

## Distribution and life-cycle of *Nelima gothica* (Opiliones, Sclerosomatidae) in Danish dunes

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**Abstract.** Pitfall trapping in the National Park Thy, north-western Jutland, Denmark, in 2011 and 2013 revealed 3654 specimens of the harvestman *Nelima gothica*. In most European countries, including Denmark, this species has been considered rare and little information is available on its biology. The species was found predominantly in the yellow dune habitat close to the North Sea coast. Here it could be either very abundant or completely absent at localities only a few kilometres apart. It also occurred in lower numbers in the grey dunes and the dune heathland, and was rare in managed grassland; it disappeared from habitats further inland. In the yellow dunes high numbers were recorded especially in rather dense *Ammophila arenaria* vegetation not disturbed by sand shifting. The phenology follows the typical pattern of North-European Phalangidae and Leiobuninae: an annual life-cycle with juveniles developing through late spring and summer months, reproduction in autumn and hibernation in the egg stage. The findings suggest that *N. gothica* may be found all along the coastal dunes of western Denmark and possibly the Wadden Sea area, though it may only locally reach high abundances. Earlier records also included the coasts of eastern Denmark.

**Keywords:** dune habitat, distribution, harvestman, life cycle, phenology

**Zusammenfassung. Verbreitung und Lebenszyklus von *Nelima gothica* (Opiliones, Sclerosomatidae) in dänischen Dünen.** Mit Bodenfallen wurden im Nationalpark Thy (Nordwestjütland, Dänemark), in den Jahren 2011 und 2013 3654 Exemplare des Weberknechts *Nelima gothica* erfasst. In Dänemark wird die Art, wie in den meisten europäischen Ländern, als selten eingestuft und es ist bisher nur wenig über ihre Biologie bekannt. *Nelima gothica* wurde in hoher Abundanz in Weißdünen der Nordseeküste – insbesondere in dichtem *Ammophila arenaria*-Bewuchs, der nicht durch Sandumschichtung gestört wurde – gefunden, fehlte aber im selben Habitat nur wenige Kilometer entfernt. In geringerer Anzahl kam die Art in Graudünen und Dünenheiden vor und nur selten im genutzten Grünland; in weiter im Inland gelegenen Habitaten war sie nicht zu finden. Die Phänologie entspricht dem typischen Muster der nordeuropäischen Phalangidae und Leiobuninae: ein einjähriger Lebenszyklus mit Entwicklung der Jungtiere vom späten Frühjahr bis in die Sommermonate, Fortpflanzung im Herbst und Überwinterung als Eistadium. Die Funde legen nahe, dass *N. gothica* überall in den Küstendünen von Westdänemark und möglicherweise in der Wattenmeerregion vorkommt, auch wenn sie nur lokal hohe Abundanzen erreicht. Frühere Nachweise liegen auch von der dänischen Ostküste vor.

*Nelima gothica* Lohmander, 1945 (Fig. 1) occurs over most of Western and Central Europe and is characterized as an “Atlantic” species (Martens 1978). Little is known about its biology because of its patchy distribution and generally low abundance. Its preferred habitat is described as “open forests near running waters” (Martens 1978) or coastal grassland (Brown & Sankey 1950). From Denmark Meinertz (1964a) found it mostly synanthropically. During a study of the arachnids of the National Park Thy in north-western Jutland, Denmark, I collected a considerable number of individuals of this species (Toft 2013). Pitfall traps were operating in all the 15 major habitat types of the area, which allowed me to define the



Fig. 1: *Nelima gothica*, female (Photo: S. Toft)

species' main habitat (coastal yellow dunes) as well as its overall habitat range. Subsequent trapping in the yellow and grey dunes of the national park covering



several localities revealed much further material. As traps were run over a full year in some of these locations, this new material also provides detailed information on the phenology of the species. This paper reports information from both studies as well as from less systematic supplementary material.

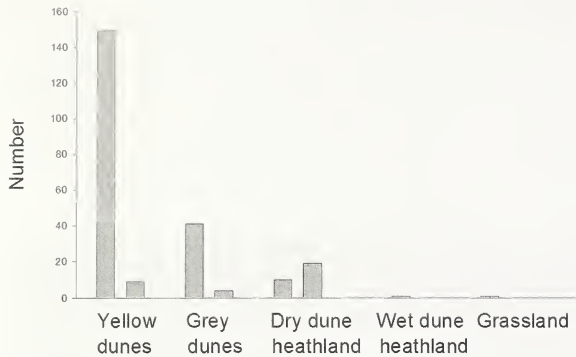
### Study area and methods

The National Park Thy is situated at the north-western corner of Jutland, Denmark (see Fig. 5) bordering 50 km of the North Sea coast. Due to this position the habitats follow an ordered sequence from the west and inland to the east: landside of the sandy



**Fig. 2:** **A.** Yellow dune. Hanstholm Reserve south. **B.** Grey dune. Hanstholm Reserve south (Photos: S. Toft)





**Fig. 3:** Comparable trap catches of *Nelima gothica* in various dune habitats along west-east transects in the National Park Thy, Denmark. Data from Toft (2013) except the grassland record. Each bar represents a separate locality; the grassland site was approximately 2 km from the sea. The sampling also included pine and spruce plantations, fresh wetlands, limestone slopes, managed meadows and cultivated fields further from the coast (two localities of each), but the species was not recorded in any of these.

beach are the yellow dunes, then the grey dunes, followed by dune heathland; the latter may be dry *Calluna/Empetrum* heathland or wet *Erica tetralix/Myrica gale* marshland in depressions. Coniferous plantations and managed meadows follow further inland. Collections in 2011 included all available habitat types (15 in all; for details see Toft 2013). Each habitat type was represented by two localities (one in the north and one in the south of the national park); each locality was sampled with 3 pitfall traps; and sampling was restricted to two periods: spring (mid May – June) and autumn (October – mid November).

Collections in 2013–14 concentrated on the yellow and grey dunes. Yellow dunes constitute the outer sandy formations from the beach and 20–100 m inland (Fig. 2A). They are covered by rather homogeneous grass vegetation, mostly marram (*Ammophila arenaria*). Strong westerly winds often cover exposed parts of the dunes with sand blown in from the beach; these areas will have lower vegetation density and height. Grey dunes only occur further inland. The dune hills were originally formed by shifting sand (often as parable dunes). They may be covered by a mosaic of vegetation types including both grey dune and heathland (*Calluna vulgaris*, *Empetrum nigrum*) vegetation (Fig. 2B). Grey dune vegetation is poor (though rich in species) and often with much

bare ground; it may consist of scattered *Ammophila arenaria*, *Carex arenaria*, or low carpets of moss or lichens. In the context of the present investigation, grey dune includes southfacing slopes with poor vegetation cover and blowouts in various stages of vegetation recovery (from bare sand to complete cover of mosses and lichen), but dwarfshrub (heathland) patches were avoided. All localities are at altitudes of 5 – 25 m above sea level. Sampling was done at 16 localities distributed over the national park. Of these, 8 were in yellow dunes and 8 in grey dunes. Three yellow and three grey dune sites were sampled throughout a full year (March 2013 – April 2014) with 20 traps at each site; they are termed “main study sites”.

At the yellow dune sites, 10 traps were situated on exposed spots with recent sand shifting, i.e. the marram vegetation was low and scarce and a considerable proportion of the ground was bare sand; the other 10 traps were placed in more mature, dense marram vegetation with no recent sand shifting and with subsequent accumulation of marram litter. No systematic habitat difference existed between the grey dune trap sites. Five yellow dune and 5 grey dune sites were each sampled by 10 traps operating for one month in spring (mid May – mid June), one month in summer (mid July – mid August), one month in early autumn (mid September – mid October) and one month in late autumn/winter (mid November – mid December); these are termed “supplementary study sites”. At all sites the traps were placed in lines parallel to the coast with a distance of 5 m between them. They consisted of double plastic beakers, 8.5 cm in diameter and 11 cm deep, covered by a wooden roof. A concentrated salt solution with detergent was used as preservative and the traps were emptied twice per month.

Samples providing additional material for the distribution map included hand-collected material from yellow dunes along the Danish west coast from the northern tip of Jutland to the Wadden Sea in the south (2014). The collections in Thy showed that *N. gothica* had its main occurrence in the yellow dune and that it occurred abundantly at several localities in the National Park. Since yellow dunes form a nearly continuous belt along the whole North Sea coast of Jutland, it was hypothesized that the species might have a more extended distribution in this habitat. Adults as well as juveniles were identified in order to reveal the life cycle. To describe the development and (if possible) distinguish the juvenile instars, two mea-

**Tab. 1:** Total pitfall trap catches (females/males/juveniles = total) of *Nelima gothica* in the National Park Thy, Denmark in 2013. On some localities traps were operated in habitat pairs, i.e. the grey dune site was placed a few hundred meters inland of the yellow dune site. Numbers were not adjusted for difference in trap numbers or trapping period (Whole year: March 2013 – April 2014; Partial: one month in spring, summer, autumn and winter 2013). Localities are listed from north to south.

Locality	# traps	Trapping period	Yellow dune		Grey dune	
			Position	Nos. caught	Position	Nos. caught
Hanstholm Reserve, north	20	Whole year	57°04'48"N 8°33'03"E	0	57°04'51"N 8°33'22"E	1/0/0= 1
Hanstholm Reserve, south	10	Partial	57°03'32"N 8°31'57"E	352/914/161= 1427	57°03'42"N 8°31'38"E	3/8/1= 12
Klitmøller	10	Partial	57°01'24"N 8°27'20"E	7/5/11= 23	57°01'04"N 8°28'10"E	4/5/1= 10
Hans Broges Bakker	10	Partial		–	56°59'47"N 8°30'17"E	0
Bøgested Rende	10	Partial	56°58'43"N 8°24'15"E	623/489/85= 1197		–
Nr. Vorupør	10	Partial		--	56°57'19"N 8°24'06"E	1/2/3= 6
Stenbjerg	20	Whole year	56°55'36"N 8°20'04"E	122/255/22= 399	56°55'31"N 8°20'17"E	26/32/6= 64
Lyngby	10	Partial	56°52'36"N 8°17'22"E	54/127/89= 270	56°52'37"N 8°17'31"E	7/3/0= 10
Lodbjerg Klint	10	Partial	56°48'47"N 8°14'49"E	0		–
Lodbjerg Klint	20	Whole year		--	56°48'38"N 8°15'07"E	0/0/1= 1
Agger Tange	20	Whole year	56°46'13"N, 8°13'46"E	0		–
TOTAL				3316		104

surements were taken with a binocular micrometer: the length of the chelicerae and the length of the tibia of the first leg (Tibia I). Two other sclerosomatid species were present in the habitats (*Leiobunum rotundum* and *L. blackwalli*) and similar measurements were taken from adults and juveniles of these. Both *Leiobunum* species had relatively much slimmer tibiae than *N. gothica* in all stages. The material is in the private collection of the author.

## Results

In 2011, 234 specimens of *Nelima gothica* were collected from various habitats in the National Park Thy (Toft 2013). Additional material from yellow and grey dunes comprised 3420 individuals in 2013. *N. gothica* thus turned out to be a quite abundant species in the area. Numerically it was the 4th most abun-

dant opilionid in the total trap catches of 2013, surpassed only by *Phalangium opilio*, *Oligolophus tridens* and *Paroligolophus agrestis*. At two of the localities it was the second most abundant harvestman (after *P. opilio* and *O. tridens*, respectively).

**Habitat distribution.** The 2011 data indicated yellow dunes as the main habitat of *N. gothica* (Fig. 3). The species occurs also in some numbers in the grey dunes and in dry *Calluna/Empetrum* heathland. It becomes rare in the wet depressions of the dune heathland and managed grassland up to 3 kilometres from the sea, and it is missing completely in other types of habitats further inland. However, the very different catches at the two yellow dune localities (and similarly, though less so, at the grey dune localities) indicated considerable local variation in the abundance of the species.

Both the main distribution pattern and the patchiness are further strengthened by the 2013 catches. As the total trapping intensity in the yellow and grey dunes was the same, the summed numbers can be directly compared (Tab. 1). Overall, 3316 *N. gothica* individuals were caught in the yellow dunes and 104 in the grey dunes. At some sampling sites the species was absent and at some it was present, and this was true for both yellow and grey dune sites. Notice that in spite of the strong numerical preponderance in yellow dunes, it was actually more often absent from yellow than from grey dunes. At four of the yellow dune sites it was abundant; at two of these it was extremely abundant (both of these were supplementary sites, where the traps were not in operation during all of *N. gothica*'s life cycle). There was no obvious geographical pattern in abundance, and sites close to each other could have very different abundances. Thus, the two yellow dune sites in the Hanstholm Reserve, situated approximately 6 km from each other and connected by a continuous stretch of yellow dune habitat, produced 0 and 1427 individuals, respectively. Also, the site at Klitmøller with a low population is situated between the two sites with extreme abundance.

Only one of the three main yellow dune sites housed *N. gothica*. Here only 5 specimens were caught in the open marram vegetation (traps 1-10) against 397 in the dense marram vegetation (traps 11-20). The line of traps in the open vegetation was situated on a westerly exposed slope in low *Ammophila* only 5 m from the edge to the beach, whereas the traps in the dense vegetation were 20 m further inland and on the eastern (leeward) side of a dune. My hand collections also indicated that *N. gothica* is more abundant where *Ammophila* forms dense stands with accumulation of humid litter on the sand surface below.

**Life cycle.** The phenology of *N. gothica* is of the same type as most other phalangoid species of northern Europe (Todd 1949, Meinertz 1964c, Gnaspi 2007): eggs laid in the autumn hibernate and hatch in spring; the young develop through the juvenile instars and reach maturity in late summer. Locomotor activity of the adults peaks at the end of September (yellow dunes) or early October (grey dunes). The year's generation fades away in early November. Assuming the species has 6 juvenile instars, as is typical for sclerosomatids (Edgar 1971), all seem to be represented in the trap samples; instar I only by a

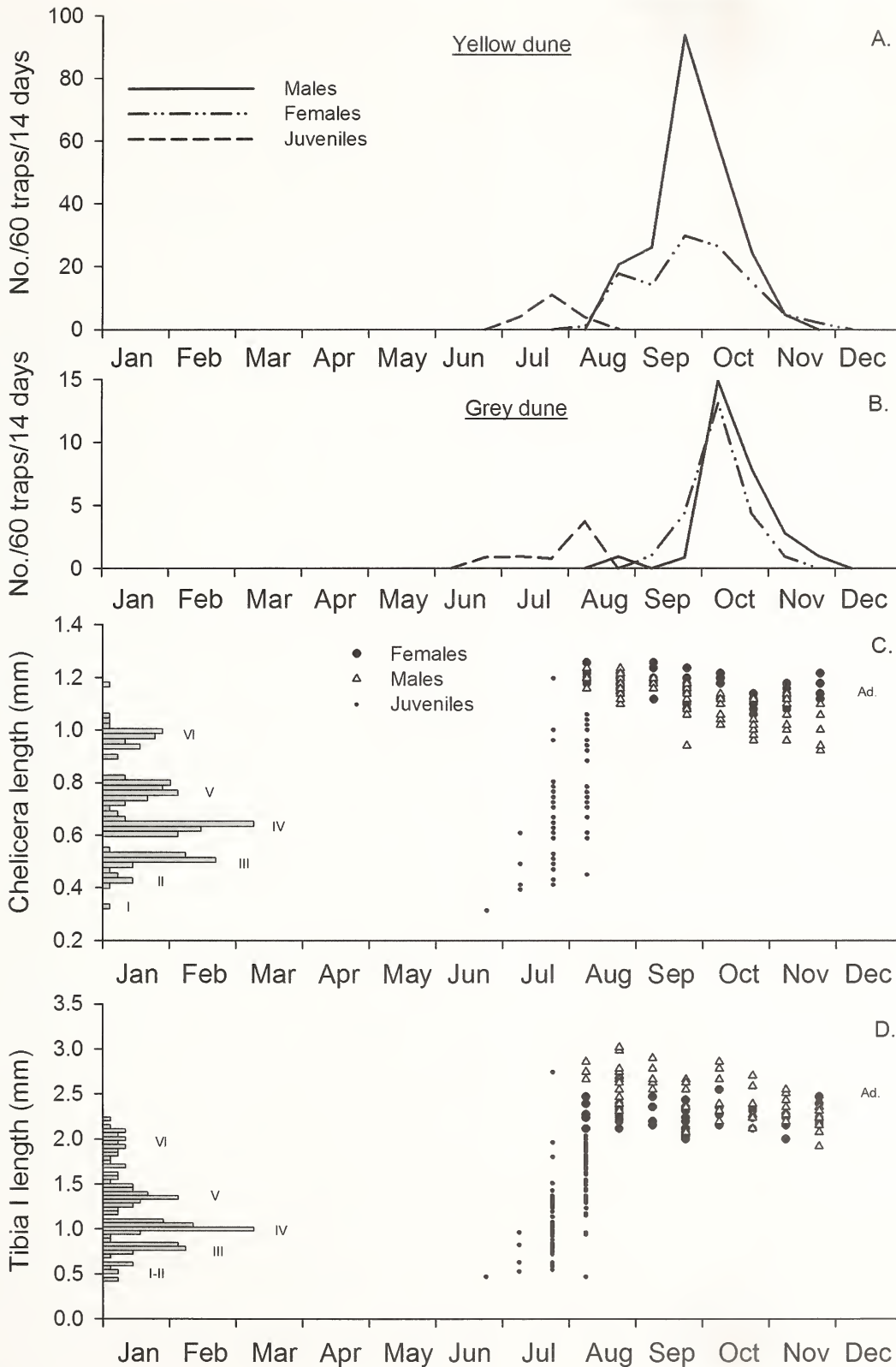
single individual, though, and clearly recognizable only from the cheliceral measurements (Fig. 4C-D). Because of this scarcity of small individuals the precise time of egg hatching cannot be pinpointed, but may be as late as mid-June (Fig. 4C). Juvenile development takes place during the following two months, and the whole cohort has reached maturity by mid-August. By December they have disappeared again after having reproduced. The peaks of juvenile, male and female activity are all one trapping period later in the grey dunes than in the yellow dunes (Fig. 4A-B).

Measurements indicate that length of the chelicerae is better to distinguish between the instars than tibia I length. The distribution of cheliceral measurements shows clear mountains and valleys that fit the expected number of instars (Fig. 4C) whereas this is much less the case with the tibial measurements (Fig. 4D). The size measurements of the adults show a decreasing trend over the season for both chelicerae and tibia I. The detailed pattern varies between the sexes. Overall, females have longer chelicerae than males, but males have longer tibiae than females. The chelicerae decreased in size in both sexes, but more strongly so in the males (Tab. 2). The tibiae decreased only in the males and were constant in the females.

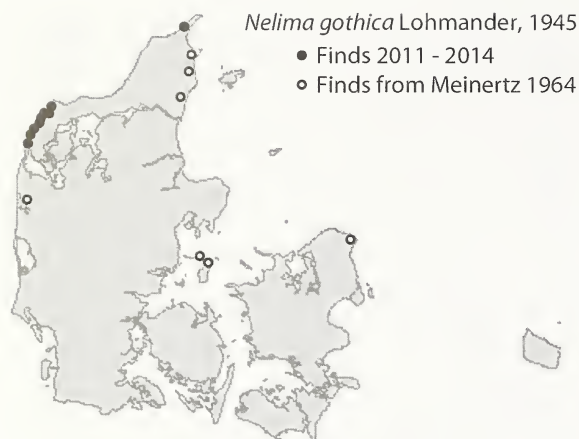
**Danish distribution.** The current distribution map of *N. gothica* in Denmark (Fig. 5) shows a strong concentration of the species along the coast of the district of Thy due to the records in the present study. These results suggest to me that the species might be present all along the Danish west coast. My one-hour hand-searches for it in the yellow dunes of 10 localities distributed along this full stretch (from the north: Kandestederne, Tornby Strand, Blokhush, Slettestrand, Bulbjerg, Vedersø Klit, Søndervig, Bjergeborg Strand, Blåvandshuk, Fanø) revealed its occurrence only at one place, i.e. at the northernmost locality (Kandestederne). However, as shown by the records from Thy, the species can be widely distributed at low densities. It is therefore likely that the species does occur along the whole coastline, but that trapping or much more intensive searching is needed to reveal its existence.

The former records from Meinertz (1964b) are also included in the map. They indicate a much wider Danish distribution. Notice, however, that though these are allegedly from "synanthropical habitats" (Meinertz 1964a), they were all taken near the coast. Thus, there is no evidence for true inland





**Fig. 4:** The life cycle of *Nelima gothica* in Denmark (National Park Thy). (A-B) Pitfall trap catches from yellow dunes (A) and grey dunes (B). Data are combined from 3 localities of each dune type (20 traps each), but the species was found in numbers on only one of each. (C-D) Size measurements of selected specimens in relation to season (C: chelicera length; D: Tibia I length). Bar plots along the ordinate show distribution of all juvenile individuals measured, indicating approximate instar separation.



**Fig. 5:** Distribution map of *Nelima gothica* in Denmark. The concentration of dots at the north-western corner of Jutland depicts the position of the study area (the National Park Thy).

distribution of the species in Denmark. They were probably collected on house walls in disturbed grassland. My own grassland record (Fig. 3) was from a similar place, i.e. a trap placed along the walls of a summer house.

## Discussion

In the National Park Thy *N. gothica* is a strictly coastal species that reaches maximum abundance in the habitat nearest to the sea, i.e. in the yellow dunes. Its numbers gradually decrease going into inland habitats: it is well represented in the grey dunes and the dune heathland, but only in very low numbers in

other habitats only a few kilometres further inland. The coastal affinities of the species have been recognized previously (Martens 1978), but its European distribution shows that it is by no means restricted to seaside habitats. Thus, the distribution maps from the UK (<http://srs.britishtspiders.org.uk/portal/p/Summary/s/Nelima+gothica>) and Germany (<http://www.spiderling.de/arages/Verbreitungskarten/species.php?name=Nelima%20gothica>) show no concentration of finds near the sea. The UK website mentions “walls” in “gardens and parks” as habitats for many finds. Clearly *N. gothica* is not exclusively a coastal species. It remains to be seen whether it has a broad habitat niche or, perhaps more likely, it is diplo-stenoeious, i.e. occurs in two (to the human eye) distinct habitat types; such a distribution has been described by Komposch & Gruber (2004) for other harvestman species. So far high population densities have only been reported from coastal grassland habitats.

In spite of the seaside habitat (yellow dunes) being obviously the core habitat of *N. gothica* in the area, very high densities were reached only in parts most protected from natural disturbances that primarily characterizes this habitat, i.e. from strong westerly winds and sand shifting. The denser vegetation here is likely to offer greater resistance to ground activity than the open yellow dune or grey dune vegetation. The concentration of the species in the dense vegetation therefore is possibly even higher than the data indicate. Successful hand-collecting took place at spots with rich accumulation of humid litter, and the animals were found only after “digging” through the top vegetation into the litter. Traps in the open areas may be reached mostly during night time activity. Apart from that, it is difficult to pinpoint the exact habitat requirements, because the species is absent from yellow dune localities that cannot superficially be distinguished from those where it abounds. From the British island of Skokholm, Brown & Sankey (1950) reported a situation similar to the one described here: *N. gothica* abounded in rich rather than open *Festuca* grassland on rocky ground and it could reach very high densities.

As expected, the life cycle of *N. gothica* turned out to follow the pattern of northern temperate Phalangidae and Leiobuninae (Martens 1978) with a very fast developmental phase in spring and early summer, followed by autumn reproduction and hibernation at the egg stage. The decreasing size of adults during

**Tab. 2:** Statistical analysis of measurements of chelicera length and tibia I length of *N. gothica* in relation to sex and season (unit = ½ month). D.f. – Degrees of freedom; F – F-ratio; n.s. non-significant; \*\*  $P < 0.01$ , \*\*\*  $P < 0.0001$

	D.f.	F	Male slope	Female slope
Chelicerae – whole model	3,111	49.1***		
Sex	1	54.4***		
Season	1	65.1***	-0.0266***	-0.0068**
Sex*season	1	22.7***		
Tibia I – whole model	3,108	33.6***		
Sex	1	55.2***		
Season	1	30.4***	-0.0725***	-0.0058 <sup>n.s.</sup>
Sex*season	1	22.1***		

the autumn may need consideration. The data (Fig. 3C-D) indicate that all subadults become adults over a very short period of time, i.e. a synchronous maturation. This seems to rule out the possibility that the small adults late in the season are slow-developing latecomers that take over after the fast-developing early individuals have ended reproduction. However, the alternative explanation, that large individuals reproduce first, disappear and leave the scene for the smaller ones, also seems to be contradicted by the complete lack of small individuals early in the adult period (unless these individuals postpone their activity). A final answer to this question cannot be given here.

My searches for *N. gothica* along the Danish North Sea coast were not particularly successful. Probably, a one-hour hand-collecting effort is too little to reveal the presence of the species, unless one happens to hit one of the “hot-spots” of high abundance. Even in the National Park Thy some localities lack the species completely, and at others it is so rare that a substantial trapping effort is needed to reveal it. I therefore find it likely that the species occurs in local populations along the whole Danish west coast and on the Friesian Islands of the Wadden Sea, where similar dune formations to those in Thy exist. According to Meinertz (1964b) *N. gothica* also occurred along the coasts of eastern Jutland and the Danish islands. No similar records exist from recent years and a considerable collecting effort (as that of Meinertz (1964a, 1964b) himself) may be needed to reveal whether the species is still present here.

## Acknowledgements

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