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A mass migration of *Aeshna affinis* in southern Kyrgyzstan: attempt to provide a spatial and temporal reconstruction (Odonata: Aeshnidae)

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Abstract

A mass migration of *Aeshna affinis* is reported for the first time. The phenomenon with preceding mass emergence took place in June 2009 in the Jalalabad province in southern Kyrgyzstan. The genesis of the mass migration is summed up, reconstructed and compared with common hypotheses and literature. With reference to the ecology of *A. affinis* in Europe, the prevailing ecological and climatic conditions are discussed.

Zusammenfassung

Eine Massenwanderung von *Aeshna affinis* im südlichen Kirgisistan: Versuch einer zeitlichen und räumlichen Rekonstruktion (Odonata: Aeshnidae) – Im Juni 2009 wurde in der Provinz Jalalabad im südlichen Kirgisistan ein Massenschlupf von *Aeshna affinis* mit anschließender Massenmigration beobachtet. Neben der räumlichen und zeitlichen Rekonstruktion des Szenarios werden die wichtigsten potenziell zugrunde liegenden ökologischen, klimatischen und physiologischen Kausalzusammenhänge diskutiert sowie die aus Europa bekannten Fakten zur Ökologie von *A. affinis* jenen in Kirgisistan gegenübergestellt.

Introduction

Migration of dragonflies is one of the most interesting and intriguing phenomena in odonatology, and the number of publications dealing with this subject runs into hundreds. A comprehensive review of worldwide published data was presented by Corbet (1999). There are various reasons for dragonflies to migrate. Some species are apparently obligate wanderers and long distance migration seems to be a crucial factor to circumvent unfavourable living conditions, such as seasonal droughts, as is demonstrated in an exemplary fashion by *Anax ephippiger* (Peters 1987; Corbet 1999: 412). Other species with a highly specialised life cycle undertake an obligatory seasonal vertical migration to spend their pre-reproductive period in aestivation refuges, such as the Central Asian *Sympetrum arenicolor* (Borisov 2006b; Schröter 2010). Some species even exhibit birdlike autumnal southward migrations to avoid seasonal cold weather, as in *Anax junius*, which was found accompanying mixed flocks of migrating birds heading south (Bagg 1957, 1958). Other species are facultative wanderers, migrating irregularly only under certain conditions triggered by climate and population dynamics, with a variation in the behaviour of different populations of the same species living under different ecological conditions. For instance, in Algeria *Aeshna mixta* and *Sympetrum striolatum* exhibit a vertical migration up the mountains to spend their pre-reproductive period in upland refuges with a favourable microclimate (Samraoui et al. 1998), whereas in temperate latitudes these species do not have any reason for an according migration. The same applies to *Anax parthenope* and *Sympetrum fonscolombii* in the Kazakh western Tian Shan, where both are supposed to undertake autumnal migrations southwards (Borisov 2009), but according to current knowledge do not do so in the Central or Southern European part of their distribution.

A trigger for many species to undertake spatial displacement is preceding mass emergence with subsequent high population densities (Fraenkel 1932; Dumont & Hinnekint 1973; Corbet 1999). Such mass migrations have always fascinated people and reports of huge swarms of migrating dragonflies, often of *Libellula quadrimaculata*, which might comprise billions of individuals (Fraenkel 1932), date back to the 19th Century (Richter 1863; Cornelius 1862). Some species like *L. quadrimaculata* with a huge distribution area exhibit at more or less regular intervals mass abundances with subsequent swarm migration (Dumont & Hinnekint 1973; Haritonov & Popova 2011). On the other hand, species with different population dynamics and less disposed to mass emergence never or only exceptionally reach an abundance level that might trigger mass migration. The inconspicuous *Somatochlora arctica*, which in Europe is considered to be occurring locally and mainly in small numbers (Wildermuth 2006), may aggregate under optimal circumstances to swarms comprising thousands of individuals (Dijkstra & Koese 2001). This seems to apply also to *Aeshna affinis*, which in Europe is considered to be widespread but seldom abundant (Dijkstra 2006) and to date has never been found to migrate in large aggregations.

Aeshna affinis has a large distribution area stretching from Western Europe over the Levant to Central Asia. In Europe, it is primarily found around the Mediterranean (Boudot et al. 2009).

The following paper aims to outline an overall picture of the entire complex of mass migration on a general level and to reconstruct and summarize mass emergence and mass migration of *A. affnis* on a local scale. A further objective is to extend our knowledge of *A. affinis* in particular, providing new aspects of its ecology from the eastern edge of its distribution.

Study region

The Republic of Kyrgyzstan is the second smallest successor state of the five former Central Asian Soviet republics and shares borders with China, Tadzhikistan, Uzbekistan and Kazakhstan. It is landlocked and covers an area of roughly 200,000 km^2. Kyrgyzstan is a mountainous country, extending over the central and western part of the Tian Shan and the Trans-Alay range, both parts of the Himalayan orogenic belt. Dominated by high mountain ranges, almost 50 % of the national territory is situated at an altitude above 3,000 m and 90 % greater than 1,500 m above sea level (a.s.l.) (Maydell 1983: 154). The country's geographical position between the glaciated peaks of the central Tian Shan and the adjacent desert region of the Turan Depression, however, offers an amazing variety of different habitats, landscapes and climate types on a small scale.

The studied area was situated in southern Kyrgyzstan close to the Usbek border, near the town of Arslanbob (Арсланбоб; Жалалабат областы/ Jalalabad province; 41°20'13.94''N, 72°55'42.56''E) in the walnut-fruit forest area at the foothills of the Baubash Ata (Баубаш-Ата) mountain range. This mountain massif is up to 4,427 m a.s.l. and covers approximately 30 km of the northwestern part of the Fergana ridge. Walnut-fruit forest is restricted to altitudes roughly between 1,000 and 2,000 m a.s.l., and about 80 % is concentrated between 1,400 and 1,800 m a.s.l. (Kolov 1998; Gan & Venglovski 1997). The major tree species are walnut *Juglans regia*, maple *Acer turkestanicum* and several wild forms of fruit-bearing trees like apple *Malus sieversii*, pear *Pyrus korshinskyi*, plum *Prunus sogdiana* and barberry *Berberis integerrima*.

This forest represents the most extensive walnut forest stands worldwide and is characterized by remarkably high levels of genetic, species, and ecosystem biodiversity (Krassilov 1995; Hemery & Popov 1998). It is of major economic importance for the local population (Borchardt et al. 2010; Schickhoff & Schmidt 2004). Due to increasing pressure of exploitation by a rapidly growing population and uncontrolled change to pasture, this unique ecosystem is severely threatened (Kolov 1998; Gottschling et al. 2005; Borchardt et al. 2010; AS unpubl.). The potential area that initially was covered by walnut-fruit forest is hard to reconstruct, as this forest has experienced a long period of human exploitation. While the forest cover once may have reached the order of more than 350,000 ha, at present only 25,000-30,000 ha of dense walnut-fruit forest stands have remained (Scheuber et al. 2000; Gottschling 2005).

Walnut-fruit forest is of high significance for Kyrgyzstan, which is one of the less wooded Asian countries with an entire forest cover of less than 4 % of the territory (FAO 1990). The occurrence of dense deciduous forest is based on a specific regional climate, which deviates considerably from the arid and very continental macroclimate of southern Kyrgyzstan. While the adjacent desert lowland of the Fergana valley receives only a mean annual precipitation of 170-200 mm, the study region shows a considerably higher rate of precipitation, locally reaching at least 1,000 mm on an annual average (Franz 1973). According to Franz (1973) this is the highest precipitation rate in Kyrgyzstan. Precipitation reaches a peak from spring to early summer, a drought from mid- to late summer and a second peak in autumn (Fig. 7). The summers are usually hot with a high evaporation rate (Ponomarenko & Kenzhekaraev 1992). The annual mean temperature is approximately 8°C and surrounding mountain massifs serve as a climate divide and protect the area from cold Siberian air masses (Kolov 1998).

A general characteristic of the region is a very dynamic, unpredictable and often abruptly changing weather, which is based on a high diversity in topography, wind systems and exposure conditions on a relatively small scale (Weischet & Endlicher 2000: 403). Thunderstorms occur frequently in the region, often coinciding with hail (Lydolph 1977; Franz 1973). The altitude of the walnut forest belt is characterized geologically by alternating layers of marine sediments of the ancient Tethys Sea of the Tertiary and erosion products of Palaeozoic origin. This sedimentary environment with horizontal sandstone, clay and limestone is often cut deeply by snow-water fed river canyons (Utkina 1992; Fig. 3). The dominant geological substrate of the walnut-fruit forest is calcareous loess-like clay (Samusenko et al. 1997).

Material and Methods

Data was recorded during an extended visit from May to September 2008 and 2009. The first recording of *Aeshna affinis* data at the very beginning of the emergence period was not specific to this study but was collected in the course of a comprehensive odonatological survey of the region. After the first signs of a looming mass emergence, however, special attention was paid to the particular habitats. During the massive increase in its numbers and at the peak of its flight period, *A. affinis* took the majority of time and became the focus of the study. With simple measuring methods an approximation of the real number of individuals involved was attempted. At five randomly chosen sampling sites of 1 m^2 each within *Schoenoplectus lacustris* stands, at a distance of at least 5 m from the next site at locality 1 (Fig. 1, 2), exuviae were collected systematically on 23-vi-2009. Only exuviae fixed to plants were considered, floating individuals were omitted. With the help of a mechanical hand-held counter attempts were made to estimate the number of migrating individuals. Sometimes binoculars were used to assist visual inspection.

Climate data from the period 1950-2000 at locality 1 in Kyrgyzstan and of Brodowin in Germany (52°55’2.63’’N, 13°57’44.06’’E) was taken from Hijmans et al. (2005) at a spatial resolution of 2.5 arcmin. Climate data from the period 1971-2000 at Neusiedl am See in Austria (47°56’55’’N, 16°50’35’’E) was taken from <http://www.zamg.ac.at>.

List of sampled localities

The following three localities played a major role as key sites for the collection of data, and interpretation and reconstruction of the overall complex, and are therefore described in detail.

Locality 1 (41°19'18.61''N, 72°58'42.16''E), larval habitat of *Aeshna affinis*

The sampled habitat (Fig. 1, 2) was a sunny shallow swamp situated in a depression in a clearing of the walnut-fruit forest at 1,415 m a.s.l. The wind-sheltered clearing was used for haymaking and pasture, and was surrounded by mature stands of *Juglans regia*. The elongated swamp was approx. 180 m long and 30 m wide, up to 80 cm deep, contained no fish and was almost evenly overgrown with stands of *Schoenoplectus lacustris*, reaching heights up to 1.8 m. Muddy soil at the embankment, vegetated with *Eleocharis palustris* agg. and *Juncus inflexus*, was partly trampled and therefore kept clear by the actions of cattle. Stands of *S. lacustris* were entered at times by cows using them to wallow and cool during hot summer days, causing a pattern of open patches sparsely covered with *Polygonum amphibium* and *Ranunculus aquatilis* agg. The swamp was mainly fed by precipitation during winter and spring. During summer 2009, about two thirds of the swamp had been dried out by mid-August. In 2007/2008, after an exceptionally dry winter and a subsequent hot summer, four fifths of the swamp had almost become dry by the end of June.

Locality 2 (41°18'48.74''N, 72°58'25.12''E), canyon of Arslanbob suu river

Locality 2 was situated at 1,270 m a.s.l. on top of a steep undercut bank of Arslanbob suu river, a southeast-northwest oriented mountain river fed by snow meltwater from the Baubash Ata ridge. About 8 km downstream it runs into Kara Unkur river, a tributary of Kara Darya river, which in the Fergana valley unites with Naryn river to Syr Darya river, the second largest river of Central Asia. Locality 2 was situated approx. 800 m south of locality 1 and provided a clear view of a longer section of the canyon of Arslanbob suu river.

Locality 3 (41°20'44.51''N, 72°59'10.45''E), petrified oyster bank

Locality 3 was situated in the middle of an elongated south-north oriented petrified oyster bank from the Tertiary within mature walnut-fruit forest. The oyster bank was naturally treeless and two thirds of the plain was bare rock. In a few places at the southern half a thin soil layer allowed growth of grass and low thermophilic scrub. The site had a length of approx. 2.5 km and an average width of approx. 120 m. Due to geodynamic activities, the western side had been lifted up for approximately 20-30°, forming an inclined elongated plain descending to the east. The southern end was situated at approximately 1,600 m a.s.l., ascending to 1,800 m at the northern edge. The distance to locality 1 was roughly 1.7 km to the north. Locality 3 and 1 were directly connected by a partly sunken forest path (Fig. 2), typical for clay sediments of the region, which in combination with

Figure 1: View to the northwest over locality 1, a swamp in a walnut-fruit forest clearing. Note dark green stands of Bulrushes and in the background peaks of the 4,427 m high Baubash Ata mountain range. Photo taken just a few days before a mass emergence of *Aeshna affinis* started. Near Arslanbob, Jalalabad Province, Kyrgyzstan (18-vi-2009). – Abbildung 1: Blick nach Nordwesten über Lokalität 1, einem Sumpf in einer Lichtung von Walnusswald. Dunkelgrün die Bestände der Teichbinse, im Hintergrund das bis zu 4.427 m hohe Massiv des Baubash Ata. Das Foto datiert nur wenige Tage vor Beginn eines Massenschlupfs von *Aeshna affinis*. Bei Arslanbob, Provinz Jalalabad, Kirgisistan (18.06.2009).

the dense canopy of the mature walnut forest formed a closed or nearly closed tunnel through the forest.

Locality 4 (41°22'52.35''N, 72°59'35.55''E), Narrow rocky valley

Locality 4 was situated in a south to north oriented rocky valley in the foothills of the Baubash Ata range at 2,190 m a.s.l., above the walnut forest belt, in heavily grazed alpine pastures. This valley-like couloir functioned as a guideline and wind shaded migration route. Locality 4 was located at a distance of approx. 4 km in a northerly direction from locality 3.

Results

Time schedule of key events

20-vi-2009, locality 1
After the first recognition of emerging individuals of *Aeshna affinis*, approximately 200 exuviae were collected in a non-systematic way.

22-vi-2009, locality 1
The emergence activity had significantly increased. When I entered the vegetation at the embankment, hundreds of freshly emerged individuals took their maiden flights, mostly to perch subsequently on the surrounding walnut trees.

Figure 2: Aerial view of locality 1, a swamp in a walnut-fruit forest clearing near Arslanbob, Jalalabad Province, Kyrgyzstan. – Abbildung 2: Luftbild der Lokalität 1, einem Sumpf in einer Lichtung des Walnusswaldes nahe Arslanbob, Provinz Jalalabad, Kirgisistan (© DigitalGlobe and Google™Earth service).

23-vi-2009, locality 1
The emergence activity obviously reached its peak and several tens of thousands of freshly emerged individuals were sitting in *Schoenoplectus lacustris* stands or taking their maiden flights. Virtually every stalk of bulrush held exuviae, sometimes even aggregations of as many as 51 exuviae. Due to the clustered emergence, numerous individuals were found crippled, as the soft and yet uncured integuments of the freshly emerged individuals were damaged by others creeping on top of them.

25-vi-2009, locality 1
In the late afternoon, thousands of immature individuals were flying above the swamp, mainly at a height of 5-10 m. They formed a huge compact bubble, which was spatially clearly defined on the outside, but with unorganised bee-like swarming inside. Individuals showed a distinctly jerking and dancing flying style, with a minimum space kept between individuals.

Figure 3: Locality 2, observation point on top of the steep banks of Arslanbob suu river. Near Arslanbob, Jalalabad Province, Kyrgyzstan (11-viii-2009). – Abbildung 3: Lokalität 2, hier Beobachtungspunkt auf dem Steilufer des Flusses Arslanbob suu bei Arslanbob, Provinz Jalalabad, Kirgisistan (11.08.2009).

26-vi-2009, locality 2
Thousands of immature *A. affinis* were observed migrating upstream in a northwesterly direction above and partly within the canyon of Arslanbob suu river. The swarms seemed to consist of several superimposed layers of dragonflies moving forward in a straight-on and arranged way, with the river valley as a guideline. The space between individuals varied, on average being approximately 1 m. A nearby undercut slope, where the river turned sharply left, caused a kind of restriction on several occasions, disturbing the organisation of the flow, and even caused several smaller groups to change direction for a short time, however it took the dragonflies only seconds to reorganise.

With a mechanical hand-operated counter I made attempts to estimate the passing masses in groups of 100 individuals. When the count was stopped approximately 18,000 individuals had been recorded.

27-vi-2009, locality 3
From the higher side of the oyster bank I encountered thousands of immature *A. affinis* migrating along the forest-free corridor heading north up towards the mountains. The migrating masses were extremely approachable; the manner of

Figure 4: Locality 3, view from the southern end of a forest-free petrified oyster bank to the north. Note the upcoming summer thunderstorm, which is typically for the region. Northeast of Arslanbob, Jalalabad Province, Kyrgyzstan (02-vii-2009). – **Abbildung 4:** Beobachtungspunkt 3, Blick vom Südende einer waldfreien, versteinerten Austernbank nach Norden. Beachte die für die Gegend typische sommerliche Gewitterstimmung. Nordöstlich Arslanbob, Provinz Jalalabad, Kirgisistan (02.07.2009).

flying and swarm organisation was similar to the one observed the day before at locality 2, but swarms seemed to fly lower and concentrated roughly between 2 and 15 m in height. At least three males of *Lindenia tetraphylla* and several individuals of *Sympetrum arenicolor* were accompanying the masses of migrating *A. affinis*. A female of several present *Cordulegaster coronata*, which used the area as foraging habitat, fiercely attacked passing *A. affinis*. With binoculars I encountered a scattering of the swarms at the northern end of the oyster bank, where the forest-free corridor ended and blended again with walnut-fruit forest. With a mechanical hand counter attempts were made to estimate the passing masses in groups of 100 individuals. After recording approximately 23,000 individuals, however, I stopped counting to take a closer look at the southern end, where the forest path from locality 1 met the oyster bank. Most of the individuals flocking into the oyster bank were flying over the walnut forest, but several groups streamed straight out of the tunnel build by the canopy above the forest path.

Figure 5: Locality 4, view from the north down the valley to the walnut-fruit forest belt. Foothills of Baubash Ata range north of Arslanbob, Jalalabad Province, Kyrgyzstan (21-vi-2009). – Abbildung 5: Beobachtungspunkt 4, Blick von Norden durch ein Felstal auf den darunter liegenden Walnusswaldbereich. Vorberge des Baubash Ata-Massivs nördlich Arslanbob, Provinz Jalalabad, Kirgisistan (21.06.2009).

Due to this observation I headed southwards where I was frequently passed by groups of migrating *A. affinis* using the forest path as a guideline. At locality 1 huge numbers of swarming individuals were still present, but in a clearly reduced number compared to the observation on 25-vi. Moreover, the flight style appeared to be less organised and spread all over the open space.

28-vi-2009, locality 4
Thousands of *A. affinis* migrated up the valley, accompanied by at least two males of *L. tetraphylla.* After about half an hour of continuous migration, increasing westerly wind scattered the swarms. A few males of *A. affinis* already showed a bluish tinge, indicating a transitional maturation stage. This was the last observation of aggregated migration *A. affinis*.

From 23-vi-2009 onwards in the study region
Immature *A. affinis* were present virtually everywhere in tremendously high numbers, on clearings, meadows, scrubland, riversides and in backyards. Several times domestic fowl such as chickens and turkeys were observed preying on immature *A. affinis* perching in the vegetation of gardens and meadows.

From 16-vii-2009 onwards in the study region
The number of mating and oviposition activities at all the dried out temporary swamps of the region increased sharply and, at least until mid-August, *A. affinis* was by far the most abundant dragonfly in the study region. Probably due to high population pressure I encountered dozens, both of single females and pairs in tandem position, ovipositing in unsuitable places, whenever open muddy soil was visible, such as the edges of hay meadows, trampled areas at cowsheds, mud puddles in backyards etc. The local weather from mid-June till August was very hot and humid, with frequent strong summer thunderstorms (Fig. 4).

Abundance at locality 1

The number of collected exuviae at the five sampling sites on 23-vi-2009 ranged between 46 and 78. The area covered by *S. lacustris* was estimated to cover at least 2,700 m^2. The estimation of the number of exuviae within the entire *S. lacustris* stands based on the mean (62) equals approximately 170,000. Therefore I estimated the total number of individuals of *A. affinis* in the study region during the entire investigation period to be in excess of 350,000. For a later examination of possible parasites triggering migration, 35 ♂ and 31 ♀ have been deposited in the collection of the author, plus 1 ♀in coll. J. Arlt, Delmenhorst.

Community at locality 1

Twenty species of Odonata were observed syntopically at locality 1, of which nine were considered as autochthonous (Table 1).

Table 1. List of odonate species recorded syntopically at locality 1 in Kyrgyzstan during a mass emergence of *Aeshna affinis* in 2009. – Tabelle 1. Übersicht der an Fundort 1 in Kirgisistan syntop beobachteten Arten während eines Massenschlupfs von *Aeshna affinis* im Jahr 2009.

Species	autochthonous	abundance
Lestes barbarus	X	low
Lestes dryas		1 ♂ 2 ♀
Lestes virens [1]	X	very high
Sympecma fusca	X	moderate
Sympecma gobica	X	low
Sympecma paedisca	X	low
Ischnura forcipata		2 ♂
Ischnura pumilio		6 ♂ 2 ♀
Aeshna isoceles [2]		3 ♂, 1 ♀
Anax imperator		2 ♀
Anax parthenope	X	low
Ophiogomphus reductus		1 ♂, 4 ♀
Cordulegaster coronata		2 ♂ 2 ♀
Crocothemis servilia	X	low
Libellula depressa		2 ♂
Libellula quadrimaculata	X	low
Orthetrum albistylum		5 ♂ 2 ♀
Sympetrum arenicolor		2 ♂
Sympetrum meridionale	X	low
Sympetrum sanguineum		5 ♂

[1] The status of Central Asian populations within the taxa complex of *L. virens* is still unclear, as well as the nature of several other populations and taxa allied to this species (Jödicke 1997; Samraoui et al. 2003).

[2] Kyrgyz *A. isoceles* phenotypically corresponded to the ssp. *antehumeralis* Schmidt, 1950.

Discussion

General considerations

The most comprehensive recent analysis of dragonfly mass migration was given by Dumont & Hinnekint (1973). Their study focused on *Libellula quadrimaculata* and included a review of the numerous publications on this subject and a new hypothesis on the underlying mechanisms. In this study the point is made that migration might be motivated and triggered in different species by different mechanisms. Moreover, Dumont & Hinnekint (1973) brought to attention that a complex behaviour like dragonfly migration probably arises from complex situations and circumstances. In view of the extensive exploration of European fauna and the comparatively profound knowledge of the ecology of *L. quadrimaculata*, it should be emphasized that the present study from Kyrgyzstan, by contrast, took place in one of the odonatologically least known countries in the world, therefore distribution and ecology of the study object there is only sketchily known. Moreover, surprisingly little seems to be known about some aspects of the ecology of *Aeshna affinis* in general and *A. affinis* has never previously been the study object of mass migration.

The majority of data and articles on mass migration are more or less anecdotal in nature, mainly presenting a snapshot of a long causal chain of complex ecological, geographical, climatic and physiological interrelationships, which also applies to this article. The major difficulty in recording the mass migration of dragonflies is, of course, the restrictive conditions in being a ground-based observer and thus having inferior mobility to that of the dragonfly swarms. Another issue is the course of such events, as only few people have the time to follow the entire sequence from the very beginning of the emergence period, over the aggregation of swarms, till the final culmination, when swarms begin to wander. Hence, only very few publications on the subject are based on long term studies of population dynamics (Haritonov & Popova 2011), documenting and reconstructing the scenario from the beginning (Dreyer 1967) or even using broadcasting services and public survey to reconstruct the route of migrating swarms (Dumont & Hinnekint 1973).

The location and timing of mass emergence and mass migration in dragonflies is as yet completely unpredictable and thus the observer is condemned to lag behind the events. This was also the case in this study, and I was completely surprised by the events. That is why both applied methods and obtained data are the result of rapid improvisation rather than of a strategic approach, similar to the report of Dyatlova & Kalkman (2008). Moreover, my study was conducted in the mountains of a developing country, which restricted the transport and technical equipment capabilities considerably. Due to the huge number of individuals involved, it was unavoidable that estimation was necessary.

In literature, estimations concerning the number of individuals of wandering swarms, most notably of *L. quadrimaculata* and *Pantala flavescens,* reach orders of magnitude that are beyond those able to be verified in a scientific manner. For example, according to Cornelius (1862), wandering swarms of the first species observed at 19-v-1862 near Mettmann, Germany, comprised 2.4 billion individuals. According to Fraenkel (1932) migrating swarms extended over 330 km^2. Fraser (1993) reports that in August 1993 an aggregation of millions of migrating *P. flavescens* caused a crew member of a Chinese oil tanker to jump overboard. As no measuring method or technique exists which might derive such numbers, one is tempted to allocate such statements to anecdotal interpretation rather than to scientific investigation. Most of such publications dealing with spectacular mass swarms of *L. quadrimaculata* are of European origin and strikingly date back to the 19th century or the first half of the 20th, which might in fact point to massive loss of habitats since, rather contrary to expectations, contemporary odonatologists had a disposition given to exaggeration.

Although the estimate of the number of emerged individuals is based on simple methods and the number of sampled sites was low, in my opinion the data allow a reliable assessment of the abundance at locality 1 (Tab. 1). The estimation of the total number of individuals involved additionally contains estimations during the observation of migrating swarms at locality 2 and 3. Due to less suitable conditions, estimations of individuals observed migrating at locality 4 have not been considered in the total amount. Due to different migration directions, spatial separation of the migration routes and the temporal distance of at least 24 hours, this clearly indicated that the individuals of the swarm observed at locality 2 and the ones counted at locality 3 were not identical. Thus, double counting cannot be excluded but is considered as unlikely. Although systematic estimation and counting by the use of a mechanical hand counter was only carried out in part, making this part of the data set the most speculative one, I consider the estimations as conservative.

Predators

Virtually all of the huge webs of the spider *Argiope lobata* Pallas, 1772, which was especially common in the vegetation of small dried out swamps with high density of mating *A. affinis*, held one or more fresh or already digested individuals of *A. affinis* (Fig. 6). Several of these spiders, at places which were especially frequented by *A. affinis,* did not even show any reaction when further *A. affinis* flew into their webs.

According to Wildermuth (2011), evidence suggests that, due to gender specific behaviour, Anisopteran females in general might have a higher risk to end up as spider prey than males. However, probably due to an exceptionally high abundance and population pressure combined with male behaviour, searching the dense riparian vegetation of the dry swamps in search for females, males were prone to become entangled in the numerous spider webs (Fig. 6).

Two regional Tit species, *Cyanistes flavipectus* (Severtzov, 1873) and *Parus bokharensis* Lichtenstein, 1823, both common and characteristic of the walnut-fruit forest, were observed frequently pecking and preying on emerging *A. affinis*.

Status of *A. affinis* in Central Asia and Europe

Central Asia

With the exception of Turkmenistan, *A. affinis* has been encountered in all Central Asian successor states of the former Soviet Union so far (Borisov & Haritonov 2007). Kyrgyzstan is among the least odonatologically explored countries worldwide. Prior to an extensive study on the Kyrgyz dragonfly fauna (Schröter 2010), during which this mass migration was observed, almost no Kyrgyz data on

A. affinis had been available. The only records refer to a questionable species list, which has been partly rejected, by Krylova (1972) and an unpublished thesis by the same author from 1972. Therefore, records of *A. affinis* in Krylova (1972) are cited here with some caution (Schröter 2010: 4). According to my current knowledge, *A. affinis* is considered local in Kyrgyzstan and abundant only at the western slopes of the Fergana ridge (Jalalabad province) and locally in the plain of the Chui river (Чүй) (Chui province/ Чүй областы). In Kazakhstan, which is dominated by plains and lowland steppes, the species is however considered to be common throughout (Chaplina et al. 2007). Moreover, *A. affinis* was reported from northern Afghanistan (Schmidt 1961), whereas the record of a single male in the Mongolian part of the Dzungarian basin represents the most north-easterly finding so far (Peters 1985).

Figure 6: One of the numerous *Aeshna affinis* that ended as prey of *Argiope lobata*; the spider was especially abundant around oviposition sites of *A. affinis*. Near Arslanbob, Jalalabad Province, Kyrgyzstan (11-viii-2009). – Abbildung 6: Eine der zahlreichen *Aeshna affinis*, die Beute von *Argiope lobata* wurden. Die Spinne war in der Umgebung von Eiablageplätzen von *A. affinis* besonders häufig. Nahe Arslanbob, Provinz Jalalabad, Kirgisistan (11.08.2009).

A record from China was stated by Belyshev (1973: 424) from the Qaidam basin (Цайдам, also spelled Tsaidam) without further specification. The Qaidam basin, however, is a hyper-arid basin situated at altitudes between 2,600m and 3,300 m a.s.l. in the northern part of the Tibetan Plateau, which indicates that this was a migrating individual.

Europe

In most of Europe *A. affinis* is widely distributed but considered generally as rare or only moderately common and seldom as abundant (Dijkstra 2006).The species is locally abundant in France (Grand & Boudot 2006) but apparently scarce in Spain (Dijkstra 2006) and the Maghreb, and it is classified as vulnerable in the North African Redlist (García et al 2010). Also in Slovenia, where the species is considered to be uncommon, it is included in the Red Data List (Kotarac 1997). In the Netherlands *A. affinis* is rare (NVL 2002), which also applies for the province of Piedmont in Italy (Boano et al. 2007).

In Switzerland *A. affinis* is classified as not established yet (Gonseth & Monnerat 2002), in Germany as data deficient (Ott & Piper 1998), and in Poland the species is widespread but sparse (Bernard et al. 2009). It is considered as rare in Armenia (Tailly & Ananian 2004) and in adjacent Turkey as only sparsely distributed (Kalkman 2006). In Greece the species is apparently rare but may have been overlooked (Lopau 2010). Not surprisingly, the number of publications stating abundances of the order of thousands is rare (Brauner 2005, this study). In recent decades in Europe the species has considerably extended its area of regular occurrence northwards (Ott 1997; Sternberg et al. 2000; Bernard et al. 2002; Schiel & Kunz 2005; Brauner 2005; Bernard et al. 2009; Bönsel & Frank 2011). Under favourable weather conditions, *A. affinis* generally shows a migratory tendency, reaching as far north as the British Isles, where the species was encountered for the first time in 1954 (Longfield 1954) and repeatedly since (Parr 2007). Moreover, single wandering individuals have been recorded in Denmark (Lykke & Buhl 2007), Sweden (Billqvist & Heinzenberger 2010), Lithuania (Bernard 2005) and Finland (Schröter & Karjalainen 2009). Probably due to increasing continental summer climate the limit of distribution towards the east is shifted considerably northwards, and in Russia, *A. affinis* was regularly found reproducing up to 55°N (Peters 1987).

The southern limit of the distribution of *A. affinis* runs along the northern parts of the Maghreb (Jacquemin & Boudot 1999; Jödicke et al. 2000; El Haisouffi et al. 2010; García et al. 2010), across the Levante (Schneider 1986; Dumont 1991), Syria (Schneider 1981) to Iran (Schmidt 1954).

Flight types sensu Corbet (1999)

For a further understanding of causalities and underlying factors, it seems to be appropriate to compare and contrast the mass migration of *A. affinis* with case studies of other dragonfly species exhibiting migration. In his extensive work on behaviour and ecology of Odonata, Corbet (1999) presented a functional typology of spatial displacement of dragonflies. Therein flight activity of dragonflies is split into four types.

The first two types cover short distance obligate movements exhibited by any dragonfly: the maiden flight (type 1) and commuting within different parts of the habitat (type 2). Flight type 3 covers seasonal flights exhibited by species, which siccatate, aestivate or hibernate and spend their diapause during the pre-reproductive period in a refuge. Flight type 4 includes migration as such, further divided into obligate and facultative migratory species.

As for flight type 3, it is worthwhile to note that in Kyrgyzstan due to a very continental climate a number of species are present which exhibit a life cycle with obligate postponed maturation and seasonal refuge flights up the mountains to avoid drought and heat. During my studies on Kyrgyz Odonata in 2008 and 2009, special emphasis was devoted to such aestivation refuges. According to my current knowledge, in Kyrgyzstan mainly wind shaded north-south oriented river valleys offering a favourable macroclimate functioned as aestivation refuges. The species involved represented a well defined group, including *Sympecma fusca*, *S. gobica*, *S. paedisca*, *Aeshna mixta*, *Sympetrum arenicolor*, *S. meridionale* and *S. striolatum pallidum*. In such aestivation refuges in summer, at altitudes roughly between 1.500 and 2.200 m a.s.l., these seven species have been frequently encountered gathering in large numbers (Schröter 2010: 14 ff). While *A. mixta* appeared to be an obligate member of the regional aestivation community, in contrast *A. affinis* has never been encountered in such aestivation refuges in Kyrgyzstan (Schröter 2010). The same applies to adjacent Kazakhstan (Borisov 2006a, 2008, 2009), Tajikistan (Borisov 2006c) and, most notably, Algeria, the second area within the distribution range of *A. affinis*. Here, dragonflies undertake obligate seasonal refuge flights to uplands during the pre-reproductive period (Samraoui et al. 1998).

In Kyrgyzstan, however, there have been no indications concerning a possible prolonged life cycle with postponed maturation in *A. affinis* until now. Thus, mass migration as described in the present study did not correspond with flight type 3 «seasonal refuge flight» and in consequence exclusively flight type 4 was involved. Even though flight type 3 and 4 fundamentally differ in view of function, according to Corbet (1999: 390) movements of type 3 might resemble migratory flights in being both aggregated and directional. Indeed, if one just considers a snapshot of the initial stage, both flight types might even appear to be identical, which was also the case in the present study. The direction of both was towards the mountains. Here, the similarity at the very beginning of both flight types was emphasized by the fact that individuals of species undertaking obligate type 3 flights, namely *Sympetrum arenicolor* and *S. meridionale*, occasionally have been found to accompany swarms of *A. affinis* (see 27-vi-2009, Locality 3). Thus, as function and target of the spatial displacement of both *Sympetrum* species and of *A. affinis* differed, it can be assumed that it was merely a matter of a short time until these particular mixed species flights broke up. In the case of *Lindenia tetraphylla*, however, a species which is known regularly to undertake migratory movements most probably referred to flight type 4 (Schneider 1981; Walker & Pittaway 1987; Schorr et al. 1998) a longer temporal association might be conceivable.

Life cycle

European data on the phenology of *A. affinis* is inconsistent and not easily interpretable. Dijkstra (2006) states that the species in Europe is mainly seen from May to August. According to Kalkman (2006), in Turkey the flight period stretches from end of May till end of October, and in Greece the flight period peaks between mid-May and the end of July, with outliers during September (Lopau 2010). However, further to the east the situation appears to be more complex, raising the question of the nature of the life cycle of *A. affinis*. On the Russian Black Sea coast in the vicinity of Sotshi, Bartenev (1924) observed sexually active individuals even on 07-x-1921. On the Iranian coast of the Caspian Sea near Gorgan, Bartenev (1916) observed immature adults even in January and February.

In the plains of Central Asia *A. affinis* probably exhibits different life cycles depending on latitude. According to S.N. Borisov (pers. comm.), at theTigrovaja Balka reserve in southwestern Tajikistan at 37°N and an altitude of 350 m a.s.l., tenerals of *A. affinis* have been observed at the beginning of June, whereas reproductive behavior was not noted before the middle of October, suggesting a prolonged maturation period in this area. In contrast, populations further to the north in the plains of southeastern Kazakhstan (45-46°N) showed a considerably shorter maturation period. An according phenomenon has been observed in Central Asian populations of *Sympecma paedisca* (Borisov 2010b).

Whether in Europe *A. affinis* may also regionally exhibit a life cycle with a prolonged pre-reproductive period seems to be unknown. Some authors, however, stated that immature individuals of *A. affinis* have regularly been encountered in the mountains. In Slovenia, for instance «*Aeshna affinis* may also be recorded relatively high in the mountains during the maturation period. Its abundances are however much lower» (Kotarac 1997: 72). Moreover, no according data are available from southern Italy, Greece, Turkey, or from the Maghreb – the region where one most likely would expect *A. affinis* to show such a prolonged maturation period with aestivation flights (Samraoui et al. 1998). Therefore, only further research could answer the question if and to what extent the life cycle of European *A. affinis* may vary regionally in this respect, or if aestivation flights are involved.

Origin and fate of the swarms

During my studies (Schröter 2010), within a radius of eight kilometres around locality 1, about ten additional temporary or astatic swamps populated by *A. affi-*

nis have been examined, but none of them even approximately reached the order of abundance of locality 1, and therefore played no role in these considerations. Observations at locality 3 indicated that at least a certain number of individuals involved originated from locality 1, as direct flights from there along the forest path towards locality 3 have been noted. Further indications suggested, however, that local populations have been exposed by additional swarms flocking in from elsewhere and the present data of mass emergence is most probably just a snapshot on a local scale and the real proportions of the event remain completely unknown. Dumont & Hinnekint (1973) emphasized that particularly huge swarms might be composed of individuals of different origin. As stated above, I considered both migrating swarms as independent entities. Hence, the origin of the individuals encountered migrating at locality 2 remained unknown. This particular swarm, however, strikingly used the river valley as a guide. Provided that the swarm was oriented towards rivers from the very beginning, it could have originated from the lower course of Naryn river and the Fergana valley, as Arslanbob suu river is a tributary of the Naryn river. Virtually nothing is known about the occurrence of *A. affinis* in the Fergana valley, neither from the Kyrgyz part nor from adjacent Usbekistan. Both parts, however, might at least temporarily offer plenty of habitats potentially suitable for *A. affinis* (AS unpubl.)

Concerning the fate of the migrating swarms, only speculation is possible. It remains completely unclear why the migrating swarms of *A. affinis* headed northwards in the direction of the 4,427 m high massif of Baubash Ata. Dumont & Hinnekint (1973) assumed that the ultimate fate of migrating swarms of *L. quadrimaculata* was «... almost completely destruction».

Some regional Anisopteran dragonfly species are known as strong fliers, regularly encountered migrating at high altitudes, like *Aeshna juncea mongolica* (Wojtusiak 1994; AS unpubl.). However, in contrast to the latter species it can be doubted that swarms of the thermophilic *A. affinis* are able to withstand crossings of high, ice-covered mountain ranges. The remnants of one dead male of *A. affinis*, which was found on 12-viii-2009 on a snow field at 3,000 m a.s.l. in the Kyrgyz Alatau indicates that at least some of the migrants ended up somewhere in the high mountains.

Habitat preferences of *A. affinis* in Kyrgyzstan and Europe

The studies of *A. affinis* in Central Europe emphasize the connection with habitats showing fluctuating water levels (Schiemenz 1953; Utzeri & Raffi 1983; Schorr 1990; Mauersberger 1995; Martens & Gasse 1995; Peters & Hackethal 1996; Bernard & Samolag 1997; Sternberg et al. 2000; Brauner 2005; Schiel & Kunz 2005; Lopau 2010; Bönsel & Frank 2011). This could be confirmed for Kyrgyzstan. During my studies, reproduction of *A. affinis* was recorded exclusively at astatic habitats. In contrast, at several perennial ponds with consistent water level due to continuous water inflow, the species was notably absent and replaced by *A. mixta*, suggesting that a wide fluctuation of the water level may be considered a common denominator throughout the species' distribution range. Moreover, open muddy soil as a preferred oviposition site and a favourable microclimate, sheltered from wind by surrounding trees or bushes, are two additional features frequently stated for Europe (Utzeri & Raffi 1983; Martens & Gasse 1995; Bernard & Samoląg 1997; Brauner 2005), which in turn could be confirmed for Kyrgyzstan. Notably locality 1 as an example of an optimal habitat for *A. affinis* exhibited all three above mentioned features. Hence, the ecological requirements of *A. affinis* in view of hydrological regime and vegetation structure seem to be strikingly similar in Europe and Kyrgyzstan.

According to Sternberg et al. (2000), almost nothing is known about the larval ecology of *A. affinis*. The number of studies providing detailed information on the altitudinal limit of the species is similarly low. Although adults of this species have been frequently found at higher altitudes (Kotarac 1997; Boano et al. 2007; Grand & Boudot 2006), records of successful reproduction at higher altitudes seem to be rare. Raab et al. (2007: 136) assumed reproduction at 605 m a.s.l. in Carinthia/Austria and Henheik (2010) reported exuviae at 705 m a.s.l. from Baden-Württemberg/Germany. In 2005 an abundant population of *A. affinis* at almost 900 m a.s.l. in southern France (44°5’12.98’’N, 5°32’4.62’’E) was observed including mating and oviposition (AS & J. Arlt unpubl.). According to my current knowledge the highest reproduction record in Europe refers to a single exuvia collected in 1995 in Monti Sibillini National Park, Italy, at 1,328 m a.s.l. (42°46’20.84’’N, 13°12’56.30’’E) by H. Hunger & R. Buchwald (pers. comm.).

Such findings, however, have to be considered as exceptional in Europe. According to the majority of authors, *A. affinis* generally could be considered as a typical dweller of lowland flood plains and coastal swamps and the distribution seems to be clearly centred below 400 m a.s.l. This seems to apply to the entire European range of the species, from the Mediterranean (Dreyer 1967; Kotarac 1997; Jacquemin & Boudot 1999; Jödicke et al. 2000; Grand & Boudot 2006; Boano et al. 2007; Lopau 2010) over Central Europe (Königsdorfer & Mayer 1998; Sternberg et al. 2000; Brauner 2005; Hunger et al. 2006; Raab et al. 2007; Benken & Raab 2008; Bernard et al. 2009) to Georgia, where the species is confined to altitudes below 500 m a.s.l. (Schengelia 1975).

Although data from Eastern Europe is especially scarce, reproduction of *A. affinis* most probably is confined to low altitudes in its entire West Palaearctic range. My own observations of *A. affinis* in Romania, the Ukraine and western Russia were of abundant populations situated below 300 m a.s.l. and support this assumption. In this context, it appears thus all the more surprising that the presented Kyrgyz habitat (locality 1) was situated at 1,415 m a.s.l. and at the same time act as paradigm for an optimal habitat of *A. affinis*. This might point to the fact that at least some factors, which caused the described mass abundance and which defined an optimal habitat for *A. affinis*, were of climatic nature. This raises the question, however, why a mass emergence on a comparable scale has never been observed before in Europe. As mentioned above, climate conditions of the study area in many respects are remarkable in deviating considerably from the rest of southern Kyrgyzstan. A comparison of basic climate data between the sampled Kyrgyz habitat, a stable and strong Central European core population at Lake Neusiedl (Benken & Raab 2008) and a strong population in northeastern Germany from 2002 (Brauner 2005) reveals a remarkable resemblance in climatic parameters (Tab. 2).

Neusiedl am See is situated in Austria at Lake Neusiedl in the western part of the Eurasian steppe belt and is subject to continental Pannonian climate. Whilst the mean annual precipitation of locality 1 in Kyrgyzstan and Neusiedl am See was almost identical below 600 mm, the mean annual temperature at locality 1, situated almost 1,300 m higher than Neusiedl am See, was lower.

The most striking difference, however, referred to a significantly wider temperature amplitude at locality 1. Both the highest mean temperature in July and the lowest temperature in January by far exceeded data from Lake Neusiedl. These differences indicate that a more severe continental climate might partly be the cause of higher synchronisation of emergence and a subsequent swarm aggregation. Climate data from the village of Brodowin (Tab. 2), situated at 52°N in Brandenburg, Germany, referred to a temporary population in 2002 from which several thousand individuals of *A. affinis* emerged (Brauner 2005). This population was located in one of the driest areas of Germany, with sub-continental climate, a mean annual precipitation below 600 mm, a quick warming up during spring, hot summers and relatively cold winters (Hendl 1995). Strikingly matching precipitation rates from all three localities indicate that a mean annual precipitation rate of 600 mm or lower might be the upper limit for the establishment of strong populations of *A. affinis* within its entire range. However, *A. affinis* is known for its ability to quickly colonize suitable habitats under favourable climatic conditions (Brauner 2005). Moreover, Schiel & Kunz (2005) also pointed out that areas with a higher long-term precipitation due to annual climatic fluctuations might offer suitable habitats for *A. affinis* over a certain period.

Climate at locality 1

Detailed knowledge about the history of locality 1 concerning its hydro-climatic regime (Fig. 7) on a micro scale is confined to only two years. The presented mass emergence occurred in 2009, which during summer was extraordinarily wet. In contrast, winter 2007/2008 accumulated little precipitation and the subsequent summer of 2008 in turn was extraordinarily dry and hot. At locality 1 in 2008, only a few dozen exuviae of A*. affinis* were collected and the total species' abundance within the entire study region did not even reach a small fraction of the abundance seen in 2009 at locality 1 alone. However, the question if, and to what extent, the preceding conditions caused by the dry winter 2007/2008 and the subsequent hot, dry summer accounted for the development of a mass population remains open. In any case the results showed clearly that mass emergences do not occur every year and are probably the result of coincident and complex interactions of several climatic parameters.

Table 2. Comparison of altitude and climatic key data of locality 1 in Kyrgyzstan with two Central European populations of *Aeshna affinis*: Neusiedl am See in Austria (47°56’55’’N, 16°50’35’’E) and Brodowin in Germany (52°55’2.63’’N, 13°57’44.06”E). – Tabelle 2. Vergleich klimatischer Basisdaten des Fundortes 1 in Kirgisistan mit denen zweier mitteleuropäischer Vorkommen von *Aeshna affinis*: Neusiedl am See in Österreich und Brodowin in Deutschland. ann. mean prec. annual mean precipitation, mittlerer Jahresniederschlag; ann. mean temp. annual mean temperature, mittlere Jahrestemperatur; m-t_{min} mean minimum temperature, mittleres Temperaturminimum; m-t_{max} mean maximum temperature, mittleres Temperaturmaximum.

locality	ann. mean prec.	ann. mean temp.	altitude a.s.l.	m-t_{min} January	m-t_{max} July
locality 1	547 mm	8.5°C	1,415 m	-11.6°C	29.2°C
Neusiedl a. S.	574 mm	10.1°C	135 m	-3.0°C	26.3°C
Brodowin	531 mm	8.3°C	63 m	-3.9°C	23.3°C

Causalities for the mass migration

Flight type 4 sensu Corbet (1999) has a subordinated dichotomy: ‘obligate’ versus ‘facultative’ migration. However, the assignment of *A. affinis* to one of these classes does not appear to be straightforward. According to Corbet (1999), the distinction between facultative and obligate migration is intrinsically insecure, as it is only based on negative evidence. Indeed, over its entire range *A. affinis* is considered to be widespread, but only moderately common and seldom abundant. Therefore, it hardly appears to be a candidate for regular spectacular mass migrations easily recognised by odonatologists. Single individuals or smaller swarms, however, might well migrate undetected with the same regularity as other species connected to obligate migration and typically specialised to temporary habitats that are subject to seasonal drought. In contrast, populations of facultative migrating species undertake migrations in some years but not in others, whereas migration at the level of individuals might happen every year. Species that fall in this category are centred in temperate latitudes. This pattern of migration is the most puzzling one of all types discussed above, and it is difficult to recognise an intermediate function or causal chain behind it, especially as the proximate cues inducing migration at irregular intervals are more or less unknown.

Several authors, however, assume that migration might be inhibited visually by a critically high population density (Fraenkel 1932; Dumont & Hinnekint 1973; Haritonov & Popova 2011). This assumption is based on synchronised emergence during rapidly rising temperature in spring, which is characteristic for spring species (Wesenberg-Lund 1913). Bernard & Samolag (1997) however analysed the complete emergence of a population of *A. affinis* in Poland in detail.

This population showed a remarkably high degree of emergence synchronisation (EM_{50} = 7). As triggering factor the mechanism of lower temperature thresholds sensu Corbet (1999) was assumed. According to Bernard & Samolag (1997) such a mechanism might be considered as typical for a species like *A. affinis*, which is connected to astatic habitats prone to drying out. However, even though at locality 1 in Krygyzstan no continuous data entry was possible due to the sheer masses of emerging individuals, the synchronisation rate appeared to be even higher than in the population described by Bernard & Samolag (1997). Compared to the number of exuviae that were collected at the peak of emergence on 23-vi-2009, only a small fraction of the total individuals emerged at the five sampling sites in the following days. Thus, although exuviae have not been collected systematically after 23-vi-2009, evidence suggests that half of the population had already emerged after three days. Such an EM_{50} value corresponds with typical obligate migrating species sensu Corbet (1999), like *Anax ephippiger*, specialised to take advantage of temporary habitats (Vonwil & Wildermuth 1990).

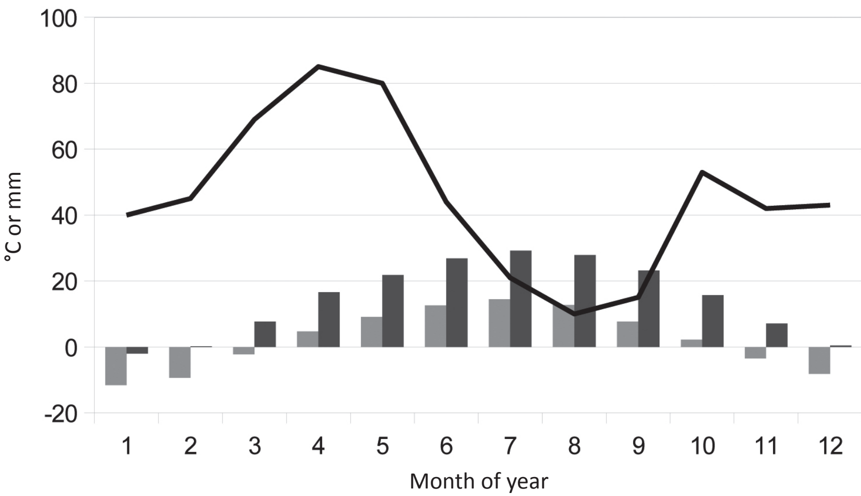

Figure 7: Mean monthly minimal and maximal temperatures and mean monthly precipitation at locality 1 in Kyrgyzstan, where mass emergence of *Aeshna affinis* occurred in 2009. – Abbildung 7: Mittlere monatliche Minimal- und Maximaltemperaturen sowie mittlerer monatlicher Niederschlag am Fundort 1 in Kirgisistan, wo es 2009 zu einem Massenschlupf von *Aeshna affinis* gekommen war. Reference, Quelle: Hijmans et al. (2005). ■ minimal temperature, Minimaltemperatur; ■ maximal temperature, Maximaltemperatur; ▬ precipitation, Niederschlag.

According to Peters (1985) synchronised emergence was characteristic for Mongolia, where in spring the temperature of the predominantly shallow and structurally monotonic water bodies in the desert rose rapidly. Here, representatives of the genus *Aeshna* frequently showed highly synchronised emergence and very high population densities. Thus, the tendency of a highly synchronised emergence might be generalized to areas with continental climate showing a sudden transition between cold winter and spring. Even though the climate of the region under study deviates considerably from the rest of southern Kyrgyzstan in being less severe continental, the range is still considerably higher than in Poland and elsewhere in Europe (Fig. 7, Tab. 2). In consequence, this also applies to two Central European localities with strong *A. affinis* populations, whose basic climate data are compared with locality 1 in Kyrgyzstan (Tab. 2).

Thus, the above stated differences may indicate that a more severe continental climate might in fact play a role in causing higher synchronisation of emergence and a subsequent swarm aggregation. Given the above mentioned connection between continental climate and tendency of synchronised mass emergence in regional Aeshnids (Peters 1985), it appears that it was not just pure coincidence that the first mass emergence and mass migration of *A. affinis* was encountered in Kyrgyzstan, a landlocked country with a severe continental climate.

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