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FIRST STEPS OF ENTOMOLOGICAL RESEARCH IN ISRAEL

Z. Avidov

In memory of the late
Professor F.S. Bodenheimer

A B S R A C T

Organized entomological research began half a century ago in Israel. Diverse aspects of taxonomy, phenology, biology, ecology, ethology and physiology were studied, with special reference to plant pests and their natural enemies. Some of these studies, carried out during the years 1922-1930 are recapitulated, the approach of research workers in those days being especially emphasized.

In Israel, as in other middle Eastern countries, insects were collected only irregularly in the past, mostly by interested visitors from Europe. The Jordan Valley, with its rela- tively rich insect fauna which belongs to different zoogeo- graphical zones, especially attracted collectors of Lepidop- tera and Hymenoptera. Nothing would have been known about local insects until the beginning of the present century without these taxonomic studies, usually undertaken with private means and without any organization.

Only a few words are needed to recount the entomological work conducted during the first two decades of this century.

The first scientific publication by a local zoologist was made in 1916, by Aharoni, who noted observations on "*Eurytoma* sp., a new pest of almonds" (the almond fruit wasp, *Eurytoma amygdali* End.). The desert locust, *Schistocerca gregaria* (Forsk.) invaded in vast swarms from the Sudan into the then-called Palestine in 1915 and caused much damage to plants. Aharoni (1920) described the developmental stages of the insect, observed its behaviour after the invasion and discussed the then-known methods of control.

Among authors from abroad who published on insect pests in Palestine, there is only one detailed paper, on the phthiriosis of the grape-vine by Mangin and Viala (1903), and some short notes on the grapevine smoky moth, *Theresimima ampelophaga* (Bayle), by Giard (1904) and on pests of almond trees by Blair (1920).

The year 1922 can be marked as the beginning of organized entomological research in Israel. Two places of entomological work were established in that year: the Entomology Department of the Agricultural Experiment Station of the Palestine Zionist Executive (now known as the Volcani Institute of Agricultural Research) and the Plant Protection Department of the British Mandatory Government. The main task of the Government Department was the implementation of the Plant Protection Ordinance: prevention of importation and propagation of plant pests. The Entomology Department of the Experiment Station therefore specialized in reseach, most of the work being conducted by the late Professor F.S. Bodenheimer or under his aegis.

Half a century has passed since the beginning of entomological research work in Israel and it is desirable to recount its first steps. This paper deals only with work carried out during the 1920s and does not include research in medical entomology or history studies. It is, of course, impossible to mention all the various studies conducted in those days, their number being too large for such a brief history. Only studies which show the special approach of entomologists in those days to their problems, and their means of solving them, will therefore be recapitulated.

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"The first task without which no organized entomological activity was thinkable was the preparation of a pest-fauna inventory. Only 10-20 local pests were known by name up to then and of even fewer (*Schistocerca gregaria, Eurytoma amygdali, Pseudococcus vitis*) was known more than the name. Therefore, it was necessary to determine: 1. Which pests attack the various crops? 2. Which are economically the most important? 3. What is the life history of these important pests, at least in rough outline?" (Bodenheimer, 1930a).

More than 400 different pest species, beside the fortuitous ones, were recorded up to 1930. Many among them were found to be dangerous to their host plants and the life-history of some was investigated.

"The changing economic status of the various crop cultures during those years was confusing. In the beginning of the decade almonds, vine and cereals were named as the most important crops, as concerns pest control. Later came the big boom of tobacco growing quickly declined to a moderate dimension. Only during the last 3-4 years has the eminent importance of the citrus growing become marked... Vegetables acquired only lately economic importance .... the same goes for the growing of fruit trees, especially in the mountain region". (Bodenheimer, 1930a).

The result of these considerations was that in the very short period of eight years it was necessary to study the pests of very different plant cultures. Another difficulty is the climatic diversity in this small country, which influences not only the pests' distribution, but also their life history. The number of their annual generations and the date of their appearance and infestation on the host plants were found to differ in the various regions of the country.

Much of the land in this country was still a wilderness then, permanently or temporarely uncultivated. Vast swampy and rocky areas were turned into fertile fields in those days. The transition from barren land to cultivated fields brought about great changes in the insect fauna, which had to leave their original breeding grounds. Insects that formerly fed on wild plants only were therefore forced to search for other areas to live in. Among them were many species which encroached on tilled fields in their vicinity. But other species adapted themselves to the new host plants and became permanent pests.

Among these "residual pests" were various species of tenebrionid beetles (especially of the genera *Erodius, Mesomorphus* and *Opatrum)*,but also local species of grasshoppers, such as *Calliptamus palestinensis* Bodenheimer, caterpillars of the painted lady *Vanessa cardui* L. (Nymphalidae) and of the arctiid *Ocnogyna loewi* Zell. The main infested plants were tobacco, egg plants, corn, cucurbitaceous species, beets, vines and almond (seedlings recently planted). Various cultural methods to control their infestations and to prevent their spread to cultivated fields were developed and successfully used (Bodenheimer, 1926a).

The cereal leaf beetle, *Marseulia dilativentris* Reiche (Chrysomelidae), and the cereal leaf miner, *Syringopais temperatella* Led. (Scythridae) regularly spread from uncultivated or shallowly ploughed fields, thereby endangering young barley, wheat and oat plants. Both species occur in eastern Mediterranean countries and are feared by the native farmers. Investigations on their biology by careful field observations showed that these pests cannot survive in well-cultivated fields. Tilling by European deeper ploughs during summer therefore considerably decrease their populations (Bodenheimer and Klein, 1928; Bodenheimer, 1929).

The Angoumois grain moth, *Sitotroga cerealella* (Olivier) occurs in most countries of the world. Due to the very primitive nature of granaries in those days, grain losses in this country amounted to 20-25% of wheat and 10-15% of barley, while in corn it was only 5%. Furthermore it was found that infested wheat grain could not produce any plants, the reduction in infested barley being about 50%. The grain moth raises 5-6 annual generations in the coastal plain, laying a total of 80-180 eggs per female. One pair of moths should therefore produce about 30 billion moths during one year; actually, however, only 400-450 moths were produced. Due to extreme summer and winter temperatures this number was still further reduced, so that the number of moths does not differ much from year to year (Klein, 1930a).

The leopard moth, *Zeuzera pyrina* (L.) (Cossidae), was a serious pest of local olive trees. Its damage increased after grafting these trees with varieties imported from Europe, being even more severe on young apple trees which were then being planted in Jewish settlements. Due to favourable climatic conditions in this country the moth completes its development here in a single year. By cutting open more than one hundred leopard moth larval burrows in host plant trunks and branches, it was found that the structure and the course of these burrows were quite different in the two host plants (olive and apple). Means of control were then developed (Bodenheimer and Klein, 1927) which are still in use.

Information was received from various parts of the country during the years after World War I concerning the withering and dying-off of almond and apricot trees, sometimes extending to entire orchards. Buprestid larvae of the almond borer, *Capnodis carbonaria* Klug, and the peach capnodis, *Capnodis tenebrionis* L., were considered as the possible causal agents.

Several hundred trees, thought to be infested by these larvae, were rooted out and examined. The majority of these trees, most of which were still living, were free from any infestation. But up to 15 larvae were sometimes found in a single dead tree. It was concluded that *Capnodis* is generally only a secondary pest which infests weak, underdeveloped, dying or dead trees (and also sometimes very young trees in nurseries). The primary factor is the planting of threes in unsuitable soil, and the negligence of orchard cultivation during and after the World War. Uninfested, dying trees were quite often found under these conditions, and it was concluded that planting in suitable soil and continuous tree treatment may prevent infestations. Likewise, undeveloped or dying trees should be destroyed, in order to prevent the pest's development (Bodenheimer, 1930a).

Pomefruit tree cultivation was very limited in the Jewish settlements. At Petah Tiqwa one large fruit-bearing plantation of apple, pear and quince trees existed. The fruit was heavily infested by the codling moth, *Carpocapsa pomonella* (L.). Bodenheimer and Naim (1930) investigated the life-history of the pest during three years by careful observations and rearings using burlap bands for phenological and epidemiological studies. Fruits of the various varieties were examined at picking time. Among the authors' conclusions may be mentioned: the local (Arabic) apple varieties begin their blossoming a long time (ca. 1 $^{1}/2$ months) before the earliest European apple and pear varieties. Their presence, therefore, enables the pest to develop its first generation early in spring and gives rise to the enlarged population of the second general tion. The late pear varieties and especially the quinces, whose last fruits ripen as late as October, cause the prolongation of the developmental period and extend the moth's activity until autumn. The infestation rate greatly differed among the various varieties and it seemed to be proportional to their yield, but on the whole, climatic factors influenced the pest's epidemiology.

The most important pest of the fig tree was the fig wax scale, *Ceroplastes rusci* (L.). Bodkin (1927) investigated its life-history in the hill region, where the pest raises two annual generations. Although the number of eggs per female was about 1000, mortality of the crawlers was enormous, particularly caused in summer by climatic factors, but also by natural enemies. At the beginning of winter the small branches and twigs were sometimes incrusted with the females. The scales' sucking retards the development of young shoots and fruits; additional damage to the tree is caused by the sooty mold which develops on the honeydew excreted by the insects.

Larvae of the almond sawfly, *Palaeocimbex quadrimaculata humeralis* (Muell.) feed on leaves of stonefruit trees, particularly almonds in the hill region during early spring. Most of the leaves were sometimes devoured, thus retarding or arresting the development of the young fruit. Development of the immature stages takes only 4-5 weeks, much mortality of the young larvae being caused by hot and dry khamsin winds. The ichneumonid *Spilocryptus incubitor* Stroem. parasitizes the sawfly larvae a few days before they spin their cocoons. The biology of the pest and its parasitoid, both of which raise one annual generation, are thus very well synchronized (Bodenheimer, 1932a).

Many insect species multiplied their populations due to the intensification of vegetable growing during the 1920s in various parts of the country. Among these pests were aphids (on many host plants); the cabbage flea beetle, *Phyllotreta cruciferae* Goeze, and the oriental cabbage webworm *Hellula undalis* (F.), all attacking young cruciferous plants, and green leafhoppers of the genus *Empoasca,* infesting solanaceous plants. These leafhoppers were very active in summer, particularly on eggplants and tomatoes. Flowering and fruiting of heavily infested plants was greatly retarded. Experiments in controlling all these pests were carried out and achieved satisfying results (Bodenheimer and Klein, 1929).

Citrus industry started to prosper again some years after World War I, large new groves being planted in various parts of the country. At first the pest situation was not oppressing. But there was the menace that the Florida red scale, *Chrysomphalus aonidum* (L.), would spread from the north of the country - its distribution area in those days - to the main citrus center in the coastal area. The pest arrived there at the end of the third decade of this century. But quite soon other insect pests were threatening the citrus industry. This brought about extended studies on the Mediterranean fruit fly and on scale insects.

The Mediterranean fruit fly, *Ceratitus capitata* (Wiedemann), was actually already well known to the local citrus and apricot growers as a serious pest, but nothing was known about its life history. The first step of the investigation was to determine its various host plants and their seasons, and also the rate of their infestation. The fruits most frequently attacked were oranges, apricots, and peaches. Hosts of minor economic importance were apples, prickly pears, figs, bananas, guavas etc. Orange served the fly as winter shelter and there it developed from November until March. Afterwards the fly moved over to apricots and peaches which were its hosts from April until July. In summer, and until autumn, it lodged in the fruits of prickly pear, fig, apple, guava and other plants. The timing of the fly's attacks was due to the climatic conditions prevailing in the various areas and the available host plants. Therefore it differed in the Jordan Valley from the coastal plain or the Judaean hills. Using the formula of an equilateral hyperbola, developed by Pierce and Blunck, the developmental threshold and the number of generations in the various regions of the country were calculated (Bodenheimer, 1925a, 1925b). Natural enemies of the fly were not found locally, thus a request was made for its parasitoids. In the winter months of 1925/26, fly's pupae parasitized by the braconid *Opius humilis* Silvestri were shipped by boat from the U.S. Department of Agriculture Parasite Laboratory at Honolulu, Hawaii, to Alexandria, Egypt, in cold storage and from there by mail to Tel-Aviv. The journey took about six weeks. On the way 17 *Opius* adults emerged, but arrived dead, no more parasitoids emerging from this shipment (Bodenheimer, 1930a).

The first investigation on biological control in this country begun in 1925 and was directed against the citrus mealybug, *Planococcus citri* (Risso). During three years the life-history of the mealybug was studied by means of a great amount of laboratory rearings and the ecological details of its development were determined. Encouraged by reports of good biological control of mealybugs in California by the Australian coccinellid *Cryptolaemus montrouzieri* Mulsant, this predator was introduced from Egypt. After an extensive study on its biology in the laboratory and the orchard, it was concluded that the attempts to establish this lady beetle here ended in failure. The reason was that two very difficult seasons have to be tolerated in this country (as afterwards found also in Egypt and Algeria): a humid and cool winter and a dry, very hot summer. The favourable seasons, spring and autumn, were too short to enable a real recovery in the number of this lady beetle individuals.

Investigations were simultaneously conducted by mass rearings the local natural enemies of the mealybug. Among them the brown lacewing, *Sympherobius sanctus* Tjeder, seemed to be successful in controlling the pest and special methods for its mass rearing and release were developed. Large numbers of the gall midge *Dicrodiplosis* sp. sometimes appeared in mealy bug cultures, and were very troublesome in the rearings of the pest and its natural enemies. In the orchard, however, *Dicrodiplosis* showed no signs of controlling the pest. Some hymenopterous and dipterous parasitoids, lady beetles and predaceous mites were also found as natural enemies of the citrus mealybug, but they were of no practical significance in controlling it (Bodenheimer and Guttfeld. 1929).

Mass rearing of another scale insect predator, the Australian lady beetle, *Rodolia cardinalis* (Mulsant), began after a heavy outbreak of the cottony-cushion scale, *Icerya purchasi* Maskell in citrus groves of the central coastal plain, toward the end of the reported decade (Bodenheimer and Tenenbaum, 1933).

Studies of the life history of various scale insects, such as California red scale, *Aonidiella aurantii* (Maskell), the chaff scale, *Parlatoria pergandii* Comstock, and the Florida wax scale, *Ceroplates floridensis* Comstock, were initiated at about the same time. These included many field observations and especially long-term, systematic, monthly counts of the pests' populations. The aim of these studies was to follow the seasonal fluctuations of the pests in orange groves (the final results were published only much later: Bodenheimer, 1951).

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Agricultural entomology was of course the main task at the Agricultural Research Station. At the beginning information on the local pest fauna as well as on other insects was very meager. It is an established fact that sometimes unharmful insects may become injurious to plants, as shown above in connection with the residual pests. Thus it became necessary to collect as many insects as possible from the various parts of the country, in order to establish a general inventory of the insect fauna. This work was done from the first days in different ways; only the most intensive parts of the collection work will be noted.

Excursions were very often made to various parts of the country and insects collected, not only in the cultivated fields and groves, but also, and perhaps more, in their surroundings, the wild land. Scale insects, aphids, grasshoppers, beetles, and ants were systematically collected. Certain areas were marked in various parts of the country and insects (especially grasshoppers) collected fortnightly during a couple of hours. This method enabled the collector to draw conclusions about the phenology and ecology of these insects throughout the year.

At the beginning of the colonization of the "Emek" (Esdraelon Valley), in which large swampy areas were to be reclaimed, and before draining the Kabara-swamps in Samaria and also at the initiation of the restoration programme of the old neglected forests (the trees of which were heavily damaged by goats during the former regime), insects were collected before they were expelled or destroyed. Acetylene light-traps were set up at six places in various parts of the country to catch insects, especially moths and beetles which are active at night. All these collections were continued during the decade. Most of the insects collected in these different ways were forwarded to specialists abroad for identification.

The first publication of this work's results was on scale insects Bodenheimer, 1924) and gave morphological and phenological details on 65 species, eight of them being new to science. A second and a third note on the Coccidae of Palestine were soon to be published by the same author (Bodenheimer, 1926b and 1927).

The light-trap catches during 1925-1930 resulted in records of 261 beetle species, 174 of them being new to the local fauna. The large majority consisted of small to very small species of nocturnal habits. Their distribution over the different months of the year as well as the localities where they were caught in the traps were listed (Bodenheimer, 1932b).

Based on earlier literature and on results of the collecting, field observations and laboratory tests during the 1920s, all details of knowledge about the Orthoptera-fauna in Palestine, within the boundaries of the British Mandate, were summarized, with explanations of the zoogeography and ecology of these insects. Altogether 206 species were recorded, among them 18 blattids, 20 mantids, 1 phasmid, 39 tettigoniids, 22 gryllids, 93 acridids, and 13 forficulids (Bodenheimer, 1935). Some years earlier a key for the mantids and blattids of this country was published in Hebrew, which recorded 14 species of the former and 11 species of the latter family (Bodenheimer, 1926c).

Ants of Palestine collected during the years 1922-1928 were identified by Menozzi (1933). In this detailed list, with descriptions of species, keys and zoogeographic considerations, he recorded 26 genera with 48 species, 16 subspecies and 33 varieties.

Two small faunistic lists were published on lepidopterous species new to the local fauna wherein 100 micros and 70 macros were recorded. These species were reared from larvae or caught by light-traps (Bodenheimer, 1930b and 1932c).

In July 1927 an expedition set out by foot and camel through the Sinai Peninsula and towards its central part. The main aim of this expedition was the clarification of the origin of the tamarisk-manna. But insects were also collected in all localities on the way, desert and oasis. The number of the collected and recorded insect species was 216 and among them were three new genera and 15 new species. The main manna secreting insects on the tamarisk trees were found to be the mealybugs *Trabutina mannipara* (Ehrenberg) and *Naiacoccus serpentinus minor* Green, but honeydew was also found to be secreted in small extent by two jassid leafhoppers: *Euscelis decoratus* Hpt. and *Opsius jucundus* Leth. The results of this expedition were published in the form of a book (Bodenheimer and Theodor, 1929) in which other contributions by additional authors, on tamarisks and wheat in the Sinai-Peninsula, were also included.

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While studying the life-history of plant pests, many details of ecological importance were examined and recorded. General investigations in ecology were thus initiated, usually using plant pests as models. Most of the ecological work in those days was carried out to determine the influence of climatic conditions on the development and population growth of insects. The number of investigations and publications in this field was so great that it is possible to give here only a few examples.

Climatic conditions in this country differ very much in its various regions. There are considerable differences in the three main areas, namely the hot and dry Jordan Valley, the humid coastal plain and the cooler hills, during all seasons of the year. The same insect species may occur in these regions at different seasons and raise a different number of annual generations, as explained above. But in the same area there may also be climatic differences from year to year. The use of a formula to forecast the possibility of population increase under given temperature conditions could facilitate control arrangements in times of necessity. The equilateral hyperbola, developed by Pierce and Blunck, was selected for this purpose. Its application was very simple and it gave satisfactory results for various insects. The threshold of development and the amount of days-degrees needed for producing a single generation could be calculated on the basis of rearing data and the number of possible generations at different temperatures could then be computed (Bodenheimer, 1926d).

The so-called temperature preference of some storage insects was studied in Herter's temperature gradient chamber. It was concluded that such preference is a fiction, inasfar as only 4 to 6°C or even 10 to 14°C include in some cases 50% of all individuals. The temperature preference clearly depends upon the starting temperature. No relation was found between the monthly average temperatures and the preference (Bodenheimer and Schenkin, 1928).

A series of experiments was conducted on the influence of relative air humidity on the temperature preference of some beetles. At first the different humidities during the experiment in the gradient chamber had no influence whatsoever, but a prolonged stay at various humidities before the experiment provoked definite shifts, in dry atmospheres, inducing a progressive rise for over 14 days from 35°C to 37°C, in high humidities a drop from 35°C to 33°C, remaining stable at 60% relative humidity (Bodenheimer, 1930c).

A comprehensive study on the activity of the harvester ant, *Messor semirufus* E. André, and its dependence upon temperature and other factors was carried out during five consecutive years. Observations on the ants activity were made near the openings of 17 nests, once every fortnight, at three-hour intervals, by day and by night. The activity of the ants was graded and the number of outcoming individuals counted. Laboratory experiments were carried out to determine the temperature preference and the various activity grades; ants were kept in gypsum nests to examine their survival during the various months.

It was soon discovered that the ants' activities were not related to the ambient temperatures but depended upon those of the soil surface where the ants were moving. Two peaks of annual activity were found, in April and in December, and two nadirs, in January-February and in August. Outdoor activity was interrupted during winter, from November to March, at temperatures of 5 to 10°C, and in summer and autumn at temperatures above 30°C. The optimum for the ant workers was at 17-19°C. The greatest number of individuals was active during winter at noon, in spring in the evening, in summer throughout the night, and in autumn during the first half of the night. The rate of ant workers' movement on their paths was measured during all months of the year. The average speed (per meter and seconds) at various temperatures could be arranged as an equilateral hyperbola, but their zero points differed very much during the year. This phenomenon may depend upon changes in the physiological condition of the ants. Neither rain, hail, dew and wind, nor moonshine and darkness, influenced the activity of the ant workers.

Ant nests were dug and their structure was found to differ between heavy and sandy soils, and also in winter as compared to summer. The maximal length of the ants' path reached 150 meters. Not only seeds were gathered into the nest, but also very different and useless substances which were afterwards ejected (Bodenheimer and Klein, 1930; Klein, 1930b).

The ecology and epidemiology of the large cabbage white, *Pieris brassicae verna* Zell., was intensively studied with special reference to the influence of temperature and air humidity of its development and mortality. Many out- and indoor rearings of this butterfly were maintained during five years. The temperature had a dominant influence on the development of the insect's various stages, while the effect of air humidity was negligible. Air humidity was however highly decisive for the number of eggs, their mortality and the various larval stages. The fatal zones for development were above 26°C (100% egg mortality) and at 13°C or 60% relative humidity, respectively (no oviposition). Hence this species becomes extinct in this country every year during spring time (khamsin season), until it immigrates again in the autumn, coming from the North (Klein, 1932).

Observations were performed during two years on a certain plot in the sand dunes near Tel-Aviv. The appearance of insects was recorded every hour fortnightly, from sunrise to sunset. Special attention was given to two scarabaeid and two tenebrionid beetles, members of the most abundant coleopterous families there. Hourly readings of air, soil surface and soil (5 and 10cm deep) temperatures were taken. The activity, frequency and the actions of the beetles were concurrently noted. Of those beetle species that do not fly (Tenebrionidae), the running speed was measured at various times of the day. In conjunction with these field observations, experiments were conducted in the laboratory to find out the various activity grades and temperature preferences of the beetles. It was concluded that all the actions, such as starting of activity, beginning of flight and creeping into the soil depended upon the temperatures of the soil's surface. Hibernation of the beetles in their soil burrows was determined by the temperature in the ambient layer of earth (mostly 10 cm deep). The laboratory experiments closely confirmed the results of field observations (Klein, 1933).

The invasion of the desert locust, *Schistocerca gregaria*, during the late years of the decade initiated research on several ecological problems not hitherto solved. The work was done in the laboratory and in the field, among the vast swarms of hoppers. Rearing of eggpods at various combinations of temperature and humidity showed that mass hatching occurred mostly at 100% R.H. and at 30°C. That means that hatching is successful only in moist soil. Measurements in the field showed that intensive migration started only when the body temperature had reached about 27°C in the morning hours and ceased at noon at 40°C, and vice versa in the afternoon. It was possible to arrange a time table for the daily movements. The activity of the migrating hopper swarms depended to a wide extent upon the air temperature. In laboratory tests cold torpor of the locusts started at 4-5°C, normal activity begun at 23°C, and instantaneous death, due to heat, took place at 51°C. The preferred temperature arose with age: from 30°C of first larvae up to 41°C of young adults. The direction of the migration was the same in all places; the hoppers moved with the wind (Bodenheimer, 1930d).

The diet of most of insects is quite restricted, often to only one or two plant families, but frequently only to one or two genera or species. Polyphagous insects are likewise limited in their food selection and especially adapted to plants of their normal habitat. This was demonstrated in regard to two very polyphagous insects. Leaves of plants collected in fields, orchards and uncultivated land, as well as of newly imported plants in the acclimatization garden were offered to larvae of the arctiid *Ocnogyna loewi* Zell. About 175 different plant species, belonging to 62 plant families served in these tests. The amount of the frass was graded drom 0 - 3. The results showed that the average frass grade from indigenous plants was double (2.8) that of foreign (imported) plants (1.4). While the highest grade (3) was on 2/3 of the indigenous plants, the lowest grade (1), or no frass at all, were noted on 2/3 of the foreign plants (Klein, 1928).

In tests with adults of the cereal leaf beetle, *Marseulia dilativentris,* the average frass intensity was 6.6 times higher on indigenous (1.5) than on foreign plants (0.2). No frass grade of 2 or 3 was even noted on the foreign plants. The beetles refused to eat hard leaves of indigenous plants, like olive, oleander or carob, while other papilionaceous plants were willingly eaten (Bodenheimer and Klein 1928).

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Extension service was part of the duties of research workers in those days. This necessitated frequent visits to agricultural settlements throughout the country, where control recommendations were given after examination of the pest situation in the field and the orchard. These direct and permanent contacts with the farmers were very useful for the entomologists and directed them towards their future research work. These visits also made possible cooperative work, especially in control experimentation.

Not much was locally known in 1922 about pest control methods and their application. The relatively low yields, especially of cereals, did not leave a margin for pest control expenses. It was therefore desirable to recommend cultural control methods to prevent the appearance or development of pests in grain fields.

The one known pesticide was sulfur, but it was mostly used in vineyards, against mildew. It was thus necessary to introduce insecticides, such as the stomach poisons paris green, lead and calcium arsenate, the nicotin preparations, pyrithrins and rotenone as contact poisons. Hydrogen cyanide was used to fumigate against armoured scale insects on citrus trees placed under tents, but at the end of the decade this method was replaced by oil emulsion applications. Paradichlorobenzene was introduced into tree burrows to control the larvae of the leopard moth. Storage insects were fumigated with hydrogen cyanide or sometimes with carbon bisulfide.

The machinery for applying insecticides was very primitive; hand atomizers or small compressed air sprayers. Only at the end of the decade was the first motor sprayer introduced from abroad, concommitantly with the use of oil emulsions.

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Looking back to the 1920s one may say it was a pioneering epoch for entomological research. Lack of equipment and of easy transportation and communication aggravated the work and often prolonged the time of experimentation and observations. The entomologists sometimes had the feeling that their findings, most of which were new to science, were obtained almost too easily, like skimming milk. This gave them, of course, much satisfaction. Although the number of entomologists working here in those days was relatively small, the harvest was rich: on the basis of work done during 1922-1930 about 70 scientific publications (papers in journals, bulletins and books) and about 30 extension papers (bulletins, leaflets and articles) appeared. This work was the foundation for much scientific research in later decades and up to this day.

REFERENCES

Aharoni I. 126. *Eurytoma* sp., ein neuer Mandelschädling. *Tropenpflanzer* 19:317-322.

Aharoni I. 1920. Haarbeh (The desert locust). Jaffa, 86 p. (in Hebrew).

Blair K.G. 1920. Pests of almond trees in Palestine. *Entomol. Monthly Mag.* 56:13.

Bodenheimer F.S. 1924. The scale-insects (Coccidae) of Palestine. *Zion Org. Agric. Exper. Sta.,* Tel Aviv. Bull. 1, 120 p.

Bodenheimer F.S. 1925a. The Mediterranean fruit fly in Palestine. *Zion Org. Agric. Exp. Sta.,* Extension Circ. 2, 22 p. (in Hebrew, with summary in English).

Bodenheimer F.S. 1925b. On predicting the development cycles of insects. I. *Ceratitis capitata* Wied. *Bull. Soc. R. Entomol. d'Egypte* 1924:149-157.

Bodenheimer F.S. 1926a. First report on tobacco insects in Palestine. *Zion. Exec. Agric. Exper. Sta.,* Extension Circ. 11, 42 p. (in Hebrew, with summary in English).

Bodenheimer F.S. 1926b. Second note on the Coccidae of Palestine. *Bull. Entomol. Res.*17:189-192.

Bodenheimer F.S. 1926c. Introduction into the knowledge of the Orthoptera of Palestine. I. Mantidae and Blattidae. Sefer Haschanah 1925:1-19, (in Hebrew).

Bodenheimer F.S. 1926d. Ueber die Voraussage der Generationenzahl von Insekten. III. Die Bedeutung des Klimas für die landwirtschaftliche Entomologie. *Z. angew. Entomol.* 12:91-122.

Bodenheimer F.S. 1927. Third note on the Coccidae of Palestine. *Agric. Records* (Tel Aviv) 1:177-186.

Bodenheimer F.S. 1929. Two cereal pests characteristic for Palestine. *Hassadeh* 9:596-600 (in Hebrew).

Bodenheimer F.S. 1930a. Die Schädlingsfauna Palästinas. *P. Parey,* Berlin.

Bodenheimer F.S. 1930b. Zur Kenntnis der Microlepidopteren-fauna Palästinas. *Dt. Entomol. Z. Iris* 44:169-175.

Bodenheimer F.S. 1930c. Ueber die Temperaturabhängigkeiten von Insekten. III. Die Beziehungen der Vorzugstempe-ratur zur Luftfeuchtigkeit der Umgebung. *Z. vergl. Physiol.* 13:740-747.

Bodenheimer F.S. 1930d. Studien zur Epidemiologie, Oekologie und Physiologie der afrikanishchen Wanderheuschrecke, *Schistocerca gregaria* Forsk. (in collaboration with G. Fraenkel, K. Reich and N. Segal). *P. Parey,* Berlin.

Bodenheimer F.S. 1932a. Oekologische Beobachtungen an *Cimbex quadrimaculata* (Hym. Tenthr.) in Palästina. *Z. Pfl. Krankh. und Pfl. Schutz* 42:351-363.

Bodenheimer F.S. 1932b. Studies on the ecology of Palestinean Coleoptera. I. Coleoptera at light-traps. *Bull Soc. R. Entomol. d'Egypte* 1932:52-65.

Bodenheimer F.S. 1932c. Beitrag zur Kenntnis der Lepidopteren-fauna Palästinas. *Dt. Entomol. Z. Iris* 46:93-96.

Bodenheimer F.S. 1935. Oekologisch-zoogeographische Untersu-chungen über die Orthopterenfauna Palästinas. *Arch. Nat. Gesch. N.F.* 4:88-216.

Bodenheimer F.S. 1951. Citrus Entomology in the Middle East. W. Junk, Hague.

Bodenheimer F.S. und Guttfeld M. 1929. Ueber die Möglichkeiten einer biologischen Bekämfung von *Pseudococcus citri* Risso (Rhy. Cocc.) in Palästina. *Z. angew. Entomol.* 13:67-136.

Bodenheimer F.S. and Klein H.Z. 1927. Studies on the life-history and the control of *Zeuzera pyrina* L. in Palestine. *Zion Exec. Agric. Exper. Sta., Agric. Records* 1:63-88.

Bodenheimer F.S. und Klein H.Z. 1928. Beiträge zur Kenntnis von *Marseulia dilativentris* Reiche (Col. Chrysom.) *Z. angew. Entomol.* 14:343-355.

Bodenheimer F.S. and Klein H.Z. 1929. The green leafhopper, a new pest of eggplants. *Agric. Exper. Sta.*, Leaflet 34, 3 p. (in Hebrew).

Bodenheimer F.S. und Klein H.Z. 1930. Ueber die Temperaturabhängigkeiten von Insekten. II. Die Abhängigkeit der Aktivität bei der Ernteameise *Messor semirufus* E. André von Temperatur und anderen Faktoren. *Z. vergl. Physiol.* 11:345-385.

Bodenheimer S.S. und Naim A. 1930. Studien zur Lebensgeschichte von *Carpocapsa pomonella* (Lep. Tortr.) in Palästina. *Anz. Schädl. Kunde* 6:73-79.

Bodenheimer F.S. und Schenkin D. 1928. Ueber die Temperaturabhängigkeiten von Insekten. I. Ueber die Vorzugstemperatur einiger Insekten. *Z. vergl. Physiol* . 8:1-15.

Bodenheimer F.S. and Tenenbaum B. 1933. *Icerya purchasi* Mask. and its control in Palestine. *Hadar* 6:32-34.

Bodenheimer F.S. und Theodor O. 1929. Ergebnisse der Sinai Expedition 1927 der Hebräischen Universität, Jerusalem. I.C. Hinrichs, Leipzig.

Bodkin G. E. 1927. The fig wax scale (*Ceroplastes rusci* L.) in Palestine. *Bull. Entomol. Res.* 17:259-263.

Giard A. 1904. L'*Ino ampelophaga*, ravageur des feuilles de la vigne en Palestine. *Rev. viticult.* 21:591-592.

Klein H.Z. 1928. Beitrag zur Kenntnis von *Ocnogyna loewi* Z. (Lep.). *Z. wiss. Ins. Biol.* 23:144-150.

Klein H.Z. 1930a. Zur Lebensgeschichte und Epidemiologie der Getreidemotte *Sitotroga cerealella* Oliv. *Anz. Schädl. Kunde* 6:97-100.

Klein H.Z. 1930b. Beobachtungen an Nestern von *Messor semirufus* E. André (Hym. Formic.) in Palästina. *Z. wiss. Ins. Biol.* 25:45-52 & 141-156.

Klein H.Z. 1932. Studien zur Oekologie und Epidemiologie der Kohlweisslinge. I. Der Einfluss der Temperatur und Luftfeuchtigkeit auf Entwicklung und Mortalität von *Pieris brassica* L. *Z. angew. Entomol.* 19:395-448.

Klein H.Z. 1933. Zur Oekologie einiger Dünenkäfer. *Z. wiss. Zool.* 144:240-261.

Mangin L. et Viala P. 1903. Sur la phthiriose, maladie de la vigne, causée par le *Dactylopius vitis* et le *Bornetina corium*. *Compt. Red. Acad. Sc. Paris* 84:397 ff.

Menozzi C. 1933. Le Formiche della Palestina. *Mem. Soc. Entomol. Ital.* 12:49-113.