https://doi.org/10.29321/MAJ.10.A04602

The Fluted Scale, *Icerya purchasi* Mask., as a Pest of Wattle in South India, and its control by the Biological Method

By Y. RAMCHANDRA RAO, M.A., F. R. E. S.,
Retired Entomologist,
and
M. C. CHERIAN, B.A., B. Sc. (Edin.), D. I. C.,
Government Entomologist, Coimbatore

Foreword The Fluted Scale, *Icerya purchasi* Mask., was first reported as a pest on wattle in April, 1928 on the Nilgiris, and during the years 1928 -1930 measures were taken to check its spread first by the application of the Pest Act and later on by the importation (mainly from California and Egypt) of its natural enemy, the Ladybird--*Rodolia (Vedalia) cardinalis* Muls. A preliminary paper on this subject was prepared and read by one of the authors at the Indian Science Congress at Allahabad in January, 1930, but was not published pending the preparation of a fuller account, which, however, did not unfortunately materialise. After having been under fairly efficient control for over a decade, the scale had again increased in numbers by 1941, when it was reported to be causing much damage on the Nilgiris, and what was even more serious, it was detected on wattle at various places on the Upper Palnis also in 1941-42. Consequently, laboratories were established at Kodaikanal in July 1942 and at Fernhill in September 1943 to breed the Rodolia Ladybird. In view of the likelihood of the spread of the pest beyond its present limits and the consequent threat to the expanding fruit industry of India, it is proposed to present in this paper a short account of the spread of this pest in South India since its first appearance and indicate the present position in regard to its control.

The first appearance of the Scale in South India The presence of the Fluted Scale in South India was first brought to the notice of the Madras Agricultural Department by Mr. J. P. Parry of Ootacamund, Nilgiris, who reported, under cover of a letter dated the 11th April 1928 accompanied by specimens, a serious attack of this scale on his wattle plantation at MacIvor's Bund near Avalanche on the Nilgiri Plateau. An examination of the specimens confirmed the identity of the scale insect and a reference to available literature revealed that one had to deal with a pest with dangerous propensities for attacking valuable fruit crops such as the orange and the apple, and indeed, Fletcher (1917) had already given a note of warning as early as 1917 of the possibility of its entrance within Indian limits from Ceylon. A prompt visit paid to the infested areas on the Nilgiris showed that the pest was by no means confined to the wattle plantations at MacIvor's Bund but was also to be found on wild wattle (*Acacia de-albata*) at Keti, on

PLATE - I

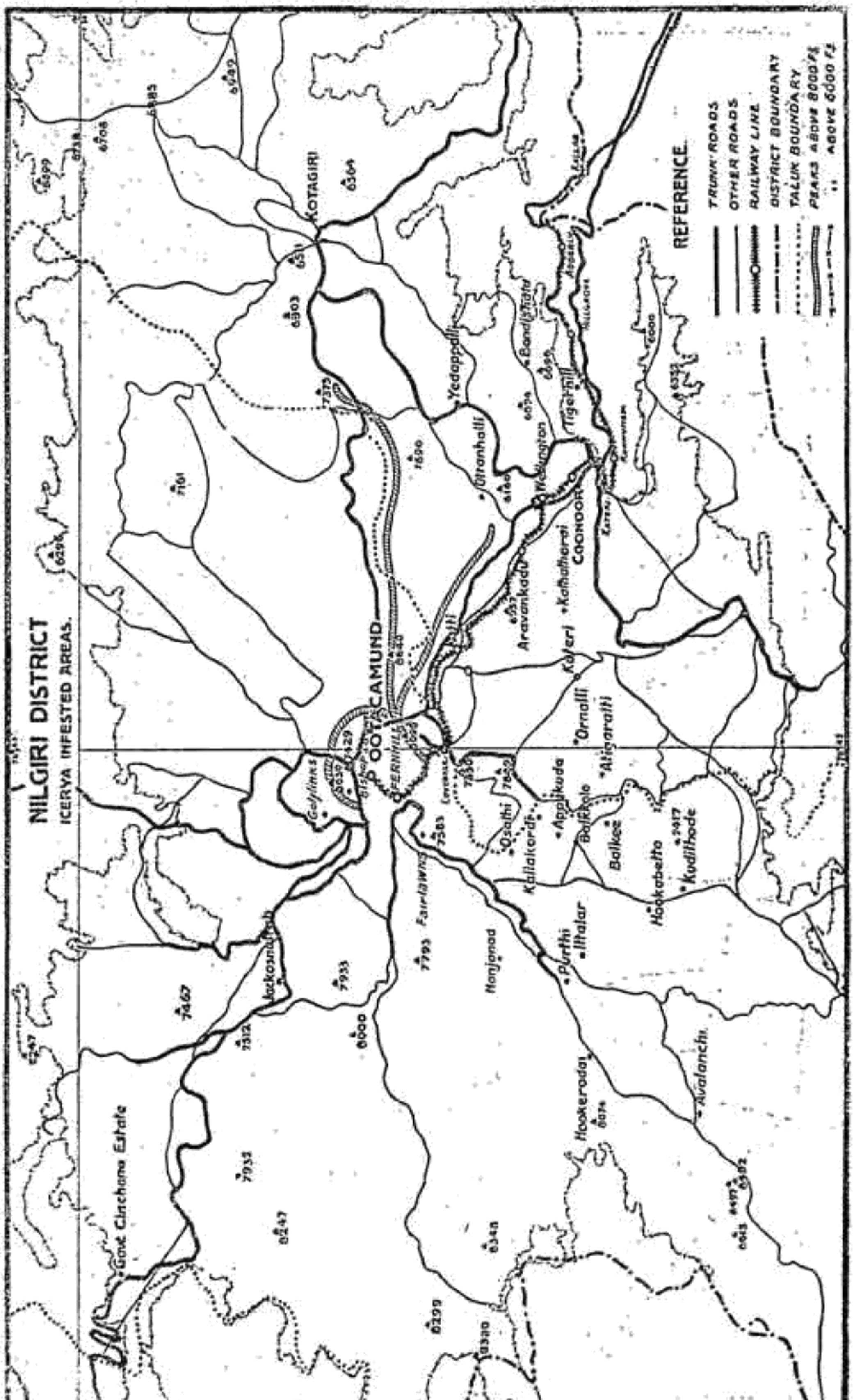
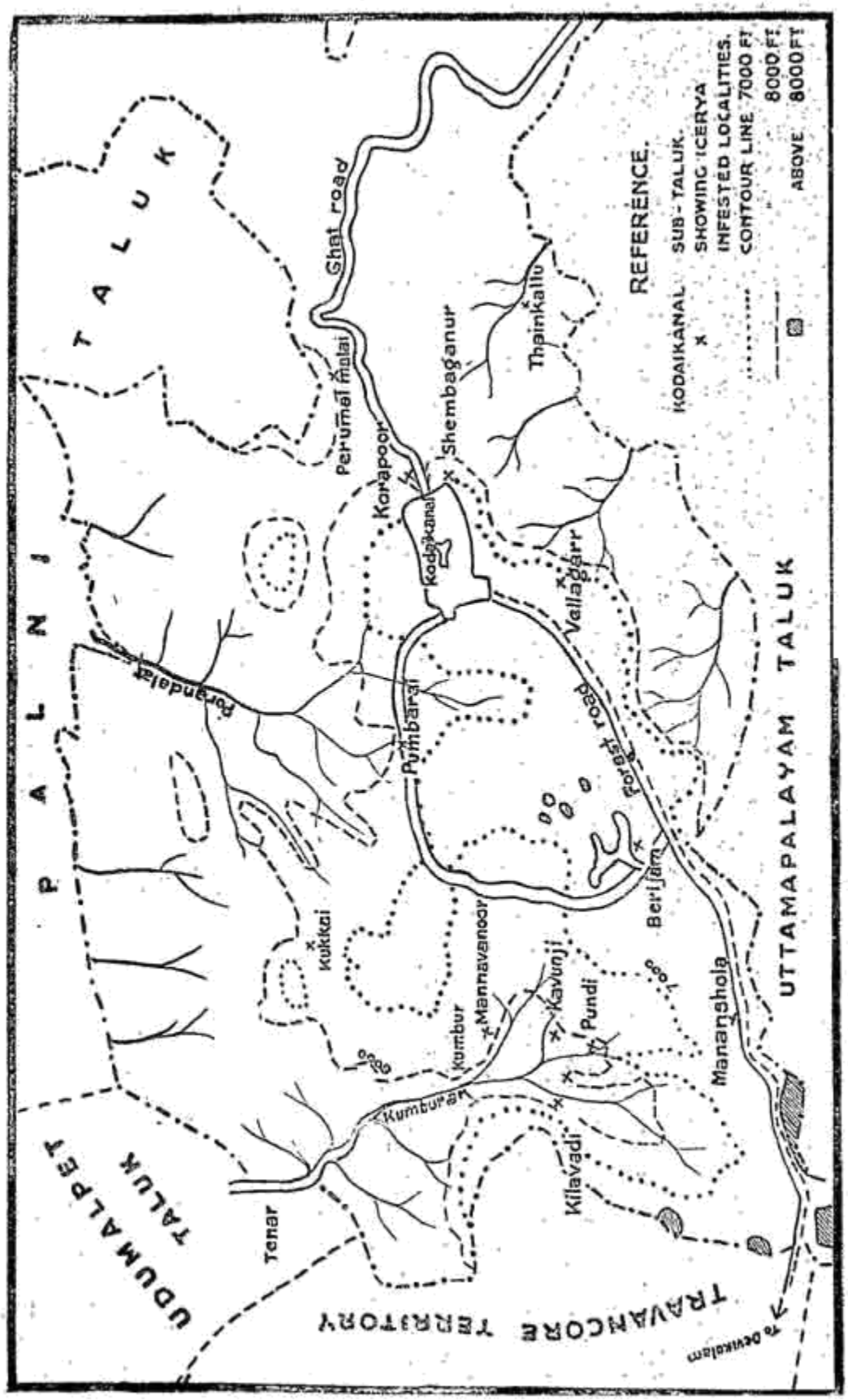

NILGIRI DISTRICT
ICERYA INFESTED AREAS.
REFERENCE.
TRUNK ROADS
OTHER ROADS
RAILWAY LINE
DISTRICT BOUNDARY
TALUK BOUNDARY
PEAKS ABOVE 8000 Ft
ABOVE 6000 Ft
OOTACAMUND
KOTAGIRI
COONOOR
Wellington
Aravankadu
Kateri
Ornalli
Yedappalli
Tigerhill
Fairlawns
Naduvattam
Avalanchi
Hookerodai
Kallakorai
Ithalar
Balkote
Hookabetta
Kudithode
Gate Cinchona Estate

PLATE - II


PALNI TALUK
UTTAMAPALAYAM TALUK
UDUMALPET TALUK
TRAVANCORE TERRITORY
REFERENCE.
KODAIKANAL SUB-TALUK.
SHOWING ICERYA INFESTED LOCALITIES.
CONTOUR LINE 7000 FT
8000 FT.
ABOVE 8000 FT
Ghat road
Perumal Malai
Korapoor
Shembaganur
Thainkallu
Kodaikanal
Vallagarr
Forest road
Pumbarai
Periyakulam
Kukkai
Kumbur
Mannavanoor
Kavunji
Pundi
Berijam
Manangola
Kumburam
Kilavadi
Tenar
To Devikolam

broom (*Cytisus scoparius*) and gorse *(Ulex europaeus)* at Fairlawns and other localities. The infestation at Keti, moreover, appeared to be at least three years old, and this estimate was confirmed by the local coolies, who declared (in April, 1928) that they had during the preceding two or three years noticed this "bleeding insect" (Tamil : *Rethappuchi*), so-called by reason of the raddish stains caused on clothes when accidentally squashed in these places.

The present distribution of the Scale in South India—*Nilgiris* In the course of subsequent visits to the Nilgiri area during the years 1928 and 1929, careful surveys were made to note the distribution of the pest, and during 1930 periodical visits were paid to the infested localities in order to examine the results of the liberation of predator beetles. All infested places were marked on a map of the district, and by the beginning of 1931, when the special staff employed on Icerya control work was withdrawn, the distribution of the pest was as shown in Plate I. The infested areas appear to lie mostly in the valleys to the south of the Great Dodabetta Divide that runs from Ootacamund eastwards to Kotagiri. Moreover, they are apparently organically connected with the main roads and bridle-paths of this part of the plateau. (1) To the west, we have along the Ooty—Avalanche road : Fairlawns, Nanjanad, Osatti, Hookeradai, Ittalar, MacIvor's Bund and Avalanche ; (2) due south along the road from Ooty to the Kundahs : Fernhill, Lovedale, Kallakorai, Appukkodu, Balakola, Baikee, Oranalli and Adigaratti ; (3) along the Keti—Katteri road : Kollimalai, Katteri and Kothathorai ; (4) along the Ooty—Coonoor road : Tiger Hill, Keti, Aravankad, Wellington, Jakatala and Coonoor ; and (5) along the Wellington—Coonoor —Kotagiri roads : Springfield, Bandyshola, Idaipalli, Banniway, Ottanhatti, Kotagiri and Kodanad Road. A survey recently made by M. S. Kylasam in July, 1942 showed that a new area to the north-west of Ootacamund *viz.* Jachos Nullah, along the Ootacamund—Gudalur road, had also become infected. Most of these localities are between 6,000 and 7,500 feet above mean sea level.

Upper Palnis The first report in regard to the appearance of this scale on the Upper Palnis was from Kavunji (to the west of Kodaikanal) in June, 1941, since which time, it has been found to occur in various other localities in the Kodaikanal area. (1) Kumbur Valley : Kavunji (6,200 ft.), Poondi (6,400 ft.), Kailavari (6500 ft.), Mannavanoor (6,300 ft), Polur (6,000 ft), and Kumbur (5,900 ft.) ; (2) to the north, Kukkal (5500 ft.) and Poombarai (6,300 ft.) ; (3) to the south & south-west, Marianshola (7,700 ft.), Berijam Lake (7,100 ft.), and Vellakamedu (6,500 ft.), and (4) to the east, Kodaikanal (7000 ft.), Shembaganur (6,000 ft.), Korappoor (5,500 ft.), Perumalmalai (5500–5000 ft.) and Thainkal (4200 ft.), *vide* Plate II. According to Subbiah the pest was found on wattle in May, 1942 in a neighbouring area at Devicolam (Travancore State), where probably it should have been introduced at about the same time.

Outside the Hills It is rather difficult to say where else the scale has spread in South India, as its presence is not likely to be recognised and reported until the attack has become really serious One of the writers (Rao) recently noted the pest at Bangalore on a small rose bush at Mavalli, and it appears not unlikely that it will be found in some other places in India if a special survey is conducted.

The Origin of the Pest in South India Although no direct evidence is available as to how exactly the pest had made its entry into the Nilgiris, there would appear to be little doubt that the scale has been introduced through the medium of imported orchard stock or flowering plants. At Holly Mount, a bungalow at Wellington, S. Ramachandran found some rose bushes and a potato creeper (*solanum seaforthianum*) infested by this scale in May, 1928, and on enquiry, he was told that an apple plant of origin outside India planted by a former occupant of the property had been killed by an infestation of the scale. If this be a fact, this might well have been the source of the present outbreak of the Fluted Scale, as it could easily have spread from this nucleus in the direction of Keti, Coonoor or Fairlawns through the agency of coolies and cattle At MacIvor's Bund, it was reported that the attack was first noticed around a culvert built of stones brought as head-loads from the neighbourhood of Keti, and an inspection of the stone quarry at Keti, later on, showed that it was situated in the midst of an area of infested wild wattle. (An examination of the infested areas on the Nilgiris has clearly indicated that the dispersal of the pest has been mainly along foot-paths, cattle-tracks, bridlepaths and roads. The newly hatched bugs are very active and are capable of wandering some distance over the ground and along the branches of plants in search of fresh feeding places, whence they readily get transferred on to the clothes of coolies or the hairy coat of cattle passing among infested bushes. Sometimes the use of affected branches of wild wattle as packing material carried on head or on pony-back may also be directly instrumental in carrying the pest to new localities. According to Balachowsky (1929), the newly hatched young bugs may, by reason of their extreme lightness, be transported over long distances by heavy winds.

Though it is apparently more likely that the infestation had reached India from Ceylon, the possibility of its having made its entry from other countries of origin cannot be discounted. In any case, the fact of its having reached India from outside would call for stricter scrutiny of imported plants by sea or air.

The host-plants of the Scale The Scale is known to have a very wide range of food-plants in the countries in which it has been introduced, including among them a good many cultivated plants, such as orange, apple, pomegranate, castor, rose, pear, peach, coconut, etc. On the Palnis and Nilgiris, however, although quite a large number of plants have been found

subject to attack, most of them are wild species of no consequence economically. The following are the only plants of economic importance among the affected flora :—three species of commercial cultivated wattles *viz: Acacia decurrens, A. mollisoni,* & *A. melanoxylon,* rose bushes (*Rosa* spp.), and *Citrus* spp.. On the Upper Palnis, Subbiah has found that *Acacia de-albata* is the most susceptible and *Acacia mollisoni* the most resistant among the wattles, and also that wattles growing on rocky areas or on shallow or gravelly soils are more severely infested than those growing on rich and deep soils, which are comparatively free. He also found that new shoots springing up from coppices and root-suckers are badly infested, while seedling plants are generally free. Berijam plantation, consisting of *Acacia mollisoni* was lightly infested, whereas the plantations at Kodaikanal and Marianshola (with other species) were badly hit. The large number of plants liable to infestation would appear, however, to testify to the cosmopolitan tastes of the scale, though the special favourites would appear to be the wild wattle (*Acacia de-albata*), the St. John's Wort, the broom and the gorse. A complete list of the plants found attacked on the Nilgiris and the Upper Palnis is given below, and it is seen that the species attacked are different in many cases in these two areas. The following species would appear, however, to be common to both these hill areas :—*Anaphalis aristata, Artemisia parviflora, Conyza ambigua, Acacia de-albata, Citrus* spp., *Hypericum mysorense, Osyris arborea* & *Rosa* sp.

Host Plants of Icerya Purchasi on the Nilgiris and Upper Palnis

Natural orders	Plants on the Nilgiris	Plants on the Upper Palnis
Compositae	1 *Anaphalis aristata*	1 *Anaphalis aristata*
	2 *Anaphalis neelgheriana*	2 *Artemisia parviflora*
	3 *Anaphalis* sp.	3 *Artemisia vulgaris*
	4 *Artemisia parviflora*	4 *Conyza ambigua*
	5 *Artemisia* sp.	5 *Erigeron mucronatus*
	6 *Bidens pilosa*	6 *Helichrysum bracteatum*
	7 *Conyza ambigua*	
	8 *Eupatorium glandulosum*	
Euphorbiaceae	9 *Euphorbia rothiana*	
	10 *Glochidion velutinum*	
Leguminosae	11 *Acacia de-albata*	7 *Acasia de-albata*
	12 *Acacia decurrens*	8 *Acacia decurrens*
	13 *Acacia melanoxylon*	9 *Acacia melanoxylon*
	14 *Acacia mollisoni*	10 *Acacia mollisoni*
	15 *Cytisus scoparius*	11 *Crotalaria fysoni*
	16 *Sophora glauca*	12 *Crotalaria burneae*
	17 *Ulex europaeus*	
Solanaceae	18 *Solanum jasminoides*	
	19 *Solanum seaforthianum*	

Labiatae	20 *Leucas helianthemifolia*	13 *Anisochilus argentea*
	21 *Leucas zeylanica*	14 *Leucas vestita*
		15 *Leucas ternifolia*
		16 *Plectranthus coetsa*
		17 *Pogostemon mollis*
Rutaceae	22 *Citrus* spp.	18 *Citrus* Spp.
Rosaceae	23 *Pyrus mali*	19 *Pyrus communis* (Country pear)
	24 *Rosa* sp.	20 *Rosa* sp.
		21 *Rubus* sp. (Rasp-berry)
Rubiaceae	25 *Oldenlandia articularis*	22 *Oldenlandia herbacea*
		23 *Oldenlandia stylosa*
		24 *Oldenlandia swertioides*
Myrtaceae	26 *Eucalyptus susceptibile*	25 *Eucalyptus glaucum*
	27 *Rhodomyrtus tomentosus*	
Acanthaceae	28 *Justicia simplex*	26 *Justicia procumbens*
		27 *Strobilanthus kunthianus*
Santalaceae	29 *Osyris arborea*	28 *Osyris arborea*
Hypericaceae	30 *Hypericum mysorense*	29 *Hypericum mysorense*
Buxaceae		30 *Sarcococca trinerva*
Sapindaceae	31 *Dodonaea viscosa*	
Geraniaceae		31 *Oxalis corniculata*
Caprifoliaceae		32 *Viburnum coriaceum*
Berberidaceae	32 *Berberis tinctoria*	
Ericaceae	33 *Gaultheria fragrantissima*	
Loranthaceae	34 *Loranthus cuneatus*	
Umbelliferae	35 *Bupleurum mucronatum*	
Apocynaceae	36 *Carissa paucinervia*	
Rhamnaceae	37 *Rhamnus virgatus*	
Coniferae	38 *Callitris rhomboidea*	

Life-history and habits of the Scale *Icerya purchasi* Mask., popularly known as the Fluted Scale or the Cottony Cushion Scale, is an insect belonging to the Monophlebine group of mealy-bugs. The full-grown female scale is (Fig. 1, Plate III) quite a big and conspicuous insect not likely to be forgotten when once seen, especially when it occurs, as it generally does, in large white masses on the affected twigs. The mature female is about 1/5 in. long and greyish brown in colour, and secretes a large, elongate, fluted mass of white mealy-wax, more than twice as long as the body, inside which 400 to 1,000 small, oval, brickred eggs are closely packed. At Kodaikanal, M. S. Subbiah recently (1942) found 1409 nymphs crawling out of the egg-sac of a female scale under observation, in the course of two months. In large specimens the number of the progeny may exceed even 2,000. The young bugs, which are bright red with elongate black legs, on emergence from the egg-sacs, actively swarm up towards the succulent parts of the branches. The young ones are very active and would appear to be able to crawl on the ground and cover some distance in search of suitable

host plants After fixing itself upon a twig or a leaf, the nymph feeds and grows until it is ready for a moult. There are three moults in the case of the females, and the young bugs would appear to change their feeding places after each moult. Males are very rare, and in most cases reproduction would appear to be independent of fertilisation by the male (Hughes-Schrader, 1930). The duration of the life-cycle is apparently dependent on the temperature conditions of particular localities and of the season of the year. Working at Coimbatore during the months August to November 1928, T. V. Subramaniam found the duration of the egg stage to be 7 to 10 days, the I instar–12 to 23 days, the II instar–12 to 28 days, and III instar — 15 to 32 days. The duration of the life-cycle from egg to adult stage would thus be 46 to 93 days. On the Nilgiris, the shortest period for the egg-stage would appear to be 15 days. Nymphs inoculated on castor on 12—2—30 became adult during the week ending 12—4—30 (about 59 days); on apple on 19—3—30, became adult on 3—5—30 (about 45 days); on orange on 19—3—30, on 17—5—30 (about 59 days); and on Acacia on 1—5—30, between 21 and 28—6—30 (52 to 59 days). The scale is able to oviposit within 10 to 15 days, so that the shortest life-cycle from egg to egg-laying by the adult is 70 to 75 days in the hot season. According to Kuwana (quoted by Hughes-Schrader, 1930), the life-cycle occupies approximately four months under favourable conditions in Japan, and similarly according to Leonardi (*ibid*) three generations annually is characteristic of the species in Italy. On the Nilgiris, the length of a generation may be $2\frac{1}{2}$ to 3 months in the hot season and about two months longer in the colder parts of the year. On the Upper Palnis, Subbiah found in one case, where fresh nymphs were inoculated on Acacia in March, 1943, that nymphs of the new generation crawled out only on the 15th November, 1943 from the egg-sac. In this case a generation has lasted nearly eight months. In nature however, there is a good deal of overlapping of generations, and taking everything into consideration, it may be considered that there may be two to three generations of the scale on the hills.

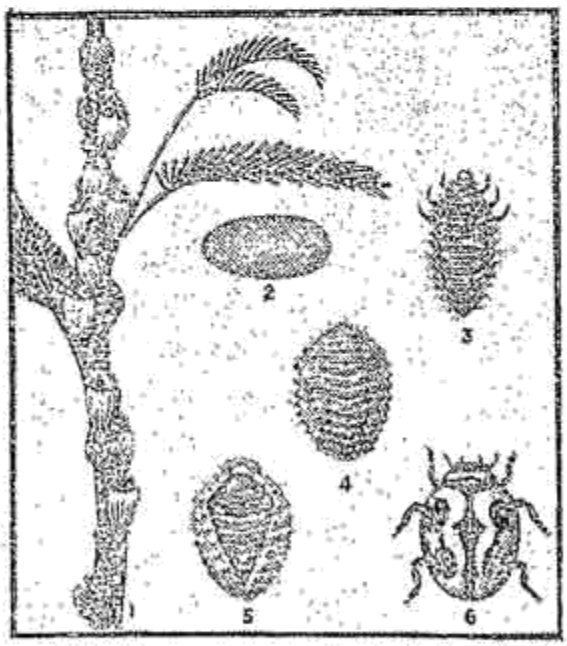
Effect of weather conditions on the Scale Observations made in the course of the control work on the Nilgiris and the Upper Palnis indicate that the pest flourishes best during the dry, hot season, i e., from the middle of January to the middle of June. During the monsoon rains, the insect experiences a set-back. The young ones may be washed down and killed by the impact of rain, and the scales themselves may become subject to fungus-attack, especially during November—December. In the interval between the end of the South-west monsoon and the onset of the North-east monsoon (September—October), warm weather usually prevails on the hills, when conditions are favourable for the increase of the scale, but with the appearance of the cold drizzly weather, characteristic of the North-east monsoon, there is a perceptible decrease in activity.

Natural enemies and diseases Two insect enemies and a parasitic fungus have been found attacking Iceiya scales on the Nilgiri Hills:—

1. A lady-bird beetle—*Rodolia* (*Vedalia*) *roseipennis*, Muls., 2. a micro-lepidopterous caterpillar—*Stathmopoda melanochra* Meyr., and 3. a *Cladosporium* sp.—a parasitic fungus.

1. *Rodolia roseipennis* Muls. It is an indigenous species of lady-bird which is known to attack various other scale insects in South India. It lays yellowish eggs on the scale, and the rosy grey grubs that hatch out feed on the eggs inside the egg-sac of the bug, very often emptying it completely. (In this connection, it may be noted that the eggs of the imported lady-bird, *Rodolia cardinalis*, are smaller, but bright red, while the grubs are more dusky and can be recognised by the presence of pairs of dorsal black warts, and feed voraciously on the scales themselves). Subbiah has worked out its life-history at Kodaikanal. He found it to be a very shy breeder. There was much variation in the duration of the different stages, the period being shorter in the warmer months: egg-period—6 to 26 days; larval period—20 to 28 days; resting period—7 to 13 days; pupal period—12 to 23 days; and the total period from egg to adult—46 to 77 days. The longevity of the adult varied from 14 to 89 days. This species has been found also in Ceylon, at Bangalore and in various places in the Madras Presidency, and is apparently widely distributed in South India. Though it doubtless functions as a check, it is neither sufficiently prolific nor even efficient enough as a predator to exert any control on the pest.

PLATE III



1. Wattle with the larvae of Rodolia feeding on the scales.
2. Egg of Rodolia.
3. Larvae „
4. Prepupa „
5. Pupa with the pupal skin split up.
6. Rodolia beetle.

2. *Stathmopoda melanochra* Meyr. This caterpillar belongs to the family *Heliodinidae*, and has the habit of entering the egg-sac of a mature scale and after attaching the sac firmly to the surface of the twig with a silken web, of feeding on the eggs inside. At first, it was mistaken for a scavenger on dead scales and mealy detritus, but closer observations established that it was a real predator. In fact, its activities in attacking the live material of

Icerya collected for feeding the grubs of *Rodolia cardinalis* in the breeding laboratory have proved a serious impediment in breeding the ladybird. Specimens of moths reared at Keti were sent in 1930 to Mr. T. B Fletcher, Imperial Entomologist, Pusa, and were identified by him as *Stathmopoda melanochra* Meyr. and in his letter dated the 4th November 1930, he remarked as follows: "This is an Australian species, common at Sydney, and nearly related to other Australian species, but without any near relatives in India. It looks, therefore, as if it had been introduced by accident with plants from Australia. The larval habit has not been observed in Australia". Messrs. M. S. Kylasam and M. S. Subbiah made the following observations on its life-history while in charge of the breeding work at Keti:— Parent moths lay their eggs singly on the corrugations of the egg-sac of the scale. The eggs are small, pearly-white when fresh laid, turning pink during development and have a sculptured shell. The young caterpillars burrow into the egg-sac and feed on the eggs. After finishing one egg-sac they find their way to the next one. It is presumed that each caterpillar may account for 6 to 10 egg-sacs. As per observations of Subbiah, the duration of the complete life-cycle may be about 12 to 16 weeks. Pupation takes place in a white silky cocoon among empty egg-sacs. The moths are poor breeders and lay eggs sparingly. It is found both on the Nilgiris and Upper Palnis. According to Subbiah, it is seen on the Palnis only between July and September.

3. *Cladosporium* sp. Scales attacked by fungus were examined by the Government Mycologist, Coimbatore, and identified to belong to the genus *Cladosporium*. It is in greatest evidence on the hills during the damp cold weather prevailing during the North-east monsoon rains.

Control Measures Observations made in the infested areas showed that such natural enemies as were already existent were not capable of bringing the pest under efficient control and it became necessary to devise measures calculated to prevent it from spreading to fresh areas. All ideas of controlling the pest by spraying had to be given up, as the infestation was not confined to cultivated wattle but spread over wide areas of broom, gorse and St. John's wort. The only feasible measure in the above circumstances was that of cutting and burning the infested bushes. With the sanction of the Government of Madras, the help of the Pest Act was invoked, and the destruction of infested broom at Fairlawns was first taken up under the supervision of the Curator, Government Botanical Gardens, Ootacamund, and executed by the Agricultural Demonstrator, Ootacamund. The operation was begun by the end of January, 1929, and by the end of March, 1929 an area of about 149 acres of infested broom had been cleared at a total cost of about Rs. 2,190. April, however, it was found well nigh imp and it was felt that nothing could be done t in December. As by April, the efforts that he natural enemy of

the scale promised to bear fruit, Pest Act operations were kept in abeyance for the time being.

Methods of Biological Control Published information on the history of this well-known scale insect shows that it is a native of Australia that has been carried to various parts of the world through the medium of ocean-borne commercial traffic. It was first noted in California in 1868 on wattle but in course of time it spread throughout the state and by 1886 it was a serious menace to the orange and lemon industry. Finding the futility of mechanical methods of control such as spraying, the United States Bureau of Entomology sent an entomologist, Mr Albert Koebele, on a tour round the world to discover the original home of the scale and to search for its natural enemies, if any. Although Koebele found the scale on various islands in the Pacific Ocean, it was only in the south of Australia that he found its natural enemies in action. They included, besides others, the ladybird, *Rodolia cardinalis* and the fly, *Cryptochaetum iceryae*, which kept the scale in such effective check as to render it a harmless insect. The story of the introduction of the ladybird, *Rodolia (Vedalia) cardinalis*, into California and the marvellously rapid and effective control brought about thereby is one of the romances in the development of economic entomology, that has served to capture the imagination of the public and to bring the biological control method into the lime-light.

Since then, the introduction of the ladybird was adopted by various countries into which the scale had strayed and become a serious pest, with similar success, viz. Hawaii, Florida, South Africa, Japan, Brazil, Portugal, Palestine, France, Argentine, Sicily, Egypt, etc. The latest country to be invaded by the scale was Ceylon, where it was first noticed in December, 1915, and later on was found to have spread all over the highlands of that island. The importation of the Rodolia beetles was effected from South Africa in the course of six consecutive consignments during the years 1918, 1919 and 1920 (Hutson, 1920), and the efficiency of the work of the predator beetle is testified to by the fact that Dr. Hutson, the Ceylon Entomologist, wrote in 1928, in response to a request from Coimbatore for a supply of ladybirds, that it "was difficult to find either the scale or the beetle anywhere in Ceylon".

(To be continued)