Studies on the zoogeography and ecology of palaearctic Coccidae I-III

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The study of Coccidae has been restricted mainly to description of species and control of those forms which are injurious. Species of which the life-history is well known are very limited even in number. It is only recently that this extremely interesting group of insects has been studied by Vayssière, Balachowsky, and the writer (1) in connection with the problems of zoogeography and ecology. The following pages aim to extend our knowledge in these respects.

I. The zoogeography of Coccidae in the South Eastern Palaearctis.

1) Zoogeographical elements.

In the zoogeographical division of the southern Palaearctis we adhere closely to the phytogeographical classification of A. Eig (2). Its application to problems of animal distribution gives most satisfactory results, as the writer has shown in another paper (3).

We wish to restrict ourselves here to a sketch and tabulation ot this zoogeographical system. All these units are territorial, and characterize the main actual area of the species under consideration. They may be characterized by special conditions in annual cycles of temperature, precipitation and humidity as well as by special plant-associations and endemic genera and species. All of them possess a series of endemics in the systematic groups. These differences are more pronounced among the higher territorial units of the system.

Animal associations are certainly characteristic also, but our knowledge of them is very restricted at present.

The units of the Southern Palaearctis are:

Classe	Name	Abbreviation
I.	*Regnum:* Holarcticum	(Hol.)
1.	*Subregnum:* Palaearcticum	(P. arct.)
A.	Regio: Euro-Sibirica	(ES.)
B.	Regio: Mediterranea	(O. M.)
a)	Subregio: Tyrrheno - Lusitanica (Mediterranea Occidentalis)	(M. Occ.)
α)	Territorium: Andaluso-Canariensis	(A. C.)
β)	Territorium: Franco-Algerica	(F. A.)
b)	Subregio: Balcano - Syriaca (Mediterranea Orientalis)	(M. Or.)
C.	Regio: Saharo-Sindica	(SS.)
D.	Regio: Irano-Turanica	(IT.)
a)	Territorium adnexum: Mauretanicum	(Maur.)
II.	*Regnum:* Palaeotropicum	(P. trop.)
1.	*Subregnum:* Aethiopicum	(Aeth.)
A.	Regio: Sudano-Deccanica	(SD.)

Species distributed equally over two or more units are classified e. g. as: Mediterraneo/Irano-Turanian (M/IT), etc. Species which penetrate only slightly into another unit or which are very common in one region, but very rare in another, are recorded as a penetration only. An Eurosiberian species which occurs in small numbers, in Southern France, for example *Targionia alni* March., is characterised as ES., Penetration Med. Another important element among the scale insects are the cultural immigrants, mainly from tropical or subtropical regions. The tropical species very often remain restricted to hot houses or botanical gardens only, and their area remains limited. The subtropical immigrants on the contrary, thrive very well under the climatic conditions of the Southern Palaearctis.

We have analyzed 429 species of Coccidae, found over an area extending from the Madeira Islands to Turkestan. It must be realised that the Mediterranean territories are those which are by far the best explored. (Signoret, Targioni-Tozzetti, Marchal, Leonardi, Silvestri, Lindinger, Vayssière, Balachowsky, Bodenheimer, Mercet...). The Saharo-Sindian territory has just passed its first period of exploration

(Hall, Balachowsky, Bodenheimer). The Irano-Turanian territories are still practically terra incognita, but their exploration is now under

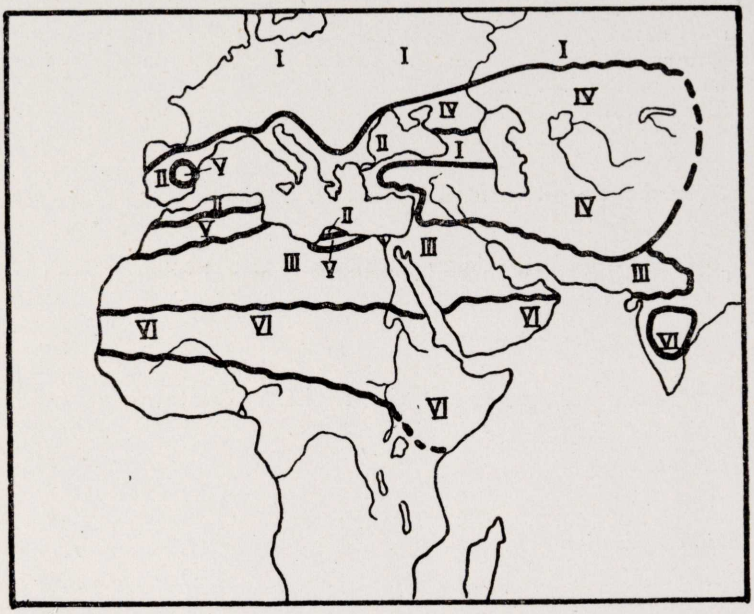

Fig. 1.—Sketch of the zoogeographical division of the south Eastern Palaearctis. I. Euro-sibirian Region; II. Mediterranean Region; III. Saharo-Sindian Region; IV. Irano-Turanian Region; V. Mauretanian territory; VI. Sudano-Deccanian Region (Palaeotropic).

way (Kiritshenko, Archangelskaia). The 429 species above mentioned may be grouped as follows:

Group	No. of species
Holarctic	11
Eurosibirian (Med. Penetr.)	25
Medit. / Eusib.	9
Omni-Mediterranean	41
Andaluso-Canarian	15
Franco-Algerian	92
Mediterranean Oriental	20
Med. / Saharo-Sindian	7
Saharo-Sindian	70
Saharo-Sindian / Irano-Turanian	5
Irano-Turanian	11
Mauretanian	7
Mediterranean / Irano-Turanian	12
Eurosibirian / Irano-Turanian	3
Sahara-Sindian / Sudano Deccanica	9
Palaeotropic	6
Cultural immigrants (mainly subtropical)	86
Total	429

This analysis gives a zoogeographical spectrum (cultural immigrants are excluded):

Holarctic	11	3,2 %
Eurosibirian	31	9,0 %
Mediterranean	182	53,1 %
Saharo-Indian	80,5	23,5 %
Irano-Turanian	28	8,2 %
Tropical	10,5	3,1 %
	343	100,1

In order to illustrate this classification, we choose some typical representations of all units (cf. Appendix, pp. 270-271).

The 23 endemic genera (16 of them containing one species only) are:

Saharo-Sindian	*Osiraspis* *Pseudotargionia* *Greenoripersia* *Monophleboides* [1] *Neomargarodes* [2]
Omnia Mediterranean	*Cryptaspidiotus* *Micrococcus* *Nidularia*
Mediterranean (Occid.)	*Mercetaspis* *Protargionia* *Parafairmairea* *Iberococcus*
Mediterranean (Orient.)	*Melanaspis* *Euphilippia* *Bodenheimera* *Marchalina*
Irano-Turanian	*Longisomus* *Spinococcus*
Mediterranean / Irano-Turanian	*Gueriniella*
Irano-Turanian / Saharo-Sindian / Mediterranean	*Adiscodiaspis* *Trabutina*
Irano-Turanian / Saharo-Sindian	*Najacoccus*

1 Some aethiopian species should probably be included in this genus.

2 An undetermined form, probably belonging to this species, was recently discovered by Kiritshenko in Ukrania.

The zoogeographical spectrum is at present merely an index of the actual exploration. There is little doubt that the Irano-Turanian element must be fairly rich, as well as the Saharo-Sindian element. It is certainly far poorer than the Mediterranean element, but may still gain in its relative percentage.

The percentage of the tropical element seems lower than it should be. This is partially at least due to the exclusion of cultural immigrants. All tropical and subtropical ubiquitous species have been included there. But it seems that some species at least had entered the territory before man had introduced cultural plants and may even have originated here. To this group belong: *Aspidiotus hederae* Vall., *Ceroplastes rusci* L., *Saissetia oleae* Bern. a. o. m.

We have a better view if we compare the zoogeographical spectrum of some countries (always excluding cultural immigrants):

Country	No. of species	Trop.	SS.	Med.	IT.	ES. + Hol. %
Egypt.......	81	19,8	60,5	14,8	—	5,0
Palestine....	86	6,4	29,1	46,7	11,1	6,9
Algeria.....	104	4,9	23,1	52,7	8,6	9,5
Italy........	85	3,5	1,2	66,2	2,0	27,1
Ukraina.....	62	—	2,4	21,8	33,9	41,9

Egypt is a typical Saharo-Sindian territory. The tropical influence is very important, even greater than the Mediterranean. The eurosiberian penetration is small, but the apparently complete absence of Irano-Turanian forms is remarkable.

In Palestine and Algeria the Mediterranean component is the most important, but the Saharo-Sindian element is still high. The Irano-Turanian penetration into Palestine is remarkable. In Algeria 7 out of 9 Irano-Turaniam species belong to the Mauretanian element. The higher percentage of Eurosiberian forms in Algeria is connected with the presence of boreal relicts like *Palaeococcus fuscipennis* Bär., etc., in the higher altitudes of the Atlas. The Mediterranean character in Italy is marked even more strongly than in the last mentioned countries. The higher Eurosiberian influx is explained by the fact that parts of north-eastern Italy really belong to the Eurosiberian territory.

The Ukraina is a mixed country: Eurosiberian in the north, prevalent Irano-Turanian in the south and Mediterranean in the south-eastern part of the Crimea.

This analysis confirms the soundness ot our zoogeographical division.

2) Historical elements.

The species of a given territory did not originate at the same period. Some may be autochthonous, while others immigrated at different epochs. From the middle of the tertiary period on we can follow and differentiate between the various historical influxes of groups in the southern Palaearctis. The historical element must be clearly distinguished from the zoogeographical one: *Orthezia arenariae* Vayss. is a northern immigrant, which has remained in the Atlas mountains. It has been existing there for a relatively long time and has formed an endemic species which belongs to the Franco-Algerian domain of the Tyrrheno-Lusitanian subregion; but historically it is a boreal element. *Antonina indica* var. *aegyptiaca* Hall again is a tertiary Palaeotropic relict. The species has a Palaeotropic distribution, but the variety is restricted to the Saharo-Sindian region (Egypt). It is zoogeographically a Saharo-Sindian element and historically a Tertiary Palaeotropic relict. The large majority of the Mediterranean, Saharo-Sindian and Irano-Turanian species (zoogeographical elements) belong to the Atlantic element historically. But Sudanian species participated in the formation of the Saharo-Sindian fauna, boreal species in that of the Mediterranean fauna and Central Asiatic as well as probably northern elements in the formation of the fauna of the Irano-Turanian region.

The main historical elements are:

I. Autochthonous elements.

A. Tertiary Palaeotropic relicts.

Many of these species are restricted to humid biotops, as *Pseudococcus variabilis* Hall., *Antonina* spp., etc. The genus *Cryptophyllaspis* has one representative in Madeira and the Canary Islands, three species in Ceylon, one in the Bismarck Archipelago. *Asterolecanium tenax* Bdhmr. from the Sinai has its nearest relatives in Ceylon. Other species, like *Chionaspis herbae* (Ceylon, Palestine, Sinai) are such relicts.

B. Diverse Palaeogenic elements.

Here are united a number of groups probably of very heterogenous character. They do not belong to any of the other groups, but were certainly present at the earliest times of the faunistic settlement of our territory. They are relicts of very old groups with large distribution. The distribution of the genus is generally very scattered. Of *Cerococcus,* for example, there exist:

4 species in South-Africa
5 » » Malaya
3 » » Australia
4 » » Neotropic America
7 » » the Franco-Algerian domain

of *Ctenochiton:*

14 species in Australia and New Zealand
2 » » Brazil and Mexico
2 » » the Southern Palaearctis.

C. The Atlantic element.

This element is really the most important basis for the following zoogeographical elements: Mediterranean, Irano-Turanian and Saharo-Sindian. It supplies the main fauna of the old Atlantic continent extending from Persia, Anatolia, parts of Northern Africa and some of the Mediterranean islands to the Canary Islands, Madeira and perhaps even to the West Indian Archipelago. The differentiation of the present regions began at the transition of the tertiary to the quaternary period, contemporaneously with the formation of the actual soil relief and the present climate. To these old Palaeoatlantic species may belong: *Hemiberlesia ephedrarum* Lind., *Chionaspis striata* Newst. and *Gueriniella serratulae* Sign. At this period the old Atlantic element differentiated into

1) the Palaeomediterranean element (Med. Region)
2) the Palaeosaharian element (SS. »)
3) the Palaeoiranian element (IT. »)

The Palaeomediterranean element is partly preserved today in most of the omnimediterranean species. There were two centres for the formation of new species, which resulted in the formation of:

1) the West Mediterranean element (Tyrrheno-Iberian species)

2) East Mediterranean element (Balcano-Syrian species)

The first group differentiated later into the Franco-Algerian and the Andaluso-Canarian domains.

The Palaeosaharian element had at least two old centres. The eastern part of that region is so little known that it is not advisable even to discuss the possibility of a third, more eastern centre.

The Palaeoiranian elements among the Coccidae as well as the Irano-Turanian region in general are so little known, that it is better not to speak of them at all.

II. Elements immigrant in later periods.

A. The Boreal elements (northern influxes).

1) Palaeoeuropean species may be called those species of old European stock which were forced by the progress of the glacial period to enter the north of the Mediterranean region. Today they show a mainly North-Mediterranean or North-Mediterranean / Eurosiberian distribution, as do: *Aspidiotus abietis* Schw., *Luzulaspis jahandiezi* Bal., *Sphaerolecanium emerici* Planch., *Ripersia montana* Newst., *R. tomlini* Green, *Orthezia arenariae* Vayss. and *Palaeococcus fuscipennis* Baer. from the Atlas mountains also belong to this group.

2) Angarian species are those wich originated in the Angara-continent (temperate Eastern Asia) and which penetrated into Europe after the glacial periods (in the pluvial periods of our territories). This element as remained relatively unimportant in all regions which are dealt with in this paper. There is no species of Coccidae, regarding which the writer believes it is possible to say with certainty that it belongs here. *Fonscolombea fraxini* Kalt., *Phenacoccus piceae* Loew, *Ceroputo pilosellae* Sulc *may* belong to it.

B. The Sudanian elements (south-western influxes).

Many species or their ancestors entered the Palaearctic region from the Sudan. In other groups such as *Tenebrionidae,* etc., we can easily distinguish between two waves of immigration, and older and a more recent, which is really still in progress.

(i) Palaeosudanian species are not present very clearly in Coccidae, but *Chionaspis berlesei* Leon., and *Saissetia oleae* Bern. may belong to it.

(ii) Neosudanian species are much more numerous. Besides, the large majority of the Sudano-Deccanian / Saharo-Sindian forms, the following may be recorded: *Pulvinaria serpentina* Bal., *Ceroplastes mimosae* Sign., *Halimococcus thebaicus* Hall, *Pseudaspidoproctus hyphaenicus* Hall.

C. The cultural immigrants (C. I.)

These are mainly species introduced into the territory, in their overwhelming majority accidentally, by human activity. Nearly all cultural immigrants belong here, except the few ubiquitous species which may have originated in the southern Palaearctis.

In this historic classification we have largely followed the views of B. P. Uvarov (4).

The relative importance of these historical elements for the Coccidae of different countries is:

Historic elements	Egypt		Palestine		Algeria		Italy		All species		All species including. C. I.
		%		%		%		%		%	%
Tropical relicts.......	13	16	3	3,5	4	3,8	3	3,5	19	5,5	4,4
Palaeogenic elements .	2	2,4	1	1,2	1	1,0	—	—	9	2,6	2,1
Atlantic elements.....	50	*61,7*	73	*84,9*	87	*83,6*	59	*69,4*	255	73,9	59,0
Boreal elements......	4	4,9	6	6,9	11	10,6	21	24,7	48	13,9	11,1
Sudanian elements....	12	14,8	3	3,5	1	1,0	2	2,4	14	4,1	3,2
Total..........	81		86		104		85		345		

The distribution of the Coccidae among the different historical elements is not always easily understood. It may tentatively be attempted for the Coccidae of Palestine:

Historical elements of the Palestinian Coccidae.

	No. of species	% of element
Tropical relicts................	3	2,6
Palaeogenic Elements..........	1	0,9
Atlantic Elements.............		66,1
Palaeo-Mediterranean..	32	
East-Mediterranean....	15	
Palaeo-Saharian.......	27	
Palaeo-Iranian.........	?	
Boreal Elements...............		5,3
Palaeo-European.......	6	
Angarian..............	—	
Sudanian Elements............		2,6
Palaeo-Sudanian......	—	
Neo-Sudanian........	3	
Cultural Immigrants...........	26	23,2

If we exclude the ubiquitous cultural immigrants, 80 to 90 % of the total fauna of the South-Eastern Palaearctis is autochthonous and the rest is Boreal or Sudanian. The Coccidae of the South-Eastern Palaearctis show a stock of autochthonous forms, with only a small fraction of immigrants since the middle of the tertiary period.

3) The Coccidae of Palestine; teir zoogeographical analysis.

Since the last publications (5) of the author a number of further species has been added to the list of Palestine Coccidae, which amounts today to 113 species. A full list is given here together with the localities and host plants of the species not recorded before as well as some additional data for recorded species, and certain corrections (C. I. = Cultural Immigrant).

Aspidiotus aharonii Bdhmr.	M. Or.
A. artemisiae Hall.	on *Achillaea fragantissima* and *Artemisia judaica* Koseima and Asfur (S. Pal.), Maan (Tr. Jord.) SS / O. M.
A. britannicus Newst.	O. M. / I. T., Pen ES and SS.
A. hederae Vall.	CI.
A. labiatarum March.	on *Thymelaea hirsuta*. Petra, Koseima. OM.
A. lataniae Sign.	CI.

To this species belong all records, previously given as *A. spinosus* Comst., which species has not yet been met in Palestine

A. ostraeiformis Curt.	O. M / I. T., Pen ES and SS.
A. zonatus Frauenf.	O. M / ES.
Hemiberlesia camelliae Sign.	CI.
H. herzlianus Bdhmr.	on *Ephedra*, Kadesh Barnea. EM/SS.
H. minima Leon.	on *Quercus ithaburensis*, Chedera OM.
H. nitrariae March.	SS.

Chrysomphalus aonidum L. (= *C. ficus*) / CI.

Chrysomphalus aurantii Mask. CI.

Ch. inopinata Leon. on *Pistacia palestina* M. O. at Petra.

Odonaspis ruthae Erh. on *Cynodon dactylum* near Amman P. trop. Jerusalem, introduced with lawn from Egypt.

Aonidia lauri Bché. O. M.

Targionia distincta Leon. O. M.

T. nigra Sign. on *Thymelaea hirsuta* and *Artemisia judaica* between Maan and Amman. Koseima O. M / SS.

T. vitis Sign. O. M.

Chionaspis berlesei Leon. On Chenopodiaceae at Kadesh Barnea SS / SD.

Ch. stanotophri Cooley (= *Ch. graminis aegyptiaca* Hall) SS / SD.

Ch. etrusca ssp. *engeddensis* Bdhmr.

This sub-species is the Saharo-Sindian form of the typical species, which is Mediterranean.

On *Tamarix* at Petra. SS.

Ch. evonymi Comst. CI.

Ch. herbae Green. P. trop.

Ch. noeae Hall. On *Haloxylon* at Maan. SS.

Ch. striata Newst. O. M / IT.

Lepidosaphes beckii Bché. (= *L. pinnaeformis*) CI.

L. bicuspis Hall. SS.

L. conchyformis Gmel.

This variable species develops a nanic form on the leaves. Repeated breeding of larvae from the same mother (*L. conchyformis*) always resulted in the typical form on the twigs and the nanic form on the leaves, which is different, as Mr. Green mainteins, from *L. minima*.

OM.

L. gloveri Pack. CI.

L. intermittens Hall. M. Or. / SS.

L. juniperi Lind. O. M. / I. T.

L. minima Newst. SS. ?

L. palaestinensis Bdhmr. M. Or.

L. ulmi L. ES.

Coccomytilus isis Hall.
On *Tamarix* sp. at Petra SS.
C. retamae Hall.
On *Retama retam* at Kadesh Barnea, Akaba / Maan, Petra, Beersheba SS.
C. zlocistii Bdhmr. M. Or.
Osiraspis balteata Hall.
On *Tamarix* sp. at Petra. Hall is quite correct in observing: «The female scales are not easy to find, being small and hidden in the smallest crevice». SS.
Pinnaspis aspidistrae Sign. C. I.
P. bilobis Hall. SS. / O. M.
P. zillae Hall.
On *Ephedra alta* between Akaba and Maan SD / SS.
Crypthemichionaspis africana Newst. SS.
Diaspis echinocacti Bché. CI.
D. syriaca Lind.
On *Pistacia palestina* near Jerusalem M. Or. (? IT.)
D. visci Schr.
On *Juniperus* at Petra ES / OM.
Epidiaspis gennadiosi Leon. M. Or. / (? IT.)
Aulacaspis rosae Bché. C. I.
Leucaspis ephedrae March. O. M.
L. pini Hart. (= *L. candida* Targ.) O. M. / E. S.
L. pistaciae Lind.
On *Pistacia* sp. at Petra M. Or. / (? IT.)
L. pusilla Loew. O. M.
L. riccae Targ.
On *Olea* at Haifa O. M. / I. T.
Parlatorea blanchardi (Targ.)
On *Phoenix dactylifera* at Koseima and Akaba SS.
P. ephedrae Lind.
On *Ephedra alta* near Katrani (Trans Jordania) SS / IT ?
P. judaica Bdhmr. O. M.
P. oleae Colv.
On *Nerium oleander* at Petra O. M.
P. pergandei Comst. C. I.

Pseudotargionia glandulosa Newst.
On *Acacia* sejal near Akaba, only scattered specimens
SD / SS.
Adiscodiaspis tamaricicola Mal.
On *Tamarix* sp. at Wadi Gharandal and at Koseima
SS. / (? IT.)
Eriopeltis festucae Fonsc. ES / Pen M.
E. lichtensteini Sign.
On Gramineae near Nahalal ES. / Pen M.
Filippia ephedrae Newst. O. M. ?
F. oleae Costa
On *Olea* at Jerusalem O. M.
F. striata March.
On *Ephedra* sp. at Wadi Musa and between Maan and Amman
O. M. ?
Euphilippia olivina Berl. M. Or.
Pulvinaria artemisiae Licht.
On *Artemisia* near Chedera O. M. / I. T.
P. discoidalis Hall.
On *Haloxylon articulatum* between Akaba and Maan S. S.
P. pistaciae Bdhmr. I. T. Pen M. Or.
P. subterranea Bdhmr.
The name proposed for the species living on the roots of *Rhus oxyacanthides* near Massada (1924, p. 71)
S. S.
Ceroplastes actiniformis Green C. I.
C. floridensis Comst. C. I.
C. mimosae Sign. S. D. / S. S.
C. rusci L.
On *Ficus carica* at Ain Musa C. I.
Lecanium hesperidum L. C. I.
Saissetia hemisphaerica Targ. C. I.
S. nigra Nietn.
On *Nerium oleander* at Petra. C. I.
S. oleae Bern. C. I.
Physokermes coryli L.
On *Pistacia palestina* near Jerusalem E. S. / I. T. Pen M.

Ctenochiton haloxyloni Hall.

On *Haloxylon articulatum* between Akaba and Maan S. S. / I. T.

Lecanopsis formicarum Newst.

On roots of a grass (? *Cynodon*) near Jerusalem, visited by *Tetramorium* sp. O. M. / I. T.

Aclerda ? berlesei Buffa.

On *Phragmites* near Chedera O. M.

Asterolecanium bambusae Boisd. C. I.

A. pustulans var. *sambuci* Ckll. S. D. / I. T.

A. variolosum Ratz. M / I. T., Pan ES.

Pollinia pollini Costa O. M.

Pseudococcus adonidum L. C. I.

Ps. citri Risso (= *vitis* Niedl.)

During winter *P. citri* may be found subterraneously on the roots of many plants, especially in *Citrus* orchards C. I.

Ps. lilacinus Ckll.

Recorded from *Ficus sycomorus* at Tel Aviv by Carmin and Schenkin C. I.

Ps. lindingeri Bdhmr. M. Or.

Ps. variabilis Hall. S. S. (? P. Trop.)

Ps. sacchari Ckll. C. I.

Trionymus daganiae Bdhmr. S. S.

Tr. euphorbiae Hall.

On *Euphorbia* near Amman, between the small leaves and the stem. S. S.

Rhizoecus falcifer Kunck.

On roots of *Cynodon dactylon* near Jerusalem O. M.

Ripersia artemisiae Hall.

On *Haloxylon* between Akaba and Maan
S. S.

R. asphodeli Bdhmr. M. Or.

R. phragmitis Hall.

On *Phragmites* at Wadi Misrarah near Tel Aviv S. S. / I. T.

Phenacoccus inermis Hall.

On the roots of *Neurada incumbens* on the sands near Tel Aviv
M / S. S.

Micrococcus similis Leon.

On the roots of a grass at Afule

O. M.

Antonina indica var. *panici* Hall.

On *Panicum* near Amman P. trop.

A. phragmitis March.

On *Phragmites* near Chederah

O. M.

Eriococcus araucariae Mask. C. I.

E. thymelaeae Newst.

On *Thymelaea hirsuta* at Kadesh Barnea.

On 1st of October the formation of the cocons was in progress.

? IT / Maur.

Trabutina palestina Bdhmr. SS / IT

On *Tamarix* sp. at Wadi Gherandal.

Najacoccus serpentinus minor Green SS / IT

On *Tamarix* sp. at Koseima and at Wadi Gherandal.

Bodenheimera racheli Bdhmr.

This species was originally described as *Lecanium*. The ericoccoid larvae of the species necessitated a change. Mr. E. E. Green is preparing a description ot the new genus. M. Or.

Nidularia pulvinata Planch.

On *Quercus ithaburensis* near Nahalal

O. M.

Kermes greeni Bdhmr. M. Or.

K. nahalali Bdhmr. M. Or.

Icerya aegyptiaca Dougl. C. I.

I. purchasi Mask. C. I.

Gueriniella serratulae Sign. O. M. / I. T.

Phoenicococcus marlatti Ckll.

On *Phoenix dactylifera* at Akaba S. S.

Orthezia urticae L.

On many herbs near Metullah (Upper Galilea) in June ES.

The zoogeographical groups are as follows:

Element or group	No. of species
SD / SS	5
P. Trop	3
SS	17
SS / IT	5
SS / M	6
O. M.	18
M. Or.	13
M / ES	3
ES	4
ES / IT	1
IT	2
M / IT	9
CI	26
Total	112

The zoogeographical spectrum of the Coccidae of Palestine, cultural immigrants excluded, is:

Element	M.	SS.	IT.	ES.	Tr.	CI.
No. of species	40	25	9,5	6	5,5	26
%	46,7	29,1	11,1	6,9	6,4	—

It is highly probable that the Irano-Turanian element is much stronger. It seems that the large majority of Saharo-Sindian species on *Tamarix* will prove to be SS/IT and likewise the Balcano-Syrian species of *Pistacia* may not be recorded hitherto from the Irano-Turanian region simply because the latter is one of the least known regions of the world with regard to its scale insects.

II. **Food relations of Coccidae.**

1) Host and vitality.

In current literature it is usual to summarize as host plants of the Coccidae all those plants on which a scale insect is found. This leads even to such host indications as: on «wooden box». It is quite obvious in the case in question that the wooden box is only an occasional habitat, lacking any ecological importance. In other cases similar relations are not quite as clear. In many species oviposition takes place on plants which are absolutely unsuitable hosts for the development of the larvae. It will be well to divide host plants into four groups:

1) Genuine hosts are those on which a normal development during the whole cycle takes place.

2) Tolerated hosts are those on which development during the whole cycle may take place, but the nutritional mortality is considerable.

3) Partial hosts are those on which older larvae may develop, but which are unsuitable for the development of the sensitive young larvae, especially of those freshly hatched.

4) Unsuitable hosts are those, on which no development whatsoever can take place. But the errant migrating females of *Monophlebinae* or *Eriococcinae* often deposit their ovisacs on plants of this type. This latter group should never be included in the regular list of hosts, and the third group should always be especially marked.

For *Icerya purchasi* Mask. *Citrus* is a genuine host, *Spartium junceum* a tolerated one, and the potato belongs either to the 3rd or the 4th group.

A few facts may illustrate the ecological influence of the host. In the hot interior valleys of California *Saissetia oleae* is of no economic importance on *Citrus*, but it is injurious on Olive. The climatic mortality is very high, but equally so on both hosts. The only difference is the high mortality of the young larvae on *Citrus*, their lower mortality on Olive. The difference is therefore conditioned purely by a differential nutritional mortality on both hosts.

The host also influences the egg production of the insect. *Icerya purchasi* Mask. produces 188 eggs per female on *Citrus*, 128 eggs per female on *Spartium junceum*. Those differences are sometimes very pronounced on different parts of the same host. The number of mature eggs produced contemporaneously by the female of *Chrysomphalus aurantii* is constant on the various *Citrus* species, but shows considerable and constant variations on the leaves and twigs and on the fruit:

Part of the plant	No. of observations	Average No. of eggs per female
Leaf..................	2.668	18,8
Green twig............	547	39,7
Fruit..................	780	18,8

There are some indications, that the nutrition of the host may be of high importance for the development of the scale. Thus *Pseudococcus lilacinus* Ckll. becomes injurious to the coffee plantations in Kenya only on acid soils, which are poor in exchangeable calcium. But recent experiments performed by the author with the aid of the Empire Marketing Board seem to indicate that the normal chemical manures have no decisive influence on the development of *Chrysomphalus aurantii* on *Citrus* (6).

2) Number of hosts and size of area.

There are other ecological aspects of the host relation which are of general interest. The first one is the correlation between the number of host plants and the size of the area of any one species. For this purpose we divided the territories around the Mediterranean into 20 areas. The number of species under investigation was 359, of which as complete lists of hosts as possible were compiled. The result is concentrated in table I (p. 256).

The two curves produced by plotting the data of this table in a system of coordinates are well known to the ecologist. The increase in area is accompanied by an exponential increase in the number of host plants per species (Fig. 2).

A species is more restricted in its area if the number of its host plants is limited. The greater the number of host plants, the larger is the average area ot any species. The explanation of this phenomenon is the fact that euryoec species — and polyphagy is a very important part of the euryoec character — are generally better adapted to a wider distribution.

The second diagram corresponds to the well known relation between number of species and size of area. Corresponding to the number of host plants per species the size of the area of a species grows quickly as long as the increase is from 1 to 8 hosts. Any

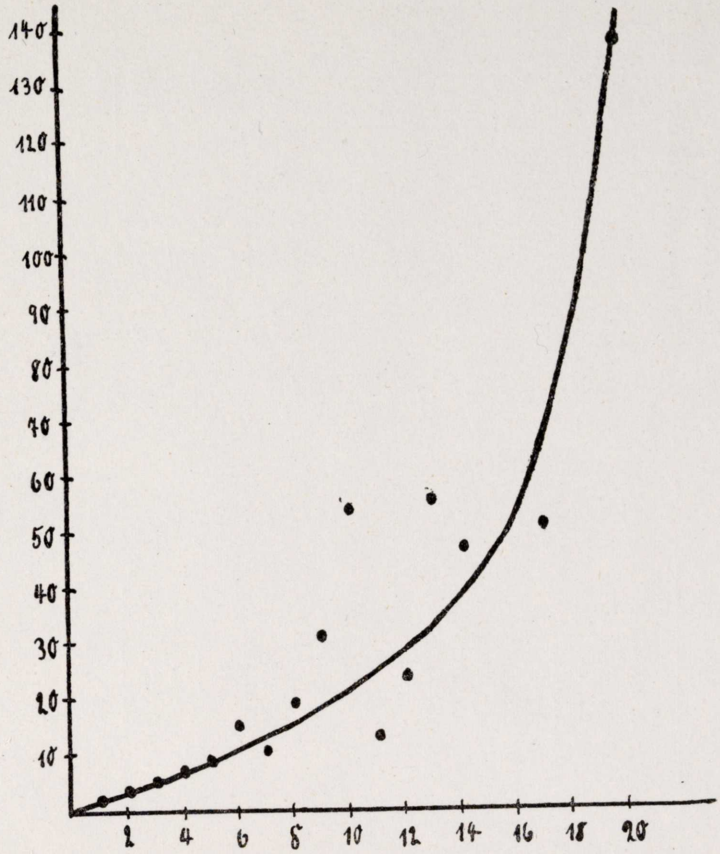

Fig. 2.—Correlation between number of host plants and number of areas occupied by species of *Coccidae*. At left: average no. of areas; below: no. of host plants.

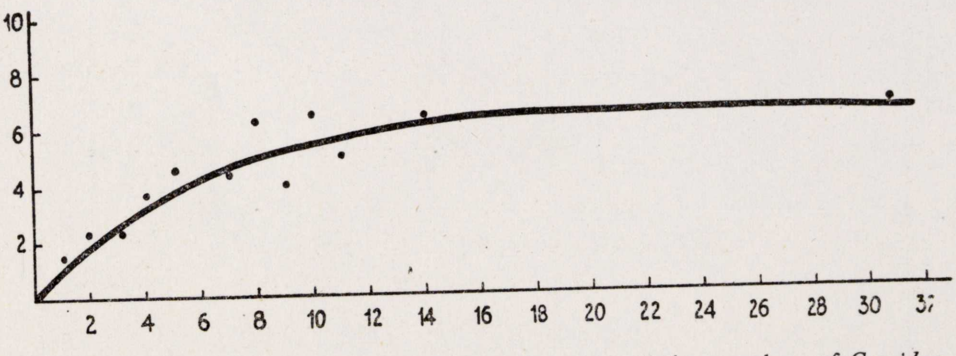

Fig. 3.—Correlation between the number of areas and the number of *Coccidae* inhabiting that number of areas. At left: no. of species of *Coccidae;* below: no. of areas occupied by these species.

further increase in the numbers of host plants adds relatively little to the size of area occupied by the species (Fig. 3).

Table I. Relation between number of host plants and size of area.

Nr. of areas.	No. of host plants. 1	2	3	4	5	6	7	8	9	10	More than 10 hosts:	Total species of hosts.	Total species of Coccidae.	Average Nr. of host plants.
1	102	25	12	5	1	1	3	—	—	—	12, 13, 72, 21	358	143	2,5
2	24	22	7	6	1	2	—	—	—	—	14, 83, 26, 18, 19	280	67	4,2
3	12	3	12	3	2	2	—	2	1	—	13, 62, 19, 19, 21	247	42	5,9
4	2	2	7	3	5	1	2	2	1	1	11, 14, 18, 27, 33	222	31	7,2
5	1	1	1	2	2	2	—	—	1	—	14, 23, 43	125	13	9,6
6	—	1	1	—	1	—	—	—	—	—	11, 35, 37	93	6	15,5
7	2	—	1	2	—	1	1	1	—	—	12, 43, 28, 33, 17	167	13	12,8
8	—	—	—	—	—	—	1	—	—	—	14, 29, 28	78	4	19,5
9	—	—	—	1	1	—	1	—	—	1	71, 16, 23, 34, 107	277	9	30,8
10	—	—	—	—	—	1	—	—	—	—	13, 102, 19, 62, 123	325	6	54,2
11	—	1	—	—	—	—	—	1	—	—	13, 11, 29	65	5	13,0
12	—	—	1	—	1	—	—	—	—	—	14, 57, 37	116	5	23,2
13	—	—	—	—	—	—	—	1	—	—	86, 72	166	3	55,3
14	—	—	—	—	—	—	—	—	—	—	33, 61	94	2	47
15	—	—	—	—	—	—	—	—	—	—	12	12	1	(12)
16	—	—	—	—	—	—	—	—	—	—	13, 17	30	2	(15)
17	—	—	—	—	—	—	—	—	—	—	56	50	1	56
18	—	—	—	—	—	—	—	—	—	—	—	—	—	—
19	—	—	—	—	—	—	—	—	—	—	—	—	—	—
20	—	—	—	—	—	—	—	—	—	—	117, 213, 95, 175, 97, 123	830	6	138,3
Total hosts...	213	133	110	81	66	42	35	45	12	13	172 [1], 130 [2]			
Nr. of Coccidae..	143	55	42	22	14	10	8	7	3	2	25 19			
Average area....	1,5	2,4	2,4	3,7	4,6	4,2	4,4	6,4	4,0	6,5	6,9 6,8			

[1] 14,6 (11-19) host plants.
[2] 30,6 (20-49) host plants.

It will be further observed that the number of species, which occur in 1, 2, 3, 4, 5, 6, 7 ... areas follows exactly one of the curves, which Willis presents in number in his book «Age and Area», i. e.: 147, 67, 42, 31, 13 ... This curve is also an exponential curve, as explained by Yule, but as Krogerus shows, it may be interpreted equally well as a hyperbola (7).

3) Host relations of endemic and introduced species of Coccidae.

Another aspect of the host relationship of Coccidae which is of general interest is a comparison between the fauna of introduced and of endemic plants. For this purpose we chose the Coccid-fauna of some plants in the territories around the Mediterranean Sea.

Table II. A. **The Coccidae of introduced plants.**

Host	Total No. of species	Cultural Immigrants	Endemic species
Bambusa	7	7	—
Citrus	26	24	2
Cycas	12	12	—
Eucalyptus	5	5	—
Livingstonea	9	9	—
Musa	11	11	—
Opuntia	12	12	—
Pittosporum	7	7	—
Total	89	87	2
For 100		97,7	2,3

All of the species on *Bambusa* are imported from the oriental region and adjacent territories. The two endemic species recorded from *Citrus* are *Aspidiotus britannicus* Newst. and *Parlatorea oleae* Calv., both very polyphagous species, and both are only of very occasional occurrence on that host. A very large part of the species living on *Opuntia* and other Cactaceae are introduced with the host plant from the Neotropic region.

We may therefore distinguish between very polyphagous cultural immigrants and between those cultural immigrants which were introduced together with their host and remained restricted to it. In order to give an idea of the comparison of such faunas we may compare the Coccids on *Bambusa* spp. (second group) with those on *Cycas revoluta* and *Musa sapientium* (first group):

Bambusa.	*Cycas.*	*Musa.*
Odonaspis secreta Ckll.	*Aspidiotus hederae* Vall.	*Aspidiotus lataniae* Sign.
Chionaspis bambusae Ckll.	*Aspidiotus lataniae* Sign.	*Chrysomphalus aonidum* L.
Lepidosaphes bambusae Kuw.	*Chrysomphalus aonidum* L.	*Chrysomphalus aurantii* Mask.
Coccomytilus bambusicola Kuw.	*Chrysomphalus dictyospermi* Morey.	*Lecanium hesperidum* L.
Tsukushiaspis pseudoleucaspis Kuw.	*Chrysomphalus aurantii* Mask.	*Ceroplastes rusci* L.
Asterolecanium bambusae Boisd.	*Howardia zamiae* Morey.	*Ceroplastes floridensis* Comst.
Asterolecanium miliaris Boisd.	*Sesakiaspis pentagona* Targ.	*Pseudococcus citri* Risso.
	Lecanium hesperidum L.	*Peudococcus nipae* Mask.
	Saissetia oleae Bern.	*Pseudococcus maritimus* Ehrh.
	Saissetia hemisphaerica Targ.	*Pseudococcus comstocki* Kuw.
	Pseudococcus citri Risso.	*Pseudococcus adonidum* L.
	Pseudococcus adonidum L.	

The obvious conclusion is that *introduced plants, which have no closely related species in the endemic flora are not suitable hosts for the endemic species of Coccidae.* Only a few of the most polyphagous species of the latter develop very occasionally on these hosts (Table II B).

It is obvious at a glance that the endemic flora is no obstacle to the cultural immigrants. 156 species living on the endemic plants among a total of 374 or 41,7 % are cultural immigrants. If we were to count the actual species concerned, their number would be reduced to about 40, since the same species reappear on many plants.

Table II. B. **The Coccidae of endemic plants.**

Host (Genus)	Total No. of species	CI.	ES.	M.	SS.	SP. resp. Trop.
Erica	11	3	4	4	—	—
Pinus	17	3	5	9	—	—
Quercus	35	4	9,5	21,5	—	—
Salix	26	12	9	3	1	1
Ceratonia	16	12	—	4	—	—
Cistus	13	4	1	8	—	—
Ficus	40	28	4	6	1	1
Juniperus	7	—	1	6	—	—
Laurus	19	14	—	5	—	—
Nerium	18	16	—	2	—	—
Olea	37	17	2	15	3	—
Pistacia	22	9	1,5	11,5	—	—
Ephedra	9	—	—	6	3	—
Artemisia	12	1	1	5	5	—
Phragmites	10	1	—	3	3	3
Panicum	13	1	—	1,5	8,5	2
Haloxylon	7	—	—	—	7	—
Tamarix	27	8	—	3	13	3
Acacia	22	15	1	1	—	5
Zizyphus	13	8	2	—	2	1
Total	374	156	41	114,5	46,6	16
For 100	100,0	41,7	10,9	30,6	12,5	4,3

Comparing the zoogeographical elements we realise that the intruders are generally more polyphagous than the endemic species and the highest percentage of oligo- and monophagous plants we find in the Mediterranean and Saharo-Sindian elements:

	CI.	Med.	ES.	SS.	Trop.	Total
No. of species	156	114,5	41	46,5	16	374
Polyphagous %	*98,7*	28,7	*70,8*	33,3	43,7	—
Mono-Olyphagous %	1,3	*71,3*	29,2	*66,7*	56,3	—

The origin and distributional character of the host may even be recognised from its scale insects (cultural immigrants excluded).

The genus *Erica* has 4 Eurosiberian and 4 Mediterranean species:

Eurosibirian species	Mediterranean species
Pulvinaria ericae	*Hemiberlesia ephedrorum*
Eulecanium franconicum	*Adiscodiaspis ericicola*
Eriococcus ericae	*Eriococcus devoniensis*
Orthezia urticae	*Anomostherium delassusi*

Among the Coccidae of *Cistus* only one species shows Eurosiberian character (*Asterolecanium fimbriatum* Fonsc.) but 8 species (*Parlatorea oleae* Calv., *Asterolecanium algeriensis* Newst., *Cerococcus cistarum* Bal., *Lecanodiaspis sardoa* Targ., *Ceroputo superbus* Leon., *Phenococcus tomlini* Green, *Gueriniella serratulae* Sign., *Orthezia arenariae* Vayss.) are purely Mediterranean.

Ephedra is prevalently Mediterranean (6 species: *Filippia ephedrae* Newst., *Filippia foucauldi* Bal., *Filippia striata* March., *Leucaspis riccae* Targ., *Leucaspis ephedrae* March., *Hemiberlesia trabuti* March.), but penetrates well into the Saharo-Sindian region (3 species: *Parlatorea ephedrae* Ldgr., *Crypthemichionaspis africana* Newst., *Pinnaspis zillae* Hall.).

The genus *Haloxylon* is purely Saharo-Sindian with 7 species: *Targionia dumonti* Bal., *Targionia haloxyloni* Hall., *Chionaspis noeae* Hall., *Pulvinaria discoidalis* Hall., *Ctenochiton haloxyloni* Hall., *Ripersia artemisiae* Hall., *Monophleboides gymnocarpi* Hall.

The genus *Acacia* (*Acacia sejal, Acacia tortilis*) is an intruder from the Sudano-Deccanian region, to which element 5 of its Coccidae actually belong: *Pseudotargionia glandulosa* Newst., *Pulvinaria serpentina* Bal., *Ceronema africana* Mefic., *Ceroplastes mimosae* Sign., *Lecanodiaspis africana* Newst. In addition we find the Holarctic and very polyphagous *Eulecanium corni* L. and *Phenacoccus farnesianae* Targ. The latter species may be of Mediterranean character, but it may also have been introduced from a tropical region into Southern France.

Some of the Mediterranean hard leaf shrubs have a very poor endemic fauna especially *Ceratonia siliqua*, *Nerium oleander* and *Laurus nobilis*. The endemic species are:

Ceratonia	*Laurus*	*Nerium*
Aspidiotus aharonii Bdhmr.	*Aspidiotus britannicus* Newst.	*Chionaspis nerii* Newst.
Chionaspis ceratoniae March.	*Aspidiotus lauretorum* Ldgr.	*Ceroplastes nerii* March.
Lepidosaphes conchyformis Gmel.	*Cryptaspidiotus aonidoides* Ldgr.	
Gueriniella serratulae F.	*Targionia laurina* Ldgr.	
	Aonidia lauri Targ.	
and 12 C. I.	and 14 C. I.	and 16 C. I.

III. **Life history and ecology.**

1) Importance of diapause and body temperature.

One of the leading entomologists of the United States has made the statement that the life history of the single species is and must be the basis for animal ecology. This is true, but unfortunately we have very few satisfactory life histories of scale insects. The life history of the Palestinian species as far as known will be discussed below. It will be useful to begin with some definitions.

The life cycle of an insect may be homo- or heterodynamic. In a homodynamic insect development is never broken. It may be interrupted because, for instance, the environmental temperature is below the development threshold of the species. But when the external temperature rises above this threshold, development immediately continues. One generation follows another. In the heterodynamic species development is interrupted at a certain period and the insect enters a torporlike resting stage with a minimal metabolism. This resting stage or diapause may be in the egg, larvae, pupal or even in the adult stage (before sexual maturity). The diapause may be induced by an unfavourable environment, but after its induction it is *not* broken by the return of optimal conditions. It breaks only at the end of a certain period, which generally seems to be fixed by heredity. Homo- and heterodynamy of a species are important ecological factors.

Some considerations seem to be worth while with regard to the body temperature of the Coccidae (8).

Many species, especially of *Diaspinae, Lecaniinae,* and some

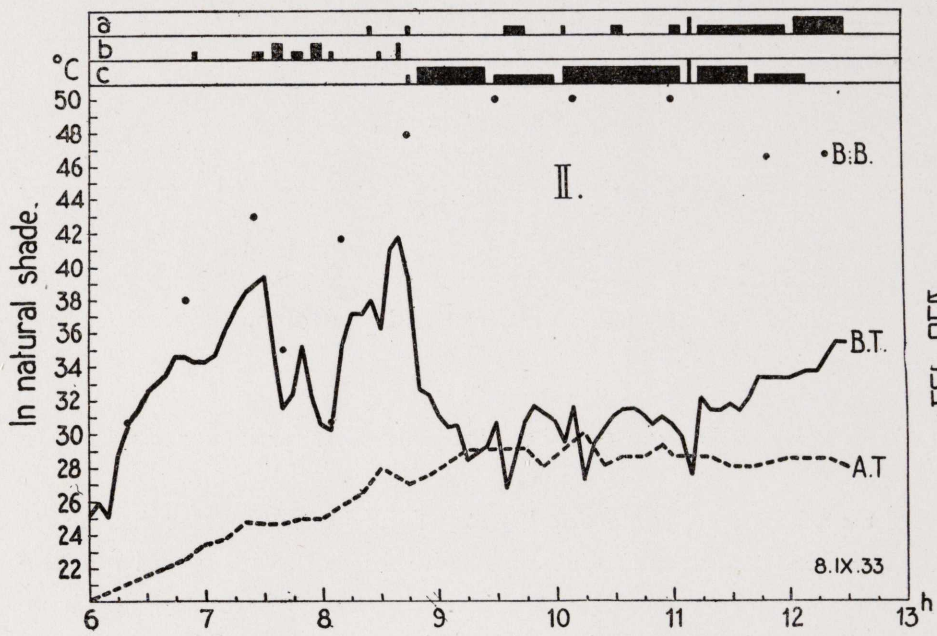

Fig. 4.—The body-temperature of Red Scale *(Chrysomphalus aurantii).*
BT = Body-temperature a = wind.
AT = Air-temperature (shade) b = shade of clouds.
BB = Black bulb thermometer c = shade by leaves.

aberrant *Eriococcinae* are exposed during the day to the radiations of the sun.

The writer has recently shown that, generally, such species have during the exposure to the sun rays, i. e. during the largest part of the day, a very elevated body temperature. In the body of *Aspidiotus hederae, Chrysomphalus aurantii* and *Lecanium hesperidum* on the leaves and fruits of *Citrus* or *Nerium* thermocouple measurements of body temperatures have generally read from 37 to 43° C, from 9 to 16 h. and shadow temperatures 26 to 29° C. During the night or in the absence of sun radiation, the body temperature of the scale insect is identical with that of its environment. Such insects are called heliotherm insects. The *Acrididae*, many *Mantidae* and *Tettigoniidae*, most *Buprestidae*, some *Tenebrionidae*, *Hymenoptera*, *Heteroptera*, etc., belong to this group. Those Coccids, which always live in the shadow, in the soil, etc., are truly poikilotherm in the old meaning of the word and may be called cyclotherm (cyclos = environment).

These phenomena are of high ecological importance, because the body temperature regulates in all poikilotherm animals the speed of metabolic processes, growth and development.

Most Diaspinae are heliotherm, especially those species which live on the leaves or young sprouts of their hosts. Other species, living on the stem of forest trees or subterraneously on the roots of steppe and desert plants are cyclotherm. Those species which live in the shadowy interior part of the leaves may also be regarded as mainly cyclotherm.

Very decidedly heliotherm species are ex. g. some of the species living on *Citrus*. Balachowski observed the following development on *Chrysomphalus aonidum* L. in Algeria (from hatching to beginning of oviposition) (9):

1st generation	54 days.
2nd —	54 —
3rd —	54 —
4th —	210 —

Such data are typical for heliotherm animals. It was likewise astonishing to find that the larval development of a locust like *Schistocerca gregaria* had the same duration: in tropical Africa, in Egypt and in Palestine. The explanation is, that during many hours of the day heliotherm insects maintain a body temperature in the neighbourhood of 40° C. During the night the external temperatures fall to the neighbourhood of the development threshold or below. The decisive temperature is the diurnal one and the differences during the nocturnal period become neglegible. But during the winter period of high cloudiness and lowered intensity of soil radiation, the species behaves mainly like a cyclotherm animal.

Breedings of *Chrysomphalus aurantii* Mask. in Palestine in heavy muslin bags changed the heliotherm behaviour of this species into a cyclotherm one:

Month	No.	Average development in days	Minimum days	Maximum days
III	1	105	—	—
IV	5	100,6	53	113
V	2	82	60	104
VI	17	63,5	51	78
VII..........	54	51,1	41	82
VIII	27	68,4	44	247
IX..........	29	87,6	44	225
XII.........	1	188	—	—

These data would suggest 3 generations during the year. As a matter of fact there are 4 to 5 generations according to the climate of the year. This retardation is in itself sufficient proof of the heliothermism of *Chrysomphalus aurantii.* Repeated series of measurements of the body temperature confirmed this statement.

2) Life history of the Palestinian Coccidae.

The number of Diaspinae, of which we know the exact life cycle, is extremely small. It is hoped that breedings will give additional details during the coming years:

Chrysomphalus aonidum L..................	4	generations
Ch. aurantii Mask........................	4 - 5	—
Lepidosaphes beckii Bché	4	—
L. conchyformis Gmel......................	ca. 3	—
L. ulmi L................................	2 or 3	—
Parlatorea pergandei Comst...............	4	—

The majority of the *Diaspinae* seem to be homodynamic. A true diapause has not yet been ascertained for any species, but it is highly probable that we will find a true diapause in species living on herbaceous plants like *Hemiberlesia nitrariae* March.

Many species of *Lecaniinae* have one generation per annum; *Physokermes coryli* L., *Pulvinaria pistaciae* Bdhmr. mature in spring; *Eriopeltis festucae* Fonsc. and *Eriopeltis lichtensteini* Sign. in summer; *Ctenochiton haloxyloni* Hall. at the end of winter. *Filippia oleae* Costa seems to have two generations, one in autumn and one in spring. *Filippia striata* March. and *Filippia ephedrae* Newst. may behave similarly, but of the former we have observed up to the present only the autumn, of the latter only the spring generation.

Ceroplastes floridensis Comst. has 2-3 annual generations; *Ceroplastes rusci* L. 2 generations near Jerusalem (Bodkin) and 3 near Tel Aviv (Carmin and Shenkin) (10). *Saissetia oleae* Bern. has at least 2 generations in the coast plain, one in spring and one in autumn.

Lecanium hesperidum L. has at least 5 annual generations. The majority of the *Lecaniinae* with one annual generation seem to have a diapause during an early larval stage. All cosmopolitan immigrants are probably homodynamic.

Among the *Asterolecaniinae*, *Asterolecanium sambuci* Ckll. has at least 3 (vide C. & S.) (10), and *Pollinia pollini* Costa 2 to 3 annual generations.

Among the *Eriococcinae* we find one group of aberrant forms, with eriococcoid larvae and lecanoid females. All these species seem to have one annual generation which matures in spring. The diapause takes place in the young larval stage. *Kermes nahalali* Bdhmr., *Kermes greeni* Bdhmr., *Bodenheimera racheli* (Bdhmr.), *Nidularia pulvinata* Planch. belong to this group. It is also probable that *Trabutina palestina* Bdhmr. and *Najacoccus serpentinus minor* Green have only one generation, which matures in the spring. The late seasonal development of *Najacoccus* and *Trabutina mannipera* in the Sinai mountains seems to be due to the high altitude (up to 6.000 feet).

All species of *Pseudococcus* seem to be homodynamic. *Pseudococcus citri* Risso has 7 to 8 annual generations in the coast plain. *Pseudococcus lilacinus* Ckll. and *Pseudococcus adonidum* L. must behave in similar manner, also *Pseudococcus variabilis* Hall. which depends on the vegetation period of its host *(Saccharum)*. *Pseudococcus lindingeri* Bdhmr., which lives on the roots of Gramineae is dependent on moist soil. Its number of generations may depend on the presence of a sufficient soil humidity. During the rainy season we find *Pseudococcus citri* in large numbers in the soil of the orange groves, developing successfully on the roots of plants like *Polygonum*, etc. The same species developes freely during winter on the roots of *Vitis vinifera*, where a fungus, *Bornetina corium* Mang. develops on its exudations. During summer their development stops and some individuals may be found in crevices of the root, probably in some stage of diapause.

Ripersia asphodeli Bdhmr. develops during the short season of active vegetation of its host. During the dry-bulb stage from spring to the beginning of winter its young larvae are in diapause. The latter is broken by the winter rains which also start the new growth of the bulb. Sexual maturity is attained in January (Carmin) (10). *Ripersia phragmitis* Hall has probably more than one generation. *Phenacoccus inermis* Hall and Nov. gen. n. sp., both of which live on the roots of *Neurada incumbens* on the dunes seem to have one generation each with sexual maturity in spring. *Micrococcus similis* Leon. has one generation with sexual maturity in winter. *Antonina phragmitis* March. seems to have about 4 to 6 generations during the year.

Our *Monophlebinae* all seem to be homodynamic. *Icerya purchasi* Mask. has 3 1/2 annual generations, *Gueriniella serratulae* Sign. 2.

Analogous to the species living in Egypt, Algeria and Europe it is probable that the *Margarodiinae*—of which a species will certainly be discovered in Palestine—will have only one annual generation. Of *Orthezia urticae* L. it is quite uncertain what the effect of a protracted drought period on the species might be.

3) General conclusions on the ecology of the life history.

A few general conclusions may be made.

1) The overwhelming majority of the species which live and develop subterraneously have only one annual generation which

reaches its sexual maturity during winter (*Ripersia*, *Ctenochiton*, *Micrococcus*, etc.) The coinciding rainy season seems to be the causing factor.

2) In all species with diapause this seems to occur in a young larval stage in which the diapause is passed (as far as known from Palestine, it may be that some *Diaspinae* may show an egg-diapause).

3) Homodynamy seems to be very common in Cultural Immigrants. It seems to be one important quality of euryoecy. It must therefore be added to the other known qualities of this group (euryphagy and eurymery; cf. Vayssière. The species with a diapause are very well adapted to a local climate and probably for this reason are not very fit for other regions. The diapause is generally fixed by heredity. A good example of this behaviour is *Ripersia asphodeli* Bdhmr.

4) In the climate of Palestine humidity is the main limiting factor. It limits distribution in the southern parts and the aridity of the summer seems to be one of the most important factors which induce a diapause. The humidity of the winter rains is the most important factor for its interruption. Diapause induction by cold, as is made probable by Balachowsky for *Icerya purchasi* in Southern France, or by heat (not known at all in this family) is not yet known from Palestine. The vegetation period of the host plant, which itself depends very largely on the rainfall, is second in importance to humidity.

If we compare the life cycles of Palestinian scale-insects with those of the Eurosiberian region we find thit—the litter: 1) The majority of the *Diaspinae* have only one annual generation in the Eurosiberian region. Diapause and hibernation generally take place in the egg stage. The overwhelming majority of the non-diaspine Coccidae have also only one annual generation, with diapause or interruption of development during the winter.

In general the Irano-Turanian species must behave very similarly. They are exposed to very severe winters and to dry hot and short summers. The main development of the species must largely coincide with the vegetation period of their host plants.

Mediterranean species may reach maturity during the mild winter, spring, beginning of summer, or autumn. The number of homodynamic species with more than one generation per year rises considerably and forms the majority, especially among the *Diaspinae*.

The accentuated aridity of the summer and autumn is the dominating factor in the Saharo-Sindian region. The active period of development coincides very decidedly in this region with the vegetation period of the host. Homodynamic species without diapause are restricted to the neighbourhood of water, to evergreen trees and to irrigated areas. In the Sudano-Deccanian summer with monsoon rains this season is probably the most favoured period of active development.

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Appendix.

The zoogeographic elements of the Coccidae of the South-eastern Palaearctis.

1. SD / SS.

Pseudotargionia glandulosa Newst.
Pinnaspis zillae Hall.
Ceronema africana Newst.
Pseudaspidoproctus hyphaenicus Hall.
Lecanodiaspis africana Newst.

2. Palaeotropic.

Odonaspis ruthae Erh.
Chionaspis herbae Green.
Ripersia cellulosae Hall.
Trionymus lounsburyi Brain.
Antonina indica var. *panica* Hall.

3. SS.

Hemiberlesia nitrariae March.
Osiraspis balteata Hall.
Pulvinaria discoidalis Hall.
Phenacoccus zillae Hall.
Phoenicococcus marlatti Ckll.

4. SS / Med.

Hemiberlesia herzliana Bdhmr.
Aspidiotus artemisiae Hall.

Phenacoccus inermis Hall.

5. Omn.-Med.

Aspidiotus labiatarum March.
Targionia vitis Sign.
Filippia oleae Costa.
Nidularia pulvinata Planch.
Margarodes mediterraneus Silv.

6. Med. Or.

Chrysomphalus inopinatus Leon.
Epidiaspis gennadiosi Leon.
Ripersia asphodeli Bdhmr.
Bodenheimera racheli Bdhmr.
Marchalina hellenica Genn.

7. Franco-Alg.

Adiscodiaspis ericicola March.
Chionaspis ceratoniae March.
Lecanodiaspis sardoa Targ.
Anomostherium delassusi Bal.
Kermes ilicis L.

8. Andal.-Can.

Aspidiotus lauretorum Ldgr.
Cryptaspidiotus aonidoides Ldgr.
Diaspis barrancorum Ldgr.
Pseudococcus aridorum Ldgr.
Phenacoccus maderensis Green.

9. Med. / ES.

Aspidiotus zonatus Frauenf.
Leucaspis pini Hart.
Kermes roboris Fourcr.
Sphaerolecanium emerici Planch.
Asterolecanium fimbriatum Fonsc.

10. ES.

Aspidiotus piri Licht.
Targionia alni March.
Eriopeltis lichtensteini Sign.
Fonscolombea fraxini Kalt.
Cryptococcus fagi Bar.

11. Holarct.

Lepidosaphes ulmi L.
Epidiaspis betulae Bär.
Eriopeltis festucae Fons.
Physokermes coryli L.
Orthezia urticae L.

12. Med. / IT.

Hemiberlesia ephedrarum Ldgr.
Chionaspis etrusca Leon.
Pulvinaria artemisiae Licht.
Antonina purpurea Sign.
Gueriniella serratulae Sign.

13. IT.

Aspidiotus transcaspiensis Marl.
Pulvinaria pistaciae Bdhmr.
Longisomus festucae Kir.
Phenacoccus chersonensis Kir.
Margarodes hameli Brandt.

14. Maur.

Targionia halophila Bal.
Phenacoccus seurati Vayss.
Eriococcus heteroacanthos Bal.
Monophlebus suaedae Vayss.
Monophlebus dumonti Vayss.

15. SS / IT.

Trionymus polyporus Hall.
Ctenochiton artemisiae Hall.
Ripersia phragmitis Hall.
Najacoccus serpentinus minor Green.
Trabutina palestina Bdhmr.

16. ES / IT.

Eriococcus aceris Sign.
Gossyparia ulmi L.

17. C. I. (Trop.)

Aspidiotus destructor Sign.
Lepidosaphes hawaiensis Mask.
Ceroplastes denudatum Ckll.
Pseudococcus boninsis Kuw.
Icerya seychellarum Westw.

18. C. I. (Subtrop.)

Aspidiotus hederae Vall.
Diaspis echinocacti Bché.
Saissetia oleae Bern.
Pseudococcus citri Risso.
Coccus cacti L.