material might no longer be registered in the mind, especially if the day spent had been a busy one.

The recognition of grain itch, therefore, depends upon (a) proper diagnosis of the skin eruption, (b) association of the condition with earlier contact with, or exposure to, materials of plant origin or stored products, particularly grain, wheat straw, hay, flour,

beans, peas, corn, barley, linseed, etc, and (c) detection of the mite in the contactant material. If the eruption is an epidemic affecting a large number of people working in the same place, and exposed to the same contactant material, as was in the present case, then the index of suspicion should be high.

In pinpointing the cause, the sites of bites on the body would also give a clue. In this particular outbreak, the two body regions most seriously affected, namely the thighs, buttock and groin as one region and the neck as another, were the exposed areas of the body nearest the wooden portions of the infested chairs. Obviously the mites had to first crawl onto clothing at the points of contact before they could reach and attack these two areas.

4. Prophylaxis and treatment

After a known exposure, early bathing and a change of clothing are effective prophylactic measures. The use of repellents such as dimethyl phthallate, diethyl toluamide, and benzyl benzoate, has its added prophylactic value against subsequent attacks particularly since the mite is an incidental transient parasite of man. The local application of miticides and acaricides including sulphur, would also help in personal prophylaxis.

Treatment of grain itch has two objectives, (a) to allay the irritation, and (b) to prevent secondary infection of excoriated lesions. Swan (1934) found a saturated solution of picric acid in 90% alcohol to be highly effective in relieving irritation. The use of warm water and vinegar had also been reported to be effective. Booth & Jones (1952) recommended for therapy, a bath followed by the application of the "NBIN formula" which is 1% DDT, 2% benzocaine (ethylaminobenzoate), 10% benzyl benzoate, 2% Tween 80 (polyoxyalkalene ether of sorbitan monooleate), and water in quantity sufficient to make 100%. They recommended the use of 300,000 units of penicillin given by intramuscular injection in cases with secondary bacterial infection.

Basically, treatment of dermatitis caused by mites would involve the use of (a) antihistamines and antipruritic lotions and ointments to prevent itching, (b) corticosteroids to prevent inflammation and to alleviate itching, (c) antibiotics to prevent or eliminate secondary infection, and (d) salves, ointments and other soothing agents.

5. Control and prevention

The complete control of grain itch and its prevention must involve the elimination of both the mite and its insect hosts. This is best done by removing or destroying the contactant material on which the insect hosts feed. Burning of the contactant material is probably the most effective and cheapest way of solving the problem as it destroys both the mite and its insect hosts. Such a measure must of course be taken only when the contactant material can be dispensed with.

The use of insecticides to destory the insect hosts is limited and ineffective in the case of wood-borers like anobiid beetles as the greater portion of the insect population harbouring the mites is deep down inside the wood where insecticides cannot reach. In the case of infested stored products meant for human or animal consumption, the use of insecticides is again limited because of the side effects of poisoning by toxic chemicals. In situations where insecticides can be used without endangering humans and domestic animals, the use of residual insecticides such as lindane (the essentially pure gamma isomer of benzene hexachloride, i.e. more than 99% gamma-BHC), and malathion, would be effective. Among the accepted and effective acaricides are several organophosphorus compounds (e.g. diazinon, parathion, dimethoate, phosphamidon) and the carbamate carbaryl.

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