A rapid survey of Odonata on Bokor Plateau, Preah Monivong National Park, Cambodia

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មូលន័យសង្ខេប

ខ្ពង់រាបភ្នំបូកគោ ដែលស្ថិតនៅតំបន់ឆ្នេរនៃប្រទេសកម្ពុជា ទ្រទ្រង់ល្បាយព្រៃពណ៌បៃតងពេញមួយឆ្នាំនៃតំបន់ដីទួលខ្ពស់ៗនិងតំបន់ដីសើម រាប់បញ្ចូលទាំងតំបន់ដីជាំដុះស្ពែ ដែលស្ថិតនៅរយៈកំពស់ប្រហែល១,០០០ម។ ទោះបីជាស្ថិតនៅក្នុងឧទ្យានជាតិព្រះមុនីវង្ស ក៏ដោយ ក៏ការកសាងរមណីយដ្ឋាននៅលើខ្ពង់រាបនាពេលថ្មីៗនេះបានបំផ្លាញតំបន់ដីសើមភាគច្រើនដែរ មុនពេលដែលជីវៈចម្រុះរបស់វាត្រូវបានសិក្សាពេញលេញ។ លទ្ធផលនៃការស្រាវជ្រាវខ្លីៗបីលើក មុនការបាត់បង់តំបន់ដីសើមនៅទីនោះត្រូវបានបង្ហាញនៅពេលនេះ។ ក្នុងរយៈពេល៦ថ្ងៃ កន្ទុំរុយ៤៥ប្រភេទត្រូវបានធ្វើកំណត់ត្រានៅលើខ្ពង់រាបភ្នំបូកគោ (1 Calopterygidae, 1 Euphaeidae, 2 Chlorocyphidae, 2 Lestidae, 11 Coenagrionidae, 1 Platycnemididae, 1 Protoneuridae, 1 Aeshnidae, 2 Corduliidae and 23 Libellulidae) ដែលរួមមានកន្ទុំរុយ១០ ប្រភេទរស់នៅតាមតំបន់ទឹកហូរ និង៣៥ប្រភេទទៀតរស់នៅតាមតំបន់ទឹកនឹង។ ក្នុងរយៈពេលដូចគ្នា មានតែកន្ទុំរុយបួនប្រភេទទេ គឺ *Aciagrion tillyardi, Idyonyx?thailandica, Lyriothemis elegantissima* and *Orthetrumum pruinosum neglectum* ដែលមិនត្រូវបានកត់ត្រានៅរយៈកំពស់ទាបជាង។ ប្រភេទ *Aciagron tillyardi* ទំនងជាបន្តពូជនៅក្នុងទីជម្រកតំបន់ដីជាំដុះស្ពែនៅលើខ្ពង់រាប ប៉ុន្តែគ្មានប្រភេទដែលពិតជារស់នៅទីនោះត្រូវបានប្រទះឃើញទេ។ កន្ទុំរុយមិនទាន់ពេញវ័យជាច្រើននៃប្រភេទ *Ceriagrion olivaceum, Neurothemis intermedia, Potamarcha congener* និង *Tholymis tillarga* ត្រូវបានប្រទះឃើញនៅលើតំបន់ខ្ពង់រាបនាខែធ្នូ និងប្រភេទ *Pantala flavescens* នាខែមេសា និងមួយចំនួនរហូតដល់ខែសីហា ដែលភាគច្រើនប្រហែលជាបានហើរមកពីរយៈកំពស់ទាបជាងដើម្បីស្វែងរកចំណី។ គ្មានប្រភេទកម្រ ឬប្រភេទដែលរស់នៅតែក្នុងតំបន់នេះត្រូវបានប្រទះឃើញទេ ប៉ុន្តែ នេះអាចបណ្តាលមកពីការសិក្សាមានរយៈពេលខ្លីពេក។

Abstract

Bokor Plateau, in the coastal area of Cambodia, supports a mixture of upper hill evergreen forest and wetlands, including *Sphagnum* peat-moss bogs, at approximately 1,000 m elevation. Despite being within Preah Monivong National Park, the recent construction of a resort on the plateau has destroyed most of its accessible wetlands before their biodiversity was fully investigated. The findings of three rapid surveys, which preceded the loss of the wetlands, are presented here. During six days in total, 45 species of Odonata (dragonflies and damselflies) were recorded on Bokor Plateau (1 Calopterygidae, 1 Euphaeidae, 2 Chlorocyphidae, 2 Lestidae, 11 Coenagrionidae, 1 Platycnemididae, 1 Protoneuridae,

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1 Aeshnidae, 2 Corduliidae and 23 Libellulidae), comprising 10 lotic and 35 lentic species. Only four species, *Aciagrion tillyardi, Idyonyx ?thailandica, Lyriothemis elegantissima* and *Orthetrumum pruinosum neglectum,* were not recorded at lower elevations during the same period. *Aciagron tillyardi* appeared to breed in peat-moss habitats on the plateau, but no obligate peat-moss species were found. Numerous non-breeding individuals of the common species *Ceriagrion olivaceum, Neurothemis intermedia, Potamarcha congener* and *Tholymis tillarga* were found on the plateau in December, and *Pantala flavescens* in April and to a lesser extent in August, most of which had probably dispersed from lower elevations to forage. No very rare or localised endemic species were detected, but this may be explained by the short survey period.

Keywords

Damselflies, dragonflies, Elephant Mountains, protected area, wetlands.

Introduction

Bokor Plateau is the south-easternmost part of the Cardamom Mountains region, within a range known as the Damrei or Elephant Mountains. The plateau reaches up to 1,081 m a.s.l. and, along its southwestern margin, sinks abruptly towards the sea, just 6 km away. It is a moist and foggy plateau throughout the year, clad in upper hill evergreen forest (Fig. 1). This has been described as "a distinctive dwarf forest 5–10 meters in height [...] on the acid and skeletal soils on the sandstone plateau... dominated by *Dacrydium elatum*, with another conifer, *Podocarpus (Dacrycarpus) imbricatus*, also commonly present. Other important associates in this dwarf forest are a variety of Fagaceae and Myrtaceae, *Vaccinium viscifolium*, and *Schima crenata*" (World Wildlife Fund, 2007).

Due to its relatively cool climate, Bokor served as a resort for French colonists and is famous for the ruins of impressive buildings which occupied the highest part of the plateau, called 'Bokor Hill Station' or the 'Station climatique du Bokor'. After the fall of the Khmer Rouge regime (one of the last resistance enclaves was on Bokor), this area attracted many tourists. Preah Monivong National Park was declared in 1993 to protect its unique environment, which harboured a rich flora and fauna, including tigers and elephants.

In 2008, however, the Sokimex Group was granted a lease to 'redevelop' Bokor Hill Station. The extensive construction work (Figs 2–4) aims to establish a resort comprising 3,000 houses plus a number of large buildings (Fig. 2), including a casino (Fig. 4). The first customers arrived in 2012. The construction work has already destroyed a large area of the low upland hill coppice, although a sufficient area of the coppice remains, if not to harbour large mammals then at least to accommodate plant and insect communities. According to the constructors' plans, however, no room is to be left for natural open areas and wetlands, represented by 'veals' (savannah-like areas on acidic sandy soil) and *Sphagnum* mires. Until recently, these open areas harboured *Nepenthes bokorensis* Mey, a carnivorous plant species endemic to the plateau (Mey, 2010), and maybe other unknown endemics. Given that one of the main purposes of a national park is to conserve biodiversity, it is disappointing that these small yet important habitats were allowed to be destroyed.

The wildlife of Cambodia was poorly investigated until recently. This was especially true for Odonata. When I first visited this country in 2006, only 53 species were definitely recorded for Cambodia, chiefly by Martin (1904) and Asahina (1967) (for a short overview see Kosterin, 2010, 2011). Of these, only three species were reported by Asahina (1967) for Bokor: *Aciagrion occidentale* Laidlaw, 1919 (probably a misidentified *A. borneense* Ris, 1911), *Ischnura senegalensis* (Rambur, 1842) and *Neurothemis intermedia* (Rambur, 1842). In recent years, Cambodian Odonata have been studied more actively (Kosterin & Vikhrev, 2006; Benstead, 2006; Roland & Roland, 2010; Kosterin, 2010, 2011, 2012; Roland *et al.*, 2011; Day, 2011; Kosterin & Holden, 2011) and the number of named species recorded in Cambodia has increased to 125.

I have made three trips to survey the Odonata of the Cardamom Mountains, in April 2010 (Kosterin, 2010), November-December 2011 (Kosterin, 2011) and August 2011 (Kosterin, 2012). On my first visit, I spent just two hours on Bokor Plateau, and on the second I spent three days and made a good examination of diverse habitats. On my third visit, for two days, I witnessed the best of the wetlands being destroyed (Figs 5–8). The data I collected during a total of six days on Bokor are therefore very incomplete, but worth presenting here. All in all, we have a sad situation when a unique nature monument is lost before it has been fully studied.

Methods

Odonata were surveyed on foot during the daytime on 23 April 2010, 8–10 December 2010 and 18–19 August

2011. The locations examined were along and close to the road from Bokor Palace through the pagoda to the Popokvil Waterfall. In previous reports (Kosterin, 2011, 2012), I ascribed names to some of the ponds and bogs, mostly after Odonata. Coordinates and elevations were retrieved from GoogleEarth.

1. Rangers' Pond: an artificial pond at the rangers' station, partly with stone banks and some grassy seepages nearby, from 10°37′33″N, 104°01′29″E to 10°37′34″N, 104°01′37″E, 1,030 m. Studied on 23 April 2010 and 9 December 2010.
2. Neglectum Brook: a small stream with brown water and a sandstone bed near the constructor's hostel, mostly hidden in coppice, with an open roadside section. 10°37′52″N, 104°01′21″E, 1,034 m. Studied on 23 April 2010 and 8–10 December 2010.
3. Old Road: a section of the original road, with some *Sphagnum* mats at roadside holes and small pools. 10°37′53″N, 104°01′18″E to 10°37′58″N, 104°01′26″E, 1,030–1,034 m. Studied on 8–10 December 2010.
4. Praemorsus Pond: a small, 2–metre deep and rather cold roadside pond with grassy banks, 2.9 km Northeast of Bokor Palace. 10°38′44″N, 104°02′21″E, 926 m. Studied on 9–10 December 2010. On 18 August 2011, the pond was still present, but its banks had been destroyed by extensive road improvements.
5. Minutissima Pit: very shallow pools over a sandy, bulldozered ground near Praemorsus Pond, with many flowering *Utricularia minutissima* Wahl. when visited, 2.9 km Northeast of Bokor Palace, 10°38′46″N, 104°02′24″E, 923 m. Studied on 18 August 2011.
6. Bokorensis Mire (Fig. 7): a large, 0.4 x 0.5 km, *Sphagnum* bog covered mostly with Cyperaceae, Juncaceae, Poaceae grasses, with very abundant club mosses, scattered shrubs, including *Vaccimium* spp., and numerous individuals of the pitcher plant *Nepenthes bokorensis*. Water levels range from 50 cm deep, with floating *Sphagnum* and submerged Juncaceae, through shallow pools with *Sphagnum*, to rather dry places with bracken. 3.0–3.7 km Northeast of Bokor Palace. 10°38′47″N, 104°02′11″E to 10°39′02″N, 104°02′24″E, 923 m. Studied on 9–10 December 2010 and 18–19 August 2011. In the latter two days, an excavator was seen digging a ditch to dry this bog out (Fig. 8).
7. Roadside pools, with open water and grassy banks, at Bokorensis Mire. From 10°38′52″N, 104°02′22″E to 10°39′02″N, 104°02′24″E, 923 m. Studied on 9 December 2010.
8. Odorata Road: an old sandy road through a veal between Bokorensis Mire and Limbata Ponds, seeping with shallow water. When visited, this site had many flowering *Utricularia odorata*. 3.6 km Northeast of Bokor Palace, 10°39′03″N, 104°02′14″E to 10°39′13″N, 104°02′26″E, 921–927 m. Studied on 18–19 August 2011.
9. Lyriothemis Pools: a chain of shallow "black" stagnant pools, connected via a tiny brook, in a rather tall forest at the Popokvil River right bank. 10°39′14″N, 104°02′15″E, 928 m. Studied on 18–19 August 2011.
10. Aciagrion Swamplet: a natural, knee-deep small swamp densely overgrown with a tussock sedge (*Carex* sp.) in the same forest near the Popokvil River bank. 10°39′17″N, 104°02′13″E, 922 m. Studied on 19 August 2011.
11. Idionyx Reach (Fig. 9): on the Popokvil River upstream of the upper bridge where there are several huts on the left bank, with a sandy bed and varying depth (from very low to about a knee-deep) and speed. The water here is dark red to black due to humic acids, and carries a thick, brownish foam. 3.6–3.9 km Northeast of Bokor Palace 10°39′12″N, 104°02′12″E to 10°39′19″N, 104°02′21″E, 925–932 m. Studied on 19 August 2011.
12. Limbata Ponds (Fig. 5): two large, but shallow (to 0.5 m) ponds, with sparse emerging grass (mostly large Cyperaceae), formed by a small brook flowing to the nearby Popokvil River near the upper bridge. 3.7 km Northeast of Bokor Palace. 10°39′04″N, 104°02′35″E, to 10°39′06″N, 104°02′39″E, 920m. Studied on 10 December 2010. On 18–19 August 2011, I witnessed heavy goods vehicles discharging soil over the ponds (Fig. 6).
13. The Popokvil River at an open area by the upper bridge, 3.9 km Northeast of Bokor Palace. 10°39′06″N, 104°02′43″E, 920 m. Studied on 18–19 August 2011.
14. The Popokvil River between the two bridges, adjacent to wide new roads through the forests, in some places seeping with water, and with an open area covered in bracken at the lower bridge. 3.9–4.9 km Northeast of Bokor Palace, 10°39′06″N, 104°02′43″E to 10°39′30″N, 104°03′09″E, 916–926 m. Studied on 18–19 August 2011.
15. The Popokvil River between the lower bridge and the waterfall (Fig. 10): powerful rapids above a rocky bed with low trees on the banks and in the water, and a slow side tributary with stony bed. 4.9 km Northeast of Bokor Palace. 10°39′30″N, 104°03′04″E to 10°39′30″N, 104°03′06″E, 912–918 m. Studied on 9 December 2010 and 18–19 August 2011. By August 2011, the foundation of a large building had been constructed just above the waterfall.
16. The Popokvil River downstream of the waterfall: a broad rocky valley descending through the tall primary forest at quite an angle. 4.9 km Northeast of Bokor Palace. 10°39′32″N, 104°03′04″E, to 10°39′34″N, 104°03′04″E, 912–918 m. Studied on 9 December 2010.

Photos of Odonata in their natural environments were taken with an Olympus Camedia C8080 digital camera, without restricting the individual's freedom or making any attempts to otherwise influence their behaviour.

Results

In the following text, 'April', 'December' and 'August' denote 23 April 2010, 8–10 December 2010 and 18–19 August 2011, respectively. Species marked as being 'on dispersal' were non-breeding individuals in December that were not associated with water bodies. It is possible that some of the other species observed on the plateau were also in their dispersal phase and do not breed here.

Calopterygidae

1. *Vestalis gracilis* (Rambur, 1842)

Common around bushes and low tree branches on the banks of the Popokvil River, plus three individuals were

Fig. 1 Upper hill evergreen forest at Bokor Hill Station, still relatively undisturbed on 8 December 2010 (© O. Kosterin).

Fig. 2 Model of the town under construction on Bokor Plateau, in a new pavilion near the pagoda (© O. Kosterin).

Fig. 3 Construction on the Bokor Plateau. 'Improvement' of a road to the Popokvil Waterfalls (© O. Kosterin).

Fig. 4 The new casino under construction, on 18 August 2011 (© O. Kosterin).

Fig. 5 Limbata Ponds, still intact on 10 December 2010 (© O. Kosterin).

Fig. 6 Limbata Ponds being filled in with soil on 18 August 2011 (© O. Kosterin).

Fig. 7 Bokorensis Mire, a large *Sphagnum* bog, still intact on 9 December 2010 (© O. Kosterin).

Fig. 8 Bokorensis Mire being drained on 18 August 2011 (note white flowers of an *Arundina* orchid) (© O. Kosterin).

Fig. 9 The Popokvil River: showing the Idionyx Reach on 19 August 2011 (© O. Kosterin).

Fig. 10 The Popokvil River: showing the rapids above the waterfall on 19 August 2011 (© O. Kosterin).

Fig. 11 The Popokvil Waterfall on 19 August 2011 (© O. Kosterin).

Fig. 12 A teneral female *Vestalis gracilis* at the rapids above the Popokvil Waterfall, 18 August 2011 (© O. Kosterin).

Fig. 13 A perching male of *Lestes praemorsus decipiens* at Praemorsus Pond, 9 December 2010 (© O. Kosterin).

Fig. 14 A copula of *Aciagrion tillyardi* at Aciagrion Swamplet, 19 August 2011 (© O. Kosterin).

found at Neglectum Brook in April, but not in December and August. Individuals congregate, with up to several tens on a bank. In August they were immature with clear wings, two teneral individuals (Fig. 12) being encountered. In April they were mature, with the wingtips having a dark brown enfumation.

Euphaeidae

2. *Euphaea masoni* Selys, 1879

Found just upstream (two males, one female, 19 August 2011) and downstream (one male, 9 December 2010) of the Popokvil Waterfall. These individuals were slightly larger than those found at low elevations in Koh Kong Province (Kosterin, 2011). The male collected downstream of the waterfall was an aberration with clear wings without wingspots, but with slight, diffuse and uneven shades of dark pigmentation (Fig. 69 in Kosterin, 2011).

Chlorocyphidae

3. *Aristocyhpa fenestrella* (Rambur, 1842)

Several males perched on rocks around pools of the Popokvil River, downstream of the waterfall on 9 December 2010.

4. *Heliocypha biforata biforata* (Selys, 1859)

One male found at the same location as above, but on bushy vegetation, as expected for this species. Unexpectedly, a teneral male was found at the Lyriothemis Pools in forest shade, obviously having dispersed from a nearby calm section of the Popokvil River. Even more unexpected was a female of the Chlorocyphidae family in grass at the walls of the Bokor Palace, a place unfit for representatives of this family, on 8 December 2010.

Lestidae

5. *Lestes concinnus* Hagen in Selys, 1862

In December, this species was common in sedges in small roadside bogs in open areas at Bokor Hill Station (five individuals observed on 8 December 2010) and Bokorensis Mire (11 individuals observed during two hours of walking on 9–10 December 2010), not recorded in August.

6. *Lestes praemorsus decipiens* Kirby, 1893 (Fig. 8)

In December, males were present around the Praemorsus Pond and Limbata Ponds (several individuals observed at each), where they perched on emerging vegetation. In August they were recorded at shallow, slightly disturbed water bodies such as Minutissima Pit. Three teneral males were found at Limbata Ponds on 10 December 2010 and a teneral female at the Popokvil River near the upper bridge on 18 August 2011.

Coenagrionidae

7. *Aciagrion borneense* Ris, 1911

(Asahina, 1967, as *Aciagrion occidentale* Laidlaw, 1919: 1 male, Bokor, 2.XII.1964). Common in December, occurring mostly among coppices during dispersal, but also recorded in sedges on the banks of Praemorsus Pond and at pools of Bokorensis Mire, which might serve as breeding places. Only one female recorded on Odorata Road in August (18 August 2011).

8. *Aciagrion tillyardi* Laidlaw, 1919 (Fig. 14)

In December, very numerous at the Praemorsus Pond and Limbata Ponds (three males were observed at the former on 18 August, even though it had already been destroyed), and on the shaded banks of the Popokvil River upstream of the waterfall. However, no individuals were found on the banks of the main river. In August this species was even more numerous, extending to any stagnant water bodies, both moderately disturbed (e.g. Minutissima Pit and Odorata Road), and undisturbed (e.g. Aciagrion Swamplet). Copulae and tandems were observed at Praemorsus Pond in December and Aciagrion Swamp in August. A teneral male made its maiden flight from a roadside hole filled with wet *Sphagnum* at Old Road on 8 December 2011. Teneral males and females were found at an open place with boulders and bracken just upstream of the Popokvil Waterfall.

The ground colour of mature individuals was saturated blue to greenish blue. This corresponds to information on specimens from Assam, where the species was described (see discussion in Kosterin, 2012) – not violet, as in Hong Kong (Wilson, 2000) or North Thailand (Dennis Farrell, pers. comm.).

9. *Agriocnemis nana* (Laidlaw, 1914)

An immature (red stage) female recorded at Odorata Road on 18 August 2011.

10. *Agriocnemis pygmaea* (Rambur, 1842)

Common in grass near Rangers' Pond in December. Present, but unexpectedly scarce, in pools of Bokorensis Mire.

11. *Archibasis viola* Lieftink, 1948

A shade-preferring species. On 18–19 August 2011, a mature male hovered above the running water of a shady Idionyx Reach (a typical habitat for this species), one found flying above Lyriothemis Pools in forest shade, and one at Aciagrion Swamplet. A teneral male found in unexpected habitat, at a small pool at Bokorensis Mire on 9 December 2010.

12. *Ceriagrion calamineum* Lieftink, 1951

Scarce mature males were found in breeding places in Bokorensis Mire (one on 9 December 2010) and Limbata Ponds (three on 10 December 2010). None found in August.

13. *Ceriagrion cerinorubellum* (Brauer, 1865)

A male found at a tiny brook at the ranger's station on 23 April 2010, at Minutissima Pit on 18 August 2011, and five teneral individuals on Bokorensis Mire were disturbed during two hours of walking on 9–10 December 2010.

14. *Ceriagrion olivaceum* Laidlaw, 1914

On dispersal. Very numerous individuals of both sexes, showing no interest in water bodies or each other, were observed in December in all open places, whether dry or wet (but seemed less frequent on Bokorensis Mire). These individuals had probably migrated from lower elevations beneath the plateau escarpment.

15. *Ischnura senegalensis* (Rambur, 1842)

(Asahina, 1967: 1 male, Bokor, 4.XII.1964). Common at the Rangers' Pond. In December, this was the only odonate at the black pools where brooks had been crossed by new roads, and also at Neglectum Brook. Present in roadside pools at Bokorensis Mire, and plentiful at the Limbata Ponds.

16. *Pseudagrion australasiae* Selys, 1876

In December, males perched on emergent vegetation at Praemorsus Pond (only one male observed) and Limbata Ponds (many), and one was recorded at a roadside pool in Bokorensis Mire. A few males and tandems were found perching on sticks emerging from water of the Popokvil River (open reach at the upper bridge), both in December and August.

17. *Pseudagrion pruinosum* (Burmeister, 1839)

Males and tandems were common above the water of the Popokvil River – frequent along open reaches and infrequent in shaded ones – but only in August. This species was more abundant than other *Pseudagrion* spp. in August, but scarce in December: the same pattern was also observed at lower elevations in Koh Kong Province.

Platycnemididae

18. *Copera vittata* (Selys, 1863)

Found in its typical habitat at small black pools in the shade of coppices (a female on 9 December 2010 at the brook forming Praemorsus Pond) or forest (tandems, males and immature 'ghost forms' at the Lyriothemis Pools on 18–19 August 2011), at the Popokvil River above the waterfall (a male and immature individual, 18 August 2011) and on shady moist cliffs downstream ('ghost' immature, 9 December 2010).

Protoneuridae

19. *Prodasineura autumnalis* (Fraser, 1922)

A male observed hovering over the water of Popokvil River between the bridges, a typical habitat for this species, on 19 August 2011.

Aeshnidae

20. *Anax guttatus* (Burmeister, 1839)

Ranging males were observed over Rangers' Pond (23 April 2010), above Odorata Road (18 August 2010) and above the road between the bridges at the Popokvil River (19 August 2011). A female oviposited into winding submerged vegetation (Fig. 15) in the shallow open reach of this river at the upper bridge.

From neighbouring Thailand, two similar species of *Anax* have been recorded (Yeh, 1999), *A. indicus* Lieftink, 1942 and *A. panybeus* Hagen, 1867. The males observed in Bokor were not examined, but the above-mentioned female was examined in the hand and its key characters can also be seen in Fig. 15. Unlike *A. panybeus,* its has no black T-shaped spot or any other black mark on the frons. Unlike *A. indicus*, the lateral light spots on abdominal segments were small and not fused into lateral bands on segments 6–8 (but the author of the latter species, Lieftink, 1942, reported this character only for males). In Thailand, A. *indicus* is restricted to the North (Yeh, 1999; Day *et al*., 2011), so it is not expected to occur in southern Cambodia.

Corduliidae *sensu lato*

21. *Idionyx ?thailandica* (Hämäläinen, 1985) (Fig. 16)

A teneral female commenced its maiden flight from a shaded bank of Idionyx Reach of the Popokvil River on 19 August 2011, and landed on the leaves of bushes and palm fronds. Females in this genus, which is rich in similar species, allow for only tentative identification, but I collected a male of *I. ?thailandica* in a jungle brook in Kep, 33 km East-Southeast from Bokor.

22. *Hemicordulia* sp.

This undescribed Indochinese species is very close to *Hemicordulia tenera* Lieftink, 1930, and has also been found in the Loei and Chiang Mai Provinces of Thailand (Kosterin, 2011, 2012). It is to be described elsewhere.

Two males were observed on 19 August 2011 patrolling half-shaded reaches (including Idionyx Reach, Fig.

Fig. 15 Female *Anax guttatus* laying eggs in submerged vegetation in the Popokvil River, 19 August 2011 (© O. Kosterin).

Fig. 16 Teneral female *Idionyx ?thailandica* on a bank on the Idionyx Reach, 19 August 2011 (© O. Kosterin).

Fig. 17 Perching male *Lyriothemis elegantissima* at Aciagrion Swamplet, 19 August 2011 (© O. Kosterin).

Fig. 18 Female *Neurothemis fulvia* on a road by the Popokvil River, 19 August 2011 (© O. Kosterin).

9) with slow to moderate currents, and sandy beds of the Popokvil River from 1000h. At 1300h – 1320h on 18 August 2011, during overcast weather between rains, about five patrolling males appeared over the shallowest pools with sandy bottoms and over the water flowing over the Odorata Road crossing a large veal, with a sedgy small brook nearly. This looked like some unusual outburst, for they were absent from this point both before, during 1150h – 1210h, and after 1530h, as well as on the next day at 0848h, 1100h and 1530h, in spite of the weather varying from short sun through overcast to drizzling rain.

At 1020h on 19 August 2011, a patrolling male appeared above Lyriothemis Swamplet, which was filled with a tussock sedge that left no open water. In Decem-

Fig. 19 Male *Orthetrum pruinosum neglectum* at Neglectum Brook, 8 December 2010 (© O. Kosterin).

ber, there was just one sighting of this species flying for a while above the Praemorsus Pond (9 December 2010).

Libellulidae

23. *Brachythemis contaminata* (Fabricius, 1793)

In December, several individuals were found at roadside pools in Bokorensis Mire, many at the Limbata Ponds nearby, and one at the open reach of the Popokvil River by the lower bridge.

24. *Crocothemis servilia* (Drury, 1770)

One territorial male of this common species was observed at Rangers' Pond on 23 April 2010 and one at the Limbata Ponds on 18 August 2011.

25. *Diplacodes nebulosa* (Fabricius, 1793)

A male and female were found in grassy seepages at Rangers' Pond in April. This species was common in Bokorensis Mire and occurred at the Limbata Ponds in December.

26. *Diplacodes trivialis* (Rambur, 1842)

Common at open places in coppice, tending to rocks, in December, probably on dispersal. This species also occurred in wetlands, e.g. Bokorensis Mire and Limbata Ponds, where it could probably breed.

27. *Indothemis limbata* (Selys, 1891)

About 10 reproductive males were perched on emergent vegetation at Limbata Ponds on 10 December 2010, and moved to surrounding grass when disturbed. Two females were observed nearby.

28. *Lyriothemis elegantissima* Selys, 1883 (Fig. 17)

Found in August in small forest pools and tiny brooks with black water and a bed of leaf litter (a typical habitat of the species) at Lyriothemis Pools and Aciagrion Swamp. At both sites, two males were observed perching on bush branches at 2–3 m above the ground or flying above the pools and chasing each other. At the former site, a female was seen ovipositing into mud at the edge of a pool.

29. *Nannophya pygmaea* Rambur, 1842

This species is more or less connected with grassy bogs. One male was found in grass at the Limbata Ponds on 10 December 2010. In August this species was common around shallow waters in open areas, e.g. Minutissima Pit and Odorata Road.

30. *Neurothemis fluctuans* (Fabricius, 1793)

Surprisingly few individuals of this elsewhere very common species were found. One male was recorded at Neglectum Brook on 23 April 2010 and one at Minutissima Pit on 18 August 2011.

31. *Neurothemis fulvia* (Drury, 1773) (Fig. 18)

Only one female (of this usually common species) was recorded on a roadside between the bridges across the Popokvil River.

32. *Neurothemis intermedia atalanta* Ris, 1919

(Asahina, 1967, as *N. intermedia degeneer* Selys (?): 1 female, Bokor, 2.XII.1964). On dispersal. Numerous immature (males still yellowish) individuals were observed in coppices in December.

33. *Neurothemis tullia tullia* (Drury, 1773)

Several individuals recorded at grassy seepages at Rangers' Pond, together with *D. nebulosa* (these species often occur together).

34. *Orthetrum chrysis* (Selys, 1891)

In December, several males kept to the open Popokvil River reach at the upper bridge. On 10 December 2010, an ovipositing female, guarded by a male, was observed. A male was seen at engraved sandstone rocks at Neglectum Brook on 23 April 2010 (but not in December or August), and another at the forest edge at Lyriothemis Pools.

35. *Orthetrum glaucum* (Brauer, 1865)

Two matching males patrolled along, and perched on stones near, a tiny temporary brook in a ditch along the newly widened road by Praemorsus Pond. Small streams are the typical habitat of this species, but this was among the smallest ones.

36. *Orthetrum pruinosum neglectum* (Rambur, 1842) (Fig. 19)

This species occurred and bred in the same locations as *O. chrysis,* but was less abundant. A male was recorded on the small Neglectum Brook on 8 December 2010, where one *O. chrysis* was also recorded. Another male, which captured a female into copula, was observed on 9 December 2010 on the Popokvil River at the upper bridge.

37. *Orthetrum sabina* (Drury, 1770)

Elsewhere this is a common species, but only a few individuals were encountered in August. Most were away from water, but this species was also observed in the Limbata Ponds site.

38. *Pantala flavescens* (Fabricius, 1798)

Large swarms containing several dozens of individuals were observed at the lee sides of French Ruins on 23 April 2010. Small swarms of young, light-coloured indi-

viduals were recorded here and there in August, but only a few individuals were registered above the Popokvil River (plus one dead female in a pool at Rangers' Pond) during three observation days in December (although the species was extremely abundant near sea level in Kep at this time). These individuals may have been on dispersal, or may breed in the many shallow pools on the plateau.

39. *Potamarcha congener* (Rambur, 1842)

On dispersal. Recorded only in December when numerous immature individuals (mostly females), indifferent to water, perched on bush branches behind the wind. At least one in view from almost every point in the coppices.

40. *Rhyothemis variegata* (Linnaeus, 1763)

One gynochromic female joined a large swarm of *Pantala flavescens* on 23 April 2010.

41. *Tholymis tillarga* (Fabricius, 1798)

On dispersal. Observed only in December, but in abundance, represented mostly (seemingly excusively) by females, which occurred everywhere at openings in the coppice. They were often observed flying even in daytime (e.g. above the Praemorsus Pond), even though the species is mostly crepuscular and more active in the evening. Not found in April and August.

42. *Tramea transmarina euryale* Selys, 1878

A male ranged over the road to Popokvil Waterfall on 9 December 2010.

43. *Trithemis aurora* (Burmeister, 1839)

Common at Rangers' Pond in April, and the Limbata Ponds and open reaches of the Popokvil River. In August, this species was also seen at Minutissima Pit and other shallow pools.

44. *Trithemis festiva* (Rambur, 1842)

Several males perched on stones at the Popokvil River at the upper bridge in December, and one was recorded here in August.

45. *Trithemis pallidinervis* (Kirby, 1889)

Recorded at Rangers' Pond (23 April 2010) and Limbata Ponds (10 December 2010), with one perching male at each.

In addition, there was an uncertain sighting of a gomphid at Neglectum Brook on 23 April 2010 and of a libellulid, most probably *Macrodiplax cora* (Brauer, 1867), at the Limbata Ponds on 10 December 2010. While ascending the Plateau on 8 December 2010 under the canopy on the tall forest on its southwestern slope, I recorded many individuals of *Lestes elatus* Hagen in Selys, 1862 and an individual of *Gynacantha* sp. They were not included into the main list because they represented a very briefly visited biotope that was quite different from top surface of the plateau.

Discussion

No doubt the list of 45 species is incomplete, and at least twice as many species would be expected on the Bokor Plateau in its natural state. However, Bokor Hill Station has now lost its veals and unique wetlands. This paper therefore summarises the scanty data I managed to collect shortly before the best natural habitats were lost.

In the future, the Popokvil River may retain some interesting lotic species, but will inevitably be polluted by the town being constructed there. The developers plan to make large artificial ponds in the town, which will support a handful of common and widespread lentic species (as the pond at the rangers' station already does). The Bokor Plateau is large and still hides interesting habitats, although none of them as easily accessible as Bokor Hill Station. They are worth being investigated.

Although the upper hill evergreen low forest of the Bokor Plateau is very distinct from the lowland tall forest in many respects, including its short height, low density and tree species composition, the overwhelming majority of Odonata species on Bokor appeared unexpectedly common. For instance, Libellulidae comprised almost half (22) of the species list. The list contains one undescribed species of *Hemicordulia* which, however, enjoys quite a substantial range in Thailand and Cambodia (Kosterin, 2011). It is noteworthy that only four of the species recorded on Bokor have not been found during similar times of year below 300 m a.s.l. in Koh Kong Province (Kosterin, 2010, 2011, 2012): *Aciagrion tillyardi, Idionyx ?thailandica, Lyriothemis elegantissima* and *Orthetrumum pruinosum*. Of these, however, *I. thailandica* was found at c. 100m a.s.l. in Kep, Kep Province (Kosterin, 2012), and *O. pruinosum* is quite common at low elevations in Thailand (Hämäläinen & Pinratana, 1999). The range of *Aciagrion tillyardi* extends to Assam, continental Thailand and South China (Guanxi, Guandong, Hong Kong) (Wilson, 2000), and *L. elegantissima* ranges through South China (including Taiwan) and has been found on one occasion in Central Thailand (Hämäläinen & Pinratana, 1999; Tsuda, 2000). The last two species may be supposed to be somewhat more 'northern' than the rest of the list, and hence have been found in Cambodia only on an elevated and cool plateau.

In spite of the presence of many small streams and the large Popokvil River, of 42 species recorded, only 10

species may be considered as obligatory lotic, namely *Vestalis gracilis, Euphaea masoni, Aristocyhpa fenestrella, Heliocypha biforata, Archibasis viola, Pseudagrion pruinosum, Prodasineura autumnalis, Idionyx ?thailandica, Hemicordulia* sp. and *Orthetrum glaucum*. Lentic species are generally more numerous and widespread than lotic species. The lack of representatives of the very diverse and mostly lotic family Gomphidae, except for one unidentified sighting, was disappointing. I expected to find some Odonata species specialised on *Sphagnum* peat-moss bogs, which were a remarkable feature of Bokor Plateau. So far, only *Aciagrion tillyardi* may be roughly considered as a peat-moss species. Although common in most lentic water bodies in the plateau, it was recorded emerging from a small, almost waterless pool covered with *Sphagnum*. This species has not been registered from elsewhere in Cambodia. In Hong Kong, it has also been found in "a hilly wet marsh area" and is said to accompany *Nannophya pygmaea* in Guangxi, Guandong and Hong Kong (Wilson, 2000), as is the situation on Bokor Plateau. In Koh Kong Province, *N. pygmaea* was observed on grassy swampy areas, but also extended to small, clear rivulets on the edges of forest (Kosterin, 2011, 2012).

It was interesting to observe that Bokor Plateau accumulates amazingly numerous individuals of certain common lowland species, such as *Ceriagrion olivaceum, Potamarcha congener* and *Tholymis tillarga* in December and *Pantala flavescens* in April and August (but not in December, when it was numerous at low elevations along with the aforementioned three species). It is likely that these dragonflies, with the possible exception of *P. flavescens*, breed at lower elevations, probably beneath the southern cliffs of Bokor Plateau where suitable lentic breeding places are abundant (but the breeding habitat of *C. olivaceum* is unknown: for discussion see Kosterin, 2011). Hence, they appear to have vertical seasonal migrations.

The rather unique peat-moss bogs occupy a restricted area on the Bokor Plateau and appear isolated from analogous communities elsewhere, being surrounded by upper hill evergreen forest. It is therefore surprising that the survey found common species here, rather than localised species with small or disjunctive ranges. No doubt this mismatch is a bias of too brief a survey, and the most interesting species that should exist in such habitats remain to be revealed. Localised and disjunctive species in such families as the Platystictidae, Gomphidae, Chlorogomphidae and Corduliidae tend to be seasonal, rare and elusive. Seasonal changes are scarcely expressed on the plateau, while the misty weather is generally unfavourable round the year for adult odonates to be active. This makes it impossible to predict where or when putative species of the aforementioned families, if any, would be found. To fully survey the Odonata of Bokor Plateau is therefore a difficult task that demands a lot of time. Unfortunately, construction work on the plateau means that time has now run out.

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