Establishment of *Delta pyriforme* (Fabricius) in the Bonin Islands, Japan (Hymenoptera, Eumenidae)

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Abstract In 1990 a large eumenid wasp was found on Chichi-jima, Bonin (Ogasawara) Islands. In structure, the wasp well agrees with Bequaert's (1928) concept of the wide-ranging "*Eumenes pyriformis*" (now a species of *Delta*) in both the male and female. However, its color pattern is quite distinctive, easily distinguished from those of all the geographical races of *D. pyriforme* so far known. Nevertheless, this wasp is considered to have been introduced from somewhere in the South Pacific or Southeast Asia, since no one had seen or collected it until 1990. It has now established itself on Chichi-jima and perhaps also on Ani-jima, though not seen on any other island of the Bonin group. Descriptions of the both sexes of this wasp are given together with notes on taxonomy and nesting biology.

Key words: Eumenidae / *Delta pyriforme* / Bonin (Ogasawara) Is. / establishment / nesting behavior / female interaction

In August 1990, a large eumenid wasp, hitherto not known from Japan, was seen on Chichi-jima, the Bonin (Ogasawara) Islands by a naturalist (N. Sebore Jr.) who had inhabited this island for a long period. Prof. T. Yamasaki of the Tokyo Metropolitan University collected thirteen specimens of this wasp in August and September 1990 on the same island but chiefly along roads. Based on this material a brief description of the female wasp was given by Yamane, et al. (1991). One of us (HM) also collected seven males and three females between 16 and 23 September, and then made observations on its nesting biology. The wasp had no doubt become common until the summer of 1991, and now it has firmly established itself on this island (Fig. 1). In June 1991 one male and one female were collected also on Ani-jima

Fig. 1. Map showing the places where adult wasps were seen or collected (★) or nests were found (●) until January 26, 1991 on Chichi-jima.

of the Chichi-jima group, but none from islets other than these two. Yamane has made an extensive literature survey and a comparison of the specimens collected with those of related forms, and has found that the wasp belongs to the *Delta pyriforme* complex and does not agree with any of its known geographical races in color pattern. In this paper, we tentatively treat it as *D. pyriforme*, discussing its taxonomy and describing its nesting biology.

Before going further we thank Prof. Tsukane Yamasaki of the Tokyo Metropolitan University for his valuable information, Mr. Shin'ya Miyano of the Central Museum of Chiba Prefecture for his kind assistance in field works, and Dr. Satoshi Hashimoto of the same museum for his identification of a geometrid moth.

Delta pyriforme (Fabricius) subsp.

Female. Structure as in the nominotypical form. Ground color black; the following parts ferruginous: clypeus, mandible, band on gena, frons below the level of lower margin of upper lobe of eye, antennal scape, pronotum largely, anterior half of mesoscutum, irregular markings in the posterior half of mesoscutum, mesopleuron extensively, dorsal part of propodeum extensively, side of propodeum almost wholly, wide central band and narrower apical band on gastral petiole, basal 1/4 to 1/3 of tergite 2, narrow inconspicuous apical band on tergite 2, last tergite, gastral sternites 1-6 almost wholly. Antennal flagellum orange yellow. Inner orbit below and supraclypeal spot yellow. Tergites 3-5 with sinuated yellowish apical bands. Legs extensively ferruginous; anterior faces of coxae and trochanters of all legs, mid and hind femora, and hind tarsus variously marked with black.

Male. Very similar to the female in coloration except in the following details. Clypeus yellow; labrum yellowish. Mandible with a yellow stripe along inner margin. Several apical segments of antenna with black spots above, and yellow below. Ferruginous part in the posterior part of gastral tergite 2 much more extensive. Yellow apical bands on tergites 3-5 much narrower than in the female.

Specimens examined. Chichi-jima: 1 ♀, Kominato — Nakayama-tôge, 16 ix 1990, 7 ♂ 2 ♀, same loc. 22-23 ix 1990, 1 ♀, Okumura, 24 ix 1990, N. Sebore Jr.; Ani-jima: 1 ♀, Takinoura, 23 vi 1991, 1 ♂, same loc. 5 vii 1991. (Specimens were collected by H. Matsuura except otherwise stated.) The following specimens collected on Chichi-jima by T. Yamasaki are deposited in the collection of the Tokyo Metropolitan University: 1 ex, Kominato, 25 viii 1990, 1 ex, Suzaki, 25 viii 1990, 10 exs, Kominato, 21-24 ix 1990, 1 ex, Omura, 25 ix 1990.

TAXONOMY

Bequaert (1918) discussed the world distribution of *Eumenes maxillosus*, enumerating ten color varieties including var. *petiolatus* (Fabricius), a synonym of *pyriformis* (Fabricius). Later, he recognized two distinct species within this "polytypic species", i. e., *E. pyriformis* to which six varieties belonged, and *E. maxillosus* to which seven belonged (Bequaert, 1928). According to him *E. pyriformis* differs from *E. maxillosus* in some structural characters. In the former the male mid tarsus is distinctly flattened, the male mid femur deeply concave in the basal third, and the sides of propodeum rounded off, without ridge that divides it into ventral and dorsal areas in both sexes. Recent vespidologists transferred these forms to the genus *Delta*.

The present form from Ogasawara no doubt belongs to Bequaert's "*E. pyriformis*", which, however, may consist of some biological species. For example, Giordani Soika (1957, 1973)

Fig. 2.

A, a large nest constructed on a tree trunk.

B, a female wasp constructing a pot.

C, wasp larvae in pots.

D, two eggs laid in a pot.

thinks that almost all the varieties recognized by Bequaert are distinct species, though Vecht (1981) considers them mere subspecies (geographical races) of *D. pyriforme* because they are largely allopatric in distribution. Though intensive comparative studies are needed to clarify the real situation of this "polytypic species", here we tentatively follow Vecht's view. The present form does not agree with any of the known subspecies of *Delta pyriforme* in coloration.

NESTING BIOLOGY

Nesting biology of this species on Chichi-jima was mainly observed by one of us (HM) in 1990 and 1991.

Nesting site. In total 45 nests were found chiefly in sunny open places. Nests were usually attached to building walls, concaved parts of rocks, tree trunks, etc. (Fig. 2A), but sometimes constructed in partly covered sites such as on inner walls of pipes and in outdoor units for air conditioners. A nest was found to be attached to the ventral part of a deserted car. For every

Fig. 3. Order of cell construction in a nest on a vertical wall.

type of substrate, both vertical and horizontal portions may be used.

Nest construction. This species is not a typical potter wasp, having a mud-daubing behavior in nesting. It constructs a hemi-spherical pot when the nest consists of only one cell, or a cluster of quatered-spherical pots (Fig. 2B, C). The pots are often irregular in shape, adjusted to uneven surfaces of substrates. The arrangement of pots varies according to the shape and condition of substrates; on the uneven rock surface, pots are placed in one or a few rows so as to fill up concaved parts, but occasionally the arrangement is rather irregular. When nests are constructed on the border of two planes meeting at a right angle, the pots are arranged in a line along the border. Sometimes pots are piled up on the previously constructed pots. An example of this type of nest is shown in Fig. 3 that indicates the order of cell construction.

The surface of substrate was always used as the bottom of pot, with the only exception where the bottom was largely made of mud. Interspaces between pots are usually filled up with mud (secondary treatment). After all the pots are constructed and after the second treatment is finished, another layer of mud may be applied to the whole nests.

The number of pots finally constructed varied as follows: 1 pot (2 nests), 3 (5), 4 (2), 6 (2), 7 (1), 8 (3), 9 (1), 10 (4), 12 (3), 15 (1), 16 (1), 18 (1), 19 (1), 22 (1). The largest nest with 22 pots arranged in a line measured ca. 35 cm in length. This means that the average length of pot is ca. 1 cm. However, a typical hemi-spherical pot measured 14.3 mm long, 22.0 mm wide and 10.1 mm deep. The opening of pot measured 5.45×4.75 mm in average ($n=4$).

Prey. We have examined 19 cells (pots) from twelve nests for captured prey. Larvae of six moth species were found to have been stored in these cells: A, a noctuid [typical caterpillar;

Table 1. Moth larvae (prey) found in 19 cells from 12 nests.

Prey species*	No. cells examined**	No. prey stored
A only	1(1)	5
D only	6(2)	8, 8, 9, 9, 10, 11
E only	2(1)	6, 9
F only	1(1)	16
A + C	1(1)	A : C = 3:1
B + F	1(1)	B : F = 1:10
C + F	5(3)	C : F = 1:13, 2:7, 2:5, 3:12, 3:6
D + F	1(1)***	D : F = 2:2
B + C + F	1(1)	B : C : F = 2:1:6

* For A-F, see text.

** Number of nests examined is given in parentheses.

*** The pot had not been completed.

Table 2. Cell contents in some nests examined in 1990-1991.

Nest		Cell number															
Code	Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16-19
6	11/18	P	P	P	P	L	L	L	L	L	L	L	L				
9	11/24	P	P	P	P	P	P	P	P	P	L	L	L	L	L	E	
15	12/26	L	LL	EL													
16	12/9	O	A	P	(E.L)	P	P	P	P	(E.L)	(E.L)						
22	1/3	-P	L	L	L	E	(E)										
36	1/5	L	L	L													
39	6/26	-P	-P	-P	L	-P	L	L	L	L	L	L	E				
40	6/27	(L)	(L)	P	P	P	P	P	P	P	P	P	P	P	P	P	P-P
41	9/23	P	P	P	-P	L	L	L	L	E	E						
42	9/9	(L)	-P	(-P)	-P	-P	-P	L	L	x							

E: egg, L: larva, -P: prepupa, P: pupa, EL: with an egg and a larva, LL: with two larvae, E.L: egg or larva, O: adult wasp had emerged, x: empty, (): found dead.

mean body length (MBL) 24.6 mm, and mean body diameter (MBD) 3.8 mm]; B, a noctuid (caterpillar; MBL 25.8 mm, MBD 4.6 mm); C, a noctuid (loopier; MBL 33.1 mm, MBD 4.9 mm); D, an unknown moth probably of the family Noctuidae (typical caterpillar; MBL 20.2 mm, MBD 3.9 mm), E, a geometrid (body size not measured), and F, *Chiasmia vagabunda* Inoue (Geometridae; MBL 18.2 mm, MBD 2.2 mm).

A pot contained 4-16 caterpillars of one to three moth species (Table 1). The weight of prey per pot was measured in six cases: 11 larvae of species D 1.6 g, 8 of the same species 1.2 g, 6 of species E 1.3 g, 9 of the same species 1.7 g, 16 of *C. vagabunda* 1.0 g, and 1 of species B and 10 of *C. vagabunda* together 0.86 g. Many of the stored larvae were of *C. vagabunda* in November and December, when numerous larvae of this moth were observed in the field on the host tree *Leucaena leucocephala* (Leguminosae). The paralyzation of prey was quite incomplete, some prey in five cells from two nests having completed their metamorphosis into the adult stage.

Development. The egg was 4.3-4.4 mm in length and 1.3 mm in diameter (n=2). The thread by which the egg hung from the ceiling of pot was 1.4 mm (n=1).

In a nest continuously observed for its development, an egg probably laid on 8th December was found to be a full-grown larva just prior to becoming a prepupa on 26th December. The rearing of three immature wasps under a constant temperature (23°C) showed a larval period of 11 to 12 days, prepupal period of 8 to 9 days and pupal period of 22 to 24 days. These figures suggest a total incubation period of less than 50 days. The arrangement of immatures in some examined nests is shown in Table 2.

Apparently anomalous oviposition. We found some interesting cases where more than one immature wasp existed in a pot (Fig. 2D). In one case observed between 8th and 29th December 1990, the second pot contained two wasp larvae, one large (14.4 mm long) and the other small (7.2 mm). The larger larva was just predating on the smaller one when the contents of the pot were being examined on 26th. Several prey remained but had begun to decay. On the same day the third pot contained one larva and one egg, the latter being attached to a paralyzed noctuid larva instead of to the ceiling of the pot. On 27th the egg

hatched and had been eaten until 29th.

In another nest observed between 2nd and 11th January 1991, an egg was laid to the ceiling of the second pot on 3rd, but on 6th the opening of the pot had been destroyed, all the prey previously stored had disappeared, and an additional egg was found near the first egg. Furthermore, a third egg was seen on 7th, when the opening of this pot had been repaired.

We failed to confirm whether these eggs had been laid by the same mothers. The following observation may be suggestive of the nature of these apparently "anomalous" behaviors. On 24th December 1990, a female wasp was seen hovering near a nest under construction, the supposed owner of which was absent on foraging. A few minutes later, the owner wasp returned to her nest with a prey, finding and attacking the foreigner wasp, which then flew away. The owner wasp again went foraging after putting the prey into a pot. One or two minutes later, again a female (possibly the previous one) came and perched on the nest, examining the inside of the pot. She flew away upon becoming aware of the observer who moved toward the nest to witness the event in detail.

Parasitoid. A pupa parasitized by a braconid wasp was found on 24th December 1990 from an incomplete nest made on a sunny surface of a rock. The nest consisted of two cells without secondary treatment.

DISCUSSIONS

Many naturalists including entomologists have visited the Bonin Islands in these thirty years, and the insect fauna of this interesting archipelago is now relatively well known (Nakane, 1970; Habu, 1986). However, no one had seen this large eumenid wasp until the summer of 1990. More than twenty years ago, a relatively large paper wasp, *Polistes jadwigae* Dalla Torre, was recorded from Chichi-jima. Since this species somewhat resembles *D. pyriforme* in size and coloration, it is not impossible that the record of *P. jadwigae* was based upon a misidentification. But, in any case, "*P. jadwigae*" itself has never been found thereafter. The collection records so far published strongly suggest that *D. pyriforme* has recently been introduced by man. This view is also supported by the fact that the Bonin population does not resemble at all those of both Taiwan and the Philippines, the most likely candidates for source areas in case of natural colonization. The Mariana Islands lack this species.

The Bonin Islands have a quite poor aculeate fauna. Among the Vespoidea only five eumenid species have been recorded, of which the largest (*Anterhynchium flavomarginatum*) may be an introduced species (Yamane, 1990). All these species may hunt for larvae of microlepidopterans such as Pyralidae and Tortricidae. Also among Sphecidae, another group of Aculeata using lepidopteran larvae as prey, most are small species; the largest [*Sceliphron caementarium* (Drury)] is most probably an introduced species and hunts for spiders (Iwata, 1971). Thus, there has been no native or introduced species that uses medium-sized caterpillars or loopers of the families Noctuidae and Geometridae in this archipelago. This may be one of the main reasons for the quick spread and establishment of *Delta pyriforme* on Chichi-jima. Since the spread of *Leucaena leucocephala*, an important host of one of the prey of this wasp, has been caused by human activities, by the introduction of this wasp we can expect a food web completely new to this archipelago.

The most recent observation on the nesting sites suggests that there is a possibility for this species to be transported to the Honshu mainland. One of us (HM) found a nest attached to

the ventral side of a deserted car which was scheduled to be sent to Tokyo. About forty such cars are constantly transported to Tokyo every two months from this archipelago (mainly from Chichi-jima and Haha-jima). Though it may be impossible for this tropical wasp to establish itself in Tokyo, attention should be paid to this route of artificial dispersal.

The nesting habits of this species in the Bonin Islands well agree with those in Thailand where the nominotypical form occurs (Iwata, 1964). But the present study will give a new insight into the interactions between nesting females among potter wasps. Though the taking-over of a preoccupied nest tube (nest usurpation) is a common occurrence among the tube-renting eumenids (Cowan, 1991), there has been little evidence for competitive female interactions to occur among the potter wasps and mud daubers. Our observations suggest the presence of such behaviors as robbing of prey caterpillars and nest parasitism.

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山根正気, 松浦秀明 小笠原諸島におけるチャイロネッタイスズバチの定着

1990年の夏に小笠原諸島父島列島の父島で、日本未記録の大型のドロバチが発見された。形態的特徴から、このハチはBequaertが*Eumenes pyriformis* (Fabricius) (現在は*Delta* 属に移されている)とした種に該当すると思われる。ただし、このtaxonはじっさいには複数の種をふくむ可能性があるため、こんご十分な検討が必要である。体の斑紋からみると、小笠原の個体群はこれまで知られているいかなる亜種にも該当しない。とくに、小笠原諸島に近いフィリピンや台湾の亜種とは著しく異なる。また、すくなくとも文献上は、本種のマリアナ諸島からの記録はない。したがって、小笠原諸島の近隣地域から最近侵入した可能性はひくい。本種が小笠原へ侵入した経緯については以下の2つが考えられる。1) 侵入時期は相当に古く、隔離されたあと固有の亜種となったが、生息密度がごく低かったため最近まで発見されなかった。しかし、なんらかの理由により、1990年以降大量に発生するようになった。2) ごく最近、東南アジアのどこかから、私たちにとって未知の亜種がおそらく人為的に導入された。

小笠原にはこれまでにハチの専門家をふくむ相当数の昆虫学者が調査で訪れており、それらの報告書には本種に該当するハチはまったく登場しないので、1)の可能性はまずない。20年以上まえにセグロアシナガバチが記録されたことがあるが、飛翔時に本種と類似する可能性はあるものの、標本にした場合見誤ることはありえない。現在のところ、2)の可能性が高い。すでに、父島では定着したと考えられ、1991年には兄島でも発見されたが、それ以外の島ではまだみつかっていない。これまで小笠原には、大型のカリバチは存在しなかったため、本種の定着は父島や兄島の生態系に少なからぬ影響をおよぼすものと思われる。

松浦による父島での観察によれば、本種は主として日当たりのよい建物の壁面、石の窪み、樹皮などに営巣する。巣は、水平面・垂直面のいずれにも造られ、1ないし20程度の泥でできた育室(ポット)からなる。幼虫のための餌としては、シャクガ科とヤガ科(計6種)の幼虫を狩り、育室あたり4ないし十数匹を蓄える。1990年の11月と12月には、巣にもちかえられた餌はほとんどがギンネムエダシャクであった。各育室には原則として1個体の幼生(卵、幼虫、蛹)のみがみられたが、2個体以上の幼生をふくむ育室が数例ながら見いだされた。これらが同じ親に由来するかどうかは不明である。この点を確認するため営巣途上の巣を観察していたところ、よそ者のメスが訪れたのが2度確認された。これまで、トックリバチ属やネッタイスズバチ属では、営巣をめぐるメス間の干渉や寄生行動は知られていないので、今回の観察はきわめて興味深い。