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Giuseppina Pellizzari & Paolo Camporese

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THE *CEROPLASTES* SPECIES (HOMOPTERA : COCCOIDEA) OF THE MEDITERRANEAN BASIN WITH EMPHASIS ON *C. JAPONICUS* GREEN

Giuseppina PELLIZZARI & Paolo CAMPORESE

Istituto di Entomologia Agraria, Università degli Studi, via Gradenigo 6, I-35131 Padova, Italia

Résumé. – Les espèces du genre *Ceroplastes* Gray (Homoptera : Coccoidea) du Bassin méditerranéen – Quatre espèces de *Ceroplastes, C. rusci* (L.), *C. sinensis* Del Guercio, *C. floridensis* Comstock, *C. japonicus* Green, sont actuellement présentes dans la région du Bassin méditerranéen. Ce travail présente une clé d'identification pour les espèces susmentionnées et des données sur la morphologie des femelles adultes de chaque espèce et notamment de *C. rusci* et *C. japonicus*. Une clé d'identification est donnée pour les quatres stades de *C. japonicus*, ainsi que des informations récentes concernant la distribution et la biologie de *C. rusci, C. sinensis, C. floridensis* et *C. japonicus*.

Abstract. – Four species of *Ceroplastes*, namely *Ceroplastes rusci* (L.), *C. sinensis* Del Guercio, *C. floridensis* Comstock and *C. japonicus* Green are currently established in the countries surrounding the Mediterranean Basin, where they show different distribution ranges. An identification key of these species is provided, together with a morphological account of their adult females. More attention is devoted to the morphology of *C. rusci* and *C. japonicus*. An identification key of the four stages of development of *C. japonicus* is also provided. The distribution of *C. rusci, C. sinensis, C. floridens*is and *C. japonicus* in the Mediterranean countries and in the world is given together with a brief account of their biology in the Mediterranean Basin.

The only work devoted to the study of the genus *Ceroplastes* Gray in the Mediterranean Basin is by Balachowsky (1933). In his work Balachowsky discusses the presence of the following species of *Ceroplastes* in the Mediterranean Basin : *C. rusci* (L.), *C. sinensis* Del Guercio, *C. mimosae* Signoret, *C. actiniformis* Green, *C. floridensis* Comstock.

Sixty years later the situation appears to have changed. At present we assume that four species of *Ceroplastes* are established in the countries surrounding the Mediterranean Basin, namely *C. rusci, C. sinensis, C. floridensis* and *C. japonicus* Green.

Among the species previously recorded by Balachowsky, *C. mimosae* and *C. actiniformis* are not included in this work. *C. mimosae* currently belongs to the genus *Waxiella*, erected by De Lotto in 1971 and is therefore not considered here. *C. actiniformis* was recorded in Egypt by Hall (1922) and in Israel by Bodenheimer (1927). With regard to Egypt, Hall himself, in 1923, stated that he had obtained no further records of this species. Later Ezzat & Hussein (1967) regretted having no material of *C. actiniformis* for their redescription of the Coccidae of Egypt. With regard to Israel, Ben-Dov (1970) did not find *C. actiniformis* in a countrywide survey on the occurrence of the genus *Ceroplastes* in Israel and assumed that it had not established.

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Another species of *Ceroplastes, C. cirripediformis* Comstock, is recorded by Gimpel *et al.* (1974) in the Mediterranean Basin. A slide with two specimens of this wax scale, collected in Italy (locality unknown) on *Clerodendron fragrans* (X.21.1966) was found in the United States Natural History Museum - Washington. As far as we know it is the only record of this species (on an exotic plant) in the Mediterranean Basin. It has not been recorded since then.

For the above reasons we consider that *C. actiniformis* and *C. cirripediformis* are not acclimatized in the Mediterranean Basin and we will deal with *C. rusci, C. sinensis, C. floridensis* and *C. japonicus* that appear to have become established, but which show different distributions throughout this area.

If we consider that *C. floridensis* and *C. japonicus,* the most recently established species, are both still spreading, we could hypothesize that during the next few years some Mediterranean countries might have at least four *Ceroplastes* species. These species are characterized by the fact that they are polyphagous and have a wide and often overlapping range of cultivated host plants. For instance the *Citrus* spp. are host plants of all four of the mentioned species; species of *Ilex, Laurus, Diospyros* and *Platanus* are host plants of *C. sinensis, C. floridensis* and *C. japonicus; Hedera helix* may host *C. rusci, C. japonicus* and *C. floridensis; Ficus* spp. are the most common host plants of *C. rusci,* but they may also host *C. floridensis.* From this we can infer that the same host plant species may host different species of *Ceroplastes.*

The aim of this work is to provide an identification key and morphological accounts of the *Ceroplastes* species known to occur in the Mediterranean Basin together with up-to-date information on their distribution. More attention is devoted to the morphology of *C. rusci,* our knowledge of which is not yet complete (although a good description is given by Hodgson (1969)) and to *C. japonicus,* the most recently introduced species. An identification key of the four developmental stages of *C. japonicus* is also provided.

Materials and methods

To prepare the slide mounts of *Ceroplastes* we adopted the method proposed by Kozarzewskaya (1968) using only young females. It is only by observing well stained specimens of young females that it is possible to detect some structures such as the filamentous ducts which are impossible to recognize in aged females or in poorly prepared specimens. 10-20 specimens coming from different Mediterranean places were studied for each species description. In the species description, the numbers in brackets refer to the average observed. The abbreviation MNHN indicates the slides lent to us for comparison by the Muséum National d'Histoire Naturelle, Paris, France. The abbreviation PPIB indicates the slide lent to us for comparison by the Plant Protection Institute, Budapest, Hungary. The abbreviation IEAP indicates the slides in the collection of the Institute of Agricultural Entomology, Padova, Italy.

The distribution data reported in this work usually refer to the most recent papers on the topic. Old data are reported only if recent ones are not available. We would like to point out that several records of *Ceroplastes* (e.g. *C. rusci* or *C. sinensis* in tropical or subtropical countries) relating to the years up to the sixties are to be considered doubtful because of misidentification due to lack of knowledge on the topic. It was only after the revision, redescription and description of the *Ceroplastes* species (De Lotto, 1965; 1971; 1978; Kawai & Tamaki, 1967; Hodgson, 1969; Gimpel *et al.,* 1974) that knowledge on the genus became clearer and consequently species identification more reliable.

With regard the species distribution, the references reported in the "Distribution maps of pests" of the Commonwealth Institute of Entomology, Map n. 373 *(C. rusci),* Map n. 412 *(C. sinensis),* Map n. 440 *(C. floridensis),* have been checked as far as possible in order to verify the reported data and to compare them with recent ones.

In this work we follow the concept of the genus *Ceroplastes* as presented by Gimpel *et al.*

(1974) and subsequently accepted by Williams & Watson (1990). Gimpel *et al.* consider *Gascardia* Targioni-Tozzetti and *Cerostegia* De Lotto as junior subjective synonyms of *Ceroplastes* Gray. In our opinion the genus *Paracerostegia* Tang, erected in 1991 to insert species with conical setae and tubular ducts with expanded inner filament, also falls within the generic diagnosis of *Ceroplastes sensu* Gimpel *et al.* (1974) and is regarded here as a junior subjective synonym of *Ceroplastes* Gray. Nevertheless we believe that some morphological characters such as the structure of tubular ducts and dorsal pores do have a systematic value and should be taken into consideration in a world revision of the genus.

Key to the mediterranean *Ceroplastes* species

Since the unmounted species belonging to the genus *Waxiella,* known in the eastern Mediterranean Basin (*W. mimosae* (Signoret) and *W. tamaricis* Ben-Dov) (Ben-Dov, 1986), are indistinguishable from the *Ceroplastes* species, it appears useful to report the morphological characters to separate the two genus.

C. cirripediformis and *C. actiniformis,* previously recorded in the Mediterranean basin, have also been included in this key. Descriptions of *C. cirripediformis* may be found in Gimpel *et al.* (1974) and Gill (1988). The distinctive charachters between *C. rusci* and *C. actiniformis* are reported from Ezzat & Hussein (1967).

1. Stigmatic setae of two types: spiniform with pointed apices in the stigmatic cleft and cylindrical with rounded apices extending on dorsum ..... genus ***Waxiella*** De Lotto

– Stigmatic setae usually of one type only, extending in one or more rows along the body margin ..... genus ***Ceroplastes*** *sensu lato* 2

2. Tubular ducts with enlarged inner filament. Stigmatic setae lanceolate, with pointed apices 3

– Tubular ducts with narrow inner filament. Stigmatic setae conical or bullet-shaped, with blunt apices 4

3. The stigmatic setae of anterior and posterior cleft usually form an uninterrupted row on the body margin (average 111 stigmatic setae on each side) ..... ***japonicus*** Green

– The anterior and posterior rows of stigmatic setae on the body margin are separated by 7-12 marginal bristle-shaped setae (average 60 stigmatic setae on each side) ..... ***floridensis*** Comstock

4. Antennae 7-segmented 5

– Antennae 6-segmented 6

5. Filamentous ducts present on ventral submargin. Without multilocular pores on abdominal segments 2 and 3 and near coxae of meso and meta-thoracic legs ..... ***sinensis*** Del Guercio

– Filamentous ducts absent. Multilocular pores present on all abdominal segments and near coxae of meso and meta-thoracic legs..... ***cirripediformis*** Comstock

6. Stigmatic setae in 1-2 rows ..... ***rusci*** (Linnaeus)

– Stigmatic setae in 3 rows ..... ***actiniformis*** Green

Ceroplastes rusci (L.)

Ceroplastes rusci is widely distributed throughout the countries surrounding the Mediterranean Basin (Portugal, Spain, southern France, Italy, ex Yugoslavia, Albania, Greece, Turkey, Syria, Lebanon, Israel, Egypt, Lybia, Algeria, Tunisia and Morocco) and is also the most ancient *Ceroplastes* species recognized in this area. There are two hypo-

theses about the center of origin of *C. rusci.* Balachowsky (1933) considered it to be the only *Ceroplastes* native of the Mediterranean Basin. He observed that it was commonly found on plants of the Mediterranean maquis (*Myrtus, Pistacia* spp.). In his opinion the colonization of cultivated fig, whose center of origin is the eastern Mediterranean, by *C. rusci* was a later step.

On the other hand, Bodenheimer (1951) considered that *C. rusci* was native of the eastern Mediterranean or of the Sudano-Deccanian region. From here it would have colonized the whole Mediterranean Basin.

In the countries surrounding the Mediterranean Basin *C. rusci* is widespread, mainly in the coastal areas, and occasionally appears as a pest of fig and *Citrus.*

Distribution. – In addition to the Mediterranean Basin, *C. rusci* is known in the Canary Islands, Madeira and the Azores (Silva Vieira *et al.,* 1983; Carnero Hernandez & Perez Guerra, 1986; Fernandes, 1981-1982); it is also known in Saudi Arabia (Matile Ferrero, 1988), Iraq and Iran (Map n. 373). *C. rusci* is recorded in some Central African countries (Ethiopia, Eritrea, Zimbabwe) (De Lotto & Nastasi, 1955; Hodgson, 1969), in South Africa (De Lotto, 1978), in Senegal, Ghana, Zambia and Sudan (Map n. 373). It was also recorded in South America (Argentina, Brazil, Uruguay) (Map n. 373) but, in our opinion, these old records need to be confirmed. It has been reported in the Pacific Islands (Irian Jaya) by Williams & Watson (1990).

Morphology of the adult female (fig.1) :

Mounted female oval in shape. 6-segmented antennae, legs well developed, with tibio-tarsal articulatory scleroses present. Claw with a minute but noticeable denticle.

Margin: stigmatic setae conical, with blunt apices. The number of the stigmatic setae is 15-29 (20) in the anterior group and 19-34 (21.7) in the posterior group in the specimens of the Mediterranean Basin. Marginal bristle shaped setae 7-11 (8.4) between the eye-spots, 1-5 (3) from the eye-spot to anterior stigmatic setae, 2-7 between the anterior and the posterior groups of stigmatic setae, 7-10 (8.7) from posterior stigmatic setae to anal cleft. The last 3-4 setae are longer than others and form a group on anal lobe.

Dorsum: membranous in young females, with 6 lateral, 1 cephalic, 1 medio-dorsal clear areas. Dorsal spines short with blunt apices. Dorsal pores numerous, scattered; most pores are unilocular (but in appearence they may look bilocular); tri-locular pores are also present. All these pores are provided with an inner filament with inner end diversely branched. Minute pores with filamentous duct scattered. Anal plates with three dorsal and one ventral setae. Pre-opercular pores 5-12 (8.2), round, just above the anal plates and sunk into the sclerotized integument of the caudal process.

Venter: quinquelocular disc pores in the stigmatic furrow form an irregular band from stigmatic atrium to stigmatic setae. Usually these pores are closer near the stigmatic cleft and the stigmatic atrium. Occasionally pores with more than 5 loculi are mingled with the five loculars in the band. There are 33-75 (60.2) quinqueloculars pores in the anterior band and 46-70 (61.7) in the posterior band. Tubular ducts 5-12 (8.7) between the antennae. Sometimes 1 tubular ducts (rarely more than one) also in the fifth abdominal segment. Cruciform pores scattered, more numerous along the submargin. Multilocular disc pores numerous around the genital opening and the sixth abdominal segment; some other multilocular pores arranged in a single row on third, fourth and fifth abdominal segments. A row of submarginal setae is present around the ventral submargin. There are 8-15 (11) submarginal setae between the eye spots, 2-7 (4) between the eye spot and the anterior band of a quinquelocular pores, 4-9 (6) between anterior and posterior band of quinquelocular pores, 13-21 (18) from posterior band to the anal lobe.

A specimen from Saudi Arabia (MNHN Paris, slide n. 10711-1) evidences a considerably higher number of quinquelocular pores and stigmatic setae than the specimens from Mediterranean Basin, respectively 80-109 quinquelocular pores and 32-43 stigmatic setae in each group.

Material examined : ITALY: Sicily, Catania, 23.10.1992 *Ficus carica,* leg. *A. Russo,* IEAP n.463,10 specimens; Napoli 20.2.1990, *Ficus carica,* leg. *P. Camporese,* IEAP n. 250, 5 specimens; Capri, 23.10.1992, *Pistacia terebinthus,* leg. *G. Pellizzari,*

IEAP n.450, 2 specimens. FRANCE: Corse, Sartene, 13.10.1902 *Ficus carica,* leg. *Marchal,* MNHN Paris, n. 10723-2, 2 specimens; Ajaccio, 10.9.1992 *Smylax aspera,* leg., *P. Dall'Ara,* IEAP n. 432, 2 specimens; Perpignan, 15.5.1977 *Ficus carica,* leg. *Rusplandy,* MNHN Paris, n. 6915-5, 2 specimens. ALGERIA: Tizi Ouzou, 2.5.1990 *Ficus*

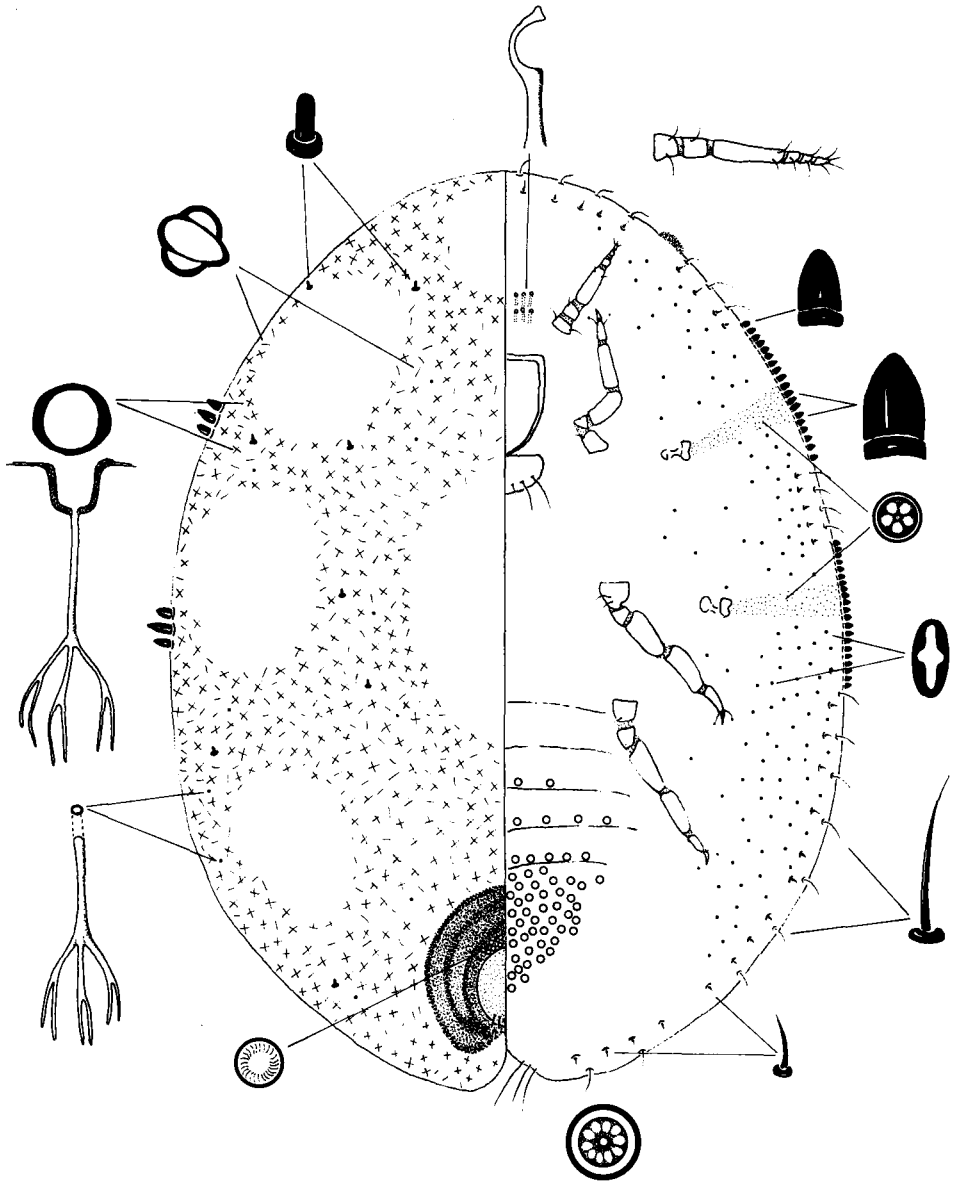

Fig. 1, *Ceroplastes rusci* (L.), adult female.

carica, leg. *Bacha,* MNHN Paris n. 11367-2, 2 specimens. SAUDI ARABIA: Taif 8.10.1978, *Ficus* sp., leg. *Talhouk,* MNHN Paris n. 10711-1, 1 specimen.

Biology. – *C. rusci* is considered polyphagous, but its most common host plants are species of *Pistacia, Myrtus, Ficus, Citrus, Nerium.* It is a pest of the cultivated fig and, at times, of *Citrus.* A list of host plants may be found in the work of Ben-Dov (1970). It is bisexual. In the countries of the Mediterranean Basin, *C. rusci* has 1-2 generations/year.

In southern France usually only one generation/year occurs (Benassy & Franco, 1974), while in warmer countries (e.g. Algeria, South Italy, Greece, Lebanon, Israel, Egypt) two generations/year occur; overwintering is carried out mostly by young adult females and 3rd instar female larvae; fecundity is influenced by the size of the female and usually varies from 800 to 1500 eggs/female (Balachowsky & Mesnil, 1935; Kashawinah & Talhouk, 1964; Inserra, 1970; Argyriou & Santorini, 1981; El-Nabawi *et al.*, 1984). Outbreaks of *C. rusci* usually occur every 2-3 years and are checked by natural enemies. Among them *Tetrastichus ceroplastae* Girault (Hym. Aphelinidae) and *Scutellista caerulea* (Fonscolombe) (=*cyanea* (Motsch.)) (Hym., Pteromalidae) play a fundamental role. The natural enemy complex has been studied by Ben-Dov (1970) and Benassy Franco (1974).

Ceroplastes sinensis Del Guercio

C. sinensis was discovered in the north of Italy (Liguria) on bigarade *(Citrus sinensis)* and was described by Del Guercio in 1900. In the following years it spread towards central and southern Italy and western Mediterranean countries. It is currently found in Portugal, Spain, southern France, Corsica, Italy, Sardinia, Sicily, Morocco, Tunisia, Algeria.

With regard to the eastern Mediterranean countries, *C. sinensis* was incidentally introduced into Israel from Italy (Bodenheimer, 1927) but Bodenheimer himself, in 1951, reported that *C. sinensis* had not become acclimatized in Israel. Ben-Dov (1970) confirms Bodenheimer's statement. With regard to Lebanon (Map n. 412) there is a single record for 1954 that needs to be confirmed.

In Turkey *C. sinensis* was first noticed by Bodenheimer (1935) in the south, but later was recorded only for north eastern areas and the Marmara region (Alkan, 1957; Altay *et al.*, 1967-72).

In Map n. 412 (1980) *C. sinensis* is reported as being present in Egypt, but it was not listed by Ezzat & Hussein (1967) nor in the List of Coccoidea of Egypt by Ezzat & Nada (1986). So we assume that it is not present in Egypt.

Since *C. sinensis* has been introduced into many parts of the world, it appears difficult to infer its native area. Because of its name, *"sinensis"*, several authors have erroneously deduced that this species was native of China. In fact the species was named *"sinensis"* by Del Guercio because he noticed that the scale infested the plants of *Citrus sinensis* more intensively than other *Citrus* species. The author himself observed that it was very similar to *C. cirripediformis,* known, at that time from Florida. Silvestri (1939) hypothesized an American origin. Gimpel *et al.* (1974) confirm that it is morphologically similar to *C. cirripediformis,* a species credited to be native of the southern United States and Caribbean Islands.

Distribution. – Outside of the Mediterranean Basin *C. sinensis* is known in the following countries. – Asia: recorded by Borchsenius (1957) from the eastern Black Sea coast and by Zoebelein (1966) for the Caspian coast of Iran. The record from China (Pen, 1960) should be considered erroneous. *C. sinensis,* in spite of its name, is not present in China, and this was confirmed by Tang (1991). Reported in the Philippines (Map n. 412). – Africa: Canary Is. (Carnero Hernandez & Perez Guerra, 1986), Madeira (Silva Vieira *et al.*, 1983), Benin, Togo, Ivory Coast, Mozambique (Map n. 412). – North America: in North America *C. sinensis* presents two distinct distribution areas: a western one (California and Mexico) and an eastern one (North Carolina and Virginia) (Gimpel *et al.*, 1974; Gill, 1988). It was reported from Bermuda by Simmonds (1957), but Hodgson & Hilburn (1991) in their survey on the Coccoidea of Bermuda stated that all the slides from

Bermuda labelled *"sinensis"* refer to *C. cirripediformis,* a species resembling *C. sinensis.* No living specimens of *C. sinensis* were found during their survey, but only specimens of *C. cirripediformis.* They concluded that "it seems likely that *C. sinensis* may never have colonized Bermuda". – Central America: the old records of *C. sinensis* for Jamaica (Map

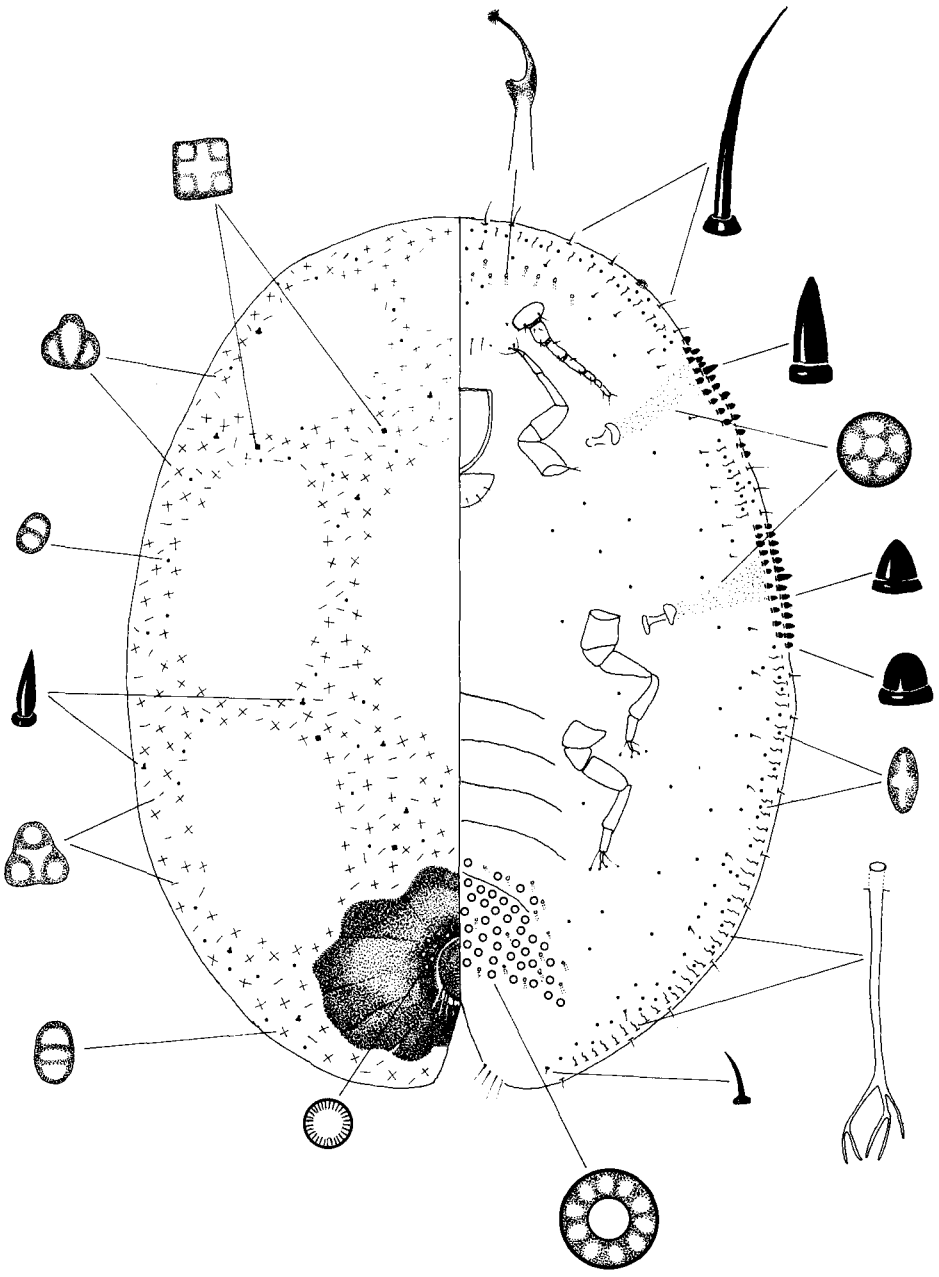

Fig. 2, *Ceroplastes sinensis* Del Guercio, adult female.

n. 412) need to be confirmed. – South America: Ecuador, Argentina, Brazil, Chile, Uruguay (Map n. 412). – Australia: New South Wales (Snowball, 1970), Norfolk Is. (Williams & Watson, 1990). New Zealand (Gimpel *et al.,* 1974).

Morphology of the adult female (fig. 2) :

Only the most important morphological characters are reported here; for a detailed description see Gimpel *et al.* (1974) and Gill (1988).

Mounted female oval in shape. 7-segmented antennae. 2 pairs of interantennal setae. Legs well developed with tibio-tarsal scleroses present. Claw without denticle (fig. 3).

Margin: stigmatic setae of different sizes and shapes : conical with blunt apices or bullet-shaped or hemispherical, distributed lateral of each stigmatic furrow. There are 23-40 (32.4) stigmatic setae in each group. 2-4 marginal bristle-shaped setae are present between anterior and posterior groups of stigmatic setae.

Dorsum: dorsal pores oval trilocular and triangular trilocular, scattered and numerically predominant on other kind of dorsal pores. Bilocular pores present, mainly on submargin. Some quadrilocular pores and a few quinquelocular distributed anterior to anal process. All the dorsal pores are provided with a thin inner filament with branched inner end. Anal plates with three dorsal and one ventral setae. Preopercular pores 12-15 (13.3) in two rows placed just above the anal plates.

Venter: 10-14 (12) tubular ducts with thin inner filament in the cephalic area and 12-20 (20) around the vulva. Filamentous ducts with minute round orefice distributed in a row around the submargin. These ducts are visible only in young, well stained females, otherwise they are unnoticeable. Multilocular disc pores concentrated around the vulva and sixth abdominal segment. A few multilocular pores may be distributed on fifth abdominal segment.

Material examined : ITALY: Albenga 19.4.1990, *Laurus nobilis,* leg. *Alma,* IEAP n. 434, 8 specimens; Bari, 22.9.1991, *Punica granatum,* leg. *G. Pellizzari,* IEAP n. 388, 2 specimens; Napoli, 23.4.1990, *Citrus* sp., leg. *Garonna,* IEAP n. 328/b, 3 specimens.

Biology. – Highly polyphagous, but especially common on *Citrus* spp. in the Mediterranean Basin. A list of host plants is reported by Snowball (1970). It is bisexual, but males are usually present in a low percentage so that it is generally assumed that parthenogenesis also occurs. *C. sinensis* presents 1 generation/year throughout its distribution areas. Overwintering is carried out mainly by young females and 3rd instar female larvae. Swarming of males occurs in November - December. Egg laying takes place in June-July. Each female may lay up to 4000 eggs (average 2000) (Silvestri, 1939). In the Mediterranean Basin its most common natural enemies are *Chilocorus bipustulatus* (L.), *Exochomus quadripustulatus* (L.) (Col. Coccinellidae), *Eublemma scitula* Rambour (Lep. Noctuidae) and the Pteromalids *Scutellista caerulea* and *Moranila californica.* Chemical control may be necessary in the *Citrus* groves.

Ceroplastes floridensis Comstock

C. floridensis was described by Comstock in 1881. He collected this wax scale in Florida on many different host plants and believed it was native to Florida. Some years later Cockerell supposed it was native to the West Indies and this hypothesis is accepted by Gimpel *et al.* (1974). Currently it is distributed worldwide in tropical and subtropical regions.

In the Mediterranean Basin *C. floridensis* was recorded by Hall in Egypt (1923) and by Bodenheimer in Israel (1924). In both these countries the scale became established and is a pest of *Citrus.*

In 1929 Balachowsky discovered a focus of *C. floridensis* in southern France and in the following years he studied its biology there (1933). Dr. A. Panis, coccidologist in the Laboratoire de Biologie des Invertébrés, Valbonne, recently confirmed the presence of *C. floridensis* in southern France (1993, personal communication).

In 1931 Lindinger noticed the presence of *C. floridensis* in Italy, in the Liguria

region, neighbouring the previously infested French region. This old record needs to be confirmed.

Years after its establishment in Israel and Egypt, *C. floridensis* expanded towards other countries. It was recorded in Malta (Saliba, 1963), Turkey (southern coastal areas) (Knorr, 1964), Syria, Lebanon (Traboulsi & Benassy, 1965), Cyprus (Georghiou, 1977), Lybia (Lal & Naji,1979), Greece (Astypalaea and Rhodes islands only) (Argyriou and Kourmadas,1980).

According to the Distribution Maps of Pests, Map 440 (1982), *C. floridensis* would be widespread throughout the Mediterranean Basin. Since the reported data on the back cover of Map 440 appeared to contrast with some known distribution data, the references were checked by us and several of them clearly appeared to be erroneus or the result of misinterpretation. For instance, with regard to the Mediterranean Basin, the cited reference of Balachowsky & Mesnil (1935 : 509-510) pertinent (according to the Map) to the presence of *C. floridensis* in Spain, Algeria, Morocco and Corsica, refers, in fact, to *C. sinensis* only. *C. floridensis* has not yet been recorded in Spain. The reported presence of *C. floridensis* on *Citrus* in Sicily (Snowball, 1970 : 57-60) also appears to be erroneous. Snowball's paper deals with *C. sinensis* only. On the other hand *C. floridensis* was never reported in the numerous papers dealing with the Coccidae of *Citrus* in Italy.

C. floridensis is currently well established in the eastern Mediterranean Basin (Israel, Egypt) and also occurs in the neighbouring countries. The records elsewhere in the Mediterranean Basin (fig. 5) point to the risk of incidental introduction.

Distribution. – Besides the recorded countries of the Mediterranean Basin, *C. floridensis* is recorded in many parts of the world. – Asia : Iran (Caspian sea coast) (Farahbakhsh, 1961), Pakistan (Karachi area) (Mahdihassan, 1976), India and Sri Lanka (Giliomee, 1966), southern region of China (Kawai, 1987; Tang, 1991). Japan : Ryukyu Is., Ogasawara Is. (Bonin) (Kawai, 1987), Malaysia (Borchsenius, 1957), Hong Kong (Gimpel *et al.,* 1974), Taiwan (Tao *et al.,* 1983). – Africa : Kenya, Uganda, Sierra Leone, Tanzania, Madagascar, Mauritius, Seychelles, South Africa (Giliomee, 1966), Comores (Matile Ferrero, 1979). – In North America *C. floridensis* is known in the following States: Alabama, Florida, Louisiana, Mississippi, Missouri, North Carolina, South Carolina and Texas. Recorded also in Maryland, New Mexico, New York, Virginia, Washington, but in these States it overwinters in greenhouses only (Gimpel *et al.* 1974). Not recorded in California (see Gill, 1988), as erroneously shown in Map n. 440 because of a misinterpretation of the cited reference. Reported in Mexico (Hamon & Williams, 1984) and Hawaii (Tao *et al.,* 1983). – Central America and Caribbean : recorded in Honduras, Nicaragua, Costa Rica, Panama, Guatemala and the West Indies (Gimpel *et al.,* 1974). Present, but uncommon in Bermuda (Hodgson & Hilburn, 1991). – South America: Ecuador (Gimpel *et al.,* 1974), Colombia (Mosquera, 1984), Venezuela (Santiago Clavijo, 1977), Brazil (Borchsenius, 1957) and Guyana. – Pacific Islands : Irian Jaya (Williams & Watson, 1990), Bonin, S. Mariana, Palau (Bearsdley, 1966). – Australia : Queensland (Browne, 1968). New Zealand (Map 440, 1982).

Morphology of the adult female (fig.3) :

Only the most important morphological characters are reported here; for a detailed description see Gimpel *et al.,* (1974).

Adult female oval in shape. 6-segmented antennae. Legs well developed without tibio-tarsal scleroses. Claw without denticle).

Margin: stigmatic setae lanceolate, with pointed apices, distributed laterally of each stigmatic cleft. There are 21-40 (29) setae in the anterior group and 23-43 (31) in the posterior group. 7-12 (9.5) marginal bristle-shaped setae are located between anterior and posterior group of setae.

Dorsum: dorsal pores mostly trilocular, scattered. Some quadrilocular pores and sometimes a few quinquelocular distributed in the median area. Anal plates with 3 dorsal and ventral setae. Preopercular pores 4-9 (6.7) just above the anal plates.

Venter: tubular ducts with enlarged inner filament distributed in a submarginal band from the eye spot to the anterior anal cleft. Multilocular disc pores concentrate around the vulva and on sixth abdominal segment. Some multilocular pores in the other abdominal segments. A few pores (usually 1-3) near the base of each coxa. These pores may be lacking.

Material examined: ISRAEL : Bet Dagan, 15.10.1989, *Hedera helix,* leg. *Ben-Dov,* IEAP n. 470, 6 specimens; Bet Dagan 24.9.1990, *Hedera helix,* leg. *Ben-Dov,* IEAP n. 469, 6 specimens.

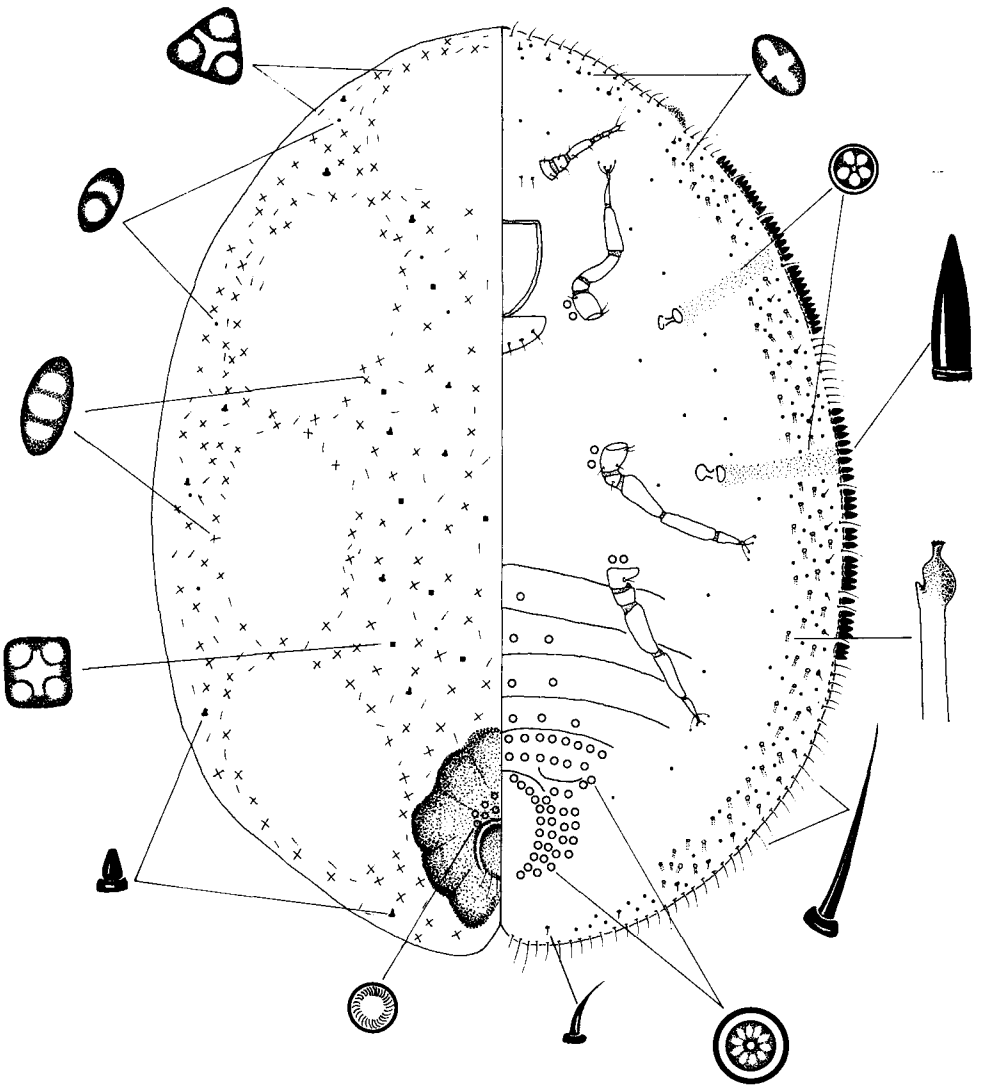

Fig. 3, *Ceroplastes floridensis* Comstock, adult female.

Biology. – Polyphagous. The most common host plants are *Citrus* spp. and ornamental plants (e.g. *Laurus nobilis, Ilex* spp.). A list of host plants is given by Ben Dov (1970). Males have not been observed (Ben-Dov, 1970; Swailem *et al.,* 1976; Hamon & Williams, 1984). Because it is considered to be one of the main pests of *Citrus,* the biology, natural enemies and population dynamics of *C. floridensis* were studied in depth in

Israel (Ben-Dov, 1976; Podoler *et al.*, 1981; Schneider *et al.*, 1987a) and Egypt (Swailem *et al.*, 1976). *C. floridensis* develops two annual generations in both of these countries: a first generation from April to September and a second generation from September to the following April; the females lay an average of 280 eggs (maximum observed 800), with no significant difference in fecundity between the two generations (Schneider *et al.*, 1987b). The development of only 1 generation/year was observed in southern France by Balachowsky (1933). The parasitoid complex was studied by Ben-Dov (1970). The most important parasitoid is considered to be *Tetrastichus ceroplastae* (Girault) (Hym., Aphelinidae). *Chilocorus bipustulatus* (L.) is considered to be an efficient predator of the larvae in the Israeli *Citrus* groves while *Moranila californica* and *Scutellista caerulea* (Hym., Pteromalidae) are the main cause of egg mortality (Podoler *et al.*, 1981).

Ceroplastes japonicus Green

C. japonicus was described in 1921 by Green who collected this species on maple plants imported from Japan. He considered this scale to be a variety of *C. floridensis* and subsequently named it *C. floridensis japonicus* var. nov.

In 1949 Borchsenius raised *C. japonicus* to a specific rank and pointed out the morphological differences between *C. floridensis* and *C. japonicus.* According to Borchsenius (1957) the native area of *C. japonicus* is eastern Asia. In China it is distributed in the northern regions (Shanxi, Shenxi, Hebei, Henan, Shanghai) (Tang, 1984). In Japan it is common in Honshu, Shikoku, Kyushu (Takahashi & Tachikawa, 1956; Kawai, 1993 personal communication). It is widely distributed in Korea (Park *et al.*, 1992).

Besides the above mentioned countries of eastern Asia, *C. japonicus* has become established in the groves of Georgia and Abkhazia (C.I.S.) (Borchsenius, 1957; Konstantinova, 1976).

With regard to the Mediterranean Basin, *C. japonicus* was first detected in northeastern Italy on *Citrus trifoliata* (Kozar *et al.*, 1984). In the following years it was also noticed in Central Italy (Florence, Pisa, Rome) (Longo, 1985) and south Italy (Marotta, 1987). Some specimens were also collected in the island of Capri. At present *C. japonicus* is widely distributed in northern and central Italy, in both coastal and inland areas, mainly in urban environments.

We studied the slides of Balachowsky collected in southern France in 1930, labelled *"C. floridensis"* and preserved in the Muséum National d'Histoire Naturelle, Paris. The specimens in the slide MNHN n. 4875-6 collected at Antibes and in the slide MNHN n. 4876 collected at Carqueiranne in February 1930 evidence the morphological characters of *C. japonicus.* Mrs. Danièle Matile Ferrero, coccidologist in the MNHN, who examined the slides, agrees with our opinion (1992, personal communication). Dr. Panis coccidologist in the Laboratoire de Biologie des Invertébrés, Valbonne, noticed the presence of *C. japonicus* in southern France for some years (1993, personal communication). Besides the study of 2 specimen collected in southern France and preserved in the Plant Protection Institute of Budapest (slide n. 1342) confirms the presence of *C. japonicus* in southern France.

Key to the female stages of *C. japonicus*

1. Three stigmatic setae in each stigmatic cleft 2

– More than three stigmatic setae in each stigmatic cleft 3

2. 3-4 quinquelocular disc pores in the stigmatic furrow. Stigmatic setae of the same size. **1st instar**

- 4-8 quinquelocular disc pores in the stigmatic furrow. Medial stigmatic seta distinctly longer than the other two ..... **2nd instar female**

3. Multilocular disc pores absent. Tubular ducts absent. Stigmatic setae 10-23 laterad of each stigmatic cleft ..... **3rd instar female**

- Multilocular disc pores present. Tubular ducts present. The stigmatic setae of anterior and posterior group usually form a uninterrupted row on the body margin ..... **adult female**

Morphology of the adult female (fig. 4) :

Mounted female oval in shape. 6-segmented antennae. Legs well developed, with tibio-tarsal scleroses absent. Claw without denticle.

Margin: stigmatic setae lanceolate with pointed apices, distributed in two rows: a row with 3-4 larger setae extending on dorsum, the others distributed along margin. The anterior and posterior group of stigmatic setae form a continuous row of 97-148 (111) setae along the body margin. A few marginal bristle-shaped setae (2-7 (4)) usually mingled with stigmatic setae (but in some specimens these setae are contiguous) may help to distinguish between the anterior and posterior group of stigmatic setae. Marginal bristle-shaped setae distributed along the body margin, except where stigmatic setae are present. There are 26-30 marginal setae between the eye-spots and 45-55 setae from the last stigmatic setae to anal lobe. The last 3-4 setae on anal lobe are distinctly longer than the others.

Dorsum: membranous in young female, with 1 cephalic and 6 lateral clear areas. Dorsal setae short, with capitate apices. Dorsal pores scattered, mostly oval trilocular and triangular trilocular. The oval trilocular predominant on other kind of pores. Some quadrilocular pores present in medio dorsal region. Irregular bilocular pores mainly distributed in submargins. In well-stained young females it is possible to recognize a thin inner filament with branched inner end associated with these pores. Minute oval pores with filamentous duct distributed in the submargins (these pore are somewhat difficult to detect). Anal plates with 3-4 dorsal setae. Pre-opercular pores 6-14 (10) just above the anal plates.

Venter: tubular ducts with enlarged inner filament form a submarginal band of 2-3 elements distributed from the eye spot to about the level of the caudal process. Cruciform pores in a submarginal band between the body margin and the band of tubular ducts. Quinquelocular pores in the stigmatic furrow form an irregular band from stigmatic atrium to stigmatic setae. There are 29-66 (41) quinquelocular disc pores in the anterior band and 24-72 (50) in the posterior band. Multilocular disc pores numerous around the vulva and on sixth abdominal segment. Several multilocular disc pores arranged in a single row in the remaining abdominal segments. A few multilocular pores (1-7) near the base of the coxae and near the stigmatic atrium. Submarginal short setae form a row along the body submargin, interrupted by the bands of stigmatic pores. There are an average of 120 submarginal setae from an anal lobe to the opposite one.

Material examined. – ITALY: Padova, 30.11.1989, *Citrus trifoliata,* leg. *P. Camporese,* IEAP n. 133, 5 specimens; Padova, 16-09-1991, *Hedera helix,* leg. *P. Camporese,* IEAP n. 400, 5 specimens; Venezia, 26-10-1989, *Hedera helix,* leg. *P. Camporese,* IEAP n. 471, 4 specimens ; Firenze 30-4-1984, *Ilex* sp., leg. *Covassi,* IEAP n. 80, 1 specimen; Riccione, 25-2-1992, *Hedera helix,* leg. *Ricci,* IEAP n. 429, 5 specimens; Roma, 29-3-1992, *Laurus nobilis,* leg. *Ricci,* IEAP n. 427, 5 specimens; Capri, 23.10.1992, *Hedera helix,* leg. *Pellizzari,* IEAP n. 446, 5 specimens. FRANCE: Valauris, 18.10.1980, *Citrus* sp., leg. *F. Kozar,* PPIB n. 1342, 2 specimens.

Biology. – Polyphagous. The most common host plants are species of *Citrus, Diospyros, Ilex, Hedera.* It is a pest of *Citrus,* mulberry and fruit trees in Georgia (C.I.S.) (Borchsenius, 1957) and of ornamental plants in urban environments in Japan (Kawai, 1977) and Italy. In Italy the commonest host plants are *Laurus nobilis, Diospyros kaki, Ilex aquifolium, Hedera helix, Acer spp.,* but it was observed also on *Fatsia japonica, Euonymus japonicus, Liquidambar styraciflua, Magnolia grandiflora, Platanus orientalis, Pyrus communis, Pyracantha coccinea, Salix babylonica, Ulmus campestris, Prunus spp.*

C. japonicus is a bisexual species in its native area (Jiang & Gu, 1988) and in

Georgia (Borchsenius, 1957). On the contrary, males have not been observed in Italy (Longo, 1985; Camporese, 1991). *C. japonicus* has one generation/year throughout its distribution areas. Overwintering is carried out by young adult females. In Italy egg-laying takes place in May-June. The size of the females and their fecundity are influenced by the host plant. The average fecundity is 1093 eggs/female on *Hedera,* 947 eggs/female on *Ilex,* 937 eggs/female on *Citrus trifoliata,* 691 eggs/female on *Laurus nobilis;* egg-hatching takes places in June; the first moult occurs in July, the second one in August; the adult females can be observed from September (Camporese, 1991).

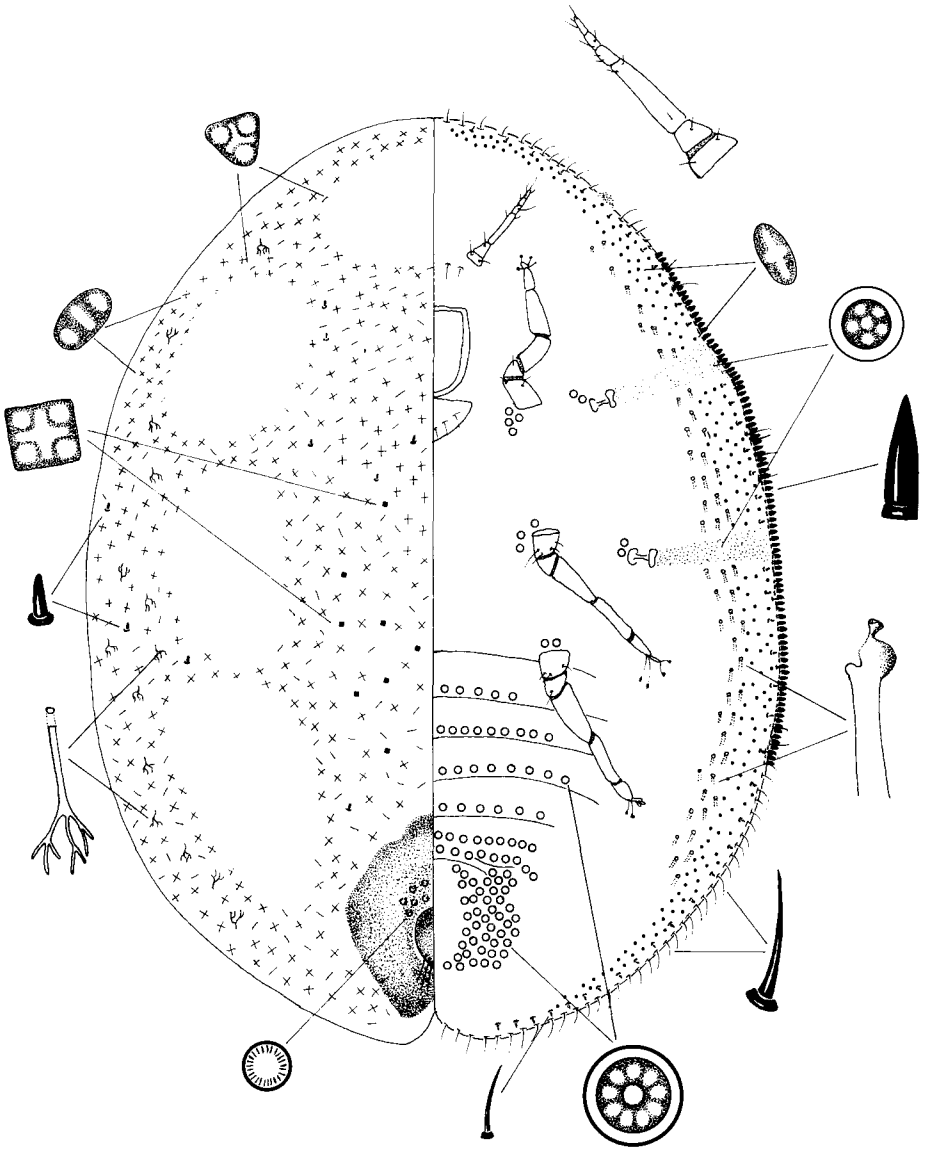

Fig. 4, *Ceroplastes japonicus* Green, adult female.

In Italy *C. japonicus* is widely distributed. From the first focus, noticed in 1983, the species expanded throughout northern and central Italy where it has become a pest of ornamentals in towns and nurseries. In southern Italy it is recorded but is not a pest. It is

important to point out that in northern Italy, where winters are cold, the other species of Italian *Ceroplastes* (*C. rusci* and *C. sinensis*) cannot survive outdoors while *C. japonicus* can stand temperatures of several degrees below zero. In such areas *C. japonicus* has became an invading species and in fact has occupied a vacant niche. Its spreading and establishment in northern Italian regions is enhanced by the absence of natural enemies. In fact *Scutellista caerulea* and *Moranila californica,* common and widespread egg predators of *Ceroplastes* sp., cannot survive in a cold climate. The occasional presence of generic predators such as *Chilocorus bipustulatus, Exochomus quadripustulatus* and *Lindorus lophantae* (Blais) (Col. Coccinellidae) has been observed (Longo, 1985; Camporese, 1991).

Specific parasitoids, present and active in the native area of *C. japonicus* (Sugonyaev, 1983; Jiang & Gu, 1988), have not been introduced into Italy. A project regarding rearing, acclimatization and release of *Chilocorus kuwanae* Silvestri (Col., Coccinellidae), considered in China and Japan among the most efficient predators of *Ceroplastes japonicus,* is being carried out in Italy.

CONCLUSION

The morphology and the current distribution of the species of *Ceroplastes* established in the Mediterranean Basin *(C. rusci, C. sinensis, C. floridensis, C. japonicus)* have been described in order to have a comprehensive work on the topic. Because, in Mediterranean countries, more than one species of the above mentioned *Ceroplastes* may be present in the same area, we have provided an identification key and a morphological account of each species to aid in species identification.

The morphology of *C. rusci,* the only native Mediterranean species, was not completely known. A comparative study on specimens from different localities of the Mediterranean Basin allows us to fill this gap.

Particular attention has been devoted to the morphology of *C. japonicus* with the primary aim of pointing out the morphological differences with the similar *C. floridensis.* For this reason an identification key of the female stages of *C. japonicus* is also provided. *C. floridensis* and *C. japonicus* have been confused for a long time because of their similarity. The main character used to distinguish the two species is the different arrangement of the stigmatic setae: usually they form a continuous row along the body margin in *C. japonicus,* while in *C. floridensis* the marginal row of stigmatic setae is interrupted by 7-12 marginal bristle-shaped setae. Besides the number of stigmatic setae on one side is greater in *C. japonicus* (average 111) than in *C. floridensis* (average 60). Other characters may help in distinguishing the two species: the number of quinquelocular disc pores in the stigmatic furrow is greater in *C. floridensis* (50-90, average 65) than in *C. japonicus* (26-70, average 45); the submarginal band of tubular ducts extends from the eye-spot to about the caudal process level in *C. japonicus,* but extends further in *C. floridensis.* Furthermore, the dorsal filamentous ducts have been recognized in *C. japonicus* but not in *C. floridensis* (see also Tang, 1991, fig. 77, 78).

Information on the current distribution of the *Ceroplastes* species in the Mediterranean Basin is provided (fig. 5). The only species which is present in all countries surrounding the Mediterranean Basin is *C. rusci. C. sinensis* and *C. floridensis* currently exhibit opposing distributions. *C. sinensis* is distributed mainly in the western Mediterranean countries and no expansion towards other countries has been reported for the last twenty years. *C. floridensis* is currently well established in the eastern Mediterranean Basin, but incidental introductions are reported towards western countries, in which its main host plant, the *Citrus,* is largely cultivated. *C. japonicus* is present in southern France and Italy, but Italy currently appears to be the only Mediterranean country in

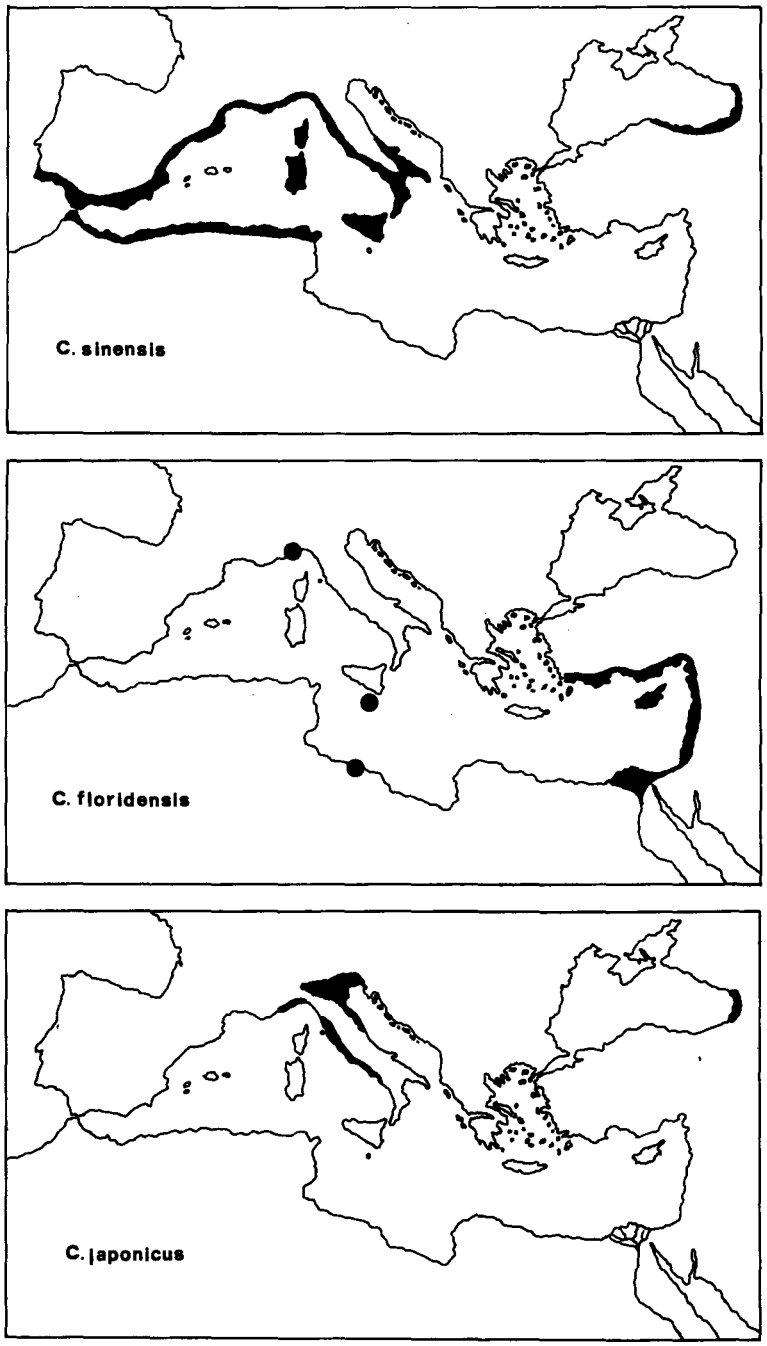

Fig. 5, distribution maps of *Ceroplastes sinensis, C. floridensis, C. japonicus* in the Mediterranean Basin. The black spots indicate isolated foci.

which *C. japonicus* is widespread. It is interesting that outbreaks of this species are especially frequent in northern Italian regions, where the winters are cold and the other Mediterranean *Ceroplastes* and their natural enemies cannot survive.

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PPIB, Budapest) for the loan of slides and helpful advice. Thanks are due to all the Italian Collegues who have provided specimens of *Ceroplastes* : Dr. A. Alma, Torino; Dr. M. Covassi, Firenze; Dr. A. Garonna, Napoli; Dr. S. Marotta, Potenza; Prof. C. Ricci, Perugia; Prof. A. Russo, Catania. We extend our thanks to Dr. Y. Ben-Dov, Israel, who supplied for study specimens of *C. floridensis* and Prof. S. Zangheri (IEAP, Padova) for review of the manuscript.

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