On the distribution and status of the African monarch (*Danaus chrysippus* (Linnaeus, 1758); Lepidoptera: Nymphalidae) in Croatia

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Abstract: From 2004 onwards, the African monarch (*Danaus chrysippus* (Linnaeus, 1758)) has been recorded in the Neretva river delta, southern Croatia. Aside from the observation of several specimens, nothing about its biology, reproduction or status there has been known so far. All the previous specimens were recorded at the end of summer, while in spring and early summer no individuals could be observed in the area. During the autumn 2017, more than 50 individuals were seen on Neretva river delta, almost all of which could be described as fresh and freshly emerged. In 2018, oviposition, caterpillars and successful metamorphosis was observed in this species for the first time in Croatia. The hostplant in Croatia is *Cynanchum acutum* L. (Apocynaceae). As far as we can observe, *D. chrysippus* migrates to Croatia every year or every several years and produces several generations there. New data about its distribution and occurrence in Croatia and Bosnia & Herzegovina are provided.

Key words: Neretva, migrant, butterflies, *Cynanchum acutum*

Zur Verbreitung und zum Status des Afrikanischen Monarchfalters (*Danaus chrysippus* (Linnaeus, 1758); Lepidoptera: Nymphalidae) in Kroatien

Zusammenfassung: Seit 2004 wurde der Afrikanische Monarchfalter (*Danaus chrysippus* (Linnaeus, 1758)) immer wieder vom Neretva-Flußdelta in Südkroatien gemeldet. Bisher waren von dort aber nur Faltermeldungen, aber keine Beobachtungen zur Biologie, Fortpflanzung und zum Anwesenheitsstatus bekannt. Die früheren Falter fanden sich alle am Ende des Sommers, wohingegen aus dem Frühling und Frühsommer keine Beobachtungen vorlagen. Im Herbst 2017 wurden dann über 50 Falter im Neretva-Flußdelta beobachtet, die fast alle als frisch geschlüpft zu bezeichnen waren. Im Jahr 2018 wurden dann erstmals für Kroatien Eiablage, Raupen und erfolgreiche Entwicklung zum Falter beobachtet. Raupenfutterpflanze in Kroatien ist *Cynanchum acutum* L. (Apocynaceae). Soweit wir heute sagen können, wandert *D. chrysippus* jedes Jahr oder alle paar Jahre in Kroatien ein und produziert mehrere Folgegenerationen dort. Neue Daten zum Vorkommen in Kroatien sowie in Bosnien und Herzegowina werden gegeben.

Introduction

With the increase in the average temperatures during the last few decades, some of the tropical species are continuously moving into more temperate areas. The African monarch, *Danaus chrysippus,* has extended its range from Africa into Europe and colonized coastal parts of Spain, France, Italy, Greece and islands like Corsica, Sardinia, Sicily and Malta (Burton 2003). At present, it is also found in the Balkan Peninsula, from the southern coastal parts of Croatia and Bosnia & Herzegovina (Koren & Kulijer 2016), coastal regions of Montenegro and Albania across Greece and Turkey (Tshikolovets 2011). In Europe, most populations of *D. chrysippus* consist of rare primary migrations from Africa in years of great abundance (Leigheb & Cameron-Curry 1999).

The data from different Mediterranean countries across Europe indicate that this species has shifted its distribution toward the north only recently. In the Iberian Peninsula, *D. chrysippus* was firstly established in 1980 and ten years later, it had created several large metapopulations (Haeger 1999, Haeger et al. 2011). A drastic increase in occurrence has also been observed in Italy during the last 30 years, with the species being recorded in Sicily, Campania, Lampedusa, Sardinia, Isole Ponziane and in the regions Emilia-Romagna and Liguria (Borgo et al. 1992, Pisciotta et al. 2008). In Malta, this species was, for the first time, recorded in 1923, but mass migrations were firstly observed in the 1990ies (Agius 2014).

In the Balkan Peninsula, the exact status and phenology is not well understood. Usually it is present in temporary coastal colonies, with very few resident populations (e.g. Greece: Peloponnesus; Sotiris 2014). In Albania, it was first recorded in 1979, followed by the records in 1982 and 1988 (Luquet & Misja 1989, Gaskin 1990). In Montenegro, it was originally recorded on two localities, at Budva and Boka Kotorska, both in September 1988 and 1992 (Jakšić & Ristić 1999). The first observations in Croatia were made in 2001 when the species was seen on two locations on Mljet island (Kučinić et al. 2011) and in 2004 when it was observed in the Neretva river delta (Perković 2006). In 2016. it was again observed in Neretva river delta and the coastal areas of Bosnia & Herzegovina (Koren & Kulijer 2016).

Aside from several sightings, nothing about its migrations, biology and reproduction is known from the northern part of Balkan peninsula. The goal of this paper is to present new observations and the first observed reproduction success of *D. chrysippus* in Croatia.

Materials and methods

After the records in 2016 (Koren & Kulijer 2016), the Neretva river delta was regularly visited by the authors in order to assess the status of *D. chrysippus* in the area. In 2017 the area was visited in October, while in 2018 the visits become regular from early spring onward. We searched for the adults as well as for the caterpillars

and pupae on the potential larvae hostplants. For each observation, locality, date and the number of individuals was noted. In the localities where the adults were seen, we followed the females and if possible, checked for the oviposition. The metamorphosis of the caterpillar was observed in nature and under laboratory conditions. Six caterpillars were collected, and the metamorphosis of *D. chrysippus* has been followed in controlled conditions in the laboratory. After the emergence, the adults were sacrificed, mounted and stored in a private collection (Koren, Pazin). Aside from the Neretva river delta, we also visited ecologically similar coastal habitats on Pelješac peninsula and island Korčula in September 2018.

Results and discussion

Altogether, we were able to record *D. chrysippus* on 22 localities of which one lays in the border area of Bosnia and Herzegovina. Most of the localities, 13, are located within Neretva river delta, one on Pelješac peninsula and eight south of the Neretva river. The list of the localities containing the relevant toponyms, a short description of the habitat, altitude, coordinates, dates of the visits and observers are presented below. Localities are arranged in geographical order from north towards south (Fig. 1).

Abbreviations of observers: AS = Ana Štih; BI = Bariša Ilić; DD = Dubravko Dender; MM = Matea Martinović; TK = Toni Koren. — All elevations in m above sea level.

1. Komin, Dobruška glavica, on the road, 0 m, 43.037396° N, 17.484347° E: 27. x. 2018, 1 adult, TK, AS.
2. Komin, near the Komin bridge, road edge, 0 m, 43.031050° N, 17.468200° E: 28. viii. 2018, 1 adult, BI.
3. Opuzen, Neretva river delta, Galičak, 3 m, 43.024933° N, 17.46245° E: 9. x. 2017, 50 adults, TK; 30. viii. 2018, 20 adults, 3 L_3, 1 L_1, TK; 27. x. 2018, 3 fresh adults, TK, AS.
4. Neretva river delta, bird observatory, 0 m, 43.02321° N, 17.461788° E: 8.XI.2018, DD.
5. Neretva river delta, Komin delta, 0 m, 43.021453° N, 17.450721° E: 23. viii. 2018, DD; 2. ix. 2018, 11 adults, BI; 17. ix. 2018, 5 adults, several caterpillars, BI; 16. xi. 2018, 1 adult, BI; 7. xii. 2018, 1 adult, BI.
6. Neretva river delta, southern part 1, 0 m, 43.021345° N, 17.463177° E: 4. ix. 2018, 1 adult, DD.
7. Neretva river delta, southern part 2, 0 m, 43.019798° N, 17.464294° E: 9. viii. 2018, 2 adults, BI; 1. ix. 2018, adults, caterpillars, BI; 4. ix. 2018, 3 adults, L_5, pupal remains, DD; 6. ix. 2018, 7 adults, 2 pupae, 5 caterpillars, BI; 7. ix. 2018, 11 adults, BI; 17. ix. 2018, 3 adults, caterpillars, BI; 7. xii. 2018, 1 adult, BI.
8. Neretva river delta, southern part 3, 0 m, 43.019141° N, 17.464783° E: 4. ix. 2018, 1 dead adult, eggs, 2 L_5, small caterpillars, pupae, DD.
9. Neretva river delta, near the "Kamp Rio", 0 m, 43.014456° N, 17.468228° E: 4. ix. 2018, 2 adults, 1 L_5, DD; 9. ix. 2018, 7 adults, BI; 17. ix. 2018, 30 adults, 1 pupa, 17 caterpillars, BI.
10. Opuzen city, industrial zone, 0 m, 43.0136595° N, 17.5515392° E: 9. x. 2017, 2 adults, TK; 14. xi. 2018, 1 adult, BI.
11. Opuzen, Crepina, meadows near the river, 1 m, 43.006822° N, 17.5185265° E: 9. x. 2017, 3 adults, TK.
12. Neretva river delta, NW of Blace, 0 m, 43.003843° N, 17.471276° E: 4. ix. 2018, 1 adult, DD; 13. ix. 2018, 2 adults, 1 caterpillar, BI.
13. Opuzen, on the crossroad east of Pižinovac, 24 m, 42.9821334° N, 17.5409998° E: 9. x. 2017, 1 adult, TK.
14. south of Raba settlement, 158 m, 42.968050° N, 17.516810° E: 17. x. 2017, 1 adult, DD.
15. Viganj, west of the settlement, 25 m, 42.984776° N, 17.098694° E: 4. xi. 2018, DD.
16. Malostonski zaljev, 0 m, 42.870649° N, 17.699548° E: 17. x. 2017, 1 adult, DD.
17. Majkovi, surrounding of the pond, 218 m, 42.773605° N, 17.910874° E: 15. x. 2017, 1 adult, DD.
18. Orašac, Poljice settlement, 86 m, 42.697232° N, 18.020819° E: 13. x. 2018, 1 adult, MM.
19. Bosna & Herzegovina, Ivanica, SW part of the settlement, ruderal area, 386 m, 42.656667° N, 18.156111° E: 25. x. 2018, 1 adult, TK & MM.
20. Dubrovnik, Brsalje street, 16 m, 42.642112° N, 18.105941° E: 13. xi. 2018, DD.
21. Čibača, S of village Žitkovići, 30 m, 42.629312° N, 18.177965° E: 8. x. 2018, 1 adult, DD & MM.
22. Dunave village, 431 m, 42.541507° N, 18.410773° E: 14. x. 2018, 1 adult, DD.

In 2017, we observed specimens from the beginning till the end of October. In total, we observed more than 50 extremely fresh individuals on Neretva river delta and only several migrating specimens at the other localities. Butterflies were in a very good condition, suggesting that they emerged in the same area and they were not immigrants. At the same time, we also observed more than ten mating pairs of *D. chrysippus*, but no oviposition was noted.

In 2018, the first record was at 9. viii., while the last record was from 7. xii. In august of 2018, we observed fresh individuals, mating pars and oviposition in several localities within Neretva river delta. Females were quickly stopping and with smooth abdominal gesture laid single eggs on *Cynanchum acutum* L. leaves. The quick search of the plants revealed more than 20 caterpillars and pupae, first of which were recorded on 28. viii. (Fig. 2). Six caterpillars were collected and their development to pupae, as well as the metamorphosis into the adult was observed in controlled conditions. Our limited observations showed that the metamorphosis from the caterpillar to the adult butterfly lasts about seven days (the quickest was in six, the longest nine days). And while these observations are very preliminary, they are in accordance with the other observations from Europe (Pisciotta et al. 2008). This is the first evidence of the completion of its life cycle in Croatia.

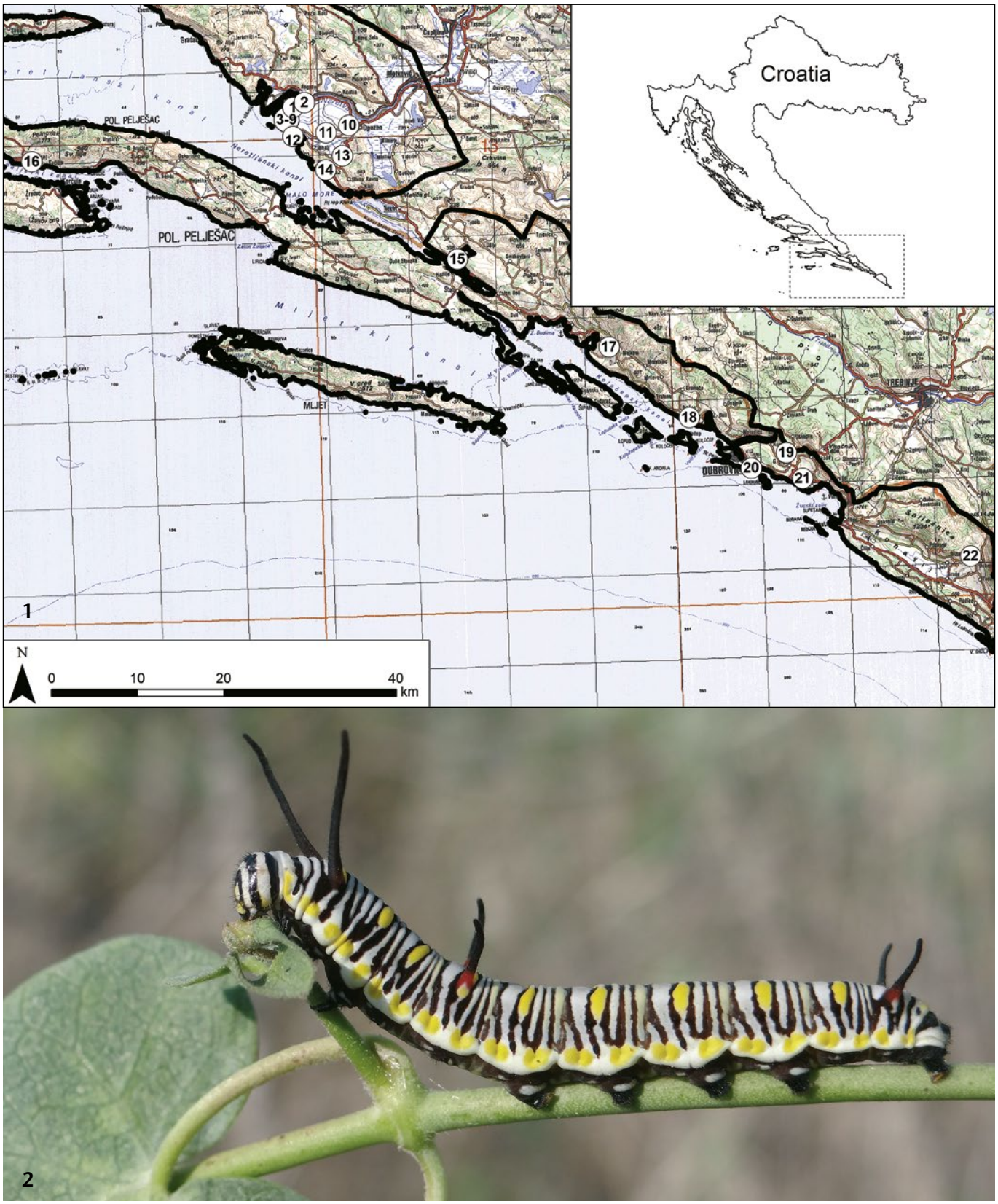

Fig. 1: Observations of *Danaus chrysippus* in Croatia in the years 2017 and 2018. Localities correspond to the numbers given in "Materials and methods" section. — **Fig. 2:** *Danaus chrysippus* caterpillar feeding on *Cynanchum acutum* in the Neretva river delta.

While the adults *D. chrysippus* were observed across the Neretva river delta, the caterpillars were observed exclusively in the narrow coastal area, and only on *C. acutum*. While *C. acutum* has been observed in the wider area of river delta, caterpillars were recorded only on the poorly overgrown parts of the habitats like embryonic shifting dunes. The usage of this plant for oviposition has already been observed in Italy (Zilli 1988) and Spain (Gil-T. 2006), but this is the first time that the oviposition was observed in Croatia.

Cynanchum acutum L. belongs to the family of milkweeds (Asclepiadaceae), and is one of many species of

this family used as larval foodplants by *D. chrysippus* (Tolman & Lewington 2008). In the Iberian Peninsula, it is one of the main foodplants for this species (Gil-T. 2006). In Croatia, *C. acutum* occurs only in the Mediterranean biogeographical region.

So far it is known from several historical localities; Pula, Crikvenica, Novi, Split, Trogir, Island Mljet and Neretva river delta, of which only the latest has been recently confirmed (Šegulja 2005). In the Neretva river delta, *C. acutum* is mostly confined to the narrow coastal zone, but can be plentiful, usually at the road verges or bushy hedges.

In the area, there is a very busy local road, one legal and one illegal camping site. Especially in the summer months, the area is strongly used for many sporting activities, which may indirectly have a negative impact on the habitat. On several localities around the road, on which *C. acutum* is plentiful, signs of anthropogenic impact are clearly visible. Some of them are even used as illegal dumping sites of building materials, and some are completely destroyed by parked cars or other vehicles. Aside from that, the natural succession of the sandy areas is occurring in many areas. The whole area where the specimens were observed belongs to the Natura 2000 site "HR5000031 Delta Neretve", and as such is under protections. Still, it would be beneficial to limit the human influence in the delta. This could easily be accomplished by limiting the access to the cars by putting fences on the road verges where *C. acutum* grows.

According to the Red book of vascular flora, *C. acutum* is endangered (EN) in Croatia (Šegulja 2005). The main threat to this species in Croatia is the reduction of wetlands in the Mediterranean area caused by anthropogenic interventions. As *C. acutum* was in the past recorded also on Pelješac peninsula (Kovačević & Jasprica 2000) and Korčula island (Jeričević et al. 2014), during this survey we visited several localities on both areas, but we were not able to find *C. acutum,* nor any stages of *D. chrysippus* on them. The observation of *D. chrysippus* from Viganj, Pelješac was done during a later visit to the peninsula, and only a single migrating specimen was observed. Accordingly, Neretva river delta remains the only locality for which we have a confirmed reproduction success.

While *C. acutum* is used as larvae host plant, due to its short vegetation period, it is not sufficient to maintain permanent colonies of *D. chrisippus* in the area. In addition, it does not maintain aerial biomass during the winter (John et al. 2015). In such areas other Asclepiadaceae hostplant are used for feeding purposes, and one of such *Periploca graeca* L., is also present in the Neretva river delta, but no caterpillars were found on it so far. This species is a known hostplant in Iraq (Abdul-Rassoul et al. 2012), but it is still not confirmed as a hostplant in Europe.

Our observations indicate that in the winter, spring and early summer *D. chrysippus* is not present in the river delta, probably due to the low winter temperatures. Migrating specimens most probably arrive from southern Europe in the mid-summer, and according to our observation produce several overlapping generations in the area. This was noted in the field, as fresh adults, worn adults, mating pairs, eggs, caterpillars and pupae were observed in the delta at the same time.

The extensive migrations were never previously observed in Croatia, but for the first time we observed individual migrating specimens. While the most numerous observations are always connected to Neretva river delta, we manage to record the migration of *D. chrysippus* on several localities along the coastal area of southern Dalmatia. Always only single specimens could be seen outside Neretva river delta, and they were in rapid flight or in feeding. While most specimens were observed on the coast, the record from village Dunave on the southern slopes of Mt. Sniježnica, is distanced about seven kilometres from the shore of the Adriatic Sea. It seems that during their migrations, butterflies are flying over the whole coastal and inner area of the shorelines.

From our observation and available data, it seems that a reproductive colony of *D. chrysippus* is present in Croatia only in Neretva river delta, and all the other observations, including the ones from Bosnia & Herzegovina, represent migrating specimens. Also, in the river delta its presence is not constant through the year but arrives in Croatia in August or a bit earlier (Kučinić et al. 2011), and is present in the area until the end of November/beginning of December. As the species has been observed in the area in 2004, and then regularly in 2016, 2017 and 2018, it is probable that this reproductive colony forms regularly in the Neretva river delta each year.

Caterpillars start to appear in mid-August and can be observed until November, which is in almost complete accordance with the observations from Spain (Gil-T. 2006). It is still not clear if the caterpillars can overwinter in the Neretva river delta. It seems that in Europe, only last instar adult caterpillars are able to overwinter, and only in most southern parts of the Mediterranean (Leigheb & Cameron-Curry 1999).

In the future, it would be interesting to visit similar habitats in southern Dalmatia, and revisit island Korčula and Pelješac peninsula in order to map the presence of *C. acutum* and check for the adults and caterpillars. Also, Mljet island should be revisited in order to see if the observations from 2001 (Kučinić et al. 2011) represented only casual migrations or in some coastal areas this species could also reproduce like in Neretva river delta. In the Neretva river delta, monitoring of the abundance and reproduction of this species during a much longer period is needed.

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