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DISTRIBUTION AND ECOLOGY OF *METCALFA PRUINOSA* AND ASSOCIATED PLANTHOPPERS IN NORTH AMERICA (HOMOPTERA: FULGOROIDEA)

The flatid planthopper *Metcalfa pruinosa* (Say) has been the focus of numerous studies because of its recent rapid expansion throughout southern Europe. This insect was introduced into northern Italy from the United States in the 1970's (DLABOLA, 1981; ZANGHERI and DONADINI, 1980) and spread throughout the Italian peninsula into Sicily and Sardinia as well as to France Corsica, Switzerland, Austria, Slovenia, and Croatia (ALMA, 2000; DELLA GIUSTINA, 1986). *M. pruinosa* is of particular concern to economic entomologists because of its potential to reach high population densities on a wide range of host plants including grapes, citrus, olives, apples, pears, and ornamental plants, among others (BAGNOLI and LUCCHI, 2000). In this paper we summarize the life histories of *M. pruinosa* and associated North American planthoppers, provide information on the occurrence of *M. pruinosa* in mixed species feeding aggregations, outline the geographic distribution of *M. pruinosa* and associated planthoppers, and compare population densities of *M. pruinosa* in sites in the United States and Italy.

LIFE HISTORIES

The planthoppers typically associated with *M. pruinosa* include the flatids, *Anormenis chloris* (Melichar) and *Ormenoides venusta* (Melichar), and the issid, *Acanalonia conica* (Say) (figs. 1-3). These insects are often found in mixed species assemblages, have similar life histories, and overlap broadly in geographic distribution in North America.

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Figs. 1-3

1 - Planthopper adults. *Metcalfa pruinosa* (far left), *Ormenoides venusta* (middle left), *Anormenis chloris* (middle right), *Acanalonia conica* (far right). 2 - Mixed species aggregations of planthopper nymphs. *Metcalfa pruinosa* (white) and *Ormenoides venusta* (green). 3 - Nymphs of *Acanalonia conica*.

M. pruinosa is one of approximately 1,100 species in the planthopper family Flatidae, of which 36 species occur in the United States, 8 species occur in Europe, and 3 are found in Italy (METCALF, 1957; NAST, 1972; D'URSO, 1995). This species was first described as *Flata pruinosa* from the eastern United States by Thomas Say in 1830 and has been placed in the genera *Poeciloptera*, *Ormenis*, and *Melormenis* by various authors (METCALF, 1957). The genus *Metcalfa* was established for this species by Caldwell and Martorell who included four additional neotropical species in the genus (METCALF, 1957). *M. pruinosa* has been mentioned in at least 150 papers published since its description (METCALF, 1957; WILSON *et al.*, 1994; WILSON and MCPHERSON, 1980a,b, 1981b).

M. pruinosa is of virtually no economic importance in the United States with the few records of its effect on plants including damage to citrus after the buds were affected by a late frost (DEAN and BAILEY, 1961; WENE, 1950), and its occurrence in large numbers on dahlias, salvia, and privet (WALDEN, 1922, 1927; WENE, 1954). This flatid is highly polyphagous having been recorded on over 120 plant species in more than 50 plant families in the United States and 330 plant species in 78 plant families in Europe (BAGNOLI and LUCCHI, 2000; MEAD, 1969; WILSON *et al.*, 1994; WILSON and MCPHERSON, 1980a).

M. pruinosa is univoltine and during the late summer and early fall females insert eggs into pre-existing openings in the bark of twigs or can excavate openings in soft corky bark (SANTINI and LUCCHI, 1984; WILSON and MCPHERSON, 1981b). The eggs overwinter in the twigs and hatch in late spring; the nymphs cut through the chorion by using an egg-burster (LUCCHI, 1994). Development of the five nymphal instars takes place throughout the summer with the first adults found by early July in the central United States and Tuscany, Italy. Details of the life history including descriptions of immature stages were provided by WILSON and MCPHERSON (1981b) (fig. 4).

Anormenis chloris (referred to as *A. septentrionalis* auct. (*nec.* Spinola) *in litt.*; O'BRIEN, 1985) has a life cycle very similar to that of *M. pruinosa* and also is found on a wide variety of host plants (WILSON and MCPHERSON, 1980a, 1981b). Females lay eggs in an elongate trough cut into the twig of a woody plant; the eggs are placed in a single line rather than scattered randomly as in *M. pruinosa* (Fig. 5). Nymphs are broader than those of *M. pruinosa* and late stage nymphs have distinct dark markings on their wingpads; adults are pale green and have truncate forewings.

Ormenoides venusta is also polyphagous and has a life cycle similar to that of *M. pruinosa* (WILSON and MCPHERSON, 1980a, 1981b). Eggs of *O. venusta* have not been found but females must deposit them in plant

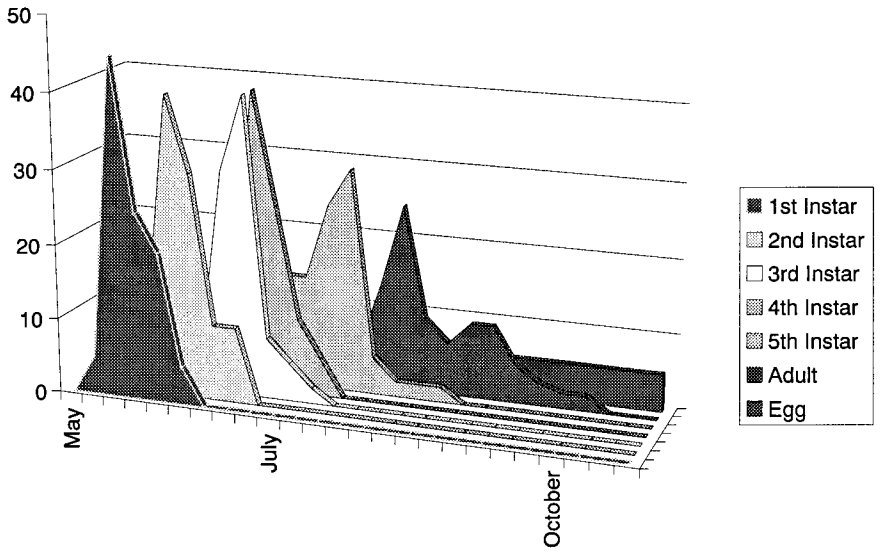

Fig. 4
Generalized life history of associated planthoppers in the central United States (from WILSON and MCPHERSON 1981b).

tissue as they have a sword-like ovipositor similar to that of other flatids (WILSON and MCPHERSON, 1981b). Nymphs are slender and bright green in color with thin white stripes. Adults are pale green like those of *A. chloris* but are smaller and have a fine brown band along the curved margin of the forewings.

Acanalonia conica is the only one of 18 species of *Acanalonia* that has been found associated with *Metcalfa pruinosa* and other flatids (FREUND and WILSON, 1995; WILSON and MCPHERSON, 1980a). This issid planthopper feeds on a wide variety of plants and lays its eggs in separate concavities cut into woody plant tissue (fig. 6) (WILSON and MCPHERSON, 1980b, 1981a). Nymphs are dark brown and have a spherical shape; adults are bright green with a network of veins on the forewings.

MIXED SPECIES FEEDING AGGREGATIONS

M. pruinosa nymphs are commonly found feeding with those of *A. chloris*, *O. venusta*, and *A. conica* (fig. 2) (WILSON and MCPHERSON, 1980a). Data on the occurrence of nymphs in aggregations are summarized for observations in southern Illinois during the summers of 1977-1979 and west central Missouri during the summer of 2000. Of the 303 nymphs recorded,

Fig. 5
Eggs of *Anormenis chloris*.

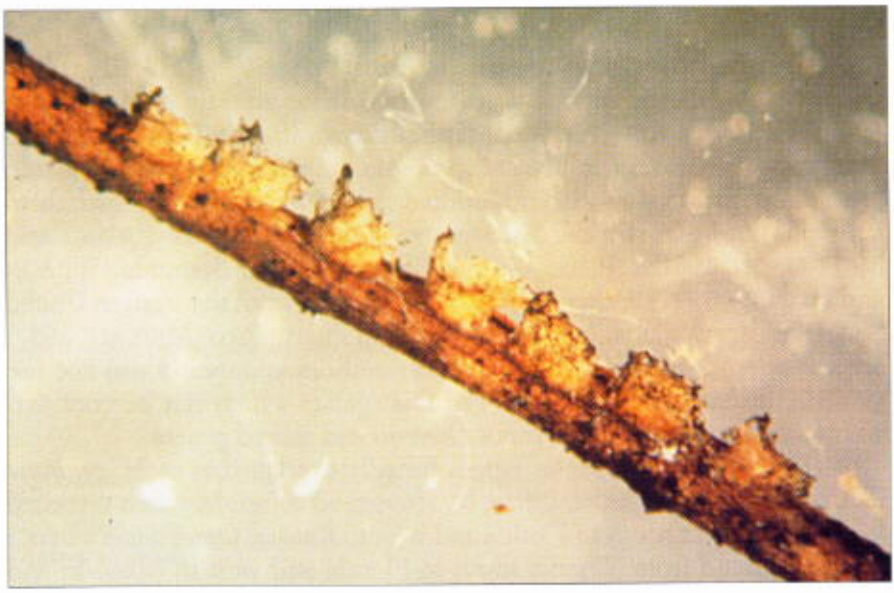

Fig. 6
Eggs of *Acanalonia conica*.

fewer than 10% were found as single individuals on a leaf or twig, 90% were found in conspecific or mixed species assemblages. Of those found in aggregations, 15% occurred in conspecific aggregations, 20% were in aggregations of two species, 32% of three species, and 33% of all four species.

Aggregations of the planthopper species cannot be the result of random assemblage because population densities are generally too low. Typically, only one or two twigs or leaves on an entire tree will harbor these planthoppers. Planthoppers must move to an appropriate feeding site in order for these mixed-species assemblages to form, and this must involve some attractant emitted by either the plant or the planthoppers that have established themselves at a particular site. It would appear to be highly unlikely for the particular place on the plant to provide an attractant as there does not seem to be any taxonomic or structural pattern relative to feeding location. However, planthopper immatures do have a large number of sensory pits (LUCCHI and MAZZONI, 1999) on the head and thorax that might serve as means for detecting pheromones or other signals emitted by other planthoppers. Further, it is assumed that planthopper adults communicate via substrate vibrations produced by an abdominal tymbal or by movements of the entire abdomen (MITOMI *et al.*, 1984). The calls produced by some species of cixiid, delphacid, and flatid planthoppers have been recorded and described (e.g., CLARIDGE and DE VRIJER, 1994; HEADY and DENNO, 1991; HOCH and HOWARTH, 1993; ICHIKAWA, 1976; MOORE, 1961; OSSIANNILSSON, 1949).

GEOGRAPHICAL DISTRIBUTIONS

The North American geographic distributions of the associated planthoppers are very similar. *M. pruinosa* is found throughout eastern North America and has been recorded from Quebec, Canada south to Florida and west to Minnesota, and Texas (WILSON and MCPHERSON, 1981b). It has also been recorded from Bermuda (WILSON and HILBURN, 1991). Other records of *M. pruinosa* from the western United States and Brazil, Cuba, Jamaica, Mexico and Puerto Rico (METCALF, 1957) are considered unreliable because most authors apparently did not use genitalic features in identification of this species which can be confused with a variety of flatids in the genus *Ormenis* and related genera.

The other three species ranges broadly overlap that of *M. pruinosa* (WILSON and MCPHERSON, 1981a, b). *Anormenis chloris* has been recorded from Connecticut south to Florida and west to Kansas. *Ormenoides venusta* has been found from Virginia south to Florida and west to Missouri and Texas. *Acanalonia conica* has been recorded from Connecticut south to Florida and west to Nebraska and Texas.

The potential effect of broad climatic features on *Metcalfa* geographic distribution was examined by WILSON and LUCCHI (2000) who constructed a climograph based on average monthly temperature and precipitation data for localities at the edges of the range of *Metcalfa* in North America. Comparison of this composite climograph to climographs for areas in Europe where *Metcalfa* has become established showed that they fall within the North American composite with the exception of the hot, dry Mediterranean climates of Italy and southern France. The successful colonization of these areas clearly indicates that these climatic conditions are not a barrier to the spread of *Metcalfa* as these insects undoubtably seek habitats with favorable microclimates within areas that would otherwise be unsuitable. Comparison of the North American composite climograph with those from a wide range of European localities suggests that these two climatic features alone are unlikely to serve as a barrier to the spread of *Metcalfa* in Eurasia.

POPULATION DENSITIES IN THE UNITED STATES AND ITALY

We undertook two brief studies to examine the differences in abundance between populations of *M. pruinosa* in Missouri, United States and Tuscany, Italy. In the first study, we collected planthoppers from 3 to 11 July 2000, totalling 45 «man-hours», at 5 different sites within 10 km of Warrensburg, Missouri. The planthoppers were collected by aspirating them from leaves and branches and by sweeping understory vegetation. We compared the results of this study to the data obtained from the transect study done on 17 July 2000 in Tuscany (see below) by calculating the number of hours it took to count the number of planthoppers. The data are summarized in Table 1.

Table 1 – Number of planthoppers encountered and number of specimens encountered per «man-hour» in Missouri, USA and Tuscany, Italy.

	Number		Number per «Man-Hour»	
Planthopper	USA	Italy	USA	Italy
Acanalonia conica	98	-	2.2	-
Anormenis chloris	405	-	9.0	-
Metcalfa pruinosa	503	11,571	11.2	964.2
Ormenoides venusta	128	-	2.8	-
TOTALS	1,134	11,571	25.2	964.2

In the second study, we counted planthopper nymphs and adults along four 50 meter transects of second growth forest in Warrensburg, Missouri and four 50 meter transects of second growth forest in Pisa, Tuscany on 10 July and 17 July, respectively. Each transect was established beginning with the the first plant encountered that bore planthoppers. For the length of each transect we recorded the number of planthoppers and the species of plant on which they occurred and made 100 sweeps of ground vegetation. The data are summarized in Table 2.

Table 2 – Planthopper abundance per 50 m transect in Missouri, USA and Tuscany, Italy.

Planthopper	Totals	Mean ±	SD
Acanalonia conica	9	2.2 ±	1.71
Anormenis chloris	38	9.5 ±	5.20
Metcalfa pruinosa	72	18.0 ±	8.29
Ormenoides venusta	9	2.2 ±	2.63
USA TOTALS	128	32.0 ±	14.72
ITALY TOTALS	11,571	2,892.7 ±	1,172.76

Tables 1 and 2 clearly illustrate the enormous differences in population densities of *Metcalfa* and associated planthoppers between sites in Italy and the USA. Although occasional population irruptions can occur in the United States (DEAN and BAILEY, 1961; WALDEN, 1922, 1927; WENE, 1950, 1954), they appear to be relatively rare and localized (LUCCHI and WILSON, personal observation). This suggestion is underscored by GIROLAMI and OLMI (personal correspondence) who undertook a wide ranging effort to collect *Metcalfa* in USA and found only two localities in Connecticut and Texas that had population levels comparable to those found in Italy. There are a number of factors that could influence planthopper populations including the presence of preferred host plant taxa, the availability of suitable egg deposition sites, the presence or absence of parasitoids and pathogens, length of the growing season, and climatic factors such as temperature and precipitation.

SUMMARY

The recent introduction and subsequent range expansion of the flatid planthopper *Metcalfa pruinosa* (Say) in southern Europe is of concern to economic entomologists because of its potential to reach high population densities on a large number of host plant species. The life histories of *M. pruinosa* and associated North American planthoppers, *Anormenis chloris* (Melichar), *Ormenoides venusta* (Melichar) (Flatidae), and *Acanalonia conica* (Say) (Issidae) are

similar in that they all are univoltine, overwinter as eggs inserted in the twigs of woody plants, and are broadly polyphagous. The eggs of the four species hatch in late spring, adults eclose from fifth instars in mid-summer, and females lay eggs in late summer and early fall. The four species are broadly sympatric over their ranges and nymphs are commonly found in mixed species feeding aggregations. Data from studies of the population densities of the four species in the United States and *M. pruinosa* in Italy are presented.

RIASSUNTO

ASPETTI COROLOGICI ED ECOLOGICI RELATIVI A METCALFA PRUINOSA *E ALTRI FLATIDI AD ESSA ASSOCIATI IN NORD-AMERICA (HOMOPTERA: FULGOROIDEA)*

La recente introduzione e la susseguente rapida diffusione del Flatide nordamericano *Metcalfa pruinosa* (Say) in molte aree dell'Europa meridionale ha suscitato notevole interesse e preoccupazione negli entomologi agrari per la sua caratteristica intrinseca di dar luogo a infestazioni massicce su un gran numero di piante spontanee e/o coltivate. Biologia e fenologia di *M. pruinosa* e degli altri «planthoppers» nordamericani ad essa strettamente associati quali i flatidi *Anormenis chloris* (Melichar) e *Ormenoides venusta* (Melichar) (Flatidae), e l'isside *Acanalonia conica* (Say) sono pressoché simili. Essi sono infatti tutti monovoltini, svernano allo stato di uovo che viene inserito nella corteccia di piante legnose, sono largamente polifagi ed occupano per lo più la stessa area geografica.

Le uova delle quattro specie menzionate schiudono in primavera inoltrata, i primi adulti compaiono a fine giugno e le femmine depongono le uova fino agli inizi dell'autunno. Le forme giovanili delle quattro specie vivono in stretta associazione sulle piante ospiti. Una particolare attenzione è posta nel presente lavoro ai dati riguardanti gli studi da noi condotti sulla densità di popolazione delle quattro specie negli Stati Uniti (Missouri) e in Italia (Toscana).

BIBLIOGRAFIA

ALMA A., 2000 – *I flatidi Italiani* - Metcalfa pruinosa *(Say): origine, diffusione e aspetti fitopatologici.* Metcalfa pruinosa*: diffusione nel continente Europeo e prospettive di controlo biologico.* – Regione Lombardia, Dir. Gen. Agric., Suppl., 55: 9-11.

BAGNOLI B., LUCCHI A., 2000 – *Dannosità e misure di controllo integrato.* In: A. Lucchi, La *Metcalfa* negli ecosistemi italiani; Agenzia Regionale per lo Sviluppo e l'Innovazione nel settore. Agricolo-forestale, Firenze, Italy: 65-88.

CLARIDGE M.F., DE VRIJER P.W.F., 1994 – *Reproductive behavior: the role of acoustic signals in species recognition and speciation.* In: Denno, R.F. and Perfect T.J. (eds.). Planthoppers: their ecology and management. Chapman and Hall, Inc. New York: 216-233

DEAN H.A., BAILEY J.H., 1961 – *A flatid planthopper*, Metcalfa pruinosa. – J. Econ. Entomol., 54: 1104-1106.

DELLA GUISTINA W., 1986 – Metcalfa pruinosa *(Say, 1830), nouveaute pour la faune de France (Hom., Flatidae).* – Bull. Soc. Entomol. France, 91: 89-92.

DLABOLA J., 1981 – Metcalfa pruinosa *(Say, 1830), eine schadliche nordamerikanische Flatide als Erstfund in der Palaearktis.* – Faun. Abhandl., 92-94.

D'URSO V., 1995 – *Homoptera Auchenorrhyncha.* In: Minelli A., Ruffo S., La Posta S. (eds.), Checklist delle specie della fauna Italiana, 42: 1-35. Calderoni, Bologna.

FREUND R., WILSON S.W., 1995 – *The planthopper genus* Acanalonia *in the United States (Homoptera: Issidae): morphology of male and female external genitalia.* – Insecta Mundi, 9: 195-215.

HEADY S.E., DENNO R.F., 1991 – *Reproductive isolation in* Prokelisia *planthoppers (Homoptera: Delphacidae): acoustic differentiation and hybridization failure.* – J. Insect Behavior, 4: 367-390.

HOCH H., HOWARTH F.G., 1993 – *Evolutionary dynamics of behavioral divergence among populations of the Hawaiian cave-dwelling planthopper,* Oliarus polyphemus *(Homoptera: Fulgoroidea: Cixiidae).* – Pacific Sci., 47: 308-318.

ICHIKAWA T., 1976 – *Mutual communication by substrate vibration in the mating behavior of planthoppers (Homoptera: Delphacidae).* – Appl. Entomol., Zool., 11: 8-23.

LUCCHI A., 1994 – *The egg-burster in the flatid planthopper* Metcalfa pruinosa *(Say) in Italy (Homoptera, Fulgoroidea).* – Proc. Entomol. Soc. Washington, 96: 548-552.

LUCCHI A., MAZZONI E., 1999 – *Wax glands and cuticular pores in nymphs of* Metcalfa pruinosa *(Say) (Homoptera: Flatidae): a light and scanning microscopy study.* – 10th Internat. Auchenorrhyncha Congr., Cardiff (Wales), 6-10 Sept.

MEAD F.V., 1969 – *Citrus flatid planthopper* Metcalfa pruinosa *(Say) (Homoptera, Flatidae).* – Florida Dep. Agric., Circ 85.

METCALF Z.P., 1957 – *General catalogue of the Homoptera.* Fasc. IV. Fulgoroidea, Part 13. Flatidae and Hypochthonellidae, 574 pp.

MITOMI M., ICHIKAWA T., OKAMOTO H., 1984 – *Morphology of the vibration-producing organ in adult rice brown planthopper,* Nilaparvata lugens *(Stal) (Homoptera: Delphacidae).* – Appl. Entomol., Zool. 19: 407-417.

MOORE T., 1961 – *Audiospectrographic analysis of sounds of Hemiptera and Homoptera.* – Ann. Entomol. Soc., Amer., 54: 273-291.

NAST J., 1972 – *Palaearctic Auchenorrhyncha (Homoptera). An annotated check list.* Polish Acad. Sci. Warszawa. 551 pp.

O'BRIEN L.B., 1985 – *New synonymies and combinations in New World Fulgoroidea (Achilidae, Delphacidae, Flatidae, Fulgoridae: Homoptera).* – Ann. Entomol. Soc., Am., 78: 657-662.

OSSIANNILSSON F., 1949 – *Insect drummers: a study on the morphology and functions of the sound producing organ of Swedish Homoptera Auchenorrhyncha.* – Opusc. Entomol. Suppl., 10: 1-146.

SANTINI L., LUCCHI A., 1994 – *Su alcuni aspetti morfologici e biologici della riproduzione in* Metcalfa pruinosa *(Say) (Homoptera, Flatidae).* – Frustula Entomol., (n. s.). 17(39): 185-197.

WALDEN B.H., 1922 – *Abundance of* Ormenis pruinosa *Say on ibota privet.* – Connecticut Agric. Exp. Sta. Bull., 285: 267-268.

WALDEN B.H., 1927 – *The mealy flatas,* Ormenis pruinosa *Say and* O. septentrionalis *Spin.* – Connecticut Agric. Exp. Sta. Bull., 234: 189-190.

WENE G.P., 1950 – *The citrus fulgorid.* – Ann. Proc. Lower Rio Grande Valley Citrus Veg. Inst., 4: 90-93.

WENE G.P., RIHERD P.T., 1954 – *Control of puss caterfipper and fulgorids attacking ornamentals during 1953.* – Rio Grande Valley Hortic. Soc. J. Tex. Avocado Soc., Yearbook 1953: 45-46.

WILSON M.R., HILBURN D.J., 1991 – *Annotated list of the auchenorrhynchous Homoptera (Insecta) of Bermuda.* – Ann. Entomol. Soc. Am., 84: 412-419.

WILSON S.W., LUCCHI A., 2000 – *Aspetti sistematici, corologici, ecologici.* In: A. Lucchi, La *Metcalfa* negli ecosistemi italiani, Agenzia Regionale per lo Sviluppo e l'Innovazione nel settore Agricolo-forestale, Firenze, Italy: 13-28.

WILSON S.W., MCPHERSON J.E., 1980a – *Mixed species feeding assemblages of planthopper nymphs (Homoptera: Fulgoroidea).* – Great Lakes Entomol., 13: 185-187.

WILSON S.W., MCPHERSON J.E., 1980b – *A list of the host plants of the Illinois Acanaloniidae and Flatidae (Homoptera: Fulgoroidea).* – Trans. Illinois Acad. Sci., 73(4): 21-29.

WILSON S.W., MCPHERSON J.E., 1981a – *Life histories of* Acanalonia bivittata *and* A. conica *with descriptions of immature stages.* – Ann. Entomol. Soc. Amer., 74: 289-298.

WILSON S.W., MCPHERSON J.E., 1981b – *Life histories* of Anormenis septentrionalis, Metcalfa pruinosa, *and* Ormenoides venusta *with descriptions of immature stages.* – Ann. Entomol. Soc. Amer., 74: 299-311.

WILSON S.W., DENNO R.F., MITTER C., WILSON M.R., 1994 – *Evolutionary patterns of host plant use by delphacid planthoppers and their relatives* (Chapter 1). In: Denno R.F., Perfect T.J., (eds.) Planthoppers: their Ecology and Management. Chapman and Hall, Inc., New York: 7-113.

ZANGHERI S., DONADINI P., 1980 – *Comparsa nel Veneto di un Omottero neartico:* Metcalfa pruinosa *Say* (sic) *(Homoptera, Flatidae).* – Redia, 63: 301-304.