A NEW, HIGHLY SEXUALLY DIMORPHIC SPECIES OF *COSMOPHORUS* RATZEBURG (HYMENOPTERA: BRACONIDAE: EUPHORINAE) REARED FROM CORSICA

MARK R. SHAW

Honorary Research Associate, National Museums of Scotland, Chambers Street, Edinburgh EH1 1JF

ABSTRACT

Cosmophorus laricio sp. nov., reared from adults of the bark-beetle *Pityogenes bistridentatus* feeding in dead twigs of *Pinus nigra laricio* collected in Corsica, is described and illustrated. The unusual behaviour of the apterous male is discussed in relation to its morphology and the species' presumed mating strategy.

INTRODUCTION

The cosmopolitan braconid subfamily Euphorinae has been variously regarded as including (e.g. van Achterberg, 1984) or excluding (S. R. Shaw, 1985, 1988; M. R. Shaw & Huddleston, 1991; see also Pitz *et al*., 2007) the tribe Meteorini, which are koinobiont endoparasitoids of larval Coleoptera and Lepidoptera. Without Meteorini, Euphorinae all have the unusual life-style of parasitising adult or nymphal insects, different genera specialising, always as koinobiont endoparasitoids, on parts of the holometabolous orders Coleoptera, Hymenoptera and Neuroptera, and the hemimetabolous Hemiptera, Psocoptera and (in one non-European case) Orthoptera (S. R. Shaw, 1985, 1988; M. R. Shaw & Huddleston, 1991). A necessity for these parasitoids is that the host has a reasonably long adult life, and a sufficient nutrient throughput, to support the development of the parasitoid, which at least partly explains the host groups that have been colonised by Euphorinae. Many euphorine genera exhibit extreme morphological features associated with attacking adult insects, usually solitarily though in a few genera gregarious species are known. Among the most specialised of all (Čapek, 1970; S. R. Shaw, 1985) is the strictly solitary genus *Cosmophorus* Ratzeburg, with its large head and huge low-slung mandibles which the female parasitoid uses to grasp the body of its adult bark-beetle (Coleoptera: Curculionidae: Scolytinae) host head-to-head (illustrated by Seitner & Nötzl, 1925, then by Hedqvist, 1998 [reproduced by van Achterberg & Quicke, 2000]) while the ovipositor is inserted; an action that generally or perhaps invariably takes place while the bark-beetle is constrained in its tunnel and with the help of a temporarily paralysing venom (Seitner & Nötzl, 1925). As with all Euphorinae, the host continues to be active and feed while the parasitoid develops, and is only killed shortly before the parasitoid is ready to leave it to spin an external cocoon; in this case situated in the bark-beetle's tunnel (Fig. 1).

Cosmophorus is a small genus, species of which are not easily collected. However, economic interest in bark-beetles, especially those affecting conifers, has helped the European fauna to come to light, though all the species known are certainly greatly under-recorded. Five European species have been described, and were keyed by Čapek (1958) and Hedqvist (1998) and also included by van Achterberg & Quicke (2000), to which a sixth is added here. Only one has so far been discovered in Britain (M. R. Shaw, 1989). All are associated with conifers, but outside Europe association of the genus with non-conifers is known (Loan & Matthews, 1973).

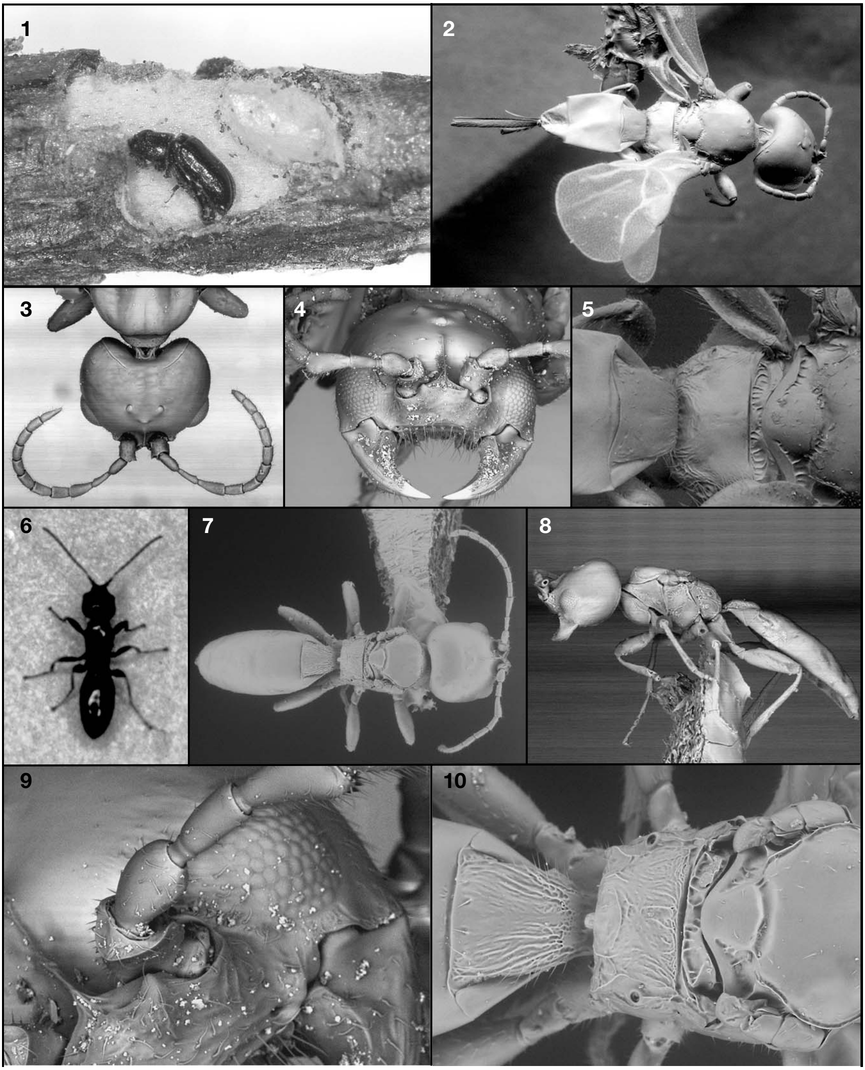
MATERIAL AND METHODS

The material from which the new species is described below resulted from the collection of a pillowcase-full of narrow (ca 0.3–1.0 cm diameter) twigs collected from a fallen mature example of the Corsican endemic tree *Pinus nigra* Arnold ssp. *laricio* Maire at 1000 m in the Forêt d'Aïtone, 3 km NE of Evisa, Corsica, on 19.vii.2001. The tree still had a profusion of brown needles attached, and it seemed likely to have fallen about 18 months previously. The twigs were transported to Scotland and left in the tied pillowcase which was kept indoors, as far as possible in an unheated room, and the prodigious numbers of adult Coleoptera and Hymenoptera that emerged and revealed themselves by resting on the insides of the pillowcase were removed during frequent inspections over the following year (usually daily except at the height of winter). No moisture was added, and after a year activity had more or less ceased. See also "Host and biology" below.

SEM images were taken on a CamScan MX 2500 (15 kV; spot size 2). Wing veins are named as in van Achterberg & Quicke (2000).

***Cosmophorus laricio* sp. nov. (Figs 1–10)**

Female (Figs 2–5). Holotype: length (excluding ovipositor) 1.6 mm; of fore wing 1.5 mm. Head in dorsal view 1.3 times as wide as long (to front of eye, i.e. excluding antennal shelf), subrectangular, temple twice as long as eye and initially almost straight behind eye then roundly narrowing in posterior two fifths; occipital carina effaced medially; posterior margin of head only relatively weakly impressed and head without medial longitudinal depression; eyes in dorsal view 3.5 times as far apart as their width, in lateral view 1.1 times higher than wide and 0.6 times as wide as temple at mid-eye level (= distance to occipital carina); ocelli small and inconspicuous, posterior pair separated by about 3.5 times their diameters, distance between a posterior and anterior ocellus about 2.5 diameters; malar space extremely short, eye almost adjoining mandibular socket; mandible relatively weak and thin for genus; head essentially unsculptured apart from a ridge leading from antennal shelf towards anterior ocellus and some rugulosity on antennal shelf but with numerous short setae and longer setae around clypeal region; antenna with 12 segments, about 1.7 times as long as width of head, third segment the slenderest and with few setae, fourth longer, basally narrow, partly setose, twice as long as wide at its apex where it is produced below, fifth and subsequent segments more cylindrical, each about twice as long as wide, 0.7 times as long as fourth segment and evenly strongly pubescent. Mesosoma about as wide as head, 1.9 times as long as high; pronotum dorsally with some punctures; mesoscutum rising steeply; mesoscutum and scutellum smooth but with short setae, those on mesoscutum rather evenly distributed at sides but becoming sparser and eventually absent centrally; scutellar sulcus shallow, crenulae almost effaced medially; propodeum largely smooth, only posteriorly and towards the more rugulose metapleuron with a few weak rugulae; mesopleuron with weak and scattered small punctures, otherwise side of mesosoma mostly smooth; hind leg with coxa smooth, femur 2.7 times as long as wide, tibia 1.5 times as long as femur and about 8 times as long as wide, tarsus about 0.8 times as long as tibia with basitarsus 0.75 as long as the remaining segments together and the fourth segment hardly longer than wide; fore wing with r practically absent so that 2-SR and 3-SR both separately arise direct from the pterostigma, 2-SR + m-cu about as long as 3-SR + SR1 (measured to wing margin where spectral), 1-CU1:2-CU1 ca 1:6. Metasoma two thirds as wide as head; first tergite gradually widening to apex where it is 0.8 times as wide



Figures 1–10. *Cosmophorus laricio* sp. nov. [NB: some of the SEM images give deceptive impressions of dimensions, as out-of-plane parts remain in good focus]. 1, emerged cocoon in situ, with host remains. 2–5, female. 2, habitus, dorsal view. 3,4 head. 3, approximately dorsal view. 4, facial view. 5, propodeum and first metasomal tergite, to show sculpture. 6–10, male. 6, whole insect, in life. 7, 8 habitus. 7, dorsal view. 8, lateral view (flagellum removed). 9, part of face, to show malar space. 10, propodeum and first metasomal tergite, to show sculpture.

as its length, almost unsculptured (similar to propodeum); subsequent tergites smooth but each with a single row of setae near apex; second tergite 0.5 times as long as first, 2.3 times wider than long and about 0.7 as long as third but scarcely differentiated from it; ovipositor sheath flattened, straight, parallel-sided, 1.2 times as long as hind tibia and 0.4 times as long as fore wing. Colour: pitchy brown, the tibiae, tarsi, basal antennal segments and mouthparts all more or less yellowish brown; wing hyaline with venation brown and pterostigma dark brown.

Male (Figs 6–10). Wingless. Size comparable with female; length ca 1.5–1.6 mm. Head less transverse, 1.2 times as wide as long; eye smaller, temple 2.8 times as long as eye, eyes in dorsal view 5 times as far apart as width of eye, in lateral view 0.5 as wide as temple at mid-eye level, malar space longer so that eye clearly well removed from margin of mandibular socket; antenna with 11 or 12 segments, about 2.3 times as long as width of head, fourth segment less flared than in female and 2.5 times as long as its width at apex, fifth and subsequent segments over 3 times as long as wide. Mesosoma smaller, 0.8 times as wide as head, 1.6 times as long as high; scutellar sulcus almost without crenulae; propodeum with more substantial longitudinal sculpture than in female; mesopleuron with an impressed groove (? may not be precoxal sulcus); hind femur ca 2.4 times as long as wide (more robust than in female); tegulae developed but wings practically absent (visible only as stumps about as long as tegula). Metasoma slender in death, about 0.7 as wide as head; 1st tergite 1.1 times as wide as long and rather densely longitudinally sculptured; second tergite 0.9 times as long as first and about 1.6 times as wide as long, and longer than third tergite. Colour as female.

Variation. There is practically no size variation. Some females (especially those that emerged in iv.2002, representing the overwinter generation: see below) have some slight development of weakly longitudinal but mostly granular sculpture towards the base of the first tergite and/or on the propodeum more generally; the first tergite is also sometimes more robust (0.9 times as wide as long). In some females the ocelli appear to be in an equilateral triangle, but in others the triangle appears flatter. In some females the radius stops abruptly some distance from the fore wing margin and is not traceable to it, but in others its continuation to the margin, although spectral, is clear. The number of antennal segments varies between 11 (9 examples) and 12 (20 examples) in males, but appears to be much more constant at 12 (27 examples) in females.

Material examined. Holotype ♀: "CORSICA: Forêt d'Aïtone, Evisa. 1000 m. Twigs d[ea]d Pinus nigra laricio 19.7.2001 with + + + Pityogenes bistridentatus, + + Pityophthorus buyssoni, few Crypturgus cinereus (also Cryptolestes) em[erged] 8.01 M. R. Shaw" (In National Museums of Scotland, Edinburgh (NMS)). Paratypes: 6 ♀, 4 ♂, same data as holotype; 10 ♀, 12 ♂, same data except em[ergence] as follows: 2001 (1 ♀, 2 ♂), iv.02 (8 ♀, 8 ♂), 15.v.02 (1 ♂), 3.vi.02 (1 ♀) and 3.viii. 02 (1 ♂); 6 ♀, 11 ♂ same locality and substrate data, "with Pityogenes bistridentatus (etc) continued breeding in capt . . . M. R. Shaw" and emergence dates as follows: 17.v.2002 (1 ♀, 2 ♂), 19.v.2002 (1 ♀, 1 ♂), 21.v.2002 (1 ♂), 22.v.2002 (1 ♂), 24.v.2002 (2 ♀, 2 ♂), 25.5.2002 (1 ♂), 26.v.2002 (1 ♂), 29.v.2002 (1 ♂), 3.vi.2002 (1 ♀, 1 ♂) and 9.vii.2002 (1 ♀); 1 ♂ "Cultured (CORSICA: Evisa, F. d'Aitone from Pinus nigra laricio scolytids). Pityogenes bistridentatus ovip. iv/v.02. Pinus sylvestris, em vi.02 M.R.Shaw". Also 2 ♀, 1 ♂ with data comparable with that of holotype, preserved in alcohol. All the foregoing deposited in NMS except 1 ♀, 1 ♂ in each of BMNH, London and RMNH, Leiden.

Etymology. Named after the distinctive Corsican endemic subspecies *laricio* Maire of *Pinus nigra* Arnold whose forests are included in the 1992 EU Habitats Directive (annex 1) because of their rich associated animal and plant communities (see also Norstedt, Bader & Ericson, 2001).

The new species can be separated from all other species found in Europe by its smaller number of antennal segments, greatly reduced sculpture of the propodeum and first tergite in the female and relatively less robust mandibles, as well as the virtually complete absence of wings in the male. Two other European species, *C. henscheli* Ruschka and *C. roubali* Čapek, have brachypterous males but in the first the wings are substantially developed, and even in *C. roubali* they extend almost to the propodeum (Čapek, 1958). Both of these species have 13–14 segmented antennae. It is of interest that all three of the European species now known with reduced or absent wings in the male sex are sexually dimorphic also in the wider shape of the first metasomal tergite and the greater extent of sculpturation of both that and the propodeum in the male (see below).

Host and biology

Many species of beetles emerged in the pillowcase, including three species of Scolytinae: very numerous *Pityogenes bistridentatus* (Eichoff), a much smaller but moderate number of *Pityphthorus buyssoni* Reitter, and a few only of *Crypturgus cinereus* (Herbst). As the parasitoids were so uniform in size, it seemed likely that they were all from the same species of host and because of its greatest abundance it seemed likely that this would be *P. bistridentatus*. To test at least whether this beetle could possibly serve as host, some adults were placed in a corked 5×2.5 cm glass tube with freshly dead 3–4 mm diameter twigs of *Pinus sylvestris* (collected in Edinburgh) at the end of iv.2002 and, when the beetles had duly entered the bark, a female parasitoid and a smear of diluted honey were added to the tube. After a few hours the *Cosmophorus* adult had disappeared from view [it was much later seen dead in the tube], and in vi.2002 a male *Cosmophorus* emerged; when bark was subsequently removed from the twigs a dead *P. bistridentatus* was found in its feeding chamber with an emerged cocoon of the parasitoid beside it (Fig. 1). Whether or not the beetle was already parasitized when it was confined, which is perfectly possible, this demonstrated that *P. bistridentatus* can be a host, but not, of course, that all of the *C. laricio* sp. nov. that were reared had developed in that species. However, the male resulting from this experiment is the same size as all the rest, and the indications are that this beetle species was the natural host for most, and perhaps all, of the type series. It was also clear that overall many of the reared *C. laricio* sp. nov. must have resulted from ovipositions that had taken place in the pillowcase, probably including all adults that emerged in 2002.

Species with fully winged females but apterous or brachypterous males are known in various Chalcidoidea (e.g the eulophid *Melittobia acasta* (Walker), the pteromalid *Nasonia vitripennis* (Walker) and many agaonids) but in these cases it is usually associated with gregariousness and mother-son or sib- mating within a confined space. Wing reduction or loss, particularly in females, occurs sporadically in several groups of cyclostome Braconidae in the Palaearctic region, but among the non-cyclostome lineages (in which Euphorinae is placed) it is very uncommonly noted; perhaps only in *Cosmophorus* affecting the male sex differentially, and even then not as extremely manifest as seen in *Cosmophorus laricio* sp. nov. (cf. Belokobilskij, 2009).

In life, the apterous males of *C. laricio* sp. nov. (Fig. 6) displayed the curious behaviour, observed on many occasions, of raising the metasoma through about 60° or more and remaining stationary for long periods in an exposed position, presumably emitting pheromones from or near the apex of the metasoma (frustratingly, no photograph could be obtained of this posture because the slightest disturbance caused them to rapidly lower the metasoma and move on, but a similar stance is figured for the brachypterous male of *C. henscheli* by Seitner & Nötzl, 1925). This behaviour must surely be associated with the flightlessness of the male, and the presumed need for the female sex to do the mate-searching. The smaller eyes of the male also suggests that it is not looking for as much as is the female, and its more strongly sculptured and robust first metasomal tergite might engage usefully with its similarly sculptured propodeum to support the metasoma in its raised position. The other European *Cosmophorus* species with flightless males seem to exhibit similar sexual dimorphisms (cf. Čapek, 1958). As long-range male sex pheromones are a rarity in Hymenoptera (but see Ruther *et al*., 2007) further investigation would be of great interest, including field observation to ascertain whether the males, despite being wingless, attempt to aggregate to form leks, as is known to occur in some Diptera in which the males emit sex pheromones (cf. Preston-Mafham & Preston-Mafham, 1993).

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REFERENCES

Achterberg, C. van. 1984. Essay on the Phylogeny of Braconidae (Hymenoptera: Ichneumonoidea). *Entomologisk Tidskrift* **105**: 41–58.

Achterberg, C. van & Quicke, D. L. J. 2000. The Palaeotropical species of the tribe Cosmophorini Capek (Hymenoptera: Braconidae: Euphorinae) with descriptions of twenty-two new species. *Zoologische Mededelingen, Leiden* **74**: 283–338.

Belokobilskij, S. A. 2009. A new enigmatic apterous cyclostome genus (Hymenoptera: Braconidae) from the Greek Islands. *Annales de la Societé Entomologique de la France* **45**: 72–88.

Čapek, M. 1958.Revision der europäischen Arten der Gattung *Cosmophorus* Ratz. (Hym. Braconidae). *Acta Entomologica Musei Nationalis Pragae* **32**: 151–169.

Čapek, M. 1970. A new classification of the Braconidae (Hymenoptera) based on the cephalic structures of the final instar larva and biological evidence. *Canadian Entomologist* **102**: 846–875.

EU Habitats Directive. 1992. Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora.

Hedqvist, K.-J. 1998. Bark beetle enemies in Sweden. II. Braconidae (Hymenoptera). *Entomologica Scandinavica*, Supplement **52**: 1–87.

Loan, C. C. & Matthews, R. 1973. *Cosmophorus capeki* n. sp., from New York (Hymenoptera: Braconidae: Euphorinae). *Proceedings of the Entomological Society of Washington* **75**: 205–208.

Norstedt, G., Bader, P. & Ericson, L. 2001. Polypores as indicators of conservation value in Corsican pine forests. *Biological Conservation* **99**: 347–354.

Pitz, K. M., Dowling, A. P. G., Sharanowski, B. J., Boring, C. A., Seltmann, K. C. & Sharkey, M. J. 2007. Phylogenetic relationships among the Braconidae (Hymenoptera:Ichneumonoidea): a reassessment of Shi *et al*. (2005). *Molecular Phylogenetics and Evolution* **43**: 338–343.

Preston-Mafham, R. & Preston-Mafham, K. 1993. *The encyclopedia of land invertebrate behaviour*. Blandford. 320pp.

Ruther, J., Stahl, L. M., Steiner, S., Garbe, L. A. & Tolasch, T. 2007. A male sex pheromone in a parasitic wasp and control of the behavioural resonse by the female's mating status. *Journal of Experimental Biology* **210**: 2163–2169.

Seitner, M. & Nötzl, P. 1925. *Pityophthorus henscheli* Seitner und sein Parasit *Cosmophorus henscheli* Ruschka. *Zeitschrift für angewandte Entomologie* **11**: 187–195.

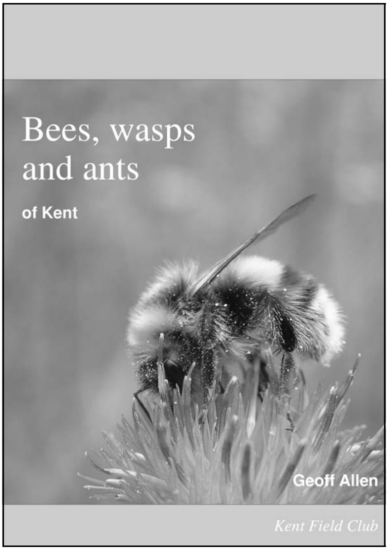
Shaw, M. R. 1989. *Cosmophorus cembrae* Ruschka new to Britain (Hymenoptera: Braconidae: Euphorinae). *Entomologist's Gazette* **40**: 241–243.

Shaw, M. R. & Huddleston, T. 1991. Classification and biology of braconid wasps (Hymenoptera: Braconidae). *Handbooks for the identification of British insects* **7(11)**: 1–126.

Shaw, S. R. 1985. A phylogenetic study of the subfamilies Meteorinae and Euphorinae (Hymenoptera: Braconidae). *Entomography* **3**: 277–370.

Shaw, S. R. 1988. Euphorine phylogeny: the evolution of diversity in host-utilization by parasitoid wasps (Hymenoptera: Braconidae). *Ecological Entomology* **13**: 323–335.

BOOK REVIEW



Bees, wasps and ants of Kent, a provisional atlas **by Geoff W. Allen.** 124pp. Designed and published by The Kent Field Club. ISBN 978-0-9561926-0-8. £22.50 including p&p, available from Mr R. Moyse, 2 West End Cottages, Doddington, Kent ME9 0BZ.

This is the first book in a brand new series produced by the Kent Field Club describing the distribution and status of the fauna and flora of Kent. Atlases at the compilation stage include ones on plants, dragonflies and seaweeds of the county all produced in a common, easy to read format, illustrated with coloured maps and photographs of key species. The year ahead will therefore be an expensive one for the Field Club assuming all the books are published on time.

There are 440 distribution maps and 7 composite maps for the 448 species of aculeate Hymenoptera recorded from Kent plotted from a database of approximately 55,000 records. All families are covered apart from the Dryinidae, Embolemidae and Bethylidae (an additional 22 species) for which a brief résumé is given. The book developed as a result of the author acting as the county referee for this group of insects and compiling the first proper electronic database for Kent's aculeate Hymenoptera. All these records have now been transferred to the newly-created Kent & Medway Biological Records Centre, Faversham, which in its first three years of existence now holds more than 2 million taxa records.

The introductory chapter describes the classification of the Hymenoptera and includes brief accounts of their nesting, foraging and parasitic behaviour in relation to Kentish species. The main part of the text (87pp) is devoted to individual species accounts with maps, where appropriate. Recording is divided into four date classes, pre-1910, 1910–1949, 1950–1984 and 1985–2007, using a combination of coloured dots and a + symbol for pre-1910. Black dots, which stand out most, have conveniently been used for the most recent period when most of the recording was undertaken. There are up to six maps per page, each measuring 8 × 5 cm, just about the right minimum size for readers to easily comprehend the distribution of species in a county the size of Kent (c. 4000 sq. km) Luckily the underlying geology and associated plant communities are relatively easy to delineate and these are displayed on each map as seven mainly east-west bands across the county. The darker colours used for the dots means that they stand out very clearly on the map even when positioned against the same colour background.

The frequency of occurrence of each species is given below the maps in numerical form: the number of post 1985 tetrad dots (equating to present distribution), the total number of tetrad dots (pre-1910–2007), the observed period of adult activity (apparently no-one seems to study any other part of the life cycle) and national and local statuses.

Coverage is pretty good (80%) with records from 898 of the 1121 tetrads representing vice-counties 15 and 16 (East and West Kent, respectively). The author rightly advises caution when interpreting the apparent changes in distribution of certain species that span several date classes indicating these might equally be due to recorder effects. John Felton and Gerald Dicker were highly active recorders over slightly different periods during 1950s–1980s with different specialisms and the maps reflect the intensity of their recording. Ideally each recording area should be surveyed a similar number of times, but with a small band of active recorders this is not possible in Kent at the present time.

Nevertheless changes in distribution are apparent – until about a decade ago there were more specimens of hornet in the county collection at Maidstone (<5) all dating from >50 years ago than from the field, whereas today the wasp appears to be spreading eastwards across the county in a true wave of expansion. If there hadn't been the odd specimens in the museum for verification, one might have concluded the hornet was an entirely new species to the county. So, collections remain important even in the digital age. Species distributions can change extremely rapidly, for example the tricolored bumblebee *Bombus hypnorum*, a recent colonist in the UK, is recorded from two isolated squares in the atlas but has appeared at numerous sites across the county this year. Kent can also expect the re-introduction of an extinct bumblebee *Bombus subterraneus* in a few years time.

The author is a gifted artist. Numerous illustrations of bees and wasps drawn by the author especially for the book are included and these are all of a very high standard. These together with a scattering of colour photographs add strength to the species accounts. References have been kept to a minimum for reasons of space, which I fell is a pity, as publication of the book would have provided an ideal place to bring together all the literature relating to aculeates in Kent.

The book ends with a number of appendices listing aculeate species possibly but not conclusively recorded from the county, species that might yet be recorded particularly those expanding their range due to climate change and doubtful species. There is also a page devoted to explaining the base map showing the land divided into a series of Natural Areas, each with a characteristic association of geology, wildlife and landform. On reflection, this map should have been placed at the front of the book for easier reference and not hidden away in the appendices.

This is the eighth atlas published by the Kent Field Club and the author is to be congratulated on bringing together all the basic information on the county's aculeate Hymenoptera in such an attractive book.

JOHN BADMIN