Rove Beetles of the Genus *Aleochara* Gravenhorst (Coleoptera: Staphylinidae) Parasitizing the Cabbage Maggot, *Delia radicum* (L.) (Diptera: Anthomyiidae), in the Northern Central Coast of California

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Source: Proceedings of the Entomological Society of Washington, 117(4):525-528.
Published By: Entomological Society of Washington
DOI: http://dx.doi.org/10.4289/0013-8797.117.4.525
URL: http://www.bioone.org/doi/full/10.4289/0013-8797.117.4.525

PROC. ENTOMOL. SOC. WASH.
117(4), 2015, pp. 525–528

NOTE

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Aleochara bilineata Gyllenhal and *Aleochara verna* Say (Coleoptera: Staphylinidae: Aleocharinae) are effective predators and parasitoids of the puparia of economically important anthomyiid flies of cruciferous crops including the cabbage maggot, *Delia radicum* (Linnaeus) (Diptera: Anthomyiidae) (Maus et al. 1998, Turnock et al. 1995, Klimaszewski 1984). *Delia radicum* is one of the most destructive pests of cruciferous crops worldwide (Coaker and Finch 1971). In the past decade, it has become a serious pest of *Brassica* crops in the Salinas Valley (Monterey County) of the central coast of California (Johnsen and Gutierrez 1997, Joseph and Martinez 2014). Adults of *D. radicum* move into the fields at various stages of plant development and lay eggs at the crown area of the plant. The emerging larvae of *D. radicum* feed on the taproot, inhibiting the translocation of nutrients and water, which affects the normal growth and development of plants.

Aleochara bilineata has been reported from most *Brassica*-producing areas worldwide and is an effective biological control agent against *D. radicum* (Hemachandra et al. 2005, 2007; Hummel et al. 2010). To determine the status of *Aleochara* species in the north central coast of California, a survey was conducted in an organically managed broccoli field in Salinas, CA. Seeds of 'Marathon' broccoli (*Brassica oleracea* L.) were planted on 2 February, 2014, in a field that was naturally infested with cabbage maggot. An application of insecticidal soap was administered to manage cabbage aphids seven weeks after planting the seeds. Broccoli root samples were collected on consecutive weeks (4, 11 and 18 April, 2014). Each week, 20 plants with root systems intact plus associated soil were sampled and carefully evaluated for the presence of cabbage maggot puparia. The puparia were labeled and stored in Petri dishes at ~21°C, L:D 16:8 photoperiod, ~45% RH, and were examined twice-weekly for the emergence of adult rove beetles and cabbage maggot flies. Rove beetles reared from puparia were stored in 95% ethyl alcohol for identification. *Aleochara* species reared from puparia were determined using current identification keys (Klimaszewski 1984). Voucher specimens were deposited in the University of Georgia Collection of Arthropods (UGCA), Athens, GA, as well as the collection of the senior author.

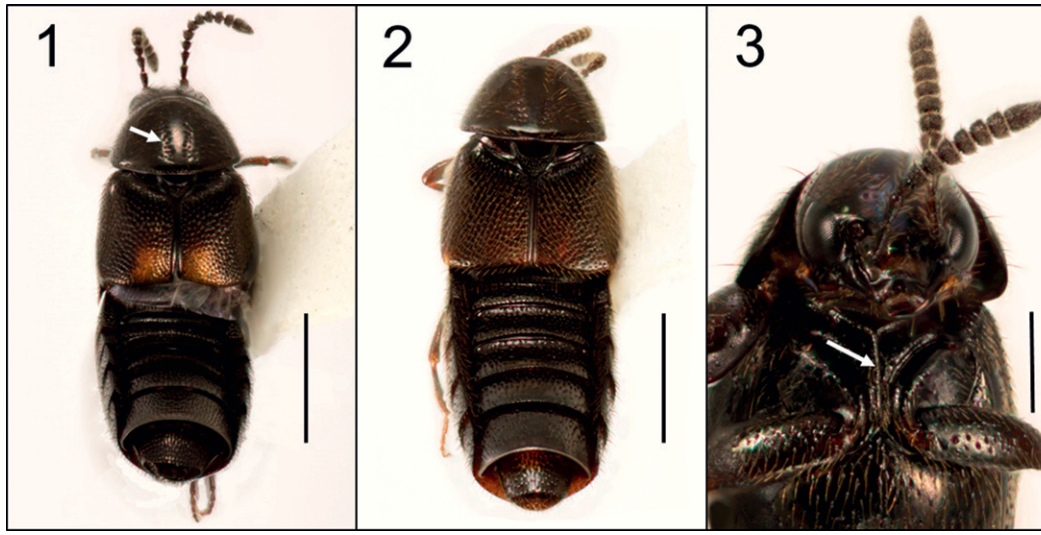
Here, we report the occurrence of *A. bilineata* and *A. verna* in a *Brassica* field in the northern central coast of California. This represents the first verified record of *A. bilineata* in California; *A. verna* previously was known to occur throughout most of the state. In the Salinas Valley, *Brassica* crops such as broccoli (*Brassica oleracea* var. *italica* Plenck), cauliflower (*B. oleracea* L. var. *botrytis*), cabbage (*B. oleracea* L. var. *capitata* L.), broccoli raab (*B. rapa* L.

subspecies *rapa*), and Brussels sprouts (*B. oleracea* L. var. *gemmifera*) are grown in excess of 34,398 ha and are valued at ca. $485 million USD (Crop report, Monterey County 2013). The economic impact of *D. radicum* on these crops is considerable. Thus, the detection of these two rove beetle species is welcomed news since they add to the known predator and parasitoid fauna affecting anthomyiid pests in this region. In one surveyed field in Salinas, 11.5%, 18.2%, and 32.2% of *D. radicum* puparia (collected on 4, 11, and 18 April, 2014, respectively) were parasitized by *Aleochara* beetles. *Aleochara bilineata* constituted 83.3%, 88.9%, and 88.9% of the emerged *Aleochara* specimens on 4, 11, and 18 April 2014, respectively. The remaining specimens of reared *Aleochara* represented the second species, *A. verna*.

All reared specimens of *Aleochara* belong to the subgenus *Coprochara* Mulsant and Rey whose diagnostic characters are elaborated on and illustrated by Klimaszewski (1984). Species of *Coprochara* are easily recognized by the presence of two longitudinal, parallel to subparallel rows of punctures on the pronotum which are separated by a distinct glabrous area extending down the pronotal midline (Fig. 1). Members of this subgenus also are recognized by the form of the mesosternum, which bears a longitudinal carina for its entire length (Fig. 3). *Aleochara bilineata* has unicolorous elytra (Fig. 2). In addition, it can be distinguished by characters of the male aedaegus and female spermatheca — the apex of the median lobe of the aedeagus being strongly produced ventrally, a long bulbous, and fewer number of coils (4–6) of the spermatheca. *Aleochara suffusa* (Casey) might be confused with *A. bilineata*, but it possesses different pubescence on the pronotum and elytra. In *A. bilineata*, the pronotum is densely pubescent with long setae and the dense pubescence of the elytra is directed towards the apico-lateral angles. In contrast, *Aleochara suffusa* differs by the pronotum being sparsely pubescent and the dense pubescence of the elytra is directed posterad. *Aleochara verna* is very similar to *A. bilineata* but differs principally by possessing two pale, yellowish-brown to rust-colored apico-median elytral spots (Fig. 1). It differs from *A. bimaculata* Gravenhorst, another species of the subgenus with elytral spots that occurs in California, by its smaller body size (2.0–4.0 mm vs. 4.0–8.0mm for *A. bimaculata*) and by the deeply impressed, coarse, setigerous punctures of the pronotum (cf. the pronotum with slightly impressed, or not, inconspicuous punctures and thin setae in *A. bimaculata*).

Aleochara bilineata is transcontinental in Canada, but ranges south into the United States to Oregon, Wisconsin, Illinois, New York, Maine, and Massachusetts (Klimaszewski 1984). Although this species was probably accidentally introduced from Europe, some consider it to be a Holarctic species (Maus 1998). *Aleochara verna* is a common species widely distributed throughout North America, and, according to Klimaszewski (1984) and Yamamoto and Maruyama (2013), probably represents a true Holarctic species that has erroneously been regarded as introduced.

Females of *A. bilineata* each lay ca. 700 eggs during their lifespan, usually near *D. radicum* puparia in the soil (Colhoun 1953, Fournet et al. 2000). Once eggs hatch, the first instar larvae of *A. bilineata* locate and enter *D. radicum* puparia. *Aleochara bilineata* larvae develop inside *D. radicum* puparia consuming the pupae and emerging as adults (Royer et al. 1998). Besides being parasitoids, *A. bilineata* adults are predators of *D. radicum* as well, with each capable



Figs. 1–3. *Aleochara* (*Coprochara*). 1, *Aleochara verna*, dorsal, arrow denotes one of two parallel longitudinal rows of punctures on pronotum, scale bar = 1 mm. 2, *Aleochara bilineata*, dorsal, scale bar = 1 mm. 3, *Aleochara bilineata*, ventral, arrow denotes the complete mesosternal carina, scale bar = 0.5mm.

of consuming ca. 23.8 eggs or 2.6 larvae per day (Read 1962). *Aleochara verna* has a similar life history and relationship with *D. radicum* (Hummel et al. 2010).

Until recently, *D. radicum* has been managed primarily using organophosphate insecticides such as chlorpyrifos and diazinon in the central coast of California (Natwick 2009). Because high concentrations of their residues were detected in bodies of water (Hunt et al. 2003), the use of organophosphate insecticides is now stringently regulated leaving growers with limited options to combat *D. radicum* infestations (CEPA 2013). In addition, it is likely that this widespread use of organophosphate insecticides has led to the development of resistance in *D. radicum* populations. Under these circumstances, the occurrence of *Aleochara* spp. is noteworthy because these beetles represent additional potential tools for *D. radicum* control.

In conclusion, this survey documents the presence of two species of *Aleochara* ectoparasitoids and predators of *D. radicum* in the California's central coast *Brassica* production areas. These findings warrant further investigation to determine the potential utility of these beetles as biological control agents. An assessment of the distribution and seasonality of *A. bilineata* and *A. verna*, and an examination of the potential role of these species in the management of *D. radicum* in organic and conventional *Brassica* fields is needed.

We thank N. Harkleroad (Agriculture and Land-Based Training Association [ALBA], Salinas, CA) for providing access to Brassica fields for this project. Also, we appreciate the technical assistance provided by J. Martinez, C. Martinez, C. Bettiga and J. Zarate in sample collection, and UC IPM for providing funding for this project.

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