Preservation of Library Materials in Tropical Countries

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BOOKWORMS, TERMITES, AND COCKROACHES, without doubt, ate many literary masterpieces of ancient Greece and Rome so that copies of certain works known to have existed have not come down to us. Classical writers were aware of the menace of insects. Insect pests of "books"—i.e. papyrus or animal skin rolls—were mentioned by Aristotle, Antophanes, Ansonius, Lucilius, Martial, Ovid, Philippus of Thessalonica, Pliny the Elder, Symphosius, and Isidorus Hispalensis. In his *Historia animalium*, written in 335 B.C., Aristotle mentions that he had found in books a creature resembling a tailless scorpion and "also other animalcules . . . resembling the grubs found in garments." (This "tailless scorpion" has been identified as the arachnid, *Chelifer cancroides.*) Horace refers to the practice of smearing books with cedar oil and storing them in chests of polished cypress. Pliny the Elder records that books found in the grave of Numa Pompilius, where they had lain for five hundred years, were in excellent condition due to the preservative effect of cedar oil.[1]

Cedar oil was, in fact, a famous book preservative for more than 3,000 years. Besides being mentioned by Horace and Pliny the Elder, it was referred to by Acron, Ausonius, Marcellus Empiricus, Martial, Martianus Capella, Ovid, Persius Flaccus, Servius the grammarian, and Vitruvius Pollio. In the Apocryphal books of the Bible it is recorded that Moses gave instructions for preservation of the books of the Pentateuch by anointing them with cedar oil and storing them in earthen vessels.[2]

Most of the early destruction of skin and papyrus rolls by insects took place in Mediterranean and sub-tropical climates. But insects have been no less a nuisance in temperate climates. Erasmus wrote that books, in order to be saved from worms, must be used. In the

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seventeenth century, Robert Hooke, the English chemist and physicist, referred to silverfish as "one of the teeth of time." E. G. Peignot, French bibliographer, in his *Insectes qui rongent les livres,* published in 1802, records that he once found "twenty-seven volumes in a row pierced by a bookworm in one continuous devastating journey."

When greater movement of people and books began to take place in the world, from the Middle Ages onwards, the danger and damage spread from country to country. The monastic libraries of Constantinople, Greece, and Britain, were ravaged by bookworms. A thirteenth-century manuscript exists entitled *Remedium contra vermes librorum.* Today the situation—as C. M. E. Towne puts it in his *Autobiography of Master Bookworm*—is that a bookworm born in a copy of the *Anthology of Caphalus* in the Abbey of Malmesbury may, later, live in a first edition of Samuel Johnson's *Dictionary* at Michigan State University. In tropical countries the danger of damage to books by termites, cockroaches, silverfish, moths, coleopterous borers, and other insects, always exists. To the librarian there is no sound more sinister than that of beetle larvae, suddenly discovered, audibly eating books and wooden bookshelves.

If cedar oil was the first preservative employed by scholars and librarians, it was by no means the only substance employed by them. The following are some of the other materials and substances—applied in various ways—which have been regarded, during the last four centuries, as effective protectors of books and book shelves:—absinthe; alum; alum and thymol; alum and vitriol; oil of anis; bitter apple; beeswax; benzine; Bertin's oil varnish; white birch bark; bitumen; borax; buck-bean; cajuput oil; camphor balls and camphor cakes; camphor wood; centaury; bitter chestnuts; dried meal of wild chestnuts; red chillies; chloropicrin; cinchona; cinnamon; cloves; clove oil; colocynth; copal varnish; copper; creosote; Derris elliptica; oil of eucalyptus; fir wood treated with lime or oil; formalin; burning of moistened gun-powder; halowax and lanolin; kerosene; khus-khus; lac varnish; lavender; leaves of margosa tree placed between the pages of books; mercurial salve; mercuric chloride; oil of mirbane; musk; red myrrh; dishes of naphthalene placed on bookshelves; neat's-foot oil; dried neem leaves; nicotine; powder of orrisroot; ozone; paraffin wax; oil of pennyroyal; black pepper; petroleum; phenic acid; plaster of paris; porpoise oil; pyrethrum powder; quassia; shavings of Russia leather; sandalwood; oil of sassafras; shellac; snuff; thymol; tobacco smoke; powdered tobacco mixed with powdered leaves of wormwood;

light-traps for moths; mechanical traps for cockroaches; turpentine; vermouth; and sprouts of wormwood.

Some of these preservatives are still in use. In India, for instance, the insides of all bookcases in one library have been coated with paraffin wax as a protection against termites. The efficacy of paraffin wax was discovered comparatively recently by F. H. Gravely, who reports:

> My first knowledge of it came from sleeping on the ground when camping in a Madras compound which proved to be riddled with termite runs. Several of us used water-proof groundsheets that we had prepared from unbleached calico by sprinkling grated paraffin wax over it and then running this into the fibre by passing a very hot iron very slowly over it. In the morning the undersides of these groundsheets were found to be covered with termite mud, but to be unharmed and have served as a complete protection to everything upon them, whereas all campers without them had had their blankets and some even their pajamas badly eaten, some of the blankets having been reduced to rags.[3]

Camphor balls and naphthalene are used in several other Eastern libraries, and mercuric chloride and cockroach traps (especially "roach hives") are still employed in many libraries throughout the tropics. Generally speaking, however, all these earlier preservatives, many of which were never really effective, have now been superseded. (Any library committee or governing body, these days, aware that its staff were burning moistened gunpowder in the library basement, would suspect a twentieth century recurrence of the Gunpowder Plot.) Even in Buddhist countries where, strictly speaking, it is sinful to slay a ravening bookworm outright, modern chemical compounds such as pentachlorophenol, methyl bromide, and dieldrin are now taking the place of sandalwood, cajuput oil, and margosa leaves.

For the librarian faced with the necessity of protecting his library from the jaws of many thousands of species of insects, it is necessary to know which is the best type of chemical warfare to wage. He must become, first, an entomologist so that he may gain appreciation of the life habits and food preferences of his insect enemies; and then a chemist, so that he may understand the properties, and possibly the dangers, of the poisons with which he hopes to kill them. There is always the sinister possibility that he will become so fascinated by interesting insects like termites and mason hornets, and such beautiful insects as silverfish, that he will decide they should be encouraged rather than exterminated.

Termites are often called "white ants" but they are not ants and they are not white. There are known to be 1,861 species of them; they have been on the earth for two hundred million years, as compared with man's one million years; Africa is their headquarters but they exist in all warm countries. S. H. Skaife says of them in his book, *Dwellers in Darkness*, that, with so much history behind them, they "have evolved a grimly efficient organization in which the individual has no rights at all and everything is run for the good of the community . . . Like all social insects, they are ruthless totalitarians." Ninety-five per cent are workers, members of the termite proletariat; five per cent are soldiers, permanently in the army; and a statistically insignificant number are queens and kings and "supplementary reproductives" whose responsibilities are much greater than their privileges. Certain species maintain fungus gardens in their termitaries; some keep and feed pets; the queens of certain species lay 30,000 eggs a day; a termitary may have a population of over a million individuals (c.f. the human cities of Alexandria, Caracas, Delhi, Ibadan, Istanbul, Johannesburg, Manila, Singapore), all derived from a single royal pair.

The food of termites includes grass, humus, dried plants, timber, woodwork of buildings, other termites, library books, files, photographs, valuable pictures, and catalog cards. If they invade a library in force they can do irreparable damage in a single night.

There are two categories of them. Earth-dwelling termites live in the soil or maintain contact with it by means of long winding tunnels; their presence in a library is generally disclosed by their mud tunnels on walls, bookcases, and furniture, or by the exploratory earthen towers they extrude between floor tiles and from cracks in concrete floors. Earth-dwelling termites create immense havoc in every country in which they exist; they may be debited, in fact, with 95 per cent of all damage to buildings and books that has been caused by *termitidae*.

In the West Indies wood-dwelling or dry-wood termites, which live above the ground and come into buildings through cracks and openings, have also caused serious damage, and it is said that certain species of them have now entered Africa through the sea ports and are eating their way into the interior. They have also been reported as abundant in the Philippine Islands and Hawaii. Their presence in window-sills, door jambs, etc. may be detected by their excreta, like

poppy seeds in appearance, which they push out from their hidden tunnels onto the floor.

Henry Smeathman in a *Philosophical Transactions* paper published in 1781 mentions serious termite damage to books in Africa; and Alexander von Humboldt in his *Essai politique sur le royaume de la Nouvelle-Espagne* in 1811 points out that their ravages account for the rarity of old books in equatorial America.

Cockroaches are said to have appeared in the Silurian age long before even the stegosaurus, the diplodocus, and the pterodactyl, but whereas these other horrors came to an end eons ago the cockroach has persisted and multiplied so that all librarians and housewives in warm countries must be familiar with it. The present writer has written elsewhere:

Cockroaches are useful only to zoology students who use them as material for exercises in dissection. There are 1,2000 species, the majority of which occur in the tropics. In addition to the damage they do to book covers cockroaches are suspected of spreading leprosy, poliomyelitis, cholera, typhoid fever and dysentery; so quite apart from any question of book preservation they are very undesirable in libraries. Their favourite food (or drink) is said to be beer but they will tackle anything from whitewash to boots. In libraries they have to be content, for the most part, with books. They are attracted by the adhesive used to stick cloth or buckram to the binding board, by the starch stiffening added to some binding cloths, by other pastes and glues employed in binding, and by certain dyes. As scavengers they enter buildings to eat organic filth of all kinds, other dead insects, and food crumbs left in rest-rooms by library staff. Their flattened bodies allow them to hide by day behind skirting boards, beneath floors, and in crannies and dark corners of all kinds. They generally enter libraries via latrines or drainpipes or by way of basements, in which they proliferate, but male coackroaches may also fly in through unscreened windows. As soon as it is dark both sexes and their families emerge from their hiding-places, find their way to books and start gnawing and sucking the book covers.[4]

Of the 1,200 known species, four have become cosmopolitan and, of these, three are commonly encountered in libraries:

The American cockroach, *Periplaneta americana*, is the species thought to spread poliomyelitis. It is darkbrown in color; both male and female are winged; although supposed to reach a length of only 1¼″ specimens nourished on the contents of Singapore (and perhaps

other) drains achieve a size beyond that permitted by entomology textbooks.

The Oriental or Common cockroach, *Blatta orientalis,* is also dark brown; its permitted size is ¾"; the female is wingless but the male has short wings.

The German cockroach, *Blatella germanica,* called Croton-bug in America, is smaller still, about ½" long; it may be distinguished by two dark stripes on the thorax; both male and female are winged. In spite of its name it is thought to have originated in Asia. Both it and the Oriental cockroach may be recognized by the oötheca, or capsule containing eggs, often seen protruding from the abdomen of the female.

The fourth cosmopolitan cockroach, *Periplaneta australasiae,* 1" long, is mainly a vegetarian and therefore not often encountered in libraries.

Cockroaches were specifically mentioned as enemies of books by Ulysses Aldrovandus in 1602. They were regarded as a pest in the Bahamas Islands in 1754, and as a scourge in China a hundred years later; in 1837 they were so abundant and ferocious in the West Indies that they attacked not only books but also the extremities of the sick and the dead.

In addition to gnawing books they emit a dark ink-line liquid which defaces the pages of books and anything else across which they scuttle.

The silverfish, *Lepisma saccharina,* has received many names: silver-moth, sugar-louse, sugar-fish, fish-moth, and slicker, are some of them. Occasionally it has been confused with the bookworm. The English poet, Thomas Parnell, for instance, in his poem "The Book-worm," described what was unmistakably a silverfish:

> Dreadful his head with clustering eyes,
> With horns without, and tusks within,
> And scales to serve him for a skin.
> Observe him nearly, lest he climb
> To wound the bards of ancient time,
> Or down the vale of fancy go
> To tear some modern wretch below . . .
> Insatiate brute, whose teeth abuse
> The sweetest servants of the Muse . . .

Entomology was evidently not Parnell's strong subject since in addition to misnaming the subject of his inspiration he was uncertain if the damage it did was executed with "tusks" or "teeth." There is no

doubt, however, that this small glistening silvery grey creature with its two antennae, spike-like tail, and two terminal filaments, does achieve considerable damage in libraries. Silverfish feed on starch, the sizing in paper, and on glue. To get at glue they damage the binding of books, especially when they are of leather, ordinary cloth or rayon fabric; they eat gum from postage stamps, envelope flaps, and date labels; they gnaw holes in papers, prints, photographs, catalog cards, and cardboard boxes. Although most active at night, they may be encountered at their work of destruction during the day in dark places such as drawers of desks.

Firebrats, *Thermobia domestica,* are very similar to silverfish in appearance but they thrive best in bakehouses, kitchens, and furnace rooms, where the temperature is about 100° F. Few libraries, even in the tropics, experience indoor temperatures as high as this, and firebrats, therefore, are only rarely encountered in libraries.

Psocids, or book lice, are small grey or pale yellow insects with soft bodies and jaws well developed for the purpose of chewing. They may sometimes be found among elderly little-used volumes that have become damp, and it is alleged that they injure the bindings of such books by eating the paste or glue. It seems more likely that they feed on the micro-fungi which form under damp conditions of storage and, consequently, that they may be exonerated from the charge of bibliophagy.

In an article which appeared in the *New York Times Book Review* in January 1933, it was claimed by P. Brooks that "the ordinary ravages of time, through climatic conditions, wind and weather, fire and flood, have been mild as compared with the damage created by the lowly worm." This "worm" is actually the larva of a beetle, or rather the larvae of one hundred and sixty species of beetles. The most notorious are the following:

Sitodrepa paniceum, the drugstore beetle. This species is cosmopolitan; it is said by Brooks to be "capable of eating arsenic and lead —in fact, anything except cast iron;" and each female of the species may produce more than 800,000 descendants in a single successful year of egg-laying. It was this pest which invaded the Huntington Library in the early 1930's.

Lyctus brunneus Ptinus fur, the powder-post beetle. The larvae of these bore long cylindrical holes in books and book shelves. *Ptinus fur* is the widely known spider beetle first mentioned by Linnaeus in 1766.

Anobium punctatum, the common furniture beetle. The larvae pack their holes with flour-like frass so that nothing substantial remains of the shelf or door jamb they are eating.

Catorama mexicana, the Mexican book beetle. This is abundant in Hawaii and a related species has caused great damage in libraries in Brazil.

Dermestes lardarium, the larder beetle. A glutton for cheese, hams, etc., this species is also guilty, when nothing more appetizing is available, of devouring the leather bindings of books.

Rhizopertha dominica. This has injured bindings in the library of the School of Tropical Medicine, San Juan, Puerto Rico.

Most of these bookworms are small dark brown or reddish-brown beetles. They fly into libraries through open or unscreened windows or crawl in below ill-fitting doors. The larvae will destroy anything from the Library of Congress printed catalog to a fragile palm-leaf manuscript.

Robert Burns, who was a better entomologist than Parnell, wrote of bookworms, when visiting a nobleman's library:

> Through and through the inspired leaves,
> Ye maggots, make your windings;
> But, oh! respect his lordship's taste,
> And spare his golden bindings.

But it requires more than poetry to stop a bookworm.

The Brown House, or False Clothes, moth, *Hofmannophila pseudospretella,* occurs in North America, across northern Europe and Asia from France to Eastern Siberia, and in Ceylon, India, Australia, and New Zealand. Its appetite and digestive ability allow it to devour such varied delicacies as corks in wine bottles, poppy capsules, and bales of rabbit hair; in libraries it injures cloth and calf leather bindings but leaves books bound in morocco leather untouched.

The mosquito-wire mesh that has to be provided over windows, vents, and grilles, in order to exclude insects from tropical libraries, seems to provide what the mud wasp—known in the Sudan, Kenya, and other parts of Africa as "mason hornet" and in Trinidad as "potter wasp"—regards as the ideal foundation upon which to build its nest of hard mud. If allowed access to a library the mud wasp will cement its nest to the rear edges of books as they stand on the shelves, to the corners of bookcases and to map and manuscript rolls. In spite of its fearsome appearance and its disconcerting interests in human earholes

it does not attack either library staff or books, but its mud has strong adhesive qualities and cannot be tolerated. (The blade of an assegai is the ideal tool with which to scrape nests of mud wasps from walls, window frames, and mosquito-wire.)

Most libraries in newly developing countries attract at least some of these hungry hordes of insects or have to contend with others the depredations of which are local and less spectacular. At the end of the last century the Institute of Jamaica in Kingston gained valuable experience in countering the attacks of bookworms and cockroaches. This was followed by experiments in insect control in Barbados and Hawaii. In 1910-19 research was conducted in British Guiana, Fiji, India, the Philippines, and Puerto Rico; in 1920-29 Trinidad was also concerned; and in the decade after 1930 Bermuda, Cuba, and Malaya were actively involved. In every territory in the tropics librarians have had to take steps to protect books from insects.

Much research carried out in temperate and technologically developed countries has been applied in less advanced areas. In particular, important work has been carried out by the Bureau of Entomology and Plant Quarantine of the U.S. Department of Agriculture. In 1929–33, also in the United States, under the auspices of a committee of the National Research Council, intensive studies, in which insects received their share of attention, were made concerning preservation of records; and in 1937 the National Bureau of Standards published a revised edition of the report by A. E. Kimberley and B. W. Scribner, which has proved so valuable not only inside the United States but also in several tropical countries.[5]

The second world war gave impetus and urgency to research, mainly by governments and manufacturing firms, into more effective ways of insect-proofing textiles, leather, cardboard cartons, and wrapping papers. In England, the Printing, Packaging and Allied Trades Research Association did valuable work; as also, in Italy, did the Instituto di Patologio del Libro.

Perhaps the major battle, fought out on more, and stranger, fronts than have existed in any war of man against man, has been against termites. To combat subterranean termites, poisoning of the soil under libraries and around the walls of buildings, has been carried out in many countries. Solutions containing trichlorobenzene, pentachlorophenol, and sodium arsenite, have proved effective; recently there seems to be a tendency for these to yield place to dieldrin. In West Africa the manufacturers of dieldrin recommend that building

sites should be treated with a diluted emulsion consisting of one gallon 20 per cent Emulsion Concentrate to 80-100 gallons of water, which should be applied to foundations at the rate of one gallon to every two feet of open trench or sprayed, one gallon to five square feet of surface area, before floors are laid. If buildings have already been erected without termite proofing, the emulsion may be applied in narrow trenches on the outside (and inside, if possible) of walls, and flooded through holes in floors. It may be sprayed on walls and woodwork, half a pint of dieldrin 20 per cent Emulsion Concentrate diluted with one gallon of water, to the point of run-off.

A recent example of a termite invasion is that which occurred in 1957 in the library of the Institute for Medical Research, Kuala Lumpur, Malaya. There the Public Works Department removed parquet flooring, bored holes two feet deep at five feet intervals both outside and inside the library walls, and poured three gallons of dieldrex emulsion into each of over ninety holes.

It has been found that earth-dwelling termites may readily be killed, also, by introducing Gammexane smoke or DDT, under pressure, into their tunnels. Termites have the habit of licking each other and then, if the licking is too vigorous, as sometimes happens, and the termite being groomed suffers an injury, it is at once killed and eaten by other termites. This means that when one termite dies of poisoning, whether from Gammexane smoke, Gammexane dust, DDT, or perhaps through picking up white arsenic or Paris green, and promptly becomes a meal for its friends, the process of poison and hygienic cannibalism continues throughout the termitary as long as the poison remains lethal.

Wood-dwelling termites, when already in buildings, have been eradicated by submitting the buildings concerned to thorough fumigation with hydrocyanic gas or methyl bromide. Professional fumigators are essential if these highly dangerous gases are employed.

If the use made of cedar oil more than three thousand years ago in the Mediterranean countries may be discounted, the practice of varnishing books in order to preserve them seems to have originated in China. A mixture of five drams of mercuric chloride, 60 drops of creosote, and 2 pounds of alcohol, was already in use in Swatow in 1887.

By 1900, mercuric chloride, with other less lethal ingredients, was being used also in the West Indies and Australia. Since then its use has become worldwide.

In Puerto Rico, before the first world war, a varnish consisting of 1 liter of wood alcohol, 30 grams of carbolic acid, and 15 grams of mercuric chloride, applied once every six months, was found successful in preventing damage by cockroaches.

In Fiji, in 1930, a solution comprising 1 ounce of mercuric chloride and 1½ ounces of carbolic acid in a quart of methylated spirits containing pyridine, was employed. In this instance the lids of the books were varnished afterwards with shellac.

About the same time, the Department of Agriculture in Ceylon was adding ammonium arsenite to 1 ounce of mercuric chloride in a pint of rectified spirits. The efficacy of the ammonium arsenite was said to be increased by addition of beechwood creosote.

In Cuba, in the early 1930's, 20 grams of mercuric chloride and 25 cc. carbolic acid, in 1,000 cc. methylated spirits, with gum shellac added to make the liquid slightly adhesive, was found to be satisfactory, although it was necessary to varnish with it twice a year.

During the 1930's, also, the library of the Imperial College of Tropical Agriculture, Trinidad, which was a pioneer library in preservation of books against insects, used a mixture of 5 grams of mercuric chloride and 60 drops of creosote in 600 cc. of strong white Barbados rum, the rum being used because it was cheaper than alcohol. At the present time this library uses a slightly different formula: 16.7 grams of mercuric chloride and 10 cc. of creosote, made up to 2,000 cc. with alcohol.

In Singapore, the University of Malaya Library uses a very successful solution made up of 1 ounce 146 grams of mercuric chloride, 2 pounds 10 ounces 292 grams of shellac, 10 ounces 292 grams of resin, and 10 fluid ounces of creosote, in 4 gallons of methylated spirits. This leaves a slight stain on end-papers but its effectiveness lasts for years.

In Ghana, at the University College near Accra, a solution of 1.6 ounces of mercuric chloride and 0.5 per cent (volume to volume) of beechwood creosote in one gallon of methylated spirits, is used.

At University College library, Ibadan, Nigeria, the mixture is 5 ounces of mercuric chloride and 5 ounces of phenol in 2 gallons of illicitly distilled gin, the last being captured and supplied by Ibadan police. (The librarian points out that the gin may "possess some virtue not yet recognized by science.")

The University of Natal, Union of South Africa, employs a substance known as "Bourne Plastic" which is manufactured in Johannes-

burg and sold as a finish for floors and furniture. If twice the amount of "thinners" recommended by the manufacturers is added it is very suitable as a book varnish giving protection against cockroaches. The formula has not been disclosed.

All these varnishes are generally applied to books with a paint brush or feather, which is drawn carefully along "the inside edges of the front and back covers, down the section joints, in the hollow between the spine of the book and the binding and on the top, bottom and fore edges," as described by the librarian of the University College of Ghana. Sometimes the entire lids and spine of the book are coated with varnish, but in every instance care has to be taken to avoid gilt lettering.

In the last few years employment of a lacquer with urea-formaldehyde as a vehicle for dieldrin or aldrin has been tried out with some success. "Insecta-Lac," containing dieldrin, has been successfully employed in the West Indies, Zanzibar, and the library of the Nigerian College of Arts, Science and Technology, Zaria, Nigeria. The manufacturers of dieldrin are cautious in their claims for it, but there is no doubt that it can rid libraries of all creeping and running insects such as cockroaches, silverfish, and perhaps bookworms, if applied to the bookshelves, library furniture and fittings, instead of to the books. There is a likelihood, in fact, that it will not be necessary to varnish books in reference libraries in the future. It will suffice to varnish the book shelves, window sills, doorways, and any cracks, crevices and corners where insects of crawling habits may be expected to hide. Books lent for home reading will still need to be protected by varnish, as they will be exposed to danger immediately when they are taken from library premises. In the tropics interlibrary loan schemes must, inevitably, be affected by the dangers to which books are exposed when in transit.

One recent development: earlier this year it was announced that the Centre National de la Recherche Scientifique (C.N.R.S.), in Paris, has available for sale a new wax—wax 212—which may be applied to bookbindings as an insecticide and fungicide and which may be preferable to any kind of book varnish. Six colors are available and samples may be obtained from the restoration workshops of the Bibliothèque Nationale, 58 Rue de Richelieu, Paris—2e.[6]

Many libraries in regions where damage to books by insects is an ever present possibility have constructed special fumigation chambers. For many years the Institute of Jamaica used a gas-tight box

in which affected volumes were treated with carbon disulphide. The Insular Library at San Juan, Puerto Rico, used a specially built gas-tight cupboard in the library basement. The Bibliotheca Bogoriensis, in Java, Indonesia, has a strongly constructed "gas chamber" built separately from the library: its interior is shelved; books are placed on the shelves with their pages fanned out, and exposed to methyl bromide, which is blown about inside the chamber by an electric fan turned on from outside after the heavy iron door has been closed. The new Raffles National Library in Singapore is also to have a special fumigation chamber.

It has been on record for more than seven hundred years that micro-fungi have a deleterious effect on paper. In 1221 Frederick II, Holy Roman Emperor, decreed that all acts recorded on cotton paper were invalid and, within a term of two years, must be transcribed on parchment. The reason given for this ruling was that the paper of that time was of poor quality and suffered from the attacks of moisture and insects.

There have been many efforts to discover how fungi can be prevented from growing on book covers. It is mainly in the present century, however, during which so many notable libraries have been established in tropical climates, that the problem has become acute.

In the last two decades damage has been reported from Bangkok, Bogor, Djakarta, Freetown, Havana, Ibadan, Kingston, Kuching, Lagos, Manila, Mombasa, Panama City, Port-au-Prince, Port-of-Spain, Rangoon, Saigon, and Singapore. Throughout the humid tropics any library where the relative humidity is higher than 75 per cent and the air temperature between 65° F. and 85° F., must expect moulds to grow on many of its books. The optimal temperature for growth of the majority of fungi, according to *British standard 1133, section 5* of 1951, is about 77° F., and L. D. Galloway and R. Burgess in their *Applied Mycology and Bacteriology* mention a relative humidity range of 85-95 per cent as conducive to growth although they point out that certain mould fungi are capable of slow growth at 75 per cent relative humidity.[7]

Fungi grow more readily upon certain book covers than upon others. A chrome-tanned leather is said to be highly resistant to moulds. A smooth finish is less conducive to growth of mould than a rough or "tacky" surface, probably because it does not retain dust, in which mould is always likely to grow.

Librarians have tried to prevent the growth of mould in several

different ways: by the air conditioning of libraries; by constant manual dusting of books and provision of fans to insure constant movement of air; by the application to book covers of various lacquers, such as those containing shellac, phenol, paranitrophenol, and urea-formaldehyde; by fumigation with formaldehyde gas, methyl bromide, or thymol vapor; by shelving books in lockable glass-fronted bookcases with an electric bulb left burning inside to dry the air (this is still done in libraries in Singapore and New Delhi); and by general diffusion of napthalene vapor or thymol. A formula for book lacquer which is said to give complete protection from mildew (and cockroaches) in the University of Florida library, is as follows: [8]

Ethyl cellulose (Type N—7)	10 ozs.
Shirlan Extra	½ oz.
Xylol	3½ quarts
Butanol	6 ozs.

Several chemical compounds, such as phenyl mercuric nitrate ("merfenil"), pentachlorophenol, betanaphthol, and paranitrophenol, are known to protect leather; Shirlan, the wartime discovery, protects cotton cloth; and, according to Galloway and Burgess, "minute traces of acetaldehyde or of ammonia in the storage atmosphere completely inhibit fungal growth." [9] It would seem, therefore, that periodic air disinfection of libraries by means of aerosol antiseptics is a field of research that may yield valuable results in the future.

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