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Odonata of the Romanian Carpathians with notes on *Somatochlora alpestris* and on the first Romanian record of *Aeshna subarctica* (Odonata: Corduliidae, Aeshnidae)

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Abstract

The Odonata fauna of the Romanian Carpathians was investigated during a summer expedition from 18-vii- to 14-viii-2009. The work was mostly focused on boreo-alpine species. It is demonstrated that *Somatochlora alpestris* is present in all parts of the Romanian Carpathians. *Aeshna subarctica* has been detected in Romania for the first time. The corresponding record represents the first known occurrence of this species in a rather large area. *Aeshna juncea* is much more widespread in the region than has been known before. *Aeshna cyanea* is present and abundant in forested areas. *Sympetrum danae* has been recorded for the first time in the Romanian western Carpathians.

Zusammenfassung

Libellen der rumänischen Karpaten mit Anmerkungen zu *Somatochlora alpestris* und dem Erstnachweis von *Aeshna subarctica* in Rumänien (Odonata: Aeshnidae, Corduliidae) – Während einer vierwöchigen Expedition zwischen dem 18. Juli und dem 14. August 2009 wurde die Libellenfauna der rumänischen Karpaten untersucht. Der Schwerpunkt lag auf der Erfassung boreo-alpiner Arten. Daher wurden vor allem potentielle Habitate in der subalpinen rund alpinen Höhenstufe aufgesucht. *Somatochlora alpestris* konnte in allen Teilen der rumänischen Karpaten nachgewiesen werden. *Aeshna subarctica* wurde erstmalig in Rumänien nachgewiesen. Dieser Fund stellt darüberhinaus das bislang einzig bekannte Vorkommen dieser Art in einem größerem Umkreis dar. *Aeshna juncea* ist in der Region offenbar deutlich weiter verbreitet als zuvor bekannt. In bewaldeten Gebieten ist *Aeshna cyanea* stets anzutreffen und häufig. *Sympetrum danae* wurde erstmalig in den rumänischen Westkarpaten nachgewiesen.

Introduction

The Carpathian Mountains are well known for their importance in the conservation of Europe's large mammals (Baltzer et al. 2009). The role of the conservation of invertebrate biodiversity might be comparably pivotal. But corresponding research has been neglected hitherto and the knowledge concerning the species inventories of invertebrates is still very sketchy (Gurung et al. 2009). This also applies to Odonata as became evident during collaborative fieldwork performed in the south-western Carpathians in 2007 (Manci & Kalkman 2008). During this campaign, the knowledge about the occurrences and ranges of boreo-alpine species of the Carpathians particularly turned out to be very incomplete. However, subsequent fieldwork immmediately yielded important contributions to the knowledge of *Somatochlora alpestris* and of *S. arctica* in Romania (de Knijf et al. 2011). This research, however, was restricted to the southern Carpathians, west of the River Olt. In order to elucidate the distributions of boreo-alpine species in much larger parts of the Romanian Carpathians, a dedicated expedition was organized in 2009. The objective was to achieve the broadest possible geographic coverage.

Methods

Abbreviations
L.: "Lac" or "Lacul" – Romanian for lake or small lake; loc., locs.: locality, localities; Mţii.: "Munţii" – Romanian for mountains; P.: "Pasul" – Romanian for pass; R.: "Râul" – Romanian for river; Vf.: "Vârful" – Romanian for peak.
Visited counties of Romania:
AB Alba; AG Argeş; AR Arad; BH Bihor; BN Bistriţa-Năsăaud; BV Braşov; HD Hunedoara; HR Harghita; MM Maramureş; SB Sibiu.

The expedition started on 18-vii-2009 in the north-westernmost part of the Romanian Carpathians, in the Mţii. Gutiului (Statiunea Izvoare). Subsequently, and in chronological order, the Mţii. Rodnei, the Mţii. Căliman, the Mţii. Hasmas, the Mţii. Harghita, the Mţii. Bucegi, the Piatra Craiului, the Făgăraş, the Mţii. Cindrel, the Mţii. Lotrolui, the Mţii. Parâng, the Mţii. Bihor, and the Mţii. Apuseni were visited. The last records were collected on 14-viii-2009.

Beforehand, promising sites were localised on available tourist maps. A closer inspection was then performed using freely available satellite images. Specifically, bogs and fens at the montane, subalpine, and alpine levels were localised. Potential habitats close to the timberline received special attention. In the field, coordinates were obtained by GPS and have been referenced to WGS 84 ellipsoid, Potsdam datum. GPS generated altitudinal data tended to be imprecise, especially in forested areas. Where there was doubt, altitudes were read from local maps.

On site, a search was made for Odonates and – where possible – these were identified with binoculars. Critical species were netted and have been identified according to Dijkstra & Lewington (2006).

When no observation of imagines could be achieved at promising sites within 20 to 30 min, the waterbodies were intensely searched for larvae using a colander. In case of poor flying conditions, the respective sites were inspected for larvae immediately. In order to reduce detrimental effects, the search for larvae was stopped on the first finding. This was done as a minimum at places where there was poor species diversity expected. This particularly applied to potential habitats of *Somatochlora alpestris* and of *S. arctica*. Consequently, only one larva has been collected from corresponding locations. Larvae were killed in boiling water and preserved in 70 % ethanol. Determination of larval species was performed according to Heidemann & Seidenbusch (1993) and specifically for *Somatochlora* larvae according to Wildermuth (2008) and to Schmidt (1951).

Results

Altogether 17 species of Odonata were recorded at 48 localities in the Romanian Carpathians.

List of visited localities with Odonata records

1. Pond N Corbi (AG); 45°21’47’’N; 24°48’24’’E; 670 m above sea level (a.s.l.). Shallow and shaded pond in a garden. Overgrown with *Typha* sp. Surrounded by coniferous forest.
2. L. Muntinu (SB); 45°22’01’’N; 23°39’11’’E; 2,000 m a.s.l. Large, obviously shallow cirque lake. Surrounded by fen pools and alpine pasture. Well above the timberline (Fig. 5).
3. Fen N L. Muntinu (SB); 45°22’03’’N; 23°39’12’’E; 1,980 m a.s.l. Fen fed by creeks leaving L. Muntinu (loc. 2). Densely vegetated with sedges. Few very small pools, virtually no open water during time of inspection.
4. Pond N P. Urdele (SB); 45°23’28’’N; 23°38’32’’E; 1,700 m a.s.l. Artificial pool next to gravel road. Located at the treeline. Densely vegetated with helophytes (*Equisetum* sp.). Boggy littoral zone with some peat moss.
5. Valea Rea (AG); 45°29’51’’N; 34°31’39’’E; 930 m a.s.l. Meadow near creek. Surrounded by deciduous forest.
6. Valea Rea (AG); 45°30’24’’N; 24°51’15’’E; 980 m a.s.l. Meadow surrounded by coniferous forest.
7. Cheile Pisicii SW Zărnesti (BV); 45°32’00’’N; 25°16’01’’E; 1,050 m a.s.l. Clearing in a limestone canyon. Deciduous forest.
8. Valea Rea (AG); 45°32’02’’N; 24°50’42’’E; 1,030 m a.s.l. Sunny spots in a narrow valley. Mixed forest.

9. Transfăgăraş road (AR); 45°32’02’’N; 24°35’21’’E; 1,100 m a.s.l. Lawn and hedges near the road.
10. Valea Rea (AG); 45°32’06’’N; 34°50’05’’E; 1,050 m a.s.l. Clearing in mixed forest.
11. Valea Rea (AG); 45°32’28’’N; 24°47’39’’E; 1,200 m a.s.l. Helocrene. Densely vegetated with sedges, *Juncus* sp., and some peat moss. Some shallow and very small pools.
12. L. Oaşa Mică (SB, AB); 45°33’10’’N; 23°37’33’’E; 1,270 m a.s.l. Sedge swamps in a tributary to the Oaşa Mică reservoir lake. Several densely vegetated pools. Lotic conditions in the middle of the pools. Several *Salix* sp. shrubs. Surrounded by coniferous forest.
13. Valea Doamnei (SB); 45°36’12’’N; 24°36’24’’E; 2,080 m a.s.l. Pool in the fens on the N slope of the Făgăraş main ridge. Location resembled a very small raised bog although peat moss was absent. Densely vegetated. Surrounded by alpine pasture and meadows. Well above the local timberline and no trees within several kilometers distance.
14. Valea Dobrani SW of Avram Iancu (AB); 46°21’12’’N; 22°46’44’’E; 1,080 m a.s.l. Helocrene spring in a clearing next to the forest road. Densely vegetated by *Juncus* sp. and moss. Numerous small pools. Environment deciduous forest.
15. Valea Divaia NW Munţele Rotund (AB, AR); 46°22’08’’N; 22°42’03’’E; 1,260 m a.s.l. Group of pools formed by a creek. Environment juniper heath, pasture, and coniferous forest.
16. Pool SW Cucurbăta Mare (AB, BH); 46°26’12’’N; 22°40’30’’E; 1,550 m a.s.l. Muddy watering place without any vegetation. Surrounded by coniferous forest, subalpine pasture, and juniper.
17. Vf. Harghita Mădăraş (HR); 46°26’38’’N; 25°35’25’’E; 1,640 m a.s.l. Shallow pools in the fens SE of Vf. Harghita Mădăraş. Environment pasture, juniper heath, and coniferous forest. Located close to the local timberline.
18. Watering place N Cucurbăta Mare (AB, BH); 46°27’28’’N; 22°41’13’’E; 1,640 m a.s.l. Shallow small lake near rough road. Densely vegetated. Environment subalpine pasture and juniper heath.
19. Vf. Fertău (HR); 46°30’37’’N; 25°35’01’’E; 1,450 m a.s.l. Fen area within the pastures on the S slope of Vf. Fertău. Fed by several helocrenes. Numerous small pools which possibly had been created by cattle and sheep. Coniferous forest in close distance.
20. Preluca Neşului, Forest E Câmpani (BH); 46°30’44’’N; 22°36’26’’E; 920 m.
21. Preluca Neşului, Forest E Câmpani (BH); 46°30’50’’N; 22°35’56’’E; 1,015 m a.s.l. Clearing in beech and maple forest. Some spots of juniper heath in closer distance. Springs nearby but dry during visit.
22. Arieşul Mare creek at P. Vârtop (AR, AB); 46°30‘58‘‘N; 22°40‘41‘‘E; 1,150 m a.s.l. Small oxbows and pools in the floodplain of R. Arieşul Mare. Environment coniferous forest and swampy meadows.

23. Culmea Gândacilor (HR); 46°32‘35‘‘N; 25°34‘15‘‘E; 1,140 m a.s.l. Shallow, temporary pool beneath forest road. Without any vegetation. Surrounded by dense coniferous forest.
24. Şicasău creek NE Liban (HR); 46°32‘48‘‘N; 25°31‘12‘‘E; 870 m a.s.l. Small oxbow of R. Şicasău. Densely vegetated (*Juncus* sp., sedges) and surrounded by deciduous forest.
25. L. Dracului (HR); 46°33’00’’N; 25°35’49’’E; 210 m a.s.l. Clearing NE L. Dracului (HR). Surrounded by coniferous forest with clear-cuttings. Intense forest management.
26. Molhaşuri Izbuce (BH); 46°35’20’’N; 22°45’25’’E; 1,205 m a.s.l. Lagg at the southern edge of the Molhaşuri Izbuce raised bog. Small pools in between sedges.
27. Molhaşuri Izbuce (BH); 46°35’23’’N; 22°45’27’’E; 1,210 m a.s.l. Well developed raised bog.
28. Padiş karst plateau (BH); 46°35’27’’N; 22°45’09’’E; 1,220 m a.s.l. Shallow and very muddy watering place.
29. Padiş karst plateau (BH); 46°35’40’’N; 22°42’17’’E; 1,244 m a.s.l. Small boggy pool. No helophytes, some floating peat moss.
30. Padiş karst plateau (BH); 46°35’41’’N; 22°42’16’’E; 1,250 m a.s.l. Group of boggy pools in karst dolines.
31. Padiş karst plateau (BH); 46°35’42’’N; 22°42’14’’E; 1,250 m a.s.l. Muddy watering place with some *Typha* sp.
32. Padiş karst plateau (BH); 46°36’38’’N; 22°42’20’’E; 1,260 m a.s.l. Transition bog in a doline depression surrounded by pasture and coniferous forest. Most of the area covered by sedges and *Sparganium* sp. Numerous very small and shallow pools.
33. Padiş karst lake (BH); 46°36’48’’N; 22°42’20’’E; 1,270 m a.s.l. Karst lake. *Sparganium* sp. and locally *Sphagnum* sp. in the littoral zone. Environment coniferous forest and pasture.
34. L. Bălan, Bălan (HR); 46°41’01’’N; 25°47’25’’E; 920 m a.s.l. Banks of the Bălan reservoir lake. Rather steep slopes covered by dense coniferous forest. Some deciduous vegetation immediately at the shoreline.
35. L. Bălan, Bălan (HR); 46°41’11’’N; 25°47’13’’E; 920 m a.s.l. Sedge swamps and fens in the tributary zone of the Bălan reservoir lake. Surrounded by coniferous forests and partly by pasture.
36. Reservoir lake E of Gheorgheni (HR); 46°43’52’’N; 25°39’10’’E; 870 m a.s.l. Reservoir lake surrounded by gardens, deciduous and coniferous forest. Shrubs and trees at the shoreline.
37. SE slope of Vf. Rățitiş (HR); 47°05’50’’N; 25°16’11’’E; 1,760 m a.s.l. Small pool in the heath and fen area on the S slopes of the Călimăn ridge. Conditions slightly lotic. Densely vegetated with peat moss and sedges.
38. Valea Lalei S Şesuri (BN); 47°33’22’’N; 24°57’07’’E; 1,190 m a.s.l. Small clearing in conferous forests.

39. Valea Lalei S Şesuri (BN); 47°33’56’’N; 24°59’19’’E; 1,046 m a.s.l. Helocrene spring on a rather steep slope. Numerous small pools.
40. L. Izvoru Bistriţei (BN); 47°34’24’’N; 24°48’51’’E; 1,660 m a.s.l. Comparably large cirque lake. Submersed specimens of *Pinus* sp. and the shape of the damp area suggests that the waterline was raised artificially.
41. Valea Bilei SW Şesuri (BN); 47°34’49’’N; 24°56’36’’E; 1,120 m a.s.l. Reservoir lake. Partly shaded by large trees.
42. Tăurile Buhăescului, S Borşa (MM); 47°35’09’’N; 24°38’44’’E; 1,840 m a.s.l. The smallest of a group of four alpine cirque ponds. No vegetation in the water. Ground covered by peat clay. In contrast to the other ponds, no significant tributaries. Surrounded by alpine pasture and scattered *Pinus mugo* shrubs.
43. Valea Bilei SW Şesuri (BN); 47°35’45’’N; 24°57’33’’E; 1,070 m a.s.l. Shallow temporary pool.
44. Watering place N Pasul Prislop (MM); 47°37’36’’N; 24°52’15’’E; 1,840 m a.s.l. Small, shallow pond used as a watering place. Obviously artificial. Helophytes (*Equisetum* sp.) in the central part. Surrounded by pasture. No forest nearby.
45. Statiunea Izvoare (MM); 47°45’22’’N; 23°42’35’’E; 920 m a.s.l. Small, shady clearing in coniferous forests. Pasture nearby.
46. Mara creek N Statiunea Izvoare (MM); 47°47’04’’N; 23°44’00’’E; 733 m a.s.l. A group of small rocky pools in the flood-plain of Mara creek. Water slightly running, shrubs at the shore. Surrounded by pasture and deciduous forest.
47. Mara creek N Statiunea Izvoare (MM); 47°47‘20‘‘N; 23°44‘29‘‘E; 714 m a.s.l. Small reservoir lake in the valley of R. Mara. Surrounded by pasture and deciduous forest.
48. Creek NE of Cheile Tătarului (MM); 47°48‘35‘‘N; 23°45‘41‘‘E; 740 m a.s.l. Small, relatively fast flowing river. No vegetation in the water and no shrubs or trees at the banks. Surrounded by pasture, no trees nearby.

List of Odonata records

1. *Calopteryx virgo* (Linnaeus, 1758)
   Loc. 35: 28-vii-2009 2♀♀. **Loc. 36**: 27-vii-2009 1♂. **Loc. 47**: 20-vii-2009 13♂♂. **Loc. 48**: 20-vii-2009 1♂.
2. *Platycnemis pennipes* (Pallas, 1771)
   Loc. 35: 28-vii-2009 numerous ♂♂ and ♀♀.
3. *Coenagrion hastulatum* (Charpentier, 1825)
   Loc. 36: 27-vii-2009 1♂.
4. *Coenagrion lunulatum* (Charpentier, 1840)
   Loc. 36: 27-vii-2009 1♂.
5. *Coenagrion puella* (Linnaeus, 1758)
   Loc. 35: 28-vii-2009 25♂♂, 10♀♀, 10♂♀. **Loc. 44**: 23-vii-2009 20♂♂, 20♂♀.

6. *Aeshna cyanea* (O.F. Müller, 1764)
Loc. 1: 04-viii-2009 1♂. **Loc. 9**: 05-viii-2009 1♂. **Loc. 12**: 08-viii-2009 3♂♂. **Loc. 15**: 11-viii-2009 8 larvae. **Loc. 18**: 10-viii-2009 1 larva. **Loc. 20**: 12-viii-2009 1♂. **Loc. 22**: 12-viii-2009 ca. 50 larvae. **Loc. 23**: 29-vii-2009 1♂. **Loc. 24**: 28-vii-2009 1♂. **Loc. 28**: 14-viii-2009 5 larvae. **Loc. 29**: 12-viii-2009 1♀. **Loc. 30**: 12-viii-2009 1♂, 10 larvae. **Loc. 31**: 12-viii-2009 2♂♂, 1♀. **Loc. 33**: 13-viii-2009 20♂♂. **Loc. 34**: 28-vii-2009 3♂♂. **Loc. 35**: 28-vii-2009 3♂♂. **Loc. 40**: 23-vii-2009 1♂. **Loc. 41**: 24-vii-2009 10♂♂. **Loc. 43**: 24-vii-2009 1♂. **Loc. 46**: 20-vii-2009 3♂♂.
7. *Aeshna grandis* (Linnaeus, 1758)
Loc. 35: 28-vii-2009 1♂.
8. *Aeshna juncea* (Linnaeus, 1758)
Loc. 4: 07-viii-2009 2 larvae. **Loc. 11**: 04-viii-2009 1♀. **Loc. 12**: 08-viii-2009 1♂. **Loc. 29**: 12-viii-2009 3♂♂, 1♀, 1♂♀. **Loc. 30**: 12-viii-2009 2♂♂. **Loc. 32**: 13-viii-2009 2♂♂, 1♀, 1♂♀. **Loc. 33**: 13-viii-2009 ca. 20♂♂, 2♀♀. 1♂♀. **Loc. 35**: 28-vii-2009 **Loc. 39**: 24-vii-2009 1♂. **Loc. 40**: 23-vii-2009 ca. 20♂♂, 1♀. 1♂♀. **Loc. 42**: 22-vii-2009 1♀. **Loc. 44**: 23-vii-2009 15♂♂, 5♀♀, 2♂♀.
9. *Aeshna mixta* Latreille, 1805
Loc. 5: 04-viii-2009 3♂♂. **Loc. 6**: 04-viii-2009 2♂♂. **Loc. 7**: 02-viii-2009 1♀. **Loc. 8**: 04-viii-2009 10♀♀. **Loc. 10**: 04-viii-2009 1♂. **Loc. 11**: 04-viii-2009 1♀. **Loc. 23**: 29-vii-2009 1♂. **Loc. 25**: 29-vii-2009 1♂. **Loc. 45**: 20-vii-2009 1♀.
10. *Aeshna subarctica* Walker, 1908
Loc. 27: 14-viii-2009 min. 5♂♂, 2♀♀.
11. *Gomphus vulgatissimus* (Linnaeus, 1758)
Loc. 34: 28-vii-2009 1♂.
12. *Somatochlora alpestris* (Selys, 1840)
Loc. 2: 08-viii-2009 1 larva. **Loc. 3**: 08-viii-2009 1♀. **Loc. 13**: 05-viii-2009 1 larva. **Loc. 17**: 30-vii-2009 3♂♂. **Loc. 19**: 29-vii-2009 1 larva. **Loc. 26**: 14-viii-2009 1 larva. **Loc. 37**: 26-vii-2009 1 larva. **Loc. 42**: 22-vii-2009 1♂.
13. *Somatochlora meridionalis* Nielsen, 1935
Loc. 36: 27-vii-2009 1♂.
14. *Somatochlora metallica* (Vander Linden, 1825)
Loc. 35: 28-vii-2009 min. 10♂♂, 2♀♀.
15. *Libellula depressa* Linnaeus, 1758
Loc. 16: 09-viii-2009 1 larva. **Loc. 21**: 12-viii-2009 1♀. **Loc. 36**: 27-vii-2009 1♂. **Loc. 38**: 24-vii-2009 1♂. **Loc. 47**: 20-vii-2009 1♂. **Loc. 48**: 20-vii-2009 1♂.
16. *Sympetrum danae* (Sulzer, 1776)
Loc. 32: 13-viii-2009 1♂, 1♂♀.
17. *Sympetrum sanguineum* (O.F. Müller, 1764)
Loc. 35: 28-vii-2009 1♂.

Discussion

The objective of the present study was to elucidate occurrences and distribution of boreo-alpine Odonate species in the Romanian Carpathians. This was largely motivated by results from fieldwork performed in 2007 (Manci & Kalkman 2008). During this expedition it became apparent that the knowledge of the Romanian Odonata is poor in general. Especially, little is known about boreo-alpine species that may be present in the Carpathian high mountain ranges.

Although the project was restricted in space and time and although performed by comparatively few investigators, de Knijf et al. (2011) provided numerous new records of *Somatochlora arctica* and of *S. alpestris* for Romania. However, these data have been obtained from a region confined to the south-western Carpathians (Mţii. Retezat, Mţii. Cindrel, and Mţii. Parâng).

In order to complement and to extend this knowledge, a much broader range of the Romanian part of the Carpathian Arch has been covered in the present study: The eastern Carpathians (Mţii. Gutiului, Mţii. Rodnei, Mţii. Căliman, Mţii. Hasmas, Mţii. Harghita) the southeastern Carpathians (Mţii. Bucegi, Piatra Craiului, Mţii. Făgăraş), and the Romanian western Carpathians (Mţii. Bihor, Mţii. Apuseni). During this project, only one excursion was dedicated to the region covered by de Knijf et al. (2011): The Mţii. Parâng were reinvestigated because data from the alpine level had not been collected before.

Considerable difficulties resulted from the fact that fens and bogs are often not indicated on local maps. Additionally, interesting habitats such as small fens and bogs can hardly be discriminated from meadows and pasture on freely available satellite images. Some consequences will be discussed in detail below.

Roughly one third of Romania's area belongs to the Carpathians, the second longest mountain range in Europe. With few local exceptions, this high mountain range is currently much less developed than, for example, the Alps or the Apennines (Baltzer et al. 2009; Gurung et al. 2009). Traditional cultivation prevails in large areas and detrimental impact on ecosystems is therefore still relatively small. This particularly applies to the subalpine and alpine levels.

However, considerable parts of the Romanian Carpathians currently seem to suffer from inappropriate forest management. Very often, extensive clearings serve the production of timber. To a considerable extent, this seems to happen illegally. Actually, careless practices of forest management were observed frequently during fieldwork. This particularly refers to the Mţii. Făgăraş and to the Mţii. Iezer (R. Dâmboviţa, L. Pecineagu). Within managed areas, the floodplains of small rivers were often covered by hard sediments of sand and silt. These sediments frequently reached heights of more than 10 cm, which evidently impairs the local reproduction of Odonata. Moreover, the beds of brooks and rivers were also affected correspondingly. Species that prefer lotic conditions (e.g., *Calopteryx* spp.) could not be observed in these regions although this could have been expected from the general appearances of these habitats.

The phenomenon can undoubtedly be attributed to the erosion of forest soils induced by the practices described above. Upstream of the managed areas, no significant impact on the floodplains and rivers has been detected.

On the other hand, associated with an elevation of the timberline, forested areas currently seem to expand to higher altitudes (Mihai et al. 2007). This possibly results from the combined effects of climate change and of the end of cultivation. If continued, this development will also affect the ranges of boreo-alpine Odonata in several respects.

Specific annotations

Calopteryx virgo was observed at creeks of the submontane level. All individuals had completely dark wings without significant hyaline parts. This suggests the presence of the subspecies *festiva*. Our results do not correspond with the distribution map presented by Rüppell et al. (2005: 210), which suggests the presence of the subspecies *virgo* in virtually all parts of the Carpathians. By contrast, the data presented here are consistent with observations from the southwestern Carpathians (UF unpubl.). At R. Prigor (Mții. Semenic) in 2007 likewise only ssp. *festiva* was found. Both sexes were consistently homochromous.

Coenagrion hastulatum and ***C. lunulatum*** were both observed at the same locality (loc. 36). However, the records are doubtful because unfortunately the individuals escaped from the net and a sufficiently precise determination was not possible anymore. While both species seemingly have not often been reported from Romania (Dijkstra 2006a), the records appear to be plausible from the ecological preferences.

Aeshna mixta was exclusively observed foraging in forested areas. With one exception (loc. 23) the distances to suitable reproduction sites seemed to be considerable. These observations are in accordance with the phenology and behaviour of *A. mixta* in Central Europe (Peters 1987; Sternberg & Höppner 2000). Most likely, the records reflect maturation behaviour.

The only observation of ***Aeshna grandis*** (loc. 35) corresponds to a typical habitat of this species (reservoir lake, forests). According to Dijkstra (2006b) some scattered records are situated close to loc. 35 (Mții. Harghita). It is likely that the species has been overlooked frequently in this region. The general ecological conditions in the Mții. Harghita are in good accordance with the species' preferences.

Aeshna cyanea is currently not considered to be widespread in South-Eastern Europe. The species has only recently been reported from Macedonia for the first time (Micevski et al. 2008). Dijkstra (2006b) regards Romania as a region where the species is generally uncommon. However, large areas of the Carpathians exhibit ecological conditions which are very similar to Central European for-

ests where *A. cyanea* is probably the most abundant Anisopteran. Where habitats are suited for both species, competition with *A. juncea* probably limits the vertical distribution (Sternberg 2000a).

The highest absolute number of records (n =18) was noted for this species (Fig. 1). It has to be stressed that the *A. cyanea* records represent occasional findings. Many other promising sites have not been investigated.

Similarly to the situation in Central Europe, *A. cyanea* also seems to occupy a large variety of habitats in the Carpathians. But shaded habitats in forested areas are preferred. This is in good accordance to Sternberg (2000a: 47) who characterises the species as a forest dragonfly («Waldlibelle»). The scattered distribution, the known preferences of the species, and the general ecological conditions in the investigated regions clearly allow one to infer a closed distribution of *A. cyanea* in the Romanian mountains.

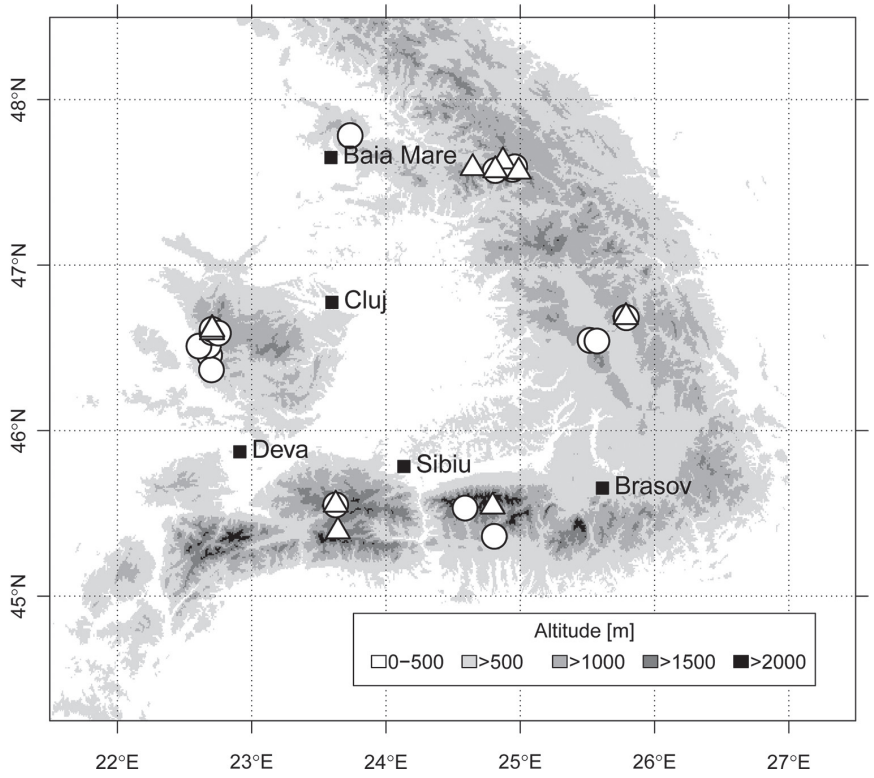

Figure 1: Map of the records of *Aeshna cyanea* (○) and of *A. juncea* (Δ) taken in the Romanian Carpathians during the present study. – Abbildung 1: Karte der Nachweise von *Aeshna cyanea* (○) und *A. juncea* (Δ) in den rumänischen Karpaten im Rahmen dieser Studie.

According to Dijkstra (2006b) only some isolated records of *Aeshna juncea* have been reported from the Romanian Carpathians. However, during this study *A. juncea* was encountered frequently at higher altitudes and in particular at locations where helophytes were present (e.g., locs. 4, 33, 40, and 44). These findings correspond with the known preferences of this species (Peters 1987; Sternberg 2000b; Dijkstra 2006b). Figure 1 shows a map of the records.

Taking into account the considerable geographic scatter of the observations, a closed distribution in the Romanian Carpathians can be inferred.

With respect to the vertical distributions, interspecific competition between *A. juncea* and *A. cyanea* may have an effect. At the Padiş Karst Lake (loc. 30) both species could be observed in considerable numbers. The respective males defended their territories in their well known, agressive manner. *Aeshna cyanea* males often succeeded in chasing off *A. juncea* males from the breeding place. After ca. 20 minutes, only *A. cyanea* could be observed. However, another 20 minutes later the tables had turned and exclusively *A. juncea* males were present.

Figure 2 shows the vertical distribution of the records of both species. Loc. 30 has an altitude of 1,250 m, which precisely falls into the level of strongest overlap. The Padiş Karst Plateau harbours numerous habitats suited for both species and will represent an ideal place to study the respective niche occupations.

The presence of *Aeshna subarctica* in Romania seems to be demonstrated for the very first time here. The species could be identified preliminarily in flight because the general appearance was significantly darker than the numerous specimens of *A. juncea* encountered before and nearby.

A mere view of the habitat (loc. 27) left few doubts concerning the species' identity. Figure 3 shows a photograph of the site, which is situated in the central part of a well developed raised bog. It can be considered a typical and ideal habi-

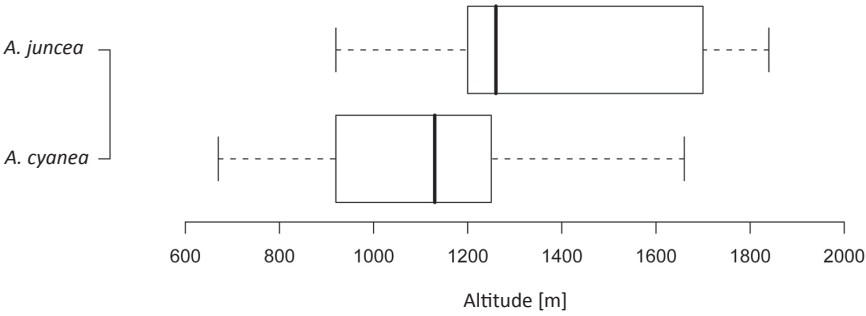

Figure 2: Box plot of the vertical distribution of the *Aeshna cyanea* and *A. juncea* records in the Romanian Carpathians during this study. – Abbildung 2: Boxplot der vertikalen Verteilung der Beobachtungen von *Aeshna cyanea* und *A. juncea* in den rumänischen Karpaten im Rahmen dieser Studie.

tat for the reproduction of *A. subarctica* which represents a truly tyrphobiontic species (Peters 1987; Spitzer & Danks 2006; Sternberg 2000c).

One male was netted and photographed. Figure 4 shows the diagnostic characters of this individual. The blue markings on the posterior regions of the abdominal segments were comparatively small. The yellow markings on the middle of segments S3-S8 lacked the triangular shape typical for *A. juncea*. Rather, they resembled an inverted "U" (S3, S4) or a horizontal "L" (S5, S6) (Fig. 4A). This feature of *A. subarctica* is described by Peters (1987: 24, Fig. 20a). The yellow

Figure 3: Raised bog "Molhaşuri Izbuce" in the Mții. Apuseni, in the Bihor County in the Romanian Carpathians. First known location of *Aeshna subarctica* in Romania (loc. 27; 14-viii-2009). – Abbildung 3: Hochmoor "Molhaşuri Izbuce" im Apuseni-Gebirge, Kreis Bihor, in den rumänischen Karpaten. Erster bekannter Fundort von *Aeshna subarctica* in Rumänien (Fundort Nr. 27; 14.08.2009).

markings on the anterior regions of the abdominal segments were restricted to small triangles. Costa and subcosta appeared darkish brown (Fig. 4B). The facial suture exhibited an approximately constant width (Fig. 4C). The occipital region lacked any yellow marking (Fig. 4D). However, two pale blue spots were found in the upper dorsal part. These could not be recognized in lateral view of the head but merely in posterior-dorsal view. The appendages appeared rounded, comparatively wide, and did not diverge (Fig. 4E).

None of the ovipositing females could be netted. The oviposition sites were located at the edges of small pools in the mire and were inaccessible. Even with binoculars, diagnostic details could not be observed sufficiently. However, the generally dark appearance of the females and the other conditions of the observation largely exclude confusion with *A. juncea*.

In spite of its considerable area, the location is not indicated as bog, fen or swamp on any of the available maps. It has been found more or less by chance. However, the place had already been mentioned as peat bog (Burescu & Togor, 2010; Dincă et al., 2010). The site seems to be identical to a bog locally known as "Molhaşuri Izbuce", as "Izbucu" (Bodnariuc et al. 2002), or as "Molhaşul Amre de la Izbuc", which according to Burescu & Togor (2010) has Scientific Reserve status.

The observation of *A. subarctica* in the Mții. Apuseni is not only significant because the species is totally new to the fauna of Romania but also because the nearest known populations are situated at considerable distances. Recently, Šácha & Bulánková (2006) found the species in Slovakia. The isolated Bulgarian

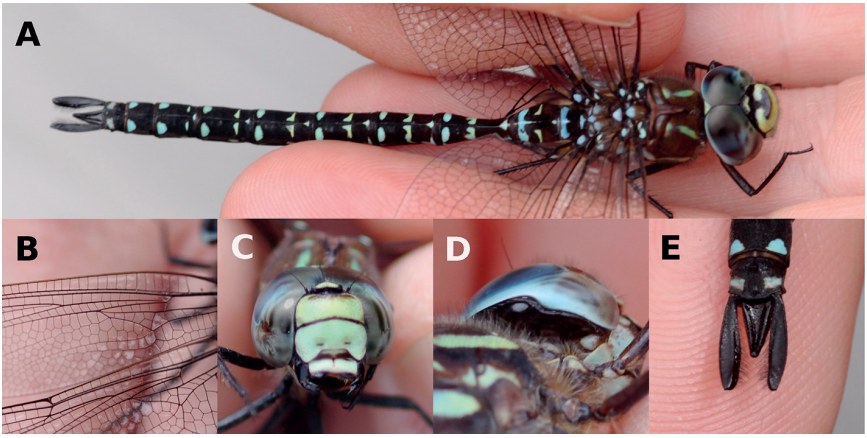

Figure 4: Some diagnostic characters of an *Aeshna subarctica* male caught on 14-viii-2009 in the Mții. Apuseni (loc. 27), in the Bihor County in the Romanian Carpathians. See text for further comments. – Abbildung 4: Einige diagnostische Merkmale eines *Aeshna subarctica*-Männchens, das am 14.08.2009 im Apuseni-Gebirge im Kreis Bihor in den rumänischen Karpaten gefangen wurde (Fundort 27). Weitere Erläuterungen im Text.

record indicated on the map of Dijkstra (2006b) seems to date back to 1960 (Peters 1987). According to Boudot et al. (2009: 100) the last observation dates from before 1980.

The record presented here is among the southernmost ones in Europe. *Aeshna subarctica* is a tyrphobiontic species with subarctic-boreal distribution. It therefore cannot be expected to be very widespread in Romania. Most of the country has a continental climate and summers are often hot and dry. The existence of bogs and fens is therefore confined to mountainous regions which dominate roughly one third of Romania's area. Taking into account these facts, the record nicely supports the idea of Spitzer & Danks (2006). Accordingly, peat bogs may serve as refugia for boreal and subarctic species in the southern latitudes of the northern hemisphere. Particularly in these regions, peat bogs will exhibit local climates which are considerably cooler than the general environment.

According to Bodnariuc et al. (2002), at least five ombrogenic peat bogs do exist very close to loc. 27. The corresponding *Sphagnum* peats are stratigraphically homogenous and exhibit ^{14}C ages of up to ca 9000 years before present. Presumably, suitable habitats for the reproduction of *A. subarctica* have therefore existed continously during most of the holocene in the Mţii. Apuseni. It is not unlikely that a closer inspection of this region will yield more records of *A. subarctica*.

Conspicuously, the records of both *Somatochlora metallica* and *S. meridionalis* (loc. 35 and 36, respectively) were merely separated by a few kilometers. Both habitats were reservoir lakes. In contrast to the typical behaviour described by Wildermuth (2008: 424), the male *S. meridionalis* was observed patrolling a sunny stretch over stagnant water. *Somatochlora meridionalis* however is expected to prefer shady lowland rivulets and rivers. Geographically, the observation is situated close to records indicated as doubtful on the map in Wildermuth (2008: 425).

Nearby, west of the investigated location many potential habitats for *S. meridionalis* do exist but the region has not been investigated.

In contrast to the location of *S. meridionalis*, the conditions of the *S. metallica* record (loc. 35) are not unusual. The comparatively large lake in between the forested heights of the Mţii Giurgeu and of the Mţii Haşmaş represents a typical habitat.

Hitherto, only a few records of *Somatochlora alpestris* are known from the Carpathians, in particular from the Romanian parts. Fieldwork in 2007 provided numerous new records of *S. alpestris* from the southwestern Carpathians (de Knijf et al. 2011). The species has also been found recently in the Ukrainian Carpathians (Holuša 2009). These locations are situated near the record of *S. alpestris* from the Mţii. Rodnei (loc. 42).

The absolute number of *S. alpestris* records from the present study is comparatively small (n = 8). This may be explained partly by the difficult and time

consuming access to most of the investigated habitats (cf. Fig. 5). In addition, the species is not always detected with ease. Males tend to visit potential reproduction sites only briefly, in small numbers, and preferably during sunny periods (Wildermuth 2008).

Finding the larvae likewise may be tedious. The corresponding records were mostly obtained after intense search of several hours. Moreover, the period in which potential habitats were visited was probably not ideal in this respect. Generally, *S. alpestris* represents a "spring species" (Wildermuth 2008). Most individuals presumably had already emerged, resulting in low densities of the larvae. For these reasons, there is a considerable chance that the species has occasionally been overlooked, especially in the Mții. Rodnei. Numerous suitable habitats do exist in this region and a closer inspection will probably yield more records. The same applies to the Mții. Apuseni/Bihor.

In spite of the small number of records, the present data suggest a rather closed distribution of *S. alpestris* in the eastern and in the southern Carpathians. This is also substantiated by the results from adjacent regions (Holuša 2009; de Knijf et al. 2011). The map of Wildermuth (2008: 381) only shows two isolated records east of River Olt. Wildermuth (2006) even suggests complete absence

Figure 5: Cirque lake in the Parâng Mountains, habitat of *Somatochlora alpestris* in the southern Carpathians in Romania (Loc. 2; 08-viii-2009). – Abbildung 5: Karsee im Parâng-Gebirge, Habitat von *Somatochlora alpestris* in den südlichen Karpaten in Rumänien (Loc. 2; 08.08.2009).

of *S. alpestris* from the Romanian Carpathians. The presence of the species in the southern Carpathians is considered very doubtful. This view must definitely be revised. Figure 6 shows the distribution of *S. alpestris* in the Carpathians based on our data and on the records taken from DE KNIJF et al. (2011) and from HOLUŠA (2009).

There is only a single larval record from the Mţii. Apuseni. However, the region features many potential reproduction sites. Most of the considerations concerning the occurrence of *A. subarctica* in the Mţii. Apuseni will also apply to *S. alpestris* and to *S. arctica*. These species are often found in association (WILDERMUTH 2008) although habitat preferences tend to differ slightly (STERNBERG 2000c, d, e). The Mţii. Apuseni represent a relatively isolated mountain range, but distances to the observations in the Mţii. Rodnei and Mţii. Cindrel are comparatively short. Considering the mobility of *S. alpestris,* it is not very likely that the occurrence is truly isolated.

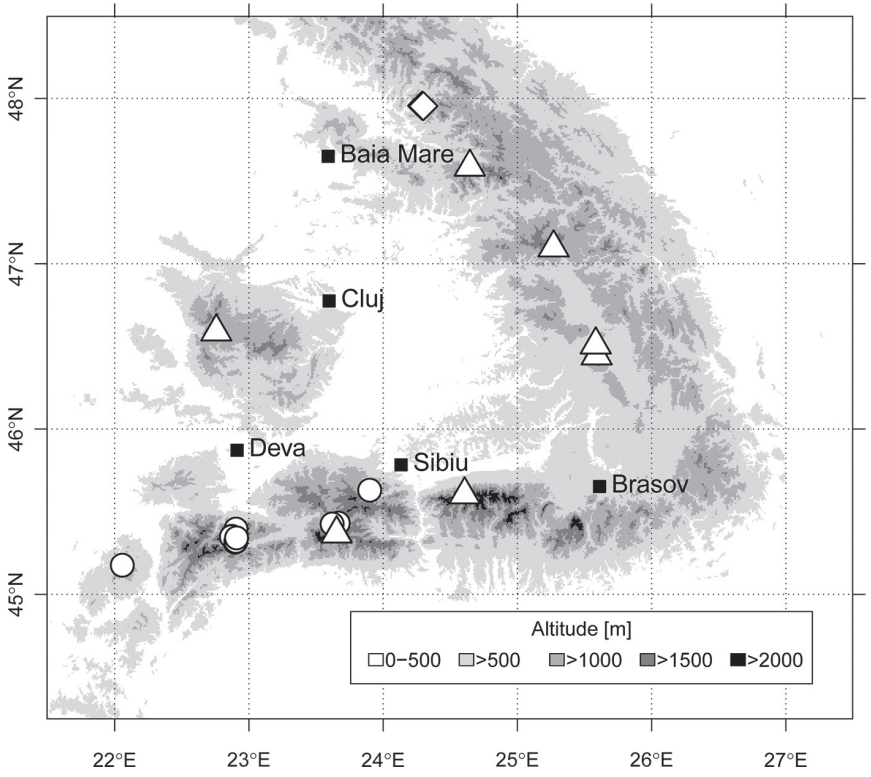

Figure 6: Recent records of *Somatochlora alpestris* (○) and of *S. arctica* (Δ) in the Romanian and Ukrainian Carpathians. – Abbildung 6: Aktuelle Nachweise von *Somatochlora alpestris* (○) und von *S. arctica* (Δ) in den rumänischen und ukrainischen Karpaten. ◇ record from Ukraine, Nachweis aus der Ukraine.

Differentiating the larvae of *S. alpestris* from those of *S. arctica* may pose a challenge. The presence of the latter species in the Southern Carpathians has recently been demonstrated by DE KNIJF et al. (2011). Some of the larvae that have been investigated for the present study exhibited intermediate abdominal patterns of hairs and bristles. Furthermore, preservation in ethanol may effect stretching of the abdomen (H. Wildermuth pers. comm.). This erroneously might suggest the presence of a *S. arctica* specimen. Therefore, absence of the triangular sclerite on S7 of the larvae of *S. alpestris* was used as a diagnostic character. This has been shown to be a reliable criterion (SCHMIDT 1951). It is also developed in earlier larval stages than F (H. Wildermuth pers. comm.).

During this study, we initially expected that larval records of *S. arctica* might also be obtained, but all collected larvae turned out to belong to *S. alpestris*. From the start, most – but not all – investigated places were suited for *S. alpestris* rather than for *S. arctica*. Habitats of *S. arctica* are often small and the localities tend to be more hidden than those of *S. alpestris*. Consequently, the detection of the sites may cause considerable difficulties. It is not unlikely that in the Carpathians, *S. arctica* is comparatively as widespread as *S. alpestris* but that it still has been frequently overlooked. This hypothesis is substantiated by a recently discovered specimen of *S. arctica* in the collection of the Hungarian National Museum (V.J. Kalkman pers. comm.). The specimen is labelled with the collecting date 24--vii-1981 and the site "Lucs", which most likely pertains to a rather large bog in the Harghita Mountains with the Romanian name "Tinovul Luci". This may be inferred from a Hungarian tourist map (Tourist Map 'Hargita – Harghita Mountains', DIMAP, Budapest, edition 2005, map scale 1:70,000), where "Tinovul Luci" corresponds to Hungarian "Lucs-Tözegláp". Moreover, a location named "Lucs" is indicated on a map in TANTAU et al. (2003).

This site was also visited briefly. However, access was virtually impossible, mostly due to the unstable peat ground. The bog seems to be partly ombrotrophic and partly minerotrophic. It is situated in between dense spruce forests. Shrubs of pine and spruce are found at the edges. The place undoubtedly harbours suitable reproduction habitats for *S. arctica*.

DE KNIJF et al. (2011) demonstrated that the distribution of *S. alpestris* in the southern Carpathians is largely controlled by altitude where the optimum falls between ca. 1,600 and 1,800 m a.s.l. The present study does not allow for a comparative analysis of the data because the number of records is too small and because the geographic coverage is much larger. Even more important, the methodologies were quite different as is clearly reflected in the results (Fig. 6). DE KNIJF et al. (2011) mostly focused on a restricted region west of the River Olt. They did not try to detect boreo-alpine species specifically, but tried to investigate as many sites suitable for dragonfles as possible. Therefore a broad range of altitudinal levels had been covered. The data set then allowed for statistical modelling of the habitat preferences. It more or less represents a random sample and the total number of observations is sufficiently large.

By contrast, the present study was dedicated to boreo-alpine species from the beginning. Many potential habitats at the alpine and sub-alpine level were specifically visited and this must result in significantly biased altitudes. This effect is clearly reflected by the altitudinal range of the *S. alpestris* records presented here (1,205 m to 2,080 m a.s.l., median 1,800 m). This clearly confirms and complements the results of de Knijf et al. (2011), but on the other hand this might suggest an erroneously high value of the species' altitudinal optimum.

With the exception of one larval record obtained from locality 16 all observations of *Libellula depressa* probably pertain to vagrant individuals. The evaluation of the other records suggests that the species may be widespread. Abundances were unexpectedly poor, however.

According to Dijkstra (2006c) the record of *Sympetrum danae* (loc. 32) seems to be the first one from the western Romanian Carpathians. Only three isolated records in the eastern Carpathians are reported. The species therefore can not be considered to be very widespread in Romania.

However, the habitat of locality 32 is in perfect agreement with the known preferences of this species. Characteristically, it occurs in transition bogs and similar habitats (Sternberg & Hunger 2000). Undoubtedly, careful investigations will yield more records. In particular, this applies to the Mții. Apuseni where literally hundreds of small transition bogs can be found in karst dolines.

Acknowledgements

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This work is dedicated to the wonderful people of Romania. May their gentleness and cordiality outlast any perils to come.

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