

[研究文章 Research Article]

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An Amendment on the Record of *Rhyothemis fuliginosa* Selys, 1883 in Taiwan — a Newly Discovered Gynomorphic Wing Pattern in Female *R. regia regia* (Brauer, 1867) (Odonata: Libellulidae)

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Abstract: The identity of Taiwanese *Rhyothemis fuliginosa* Selys, 1883 is clarified to be the gynomorphic female of *R. regia regia* (Brauer, 1867). Female Taiwanese *R. r. regia* differ from female *R. fuliginosa* mainly in having paler face with weak metallic lustre, anteriorly more strongly incurved postclypeus and stouter cerci. The reported wing patterns of various subspecies of *R. regia* are compiled from the literature for comparison. A transitional variation of the female wing pattern of Taiwanese *R. r. regia* varying from andromorphic to gynomorphic is illustrated. The case of range expansion caused by climatic warming in *R. r. regia* and other libellulid dragonflies in Taiwan is elucidated.

Keywords: Polymorphic, subspecies, climatic warming, range expansion

Introduction

After Lieftinck et al. (1984), two additional *Rhyothemis* species have been recorded from Taiwan, that are *R. fuliginosa* Selys, 1883 and *R. r. regia* (Brauer, 1867). *Rhyothemis fuliginosa* is a temperate species of libellulid dragonfly, formerly only recorded from China, Japan and the Korean Peninsula in East Asia (Tsuda, 2000), but its range could reach as south as to Fujian (Needham, 1930). It was reported for the first time as a seasonal vagrant from northern Taiwan in 2007 (Yeh et al., 2007), but so far only its females were collected from the island. *Rhyothemis regia* is a polymorphic species which inhabits the Indo-Pacific region, with eight subspecies, viz. *R. r. armstrongi* Fraser, 1956, *R. r. chalcoptilon* (Brauer, 1867), *R. r. exul* Ris, 1913, *R. r. juliana* Lieftinck, 1942, *R. r. pretiosa* Selys, 1878, *R. r. regia*, *R. r. thisbe* Lieftinck, 1953 and *R. r. uveae* Marinov, 2021, spreading over a transverse belt extending from Sabang and Simaloer in western Sumatra in the west, through the central and southern islands of the Philippines, northern Celebes, the Moluccas to northern New Guinea. Strangely, the boundary of the range is far away eastwards to Samoa and Wallis Islands in the South Pacific Ocean and northwards to Saipan and Pagan Islands in the western Pacific Ocean, without any sole record reported from in-between (Lieftinck, 1959, fig. 2). Different subspecies of *R. regia* are well isolated from each other in small insular islands or coastal areas of larger islands, but some could distribute over a wider area as in *R. r. regia* (Sumatra to Philippines), or occur in remotely disjunct localities as in *R. r. chalcoptilon* (Samoa and Saipan). These subspecies were structurally undifferentiated and could only be separated by wing pattern (Lieftinck, 1959).

Another confusing matter regarding the record of *R. fuliginosa* in Taiwan, except that only female specimens were collected, is that the females were frequently observed to copulate with the males of *R. r. regia* (Han-Ian Chiou, personal communication). The copulated females even performed normal oviposition behaviors after mating. The above observations have puzzled local researchers about the real identity of Taiwanese *R. fuliginosa* for years and led the author to explore the issue in detail. The result is presented here with a discussion on the status of *R. r. regia* in Taiwan and its range expansion caused by climatic warming.

Materials and methods

The females of Taiwanese *R. fuliginosa* were directly compared with the two females of Japanese *R. fuliginosa* and the females of Taiwanese *R. r. regia*. All specimens examined were listed below. All specimens are deposited in Taiwan Forestry Research Institute, Taipei, Taiwan (TFRI).

Japanese *R. fuliginosa* — 2♀♀, Shizuoka, Japan, 4/VIII/2012, leg. S. L. Chen & I-Lung Lee.

Taiwanese *R. fuliginosa* — 1♀, Xinyi district, Keelung City (基隆市汐止區), 9/X/2006, leg. J. H. Wu; 1♀, Xinyi district, Jilong City, 10/X/2006, leg. H. I. Chiou; 1♀, Xinyi district, Keelung City, 18/VII/2008, leg. H. I. Chiou.

Taiwanese *R. r. regia* — 1♂, Datong, Yilan County (宜蘭縣大同), 7/VII/2011, leg. W. C. Yeh; 2♂♂, Dawu, Taitung County (台東縣大武), 30/V/2007, leg. W. C. Yeh; 1♂, Xindian, New Taipei City (新北市新店), 10/IIV/2000, leg. W. C. Yeh; 1♀, Neipu, Pingtung County (屏東縣內埔), 15/IV/1996, leg. J. S. Chen; 1♀, Neipu, Pingtung County, 12/X/2004, leg. W. C. Yeh; 1♀, Xinyi district, Keelung City, 30/IX/2007, leg. H. I. Chiou.

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The wing patterns of various subspecies of *R. regia* were compiled from Lieftinck (1926, 1942, 1948 & 1959), Marinov (2021) and Ris (1912, 1913) and shown in Figs 1–29. The Minahassa female of *R. r. regia* (Figs 1–14) in Ris (1912) (pl. 6, right upper) has discoidal fenestrae on hind wings and does not belong to the nominate subspecies. It shares a similar wing pattern to the Ternate male of *R. r. pretiosa* (Figs 1–13) in Ris (1913) (pl. 6, left upper; originally as *R. r. regia* but see Lieftinck 1953a) and is recognized here as that subspecies. The Samoan male and female originally identified by Lieftinck (1959) as *R. r. chalcoptilon* is recognized here as *R. r. armstrongi* (see Marinov, 2021).

Results

Direct inspection of the two female Japanese *R. fuliginosa* revealed some features, other than wing pattern, that are different from those of the female Taiwanese *R. fuliginosa*. In the Taiwanese females, the face is yellowish-brown at middle, including clypeus and lower margin of antefrons, with weaker metallic lustre especially on the postclypeus; the postclypeus is more strongly and deeply incurved at anterior margin with lateral lobes relatively larger (Fig. 30); the cerci are stouter (Fig. 31) and the subgenital plate is more deeply and widely notched apically (Fig. 32). The Japanese females have, in comparison with the Taiwanese females, almost entirely black face with strong metallic lustre, a differently shaped postclypeus (Fig. 33), more slender cerci (Fig. 34) and a more shallowly notched subgenital plate (Fig. 35). Other differential features between the females of Japanese and Taiwanese *R. fuliginosa* include: the hairs covering the apical abdominal segments are longer and denser in the Japanese females but shorter and sparser in the Taiwanese females; the Taiwanese females have denser venation than in the Japanese females, with costal cross-vein numbers 11–13:10–12:11–13:11–13 in forewings and 11–13:6–8:7–8:11–15 in hindwings (8–9:9:9:8–9 in forewing and 8–9:6:6:8–9 in hindwings in the Japanese females); 9th sternite is generally black including a pair of styli in the Japanese females (Fig. 35) but yellowish-brown at base and the styli in the Taiwanese females (Fig. 32).

The female Taiwanese *R. fuliginosa* were further compared with the female Taiwanese *R. r. regia* and the result showed no distinct differences between them, except in wing pattern. The final conclusion is that the female Taiwanese *R. fuliginosa* in fact represents a new gynomorphic wing pattern of female *R. r. regia* that has never been reported before, although Lieftinck (1948) did show one similar example from Sabang, Sumatra (Figs 1–8). This new wing pattern is similar to that of the gynomorphic females of Japanese *R. fuliginosa* as shown in Sugimura et al. (2001, p. 282). However, the former has a dark area of hind wing a little less extensive in comparison to the latter, with the outer margin of the dark area being distinctly basal to pterostigma (reaching or exceeding pterostigma in the latter). Intra-specifically, this wing pattern is most similar to that of the Sabang female mentioned above. As in the Sabang female, the gynomorphic females of Taiwanese *R. r. regia* usually possess two faint fenestrae (more distinct in the Sabang female) on hind wing just outside of nodus, one close to anterior margin and the other to posterior margin. These fenestrae are also absent in female Japanese *R. fuliginosa*.

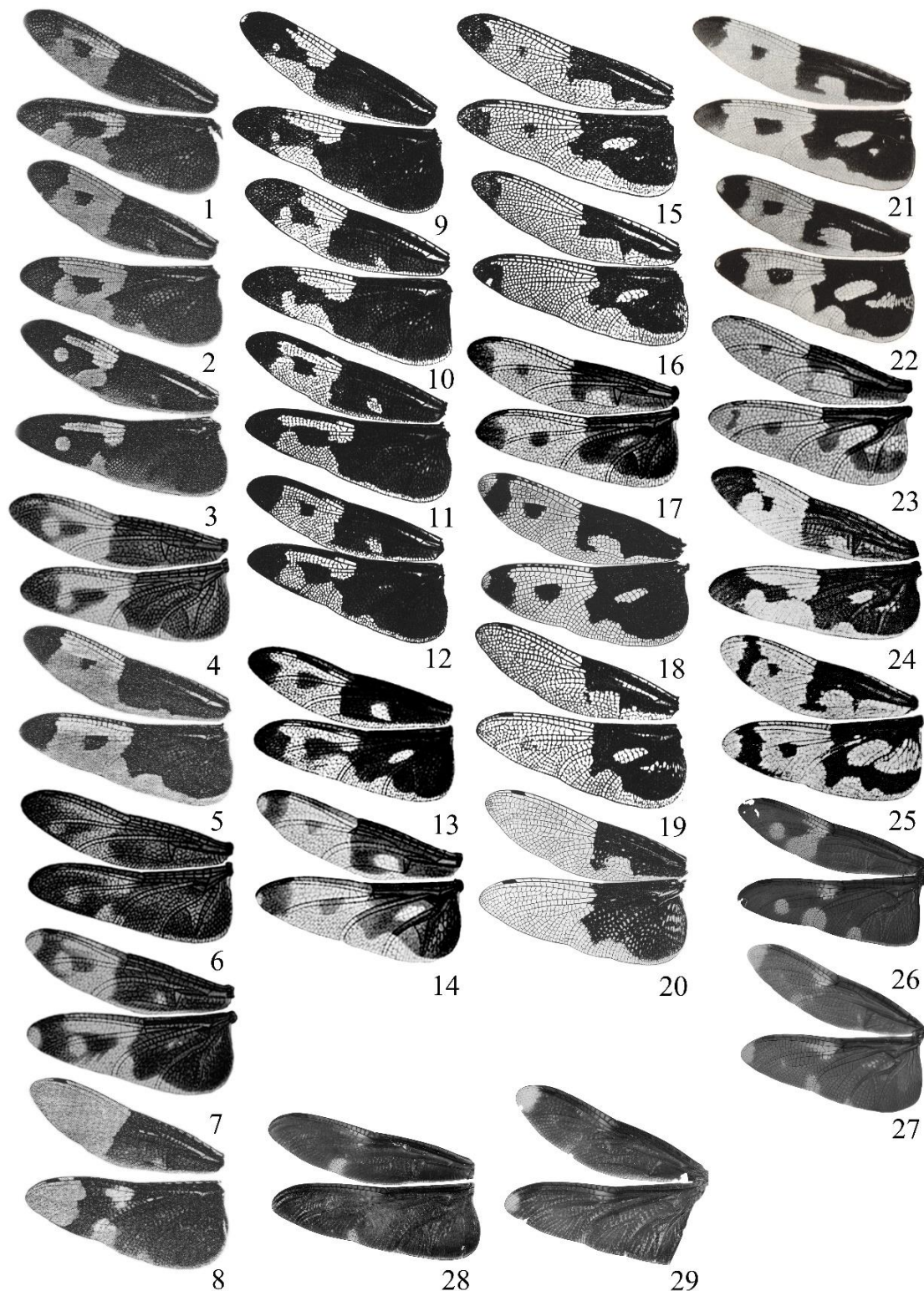
Discussion

Dichromatic variation in female wing pattern is common in the genus *Rhyothemis* (Lieftinck, 1959) and in *R. regia* has been reported for the subspecies of *R. r. exul* (Lieftinck 1942), *R. r. thisbe* (Michalski, 2012) and *R. r. chalcoptilon* (Lieftinck, 1959). The wing patterns of *R. r. regia* recorded from Taiwan are also variable and the variation is more pronounced in the female than in the male (Figs 36–42). A series of transitional variation in female wing pattern of Taiwanese *R. regia* could be found, varying from fully andromorphic type (Fig. 39) to extremely gynomorphic type (Figs 42–43), with the apical transparent area becoming larger toward the latter type.

The cases of range expansion toward the north caused by climatic warming in Taiwanese dragonflies

According to Lieftinck (1959), the northern boundary of *R. regia* had never exceeded N19° (Pagan Island) in latitude. However, the nominate subspecies has been reported from southern Taiwan (N22°) in 1996 (Yeh, 1996). This subspecies dispersed quite rapidly in the island from the south northwards (personal observation) and in 2000 was recorded from northern Taiwan (Xindian, New Taipei City, N25°, see specimens examined). Nowadays, it is widely distributed almost all over the island (Fig. 44). This kind of dispersion towards the north has been suggested to be range expansion or shift caused by climatic warming, which has proven to be common for dragonflies (Hichling et al., 2005; Ott, 2010). Similar examples of northward dispersion in Taiwanese dragonflies have also been found in *Neurothemis taiwanensis* Seehausen & Dow, 2016 and *Potamarcha congener* (Rambur, 1842) (Hu & Ma, 2018); the former has rarely been reported from northern Taiwan before 1990 (Matsuki & Lien, 1983, 1989), but is now widely distributed and common on the island (personal observation), with the northeastern boundary of its distributional range even reaching two Japanese islets, *i.e.* Yonaguni and Iriomote islands in the Ryukyu Islands where it has never been recorded before (Ozono et al., 2012).

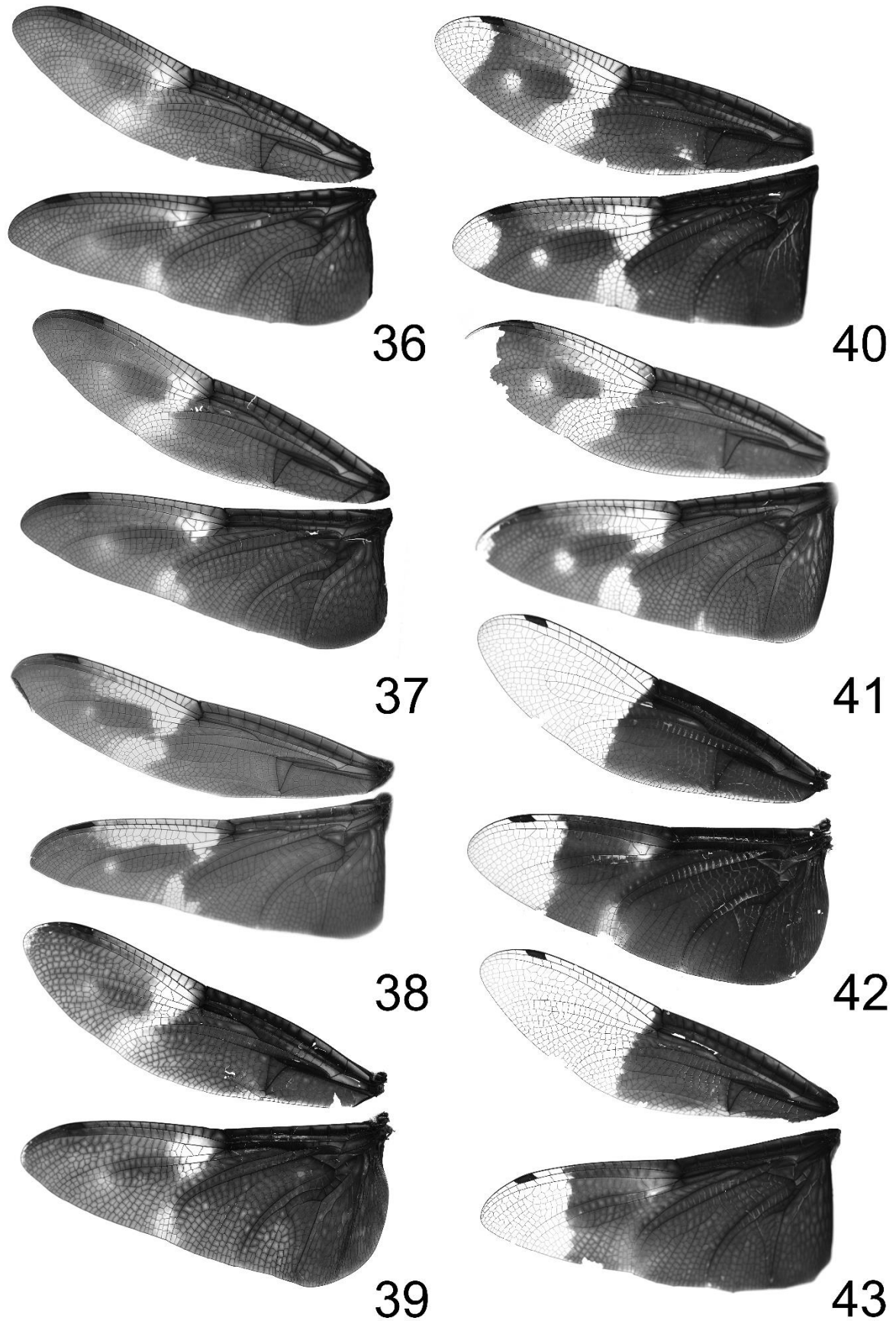
Rhyothemis regia and *R. phyllis* (Sculzer, 1776) were mutually exclusive in their distributional areas and rarely co-existed in the same local site (Lieftinck, 1953b). The nominate subspecies of *R. phyllis* has been recorded from the Ryukyu Islands since 1981 and subsequently expanded its range northwards into Kyusyu in the south of Japan (Ozono et al., 2012). Recently, *R. r. regia* has also been reported from Yonaguni Island (Kohama, 2021); hence, it is interesting to keep observing how this species will interact with *R. p. phyllis*, while it keeps expanding its range northwards as global climate becomes warmer.



Figures 1–29. Wing patterns in *R. regia* subssp. 1–8, *R. r. regia*; 9–12, *R. r. juliana*; 13 & 14, *R. r. pretiosa*; 15–20, *R. r. exul*; 21–23, *R. r. thisbe*; 24 & 25, *R. r. armstrongi*; 26 & 27, *R. r. chalcoptilon*; 28 & 29, *R. r. uveae*. 1 & 2, males, Sabang; 3, male, Engano; 4, male, Palawan; 5, male, Basilan; 6, male, Amboina; 7, female, Palawan; 8, female, Sabang; 9–12, males, northern New Guinea; 13, male, Ternate; 14, female, Minahassa; 15–17, males, Kei; 18–20, females, Kei; 21, male, Buru; 22, female, Buru; 23, female, Sumba; 24, male, Samoa; 25, females, Samoa; 26, male, Niuafo’ou; 27, female, Niuafo’ou; 28, Wallis, male; 29, female, Wallis. 4, 6, 7, 13, 14, 17, 18, 20, 22 copied from Ris (1912 & 1913), 26–29 from Marinov (2021), the others from Lieftinck (1926, 1942, 1948, & 1959).



Figures 30–35. Female characters of *R. r. regia* (30–32) and *R. fuliginosa* (33–35). a & b, face in front view; c & d, apical abdominal segments in dorsal view; e & f, ditto, in ventral view.



Figures 36–43. Wing patterns of Taiwanese *R. r. regia*. 36–38, males, 39–43, females. 36, Xindian, New Taipei City; 37, Datong, Yilan County; 38, Dawu, Taidong County; 39, Xinyi, Jilong City; 40–41, Neipu, Pingdong County; 42–43, Xinyi, Jilong City.

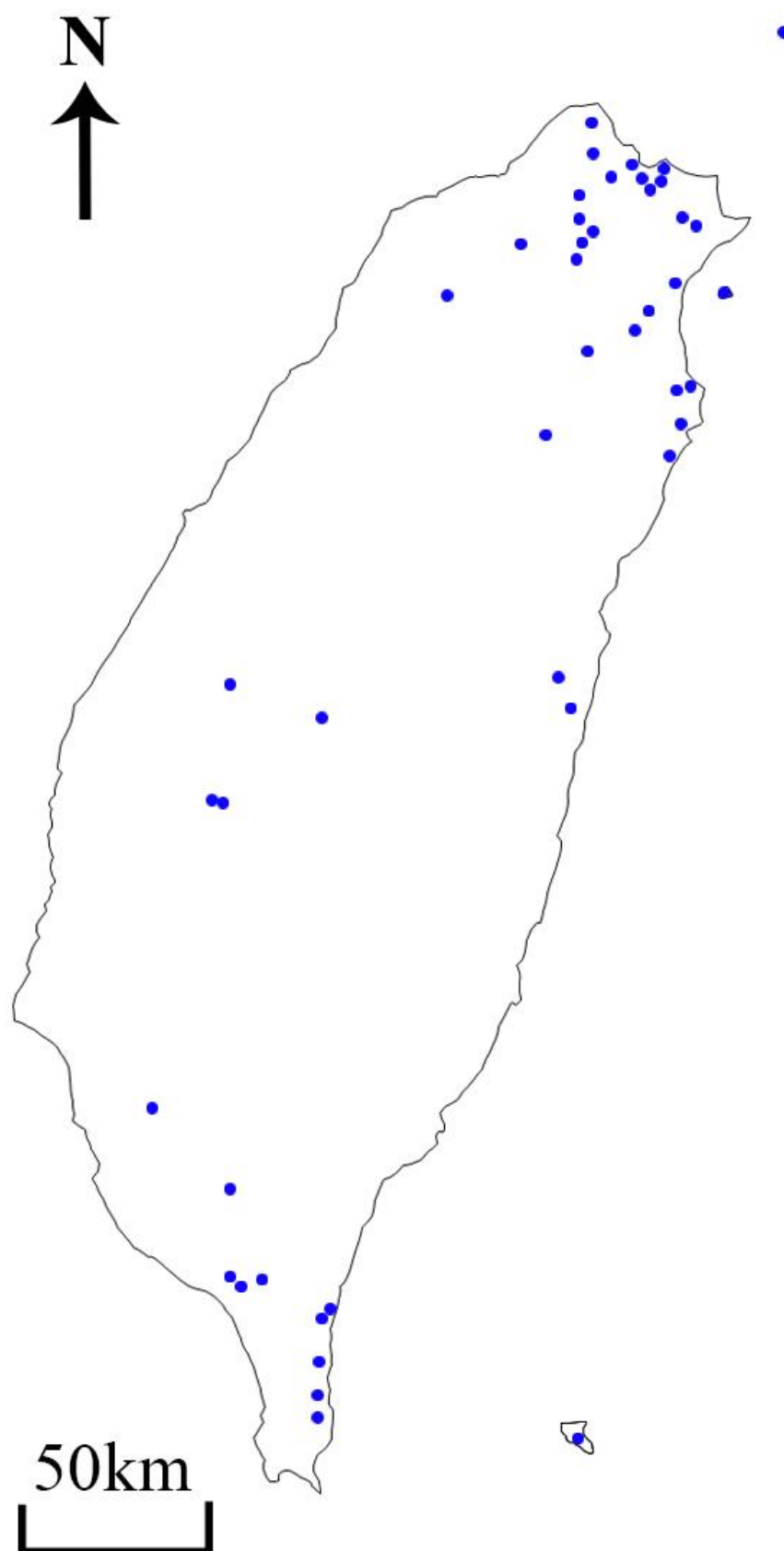


Figure 44. Distributional map of *R. r. regia* in Taiwan before 2015.

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I sincerely thank Han-Ian Chiou (deceased) who kindly reminded me of the frequent and unusual copulations between male *R. r. regia* and female Taiwanese *R. fuliginosa*; his encouragement has greatly motivated me to solve the issue presented in this study. Milen Marinov is grateful for his helpful comments on *R. r. chalcoptilon* from Samoa. Thanks are due to Lou Chi-Ming for providing distributional data of *R. r. regia* in Taiwan compiled from a database maintained by him. Szu-Lung Chen and I-Lung Lee kindly provide the female specimens of Japanese *R. fuliginosa* at my disposal.

References

- Hickling, R., Rory, D. B., Hill, J. K. & Thomas, C. D. 2005. A northward shift of range margins in British Odonata. *Global Change Biology* 11: 502–506.
- Hu, F.-S. & Ma, C.-H. 2018. Notes on communal roosting behavior in *Potamarcha congener* (Odonata: Libellulidae) in Taiwan. *Taiwanese Journal of Entomological Studies* 3 (1): 27–31.
- Kohama T. 2021. *Rhyothemis regia regia* (Brauer, 1867) (Odonata: Libellulidae), new to Japan from Yonaguni-jima Island, Okinawa Prefecture. *Gekkan Mushi* 601: 34–36. (in Japanese)
- Lieftinck, M. A. 1926. Fauna Buruana. Odonata gesammelt von L.J. Toxopeus auf Buru, 1921-1922, nebst einigen Odonaten von Amboina. *Treubia* 7 (3): 276–298.
- Lieftinck, M. A. 1942. The dragonflies (Odonata) of New Guinea and neighbouring islands. Part VI. Results of the Third Archbold Expedition 1938-39 and of the Le Roux Expedition 1939 to Netherlands New Guinea (I. Anisoptera). *Treubia* 18 (3): 441–608.
- Lieftinck, M. A. 1948. The Odonata of Engano with a survey of the dragonfly-fauna of the West Sumatran chain of islands. *Treubia* 19 (2): 279–304.
- Lieftinck, M. A. 1953a. The Odonata of the island Sumba with a survey of the dragonfly fauna of the Lesser Sunda islands. *Verhandlungen der Naturforschenden Gesellschaft in Basel* 64 (1): 118–228.
- Lieftinck, M. A. 1953b. Competition in relation to distribution in some insects of the Western Pacific. *Proceedings of 7th Pacific Science Congress* 7 (4): 75–82.
- Lieftinck, M. A. 1959. Synonymic notes on Brauer's types of Odonata in the Hamburg Museum. *Entomologische Mitteilungen aus dem Zoologischen Staatsinstitut und Zoologischen Museum Hamburg* 21: 41–48.
- Lieftinck M. A., Lien, J. C. & Maa T. C. 1984. Catalogue of Taiwanese dragonflies (Insecta: Odonata). Asian Ecological Society, Taichung, Taiwan. pp 81.
- Marinov, M. 2021. A taxonomic and biogeographic discussion on *Rhyothemis regia* (Brauer, 1867) from Samoa and neighbouring islands with introduction of *Rhyothemis regia uveae* subsp. nov. (Odonata: Libellulidae). *Faunistic Studies in Southeast Asian and Pacific Island Odonata* 35: 1–33.
- Matsuki, K. & Lien, J. C. 1983. On a collection of the libellulid dragonflies of Taiwan. *Journal of the Kyusyu Entomological Society* 5: 1–53. (in Japanese)
- Matsuki, K. & Lien, J. C. 1989. Additional notes on the libellulid dragonflies of Taiwan. *Gracile* 40: 44–67, 12 maps. (in Japanese)
- Michalski, J. 2012. A manual for the identification of the dragonflies and damselflies of New Guinea, Maluku and the Solomon Islands. Kanduanum Books, New Jersey, USA. 561 pp.
- Needhan, J. G. 1930. A Manual of the Dragonflies of China. The Fan Memorial Institute of Biology, Peiping, China. 345 pp.
- Ott, J. 2010. Dragonflies and climatic change—a recent trends in Germany and Europe. *BioRisk* 5: 253–286.
- Ozono, A., Kawashima, I. & Futahashi, R. 2012. Dragonflies of Japan. Bunichi-Sogo Syuppan, Tokyo, Japan. 531 pp. (in Japanese)
- Ris, F. 1912. Libellulinen monographisch bearbeitet. 6. *Collections zoologiques du Baron Edm. de Selys Longchamps, Catalogue systematique et descriptif*. 14: 701–836.
- Ris, F. 1913. Libellulinen monographisch bearbeitet. 7. *Collections zoologiques du Baron Edm. de Selys Longchamps, Catalogue systematique et descriptif*. 15: 837–964.
- Sugimura, M., Ishida, S., Kojima, K., Ishida, K. & Aoki, T. 2001. Dragonflies of the Japanese Arch(e)ipelago in Color, English version. Hokkaido University Press, Sapporo. 641 pp.
- Tsuda, S. 2000. A distributional list of world Odonata. Private Publication. 430 pp.
- Yeh, W. C. 1996. New records of the Odonata taken in Taiwan. *Tombo* 39 (1–4): 26–28.
- Yeh, W. C., Chiou, H. I., Tang, H. C., Wu, J. H. & Chen, S. L. 2007. Three species of dragonflies newly recorded to Taiwan. *Endemic Species Research* 9 (2): 53–62.

臺灣產黑翅蜻蛉紀錄的修訂 — 新發現的藍黑蜻蛉雌蟲雌型翅斑（蜻蛉目：蜻蛉科）

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摘要: 臺灣產黑翅蜻蛉 (*Rhyothemis fuliginosa* Selys, 1883) 的身份經澄清為藍黑蜻蛉 (*R. regia regia* (Brauer, 1867)) 的雌型翅斑雌蟲。臺灣藍黑蜻蛉雌型翅斑雌蟲與黑翅蜻蛉雌蟲的差異為臉部顏色較淡，金屬光澤較弱，後唇基前緣內凹較深而明顯，且尾毛較粗。文中經由文獻回顧整理藍黑蜻蛉各亞種已被報導過的翅斑變化以供比較，並附圖說明臺灣藍黑蜻蛉雌蟲翅斑的連續性變異。文末亦說明由於氣候暖化，所導致的藍黑蜻蛉以及其他臺灣蜻蛉科物種分布範圍擴大的例子。

關鍵詞: 多型性的、亞種、氣候暖化、分布範圍擴大