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A new species of *Conomorium* Masi (Hymenoptera: Pteromalidae), parasitizing the Fall Webworm *Hyphantria cunea* (Drury) (Lepidoptera: Arctiidae) in China

YANG ZHONG-QI¹ & HANNES BAUR²

Conomorium cuneae sp. n. is described from China. A key is provided to separate it from the other Palearctic species *Conomorium amplum* (Walker), *C. patulum* (Walker) and *C. pityocampae* Graham. *C. cuneae* sp. n. is a gregarious, primary endoparasitoid of pupae of the fall webworm *Hyphantria cunea* (Drury). The wasp has an average parasitism rate of 3.6 % in the overwintering pupae of the host, but at some places parasitism reaches 12.2 %. From a single host pupa 14–30 wasps emerged. We furthermore discuss the potential of *C. cuneae* sp. nov. as a biological control agent against the important pest *H. cunea*.

Keywords: *Conomorium cuneae* sp. n., *C. equilaterale*, *C. pelor*, parasitism rate, taxonomy, biological control, key

INTRODUCTION

The fall webworm *Hyphantria cunea* (Drury, 1773) (Lepidoptera: Arctiidae) is a serious, invasive pest first recorded in China in 1979 (Yan & Wang 1984; Wang et al. 1995). Since then it has spread to six provinces in northern China, where it damages nearly all broad leaved trees, flowers, fruit trees, and even vegetables and maize. It thus causes severe economic loss.

For biological control purposes we carried out field investigations to search for natural enemies of *H. cunea*. Currently, 23 species of primary parasitoids of the pest have been reared (Yang in press). Among these, we found a new species of *Conomorium*, which is described below. *Conomorium* Masi, 1924 (Chalcidoidea: Pteromalidae) is a small genus with only five Holarctic species. Graham (1992) recognized three European species, but subsequently Bouček (1993) described *C. pelor* from North America and Xiao & Huang (2000) *C. equilaterale* from China. The genus is easily recognized by an elongate first funicular segment (Fig. 7), protruding face at the level of the toruli (Fig. 13), short postmarginal vein (Fig. 6) and incomplete plicae (Fig. 11) (Graham 1969, 1992). The available evidence suggests that species of *Conomorium* are parasitoids of Lepidoptera pupae (see Noyes 2002).

MATERIAL AND METHODS

Over 35'000 pupae of the fall webworm were collected during early spring from all areas where the pest is reported in China (i.e. Yantai, Shandong Province; Dalian, Liaoning Province; Qinhuangdao, Hebei Province; Yangling, Shaanxi Prov-

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ince; Tanggu and Dongli, Tianjin Municipality). The pupae were reared in vials under standardized laboratory conditions. After the emergence of hosts and parasitoids, the adult parasitoids were killed with ethyl acetate, mounted on card points or card rectangles, air dried and adequately labelled prior to morphological examination under a stereo-microscope. The scanning electron micrographs (SEM) were taken with HITACHI-450. Terminology of body parts follows Gibson (1997), for terms concerning sculpture of the integument and for some expressions used in the description we refer to Graham (1969, 1992). Type specimens are deposited in the insect collections of the Chinese Academy of Forestry, Beijing, China (CAFB) and the Natural History Museum, Bern, Switzerland (NMBE). Voucher specimens of the other species mentioned in the paper (see Appendix) are deposited in the following institutions: The Natural History Museum, London, England (BMNH); Canadian National Collection, Ottawa, Canada (CNC); Collection Stefan Vidal, Göttingen, Germany (CSV); Collection Gérard Delvare, CIRAD, Montpellier (CGD); Department of Applied Zoology, University of Helsinki, Finland (DAZH); Eidgenössische Technische Hochschule, Zürich, Switzerland (ETHZ); Institute of Zoology, Academy of Sciences, Beijing, China (IZAS); Muséum d'Histoire naturelle, Genève, Switzerland (MHNG); Muséum national d'Histoire naturelle, Paris, France (MNHN); Musée de Zoologie, Lausanne, Switzerland (MZL); Naturhistoriska Riksmuseet, Stockholm, Sweden (NHRM), United States National Museum of Natural History, Washington D.C., USA (USNM).

RESULTS AND DISCUSSION

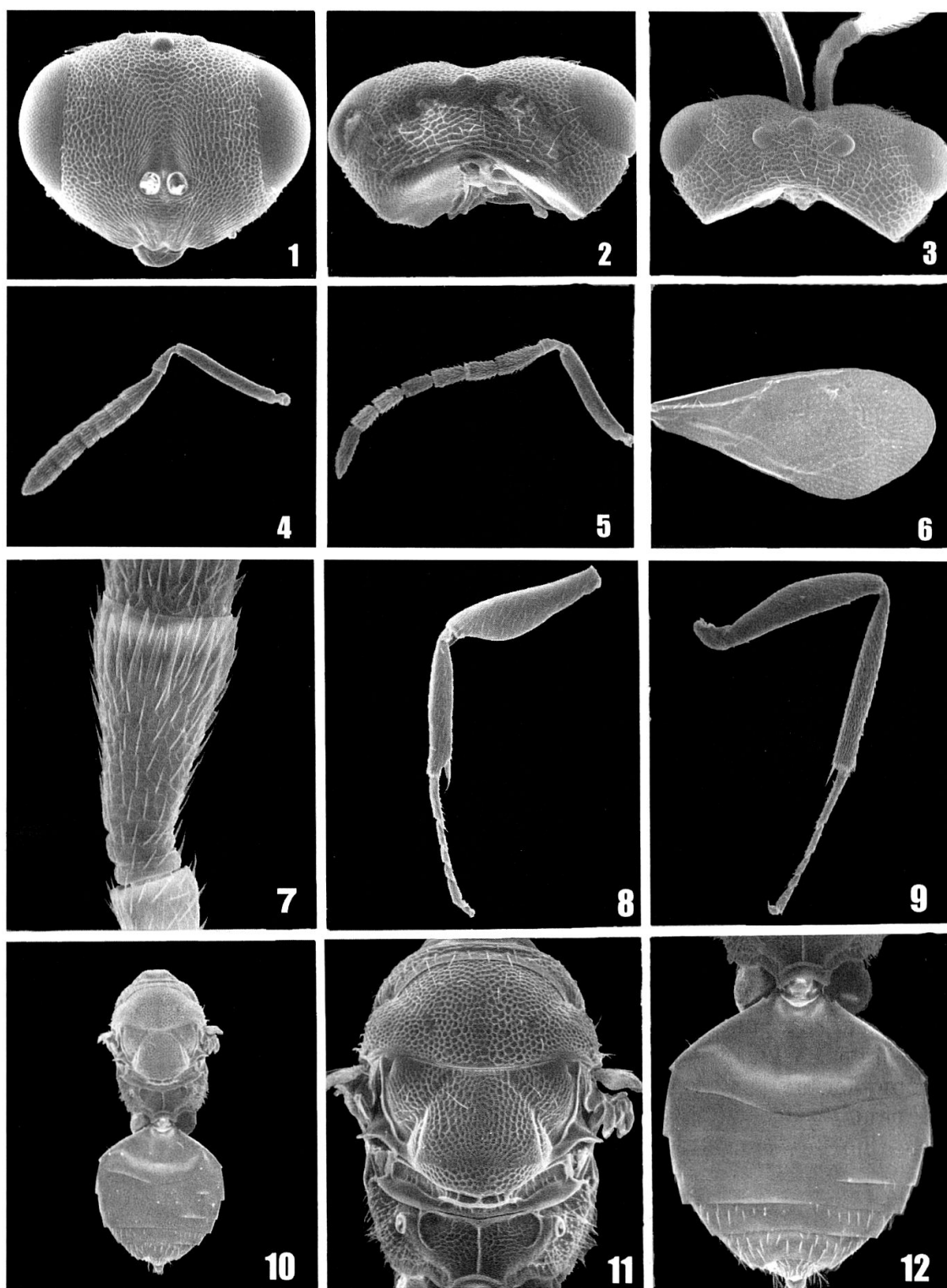
Conomorium cuneae sp. n.

(Figs 1–13)

Type material. Holotype ♀, China: Tanggu District, Tianjin City, 5.V.1998, leg. Yang Zhong-qi & Pang Jian-jun, in CAFB. Paratypes: same data as holotype, 25 ♀, 2 ♂ in CAFB, remnants of additional 5 ♀, 2 ♂ in NMBE; Shandong Province, Yantai, 15.V.1995 and 5.V.1998, leg. Zhao Dai, 24 ♀, 3 ♂ in CAFB, 7 ♀, 3 ♂ in NMBE, 1 ♀, 1 ♂ in CNC, 1 ♀ in BMNH and 1 ♂ in CGD; Shaanxi Province, Wugong, 15.V.1985, leg. Yang Zhong-qi, 25 ♀, 3 ♂ in CAFB; Hebei Province, Qinghuangdao, leg. Qiao Xiurong & Yang Zhong-qi, 60 ♀, 10 ♂ in CAFB, 1 ♀, 4 ♂ in NMBE, 1 ♂ in BMNH and 2 ♀, 1 ♂ in CGD; Liaoning Province, Dalian, leg. Yang Xiu-qing & Yang Zhong-qi, 65 ♀, 15 ♂ in CAFB. All specimens were reared from pupae of *Hyphantria cunea*.

Description female (Figs 1–2, 4, 6–12). Body length 2.1–2.5 mm. Head and mesosoma dark blue-green with metallic lustre. Antenna with scape testaceous, pedicel testaceous except more or less fuscous on upper side, anelli testaceous, flagellum fuscous. Setae on mesosoma dark. Coxae concolorous with body, rest of legs testaceous, except femora, metatibia and pretarsi more or less fuscous; wings hyaline, venation brownish testaceous; pilosity of fore wing disc infusate. Setae on callus whitish. Petiole and gaster metallic dark brown to black, first gastral tergite with a large pale spot at base.

Head (Fig 2) about 1.17 times as wide as mesoscutum, in dorsal view about 1.9–2.05 times as wide as long; vertex moderately convex; POL 1.2–1.27 times OOL, OOL 2.8–3 times OD; temple 0.45–0.48 times as long as eye length, forming a slightly acute angle with occiput. Eyes 1.47–1.55 times as high as wide, separated by 1.34–1.45 times their height, inner orbits very slightly divergent ventrally; malar sulcus superficial but traceable, malar space 0.46–0.49 times eye



Figs 1–12. *Conomorium cuneae* sp. n.: (1) head in frontal view ♀; (2) head in dorsal view ♀; (3) head in dorsal view ♂; (4) antenna ♀; (5) antenna ♂; (6) fore wing ♀; (7) anelli and first funicular segment ♀; (8) fore leg (without coxa) ♀; (9) hind leg (without coxa) ♀; (10) meso- and metasoma ♀; (11) mesosoma ♀; (12) gaster ♀.

height. Head in frontal view subtrapezoid (Fig 1), about 1.3 times as wide as high; lower margin of toruli at or slightly below level of lower ocular line; distance between toruli at most half their width; scrobes narrow and in ventral half fairly deep, extending dorsally to four fifths the distance between toruli and anterior ocellus. Head in lateral view (Fig 13) with lower face receding at an angle of about $60\text{--}65^\circ$ with respect to upper face. Head reticulate, meshes largest on gena and temple; clypeus finely striate, its anterior margin narrowly and rather deeply emarginate, more or less angulate, with a median depression touching the emarginate edge; mouth corner, on either side of clypeus, with a small depression, which is rather sharply delimited from rest of lower face by a fine carina. Antenna (Fig 4) with scape extending to about level of middle of anterior ocellus; scape about 1.00–1.06 times as long as eye height and 7.7–7.8 times as long as wide; pedicel in lateral view 2.07–2.15 times as long as wide; combined length of pedicel plus flagellum 0.8–0.9 times head width; both anelli strongly transverse and subequal in length; funicle stout, fusiform; first funicular segment constricted at base (Fig 7), 1.7–1.8 times as long as wide and about 1.25 times as long as pedicel, proximal two thirds with scale-like sculpture and distal third with a row of longitudinal sensilla; the subsequent funicular segments transverse, the second segment about 0.85–0.9 times and the sixth about 0.65 times as long as wide, each segment with one row of longitudinal sensilla and densely covered with short setae; clava 1.85–1.9 times as long as wide and about as wide as first funicular segment.

Mesosoma (Figs 10, 11) about 1.55 times as long as wide, in lateral view (Fig 13) moderately strongly bent, dorsellum and propodeum sloping at an angle of about $40\text{--}50^\circ$ with respect to dorsal plane of mesoscutum and scutellum. Pronotum short, distinctly narrower than mesoscutum; pronotal collar about one sixth as long as mesoscutum, reticulate, its anterior edge very finely carinate in middle; hind margin of pronotum with a smooth and shiny strip and a row of moderately long setae. Mesoscutum about 2.1 times as wide as long; notauli superficial and extending about two thirds length of mesoscutum; mesoscutum finely reticulate, meshes rather high, areoles small and only slightly enlarged in median part of sclerite. Scutellum as long as wide between axillulae, slightly convex in longitudinal axis (lateral view), more strongly vaulted in transverse axis (viewed from behind); reticulation on scutellum about as strong and coarse as on posterior part of mesoscutum, areoles more or less isodiametric; sculpture on frenum the same as on rest of scutellum, frenal line indicated by one or two rows of smaller and more superficial areoles; scutellum on each side with 5 setae anterior to frenal line; sculpture on inner half of axilla as strong as on scutellum, reticulation on outer half distinctly weaker but still slightly raised. Dorsellum with anterior margin slightly raised, its surface with 3–10 short longitudinal carinulae. Reticulation on meso- and metapleuron about as strong as on mesoscutum, except on upper mesepimeron, which is smooth or only very superficially reticulate. Legs (Figs 8, 9) with outer side of pro- and mesocoxa finely alutaceous, metacoxa with raised reticulation; femora moderately slender, metafemur about 4.1 times as long as wide; mesotibial spur a little longer than half length of basitarsus (16:24); metatibial spur about as long as width of metatibia (Fig 9). Fore wing (Fig 6), when laid back, exceeding apex of gaster, 2.2–2.25 times as long as wide; basal cell bare; costal cell bare on upper surface, lower surface with about 8–11 hairs in distal half, hair line widely spaced medially; wing disc on upper surface with sparse and minute hairs beyond speculum; marginal setae absent; marginal vein 1.38–1.39 times as long as stigmal vein which is 1.1–1.24 times as long as postmarginal vein; stigma small. Hind wing with length of marginal setae one tenth the wing width me-

dially. Propodeum (Fig 11) 0.61–0.63 times as long as scutellum; median area 1.56–1.63 times as wide as long; median carina strong and straight; plica bent inwards in anterior two fifths and strong, but absent posteriorly; inner corner of plica anteriorly with a depression; median area evenly reticulate, its sculpture as strong as on mesoscutum; spiracle separated from posterior edge of metanotum by its shortest diameter, the area between spiracle and plica convex; postspiracular sulcus extremely superficial, almost missing; callus covered with numerous long setae; nucha without setae, forming a lunate, transversely aciculate strip, whose length occupies about one third median length of propodeum.

Petiole wider than long, feebly and irregularly sculptured on upper side, open on lower side. Gaster (Figs 10, 12) subcircular, 1.1–1.2 times as long as wide, about 1.15 times as wide as mesoscutum and about as long as mesosoma; gastral tergites dorsally slightly sunken, first tergite occupying two fifths or slightly more length of gaster, its hind margin slightly curved backwards medially; tergites 1–4 smooth and shining, tergites 4–6 alutaceous laterally, the syntergite entirely so. Ovipositor sheaths slightly projecting.

Description male (Figs 3, 5). Body length 2.2–2.6 mm. Similar to female, except as follows: Head and mesosoma metallic green with golden tints; antenna with scape, pedicel and anelli testaceous, funicle fuscous, first and second segment testaceous beneath. Legs with trochanters, tibiae and tarsi bright yellow, femora medially and pretarsi entirely infusate. Petiole and gaster metallic dark brown with greenish tinge, first gastral tergite with a pale transverse band along posterior margin.

Head (Fig 3) with POL 1.07–1.23 times OOL, OOL about 2.2 times OD; temple about half as long as eye length. Eyes 1.41–1.47 as high as wide, separated by 1.54–1.66 times their height; malar space 0.46–0.52 times eye height; antenna (Fig 5) with scape 1.11–1.20 times as long as eye height and about 7.0 times as long as wide, extending above vertex; ventral shiny plaque extending over upper three fifths of the length of scape; combined length of pedicel plus flagellum 1.3 times as long as head width; pedicel in lateral view 1.5–1.55 times as long as wide; flagellum tapering towards tip, first funicular segment slightly constricted basally and about 1.3 times as wide as subsequent segments; funicle and clava with all segments distinctly longer than wide, each segment densely covered with setae, which project at an angle of 40–50° and are about half as long as width of segment; first funicular segment 2.2–2.4 times as long as wide, 1.3–1.4 times as long as second segment and 1.5–1.6 times as long as pedicel; second funicular segment about 1.8 times as long as wide and up to 1.15 times as long as sixth segment; sixth funicular segment 1.7–1.8 times as long as wide; clava acuminate, 3.5–3.75 times as long as wide, about as long as two preceding funicular segments combined. Basal cell and basal fold of fore wing often with very few isolated hairs; fore wing disc on upper surface with moderately long hairs beyond speculum; short marginal setae present; marginal vein 1.27–1.45 times as long as stigmal vein which is about 1.1 times as long as postmarginal vein; stigma slightly capitate, separated by about twice or slightly more its height from posterior edge of postmarginal vein.

Petiole about 0.7 times as wide as long, moderately strongly widening posteriorly, but laterally without abrupt elevation in posterior part, smooth on upper side. Gaster oblong, about 2.1 times as long as wide, 1.1–1.2 times as long as mesosoma, lateral margins parallel; hind margin of first tergite straight.

Etymology. The specific name of *C. cuneae* sp. n. is derived from “cunea”, the scientific name of the fall webworm. The name “cuneae” is a noun in the genitive case and needs not to agree in gender with the generic name.

Comments. *Conomorium cuneae* sp. nov. closely resembles some of the West-Palaearctic species. To facilitate the recognition of the new species, we present below a modification of Graham's (1992) key to European species of *Conomorium*. Note that *C. pelor* Bouček and *C. equilaterale* Xiao & Huang are excluded from the key for the following reasons. First, *C. pelor* (type series examined by Baur, see Appendix) has the pronotal collar rounded, plicae distinct in posterior half, postspiracular sulci deep and with transverse costulae, gaster acuminate, and is thus morphologically distinct from all the other species. Second, the name-bearing types of *C. equilaterale* and *C. patulum* (examined by Baur, see Appendix) proved almost identical, hence the former is most likely a junior synonym of the later. However, the status of the two species will be addressed in a more comprehensive study of the genus, which is why we prefer to refrain from any change in combination and synonymy.

Key to the Palaearctic species of *Conomorium* (♀ ♂)

- 1 Mesosoma dorsally depressed, so that mesoscutum, scutellum and propodeum almost lie in a single plane. Lower face receding at an angle of about 75–90° with respect to the upper face [According to Graham (1992): First funicular segment 1.05–1.15 times as long as pedicel and 1.5–1.7 times as long as wide. Eyes of female separated by 1.45–1.52 times their height].

C. pityocampae Graham, 1992

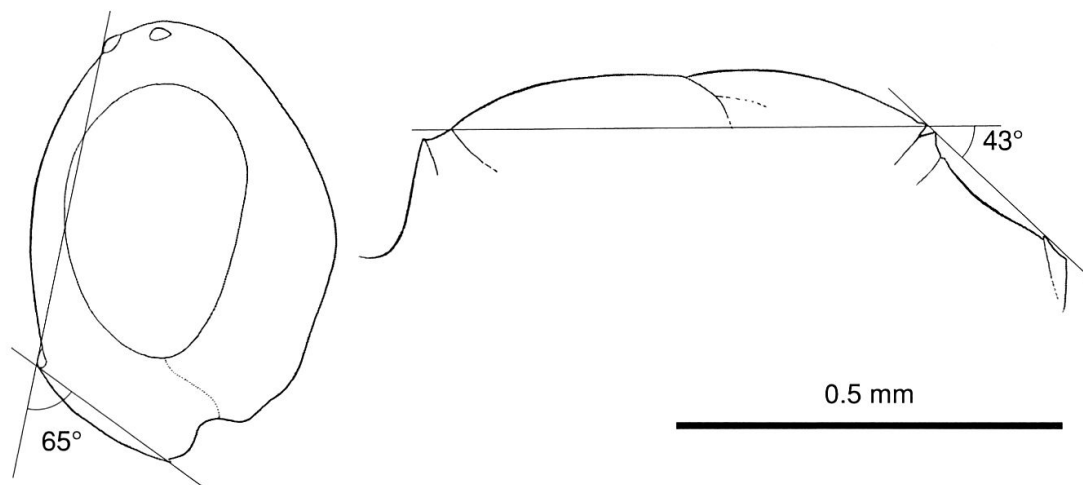


Fig 13. Head and outline of mesosoma (different specimens) in lateral view ♀.

- Mesosoma in lateral view (Fig. 13) moderately strongly bent, dorsellum and propodeum sloping at an angle of about 40–45° with respect to dorsal plane of mesoscutum and scutellum. Lower face (Fig. 13) receding at an angle of about 50–65° with respect to the upper face. 2
- 2 Eyes large, 1.60–1.75 times as high as wide, separated by 1.25–1.3 times their height. Male scape about 0.9–0.95 times as long as eye height [According to

Graham (1992): malar space 0.33–0.38 times eye height. Fore wing with marginal vein 1.05–1.20 times as long as stigmal vein].

***C. patulum* (Walker, 1835)**

- Eyes small, 1.47–1.55 times as high as wide, separated by 1.35–1.66 times their height (Fig. 1). Male scape at least slightly longer than eye height. 3

- 3 Anterior margin of clypeus (Fig. 1) narrowly and rather deeply emarginate, more or less angulate medially, with a depression touching the emarginate edge. Head in dorsal view with temple forming a slightly acute angle with occiput. Female: pedicel in lateral view 2.07–2.15 times as long as wide. Male: scape distinctly longer than eye, 1.11–1.20 times eye height; pedicel 1.5–1.55 times as long as wide; metatibiae bright testaceous; first gastral tergite with a transverse pale band along its hind margin. ***C. cuneae* sp. n.**

- Anterior margin of clypeus broadly and shallowly emarginate, median depression indistinct. Head in dorsal view with temple forming a slightly obtuse angle with occiput. Female: pedicel in lateral view 2.4–2.5 times as long as wide. Male: scape only slightly longer than eye, 1.0–1.10 times eye height; pedicel 1.7–1.85 times as long as wide; metatibiae slightly infusate medially; first gastral tergite mostly without a pale mark. ***C. amplum* (Walker, 1835)**

Biology. *C. cuneae* sp. n. is a gregarious, primary endoparasitoid of pupae of *Hyphantria cunea*. Depending on the size of the host, 14–30 individuals (usually 16–20) emerged from a single pupa. In the overwintering pupae of the pest, the average parasitism rate was 3.6 %, but at some places in Yantai City of Shandong Province it reached 12.2 %. The female and male ratio is 7.5:1. *C. cuneae* sp. nov. may play a certain role in the natural control of the pest *H. cunea* in China.

C. cuneae sp. n. is not the first *Conomorium* species recorded as a parasitoid of *H. cunea*. For instance, *C. amplum* was reared from this pest in Italy by Boriani (1994). Some earlier works (see Noyes 2002) mentioned *C. patulum* as a parasitoid of fall webworm as well, but these records could possibly also relate to *C. amplum*, because no distinction was made between the two species prior to Graham's (1992) revision. While *C. amplum* is likely to be a usual parasitoid of *H. cunea* in Europe, this likely is not the case for *C. cuneae* sp. n. As previously mentioned, *H. cunea* was introduced to China only in 1979; however, *C. cuneae* sp. n. is probably native to China because we have no records from other countries. Hence, *H. cunea* likely is not the natural host of *C. cuneae* sp. n. This is also indicated by its low parasitism rate of 3.6 %. Similarly low parasitism rates have also been found for Chalcidoidea parasitoids of other invasive pests, for instance of the horse chestnut leaf-miner, *Cameraria ohridella* Deschka & Dimic, 1986 (Lepidoptera: Gracillariidae), which attacks the horse chestnut *Aesculus hippocastanum* L. (Hippocastanaceae) in Europe. Here, the parasitism rates were far below 10 %, hence the effect of the naturally occurring parasitoids on the host populations was considered negligible (Grabenweger 2003). Concerning the use of such parasitoids as a biological control agent, their potential seems thus very limited.

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APPENDIX

Voucher specimens used by H. Baur for comparison with the new species. For abbreviations of depositories, see Material and Methods.

***C. amplum*:** Lectotype ♀ “B.M. TYPE HYM 5.1808” from Great Britain, in BMNH. France: Haute Provence, Villas Colmars, ex pupa *Arctia ?caja* (L.) (Lepidoptera: Arctiidae), 2 ♀, 1 ♂; Le Puy, ex pupa *Arctia villica* (L.) (Lepidoptera: Arctiidae), 16 ♀ 7 ♂ in MHNG. Switzerland: Valais, Stalden, ex pupa *Rhyparia purpurata* (L.) (Lepidoptera: Arctiidae), 8 ♀, 14 ♂ in NMBE.

***C. equilaterale*:** Holotype ♀ (entire, glued with right fore wing and tip of gaster on a card rectangle) from China: Hebei Province, Xiaowutai Mt. (see Xiao & Huang 2000: 193), labelled “...[in Chinese]” – “1964.VIII.14 ...[in Chinese]” – “HOLOTYPE” (original, red label) – “Holotype ♀ *Conomorium equilaterale* Xiao & Huang, 2000 lab. H. Baur 2002” (white label with red margins on the left and right hand side); the holotype agrees very well with the original description. Paratypes 4 ♀ from Hebei

Province, Xiaowutai Mt. (1), Weichang (2) and Xinglong (1), which stood together with the holotype under a handwritten note "*Conomorium equilaterale*" in the Pteromalidae collection of the IZAS. Dr. H. Xiao kindly confirmed that all 5 specimens belong to the type series. They were subsequently labelled in an unambiguous manner by Baur.

***C. patulum*.** Lectotype ♀ "B.M. TYPE HYM 5.1807" from Great Britain, in BMNH. Finland: Ingå 1 ♀, Finby 1 ♀, Hattula 5 ♀, Helsingø 2 ♀, Kyrkslätt 1 ♀, Loppi 8 ♀, Nokia 1 ♀, Nystad 1 ♀, all in DAZH. England: Hants. Romsey, Awbridge 1 ♀ in BMNH. France: Drôme, M. Ventoux, Col de Per-rache 3 ♀ 3 ♂, Le Poët-en-Percip 1 ♀, 1 ♂ in BMNH; Inde, La Membrolle s/Ch. 1 ♀ in MNHN. Sweden: ...[locality illegible] 2 ♀, Fiby Urskog Vänge 1 ♀, Nälke 1 ♀, Strömserum 1 ♀, V. Bodarne 1 ♀, Ytterselö 1 ♀, all in NHRM. Switzerland: Canton Genève, Peney 4 ♀ in MHNG; Canton Valais, Mayens de Sion 1 ♀ in MHNG, 1 ♀ in MZL, Verbier 1 ♂ in MHNG. Turkey: Usak [= Ushak] 1 ♀ in BMNH.

***C. pityocampae*.** Paratypes 7 ♀ from Croatia: Istria, Pula, and 1 ♂ from Turkey: Ophaneli, in BMNH. Croatia: Is. Cres, Vrana 3 ♂ in BMNH, 4 ♀ in CNC. Cyprus: Limassol 5 ♀ in USNM. France: Corse, Vizzavona 3 ♀, Bocognano 2 ♀ in NHRM; Drôme, Le Poët-en-Percip 1 ♀ in BMNH; Hérault, Mont-pellier 1 ♀ in MHNG; Paris 3 ♀, 2 ♂ in MHNG. Greece: Patras 6 ♀, 1 ♂ in CSV. Spain: Granada, Nerja 2 ♀; Malaga, Estepona 1 ♀ in BMNH; Mallorca, Canyamel 1 ♀ Albufera 1 ♀ in CSV

***C. pelor*.** Holotype ♀ labelled "CNC No. 21846", from USA: North Carolina: Highlands; paratype 1 ♀ from Virginia: Monterey; both specimens in CNC.

