

An analysis of feeding and optimal foraging behaviour in the solpugid *Eremobates mormonus* (Roewer) (Solpugida, Eremobatidae)

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Summary

Field observations and laboratory studies were conducted on the prey species captured by the solpugid *Eremobates mormonus* (Roewer), from Trans Pecos, Texas. Its natural diet consists primarily of insects (79.5%) and spiders (20.5%). Orthopteran insects comprised 39.7% of the total prey items, followed by spiders (20.5%), Lepidoptera (17.9%), Coleoptera (14.1%), and Heteroptera (7.7%). These solpugids prefer smaller, soft-bodied prey. Well-defended arthropods such as scorpions, millipedes, ants, velvet ants and blister beetles were avoided. Hunger level affects several parameters of feeding in *E. mormonus* including percent capture rate and overall ingestion time. Ingestion time decreases significantly as food deprivation levels increase from 6 to 72 h, whereas successful prey capture rates increase (5–65%). Prey preparation as an important component of handling time is demonstrated for the first time in a solpugid. Prey body parts characterised by high chitin content (33.7–56.3%) such as the head capsule, antennae, wings, forelegs and midlegs are selectively removed before ingestion. Head capsules were removed in 68–91% of the feeding trials, depending on prey size, followed by forewings (78%) and hindwings (66%). Body parts (thorax, abdomen, hind femur) possessing lower amounts of chitin (11.5–21.2%) are processed and ingested, supporting the nutrient concentration hypothesis.

Introduction

Solpugids represent an important component of the arachnid fauna inhabiting arid regions (Muma, 1967). Although the predatory nature of the Solpugida is well known (Muma, 1966; Cloudsley-Thompson, 1977), no detailed studies or observations have been conducted concerning the dietary preferences of solpugids in the field or the foraging behaviour of these arachnids. Muma (1966), however, provided some general information on ingestive behaviour, location of potential prey and reactions elicited by prey items in the laboratory, but no data are available concerning prey items captured under natural conditions or parameters associated with handling time. Wharton (1987) showed that *Meta-solpuga picta* (Kraepelin) is a generalist predator that feeds on a variety of arthropods.

It has been established that predators frequently ingest only certain parts of their prey and often exhibit marked preferences for specific tissues and body regions (Haynes & Sisojevic, 1966; Curio, 1976; Sih, 1980; Punzo, 1989, 1992). For example, insectivorous birds frequently remove the head capsule, legs and wings before selectively swallowing the abdomen and thorax (Sherry & McDade, 1982). Some thomisid, araneid and lycosid spiders preferentially ingest the softer tissues of an insect's abdomen while rejecting other body regions depending on the degree of satiety (Haynes & Sisojevic,

1966; Nentwig, 1987; Punzo, 1991). In addition to the selective removal of body parts, some insectivorous mammals and birds will modify (usually by some form of mastication) specific prey parts before ingestion is initiated (Curio, 1976). This has also been reported for a few arthropod predators such as decapod crustaceans and mantids (Krebs & McCleery, 1984). Although this type of behaviour, known as prey preparation, increases overall handling time, it may optimise overall energy budgets by targeting the ingestion of those prey body parts that possess a higher concentration of digestible nutrients (nutrient concentration hypothesis) (Hespenheide, 1973; Kaspary, 1990). One way for insectivores to maximise foraging bouts would be to reject prey parts high in chitin content. Chitin is either indigestible or poorly digested by insectivores in general (Scott *et al.*, 1976).

Most of the previous research on optimal foraging has focused on energy expenditure associated with search, pursuit, capture and ingestion of prey (Charnov, 1976; Lucas, 1983; Punzo & Garman, 1989), whereas prey preparation has received little attention (Kaspary, 1990). The few studies that are available focus on vertebrates (see reviews by Curio, 1976; Krebs & McCleery, 1984; O'Brien *et al.*, 1990). In this study, I examined the following parameters associated with feeding and optimal foraging in the solpugid, *Eremobates mormonus* (Roewer): (1) prey species captured in the field; (2) dietary preferences based on prey size and hardness of prey cuticle; (3) percent capture success as a function of hunger level (food deprivation); (4) the effect of hunger level and predator size on ingestion time; (5) the relationship between chitin content and prey preparation. This is the first demonstration that solpugids make decisions concerning which prey parts should be ingested.

Methods

Adult males (21–24 mm, total body length), females (22–26 mm) and immatures (<10 mm) of *Eremobates mormonus* were collected as they wandered on the ground surface at night during May–August, 1992. Solpugids were collected within a 12 km radius of Alpine, Texas (Brewster County), which lies within the northern region of the Chihuahuan Desert (Big Bend region of Trans Pecos Texas). A detailed description of the geology and vegetational zones of this region is given by Tinkam (1948). A helmet-mounted light with a red filter was used to locate and observe solpugids as they moved across the substrate. Each animal was captured and examined for identification according to Muma (1951). A total of 521 adult solpugids were observed, 78 of which (15.0%) had a prey item in their chelicerae. The prey from each solpugid was placed in alcohol for subsequent identification (Table 1).

Since adult females were encountered more frequently than males, subsequent laboratory studies were conducted on females. Solpugids were transported back to the laboratory and housed individually in clear plastic containers (20 × 15 × 6 cm). They were provided with

water on a weekly basis and fed on a diet of mealworm larvae (*Tenebrio molitor*) and crickets (*Acheta domestica*). These prey items were chosen because they are readily acceptable to solpugids (Punzo, 1994) and are not found at the collection sites, thereby minimising any choice bias from confounding subsequent prey acceptability studies. Solpugids were maintained at $23 \pm 1^\circ\text{C}$ and 70–80% relative humidity as described by Punzo (1994).

Adult female solpugids were selected at random for an analysis of dietary preferences as reflected by prey species actually captured and ingested. All prey species used in these experiments were collected from the same location as the solpugids. The experimental procedure used was identical to the protocol described by Young (1989) and Punzo (1991). Solpugids were deprived of food for 72 h before testing. Individual solpugids were placed in a clean plastic container ($15 \times 10 \times 5$ cm) which served as a test chamber. Organisms of different taxa and size classes (Table 2) were used as prey items. An individual prey organism was placed in the centre of the container with a solpugid, and the status of the prey (captured and ingested or rejected) was recorded after 24 h. Each type of prey was offered once to each of 20 different solpugids. In order to minimise any effects of experience, prey of the same species were never presented consecutively, as suggested by Nentwig (1987). All feeding trials were recorded using a Cine-8 high speed video camera (Visual Instrumentation Corp.) at 100 frames/sec. A Lafayette Super 8 Analyzer (Model 1026) was used for frame-by-frame analysis as described by Punzo (1989).

I also conducted a series of experiments to determine the effects of hunger level on percent capture success (Table 3). Twenty different solpugids were tested individually at each of four levels of food deprivation (6, 24, 48 and 72 h) according to the method described by Punzo (1989). A runway apparatus was employed (Punzo, 1989) in order to standardise test trials. The runway ($24 \times 8 \times 6$ cm) was constructed of clear plexiglass. The solpugid was placed in a holding chamber ($9 \times 10 \times 6$ cm) in a forward-facing position at one end of the runway. The prey species (*A. domestica*) was placed in a compartment ($5 \times 8 \times 6$ cm) provided with a restraining door at the opposite end of the runway. Solpugids were allowed to habituate to the holding chamber for 15 min before the start of test trials. The degree of hunger was defined as the time (h) elapsed since the last feeding, according to Dethier (1982). At the start of each trial, the restraining door of the prey compartment containing the cricket was lifted manually and a gentle stream of compressed air was introduced through an intake valve leading to the back of the prey compartment. In response to the air flow, the cricket would immediately begin to move into the runway towards the solpugid positioned at the opposite end. The percent capture success was recorded for all trials; each trial lasted until the cricket came into contact with the predator. A capture attempt was considered to be successful if the solpugid firmly grasped the cricket in its chelicerae and began to ingest the prey. An attempt was

considered a failure if the solpugid missed the cricket entirely or if the prey was grasped only momentarily before it escaped.

Experiments were conducted to determine the effects of hunger and predator size on the amount of time required to ingest a single cricket weighing 0.23 ± 0.04 g. Two predator size classes (mean body length 9.1 mm, weight 0.57 ± 0.02 g; and 23.1 mm, 1.53 ± 0.19 g), each comprising 20 different solpugids, were deprived of food for 6, 24, 48 and 72 h before testing. The time (min) required for each solpugid to ingest the prey was recorded (Table 4). Ingestion time was defined as the amount of time that elapsed between the initial grasping of the prey and the subsequent discarding of undigested cuticular fragments (Punzo, 1989). Each solpugid was tested only once in order to minimise the effects of experience.

During the course of these feeding experiments, I observed that these solpugids would selectively remove certain prey body parts during ingestion (prey preparation). This led me to conduct experiments designed to assess the relationship between prey preparation and the chitin content of various prey body parts. For these experiments, I chose the grasshopper *Boettia argentatus* as the prey species for all feeding experiments. This insect is fairly common at the sites where *E. mormonus* was collected (personal observation) and exhibits a similar temporal activity pattern to this solpugid. Specimens of *B. argentatus* were brought back to the laboratory for subsequent use in feeding trials and chitin content analyses.

Grasshoppers were separated on the basis of two prey size classes: (1) small: total body length (TBL) 10–12 mm, body weight (BW) 0.29 ± 0.01 g; (2) large: TBL

Prey taxon	Number of prey items
Arachnida	
Araneae (20.5)	
Lycosidae (A)	12
Undetermined (A)	4
Insecta	
Orthoptera (39.7)	
Acrididae (A, N)	21
Gryllidae (A)	3
Tettigoniidae (A)	1
Undetermined (A)	6
Lepidoptera (17.9)	
Noctuidae (A)	2
Nymphalidae (A)	1
Undetermined (A)	4
(L)	7
Coleoptera (14.1)	
Carabidae (A)	2
Scarabaeidae (A)	3
Tenebrionidae (A)	2
Undetermined (A)	4
Heteroptera (7.7)	
Lygaeidae (N)	1
Miridae (A)	3
Undetermined (N)	2

Table 1: Prey items captured by *Eremobates mormonus* during field observations ($n=78$ solpugids and prey items). Life cycle stage of prey: A (adult), N (nymph), L (larva). Percentage of total prey is given in parentheses.

15–18 mm, BW 0.79 ± 0.02 g. Thirty grasshoppers from each size class were used to determine the chitin content (mean chitin weight and percent chitin) of various body parts: head capsule, antennae, abdomen, thorax, hind femur, foreleg, midleg, forewing and hindwing (Table 5). Chitin weight was determined according to the method described by Zach & Falls (1978). Various body parts were freeze-dried, weighed on a Metler electronic analytical balance, immersed in 2.0 M KOH for 72 h, and reweighed. KOH dissolves all tissues except chitin.

For feeding trials, twenty adult solpugids were randomly assigned to one of two experimental groups. Each experimental group was allowed to feed on one of the two prey size classes (small or large) described previously. All solpugids were deprived of food for 72 h before testing. At the start of a feeding trial, each solpugid was presented with a grasshopper from one of the designated size classes. Again, feeding trials were recorded with a video camera as described above. I recorded the removal time (s), defined as the amount of time that elapsed from the moment the prey was grasped until a particular prey body part was detached (Table 6).

The chitin content values for various prey body parts were used to determine if there was any evidence of nutrient concentration. According to the nutrient concentration hypothesis, the removal of prey parts possessing high amounts of indigestible chitin should result in the concentration of usable nutrients while also maximising the amount of space in the gut available for additional food items (Foster, 1987; Kaspari, 1990). I calculated the difference in nutrient concentration when a particular body part was removed from the grass-

hopper, using the data collected on chitin content as described by Kaspari (1990). The various body parts were subsequently ranked by dividing the mean removal time for each body part by its chitin content. Statistical analyses followed procedures described by Sokal & Rohlf (1981). Prey body part rankings were obtained via Tukey's multiple comparison test which resulted in statistical clusters of body parts. These clusters relate to predicted performances of the solpugids at each combination of predator and prey size. Kendall's measure of concordance was used to assess the between-predator and between-prey size similarity in consumption frequencies as described by Kaspari (1990). I determined the mean consumption frequency for each prey body part for all solpugids in order to estimate any possible preferences as described by Lucas (1983). Tukey's multiple comparison test clustered prey parts according to similar consumption frequencies. All tests were two-tailed with p values set at 0.05.

Results and discussion

Eremobates mormonus captures a wide variety of prey (Table 1) and is therefore a generalised predator. No significant difference was found between the diets of males and females ($p > 0.4$). Prey consisted of insects and spiders. No evidence of cannibalism was found in this study although it has been reported for other solpugid species (Pocock, 1898; Bolwig, 1952; Muma, 1966). Orthopteran insects comprised 39.7% of all prey items, followed by spiders (20.5%), Lepidoptera (17.9%), Coleoptera (14.1%) and Heteroptera (7.7%). Arthropods with well-known chemical defences such as blister beetles (Meloidae), velvet ants (Mutillidae), ants (Formicidae), millipedes and scorpions, all of which are common in this study area (Punzo, 1989), were not captured by *E. mormonus*. This is further supported by the laboratory studies on prey acceptability (Table 2).

The results from laboratory experiments on prey capture are shown in Table 2. Smaller prey items were captured and ingested with greater frequency than those whose body size closely approximated that of the solpugids. For example, the capture rate for *Schistocerca* nymphs (8.2 mm) was 75%; this rate fell to 0% for the adults of this insect (22.6 mm) ($G = 24.6$, $p < 0.001$). Smaller lycosid spiders were also captured at a higher frequency (75%) than larger individuals (20%) ($G = 14.6$, $p < 0.01$). This is in contrast to results of similar experiments on spiders and scorpions, many of which are capable of capturing and ingesting prey items significantly larger than themselves (Curio, 1976; Nentwig, 1987; Punzo, 1989, 1991). It can also be seen that hard-bodied (heavily chitinised) prey such as carabid and tenebrionid beetles are not very acceptable to these solpugids (5–10%), whereas the softer-bodied silphid beetle, *Silpha* sp., is captured and ingested at a much higher rate (65%). Well-defended prey such as the ant, *Pheidole* sp., the velvet ant, *Dasymutilla magnifica*, and the blister beetle, *Lytta magister*, were never captured during the course of these experiments.

Prey species	Mean body length of prey (mm)	Mean body length of predator (mm)	Percentage capture and ingestion
Araneae			
Lycosidae			
<i>Lycosa avida</i> (A)	10.1	21.4	20
(I)	5.7	21.8	75
Coleoptera			
Carabidae			
<i>Cicindela punctulata</i> (A)	9.8	23.1	5
Meloidae			
<i>Lytta magister</i> (A)	12.7	22.8	0
Silphidae			
<i>Silpha</i> sp. (A)	8.6	21.5	65
Tenebrionidae			
<i>Conibius gagates</i> (A)	7.1	20.8	10
Hymenoptera			
Formicidae			
<i>Pheidole</i> sp.	3.4	21.1	0
Mutillidae			
<i>Dasymutilla magnifica</i> (A)	13.4	22.5	0
Orthoptera			
<i>Schistocerca vaga</i> (A)	22.6	22.4	0
(N)	8.2	21.7	75

Table 2: Laboratory experiments on prey items captured and ingested by *Eremobates mormonus* (adult females). Life cycle stage of prey: A (adult), N (nymph), I (immature). All prey items were collected from the same locality as *E. mormonus* ($n = 20$ for each type of prey).

Food deprivation (h)	Percent capture success
6	5
24	15
48	30
72	65

Table 3: Percent capture success for adult females of *Eremobates mormonus* (mean body length 21.4 mm) as a function of food deprivation (in h) ($n=20$ solpugids for each deprivation level). Prey species: *Acheta domestica* (mean body length 10.7 mm).

Many of the solpugids observed in the field exhibited rapid locomotor movements and frequent tapping of the substrate with the palpi. Running behaviour often appeared to be random with frequent changes in direction. This type of random cursorial searching behaviour has been reported for other solpugid species (Bolwig, 1952; Muma, 1967; Wharton, 1987) with the exception of termitophilous species which are characterised by more sedentary habits (Cloudsley-Thompson, 1961). Those solpugids encountered in the field that had a prey item in their chelicerae were almost always stationary, suggesting that these arachnids cease moving when a prey item has been captured, perhaps to facilitate prey preparation and ingestion. An analysis of video recordings of prey capture in the laboratory indicates that *E. mormonus* responds quickly to tactile stimuli as well as any locomotor activity of prey, especially upon contact with the palpi or legs. Although they will orientate towards a source of substrate vibrations, they appear to attack only upon contact with the prey species. Following initial contact, the palpi are used to pull the prey towards the head until it is firmly grasped with the chelicerae.

The ability of *E. mormonus* to capture prey increases significantly as a function of hunger level (Table 3). Solpugids deprived of food for 6 h exhibited a successful capture rate of only 5%. The capture rate increased significantly (15%) for those animals deprived of food for 24 h ($G=8.2$, $p<0.05$). At higher hunger levels (72 h), capture rates increased to 65% ($G=19.3$, $p<0.001$). This contrasts markedly with results reported for the theraphosid spider *Dugesia echina* Chamberlin, from the same study area, which exhibited a significantly higher capture rate (91%, $G=8.7$, $p<0.05$) when deprived of food for 72 h (Punzo, 1989). These results, as well as other observations that I have made on *E. palpisetulosus*

Food deprivation (h)	Mean ingestion time (min)	
	Predator size class (mean body length)	
	9.1 (0.4) mm	23.1 (1.2) mm
6	34.2 (5.4)	20.8 (3.1)
24	21.5 (2.7)	12.3 (1.6)
48	14.7 (1.3)	7.1 (0.4)
72	11.1 (0.8)	5.8 (0.3)

Table 4: Effects of food deprivation (h) and predator size on the amount of time (min) required for *Eremobates mormonus* females to ingest a single cricket weighing 0.23 ± 0.04 g. Values represent mean ingestion time in min (\pm S.D.) for 20 solpugids in each predator size class and food deprivation level.

Fichter and *Eremorhax magnus* (unpublished data), suggest that these solpugids are not as efficient at capturing their prey as are other arachnids such as wandering spiders and scorpions for which some information is available (Curio, 1976; Ford, 1978, Nentwig, 1987; Punzo, 1991). This may be due to the fact that many wandering spiders move readily between patches, but once a suitable patch is located they often assume a sit-and-wait ambush strategy (Nentwig, 1987; Punzo, 1991). This may serve to increase their level of responsiveness toward prey that move into their awareness field (Curio, 1976), as compared with solpugids which locate their prey primarily via vigorous, random and continuous cursorial locomotor activity.

The effects of food deprivation and predator size on ingestion time are shown in Table 4. A Model II ANOVA showed a significant overall effect of deprivation level ($F_{3, 36}=78.6$, $p<0.01$) and predator size ($F_{1, 36}=27.7$, $p<0.01$) on ingestion time. Scheffe F tests showed a significant difference in ingestion time between predator size classes at all levels of deprivation ($p<0.01$ for all periods of deprivation). Larger solpugids exhibited faster ingestion rates for a prey item of constant size at all hunger levels as compared with ingestion times shown by smaller conspecifics. Regardless of predator size, increased hunger level resulted in faster ingestion of food.

Values for mean chitin weights and percentages for various body parts of *Boottettix argentatus* are shown in Table 5. Antennae, head capsules, midlegs, forelegs and both pairs of wings are all characterised by relatively high chitin content (33.7–56.3%) as compared with the abdomen (11.5–13.7%), thorax (19.8–21.2%) and hind femur (15.6–17.8%). Analysis of feeding trials indicates that *E. mormonus* selectively removes the wings, head capsule and antennae (Table 6) and focuses its feeding on those body parts containing the least amount of chitin (abdomen, hind femur and thorax). This supports the nutrient concentration hypothesis.

Solpugids consumed prey parts from each prey size class in similar frequencies (Kendall's $W=0.49$, $p<0.05$ for small prey; $W=0.78$, $p<0.01$ for large prey) except for fore- and hind-wings which were very small in the smaller grasshoppers and were usually ingested with the

Prey body part	Grasshopper size class			
	Small		Large	
	Mean weight (mg)	%	Mean weight (mg)	%
Head	18.9 (2.1)	38.4	51.3 (5.7)	42.2
Antennae	1.1 (0.1)	42.3	2.9 (0.2)	43.1
Abdomen	24.8 (2.7)	11.5	59.3 (5.4)	13.7
Thorax	4.7 (0.6)	19.8	13.1 (4.0)	21.2
Hind femur	15.7 (2.3)	15.6	26.1 (3.4)	17.8
Foreleg	2.8 (0.2)	42.1	5.2 (0.3)	40.7
Midleg	1.8 (0.1)	33.7	3.8 (0.2)	34.3
Front wing			10.2 (1.2)	47.9
Hind wing			14.8 (2.7)	56.3

Table 5: Mean chitin weight (mg) and percent chitin content (%) of several body parts for two size classes of the grasshopper *Boottettix argentatus* ($n=30$ grasshoppers for each size class). Numbers in parentheses represent \pm S.D.

Body part	Grasshopper size class	
	Small	Large
Head and antennae	44.1 (5.3)	81.5 (8.2)
Abdomen	ND	ND
Thorax	ND	ND
Hind femur	ND	ND
Forewing		28.7 (6.9)
Hindwing		25.6 (4.2)

Table 6: Mean removal time (s) of *Eremobates mormonus* ($n=20$ for each size class) for grasshopper body parts from two different size classes. Values represent mean time in s (\pm S.D.). ND=body part not discarded (ground vigorously between chelicerae).

rest of the thorax. The Tukey tests showed the following clusters of consumption frequencies: for larger prey, the head capsules were removed in 91% of the feeding trials whereas forewings and hindwings were removed at a lower frequency (78 and 66% respectively). For the small grasshoppers, head capsules were removed in 68% of the feeding trials. Kendall's concordance was significant ($W=0.735$, $p<0.01$) for the mean consumption frequencies of body parts for each prey size class, indicating that the same criteria were involved in decisions to remove prey parts from both small and large prey. Video recordings indicated that once the prey is grasped firmly in the chelicerae, it is moved in a rhythmic fashion by the vertical motion of the movable cheliceral finger against the upper fonal teeth, resulting in fragmentation and grinding of the prey tissues. During this movement of the prey through the cheliceral mill, certain body parts are severed and removed as previously discussed whereas others are retained for further grinding and subsequent ingestion (Table 6). Although the forelegs and midlegs were discarded, the hind femur was processed through the chelicerae, allowing these solpugids to ingest the large muscle mass associated with this type of saltatorial limb. Hindlegs were discarded when these solpugids fed on insects (Heteroptera, Coleoptera, Lepidoptera) that did not possess such saltatorial limbs (personal observations). The mean ingestion time for *E. mormonus* feeding on small grasshoppers was 13.2 min (± 2.1 S.D.); for large grasshoppers mean ingestion time increased significantly to 24.6 min (± 3.7 S.D.) ($t=7.2$, d.f.=19, $p<0.01$).

The results from the present study indicate that *E. mormonus* is a generalised predator whose summer diet in this study area consists primarily of orthopteran, lepidopteran, heteropteran and coleopteran insects and spiders. This solpugid prefers arthropods that are soft-bodied, and is more successful at capturing smaller prey items. Hunger level affects several parameters of feeding in *E. mormonus* including percent capture rate and ingestion time. Although hunger is generally associated with a collective series of internal messages related to caloric deficit (Dethier, 1982), it has proved difficult to observe and quantify (Punzo, 1989). The degree of hunger can be influenced by the time that elapsed between feeding bouts and has been shown to affect the degree of responsiveness of a predator toward potential prey (Curio, 1976). In addition, this is the first demon-

stration for a solpugid, that prey preparation is an important component of handling time. By removing prey body parts that are difficult to digest, *E. mormonus* maximises the concentration of nutrients that can be ingested and absorbed as well as the amount of space available in the gut to receive additional food. These benefits may outweigh the additional costs associated with an increase in the overall handling time that accompanies prey preparation.

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Ceraticelus sibiricus Eskov, 1987, a spider species new to Poland (Araneae: Linyphiidae)

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Summary

A species of linyphiid spider, *Ceraticelus sibiricus* Eskov, 1987 is redescribed from Poland. It is the third member of the American genus *Ceraticelus* known in Eurasia.

Introduction

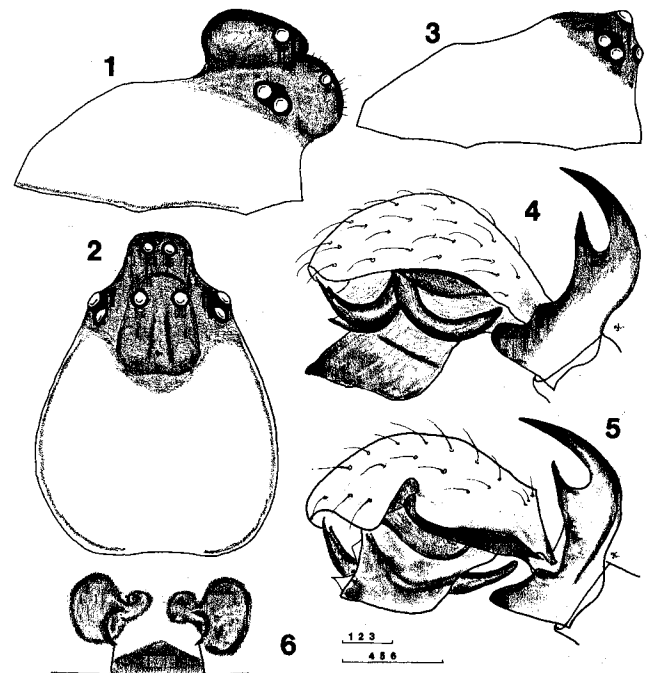
During ecological investigations carried out in the Biebrza River National Park (vicinity of Gugnny village), one of the largest swamps in Europe, 24 specimens of a linyphiid spider were caught. The spiders were identified as *Ceraticelus sibiricus* Eskov, 1987, described from the middle Yenisey area (Siberia). Another species, *C. orientalis* Eskov, 1987, was also first found and described in the same area. The mainly American genus *Ceraticelus* Simon, 1884 was hitherto known in Europe from only one species determined as *C. bulbosus* (Emerton, 1882) (Koponen, 1979, 1985), but Eskov (1987) suggested that this might be *C. sibiricus*.

Ceraticelus sibiricus Eskov, 1987 (Figs. 1–8)

Material: Poland, Biebrza River National Park (53°22'N, 22°35'E), wet meadow, 1 ♂, 3 July 1991; same locality, sedge-moss marsh, 3 ♂ 18 ♀, 5 May 1992, 2 ♂, August 1992. One male and 5 females deposited in Museum and Institute of Zoology, Polish Academy of Science (Warsaw); 1 ♂ 1 ♀ deposited in British Museum (Natural History), London; 4 ♂ 12 ♀ in collection of Institute of Biology, Białystok.

Diagnosis: *C. sibiricus* is very similar to *C. berthoudi* Dondale, 1958, from which it differs in the elongated posterior cephalic lobe in dorsal view and the shallower transverse furrow between the cephalic lobes of the male, and more widely spaced spermathecae in the female.

Description: **Male:** Total length 1.53 mm; carapace length 0.6 mm, width 0.5 mm. Carapace: reddish brown, thoracic part reticulated, cephalic lobe very dark and smooth (Figs. 1, 2), longer than broad (4:3), carrying PME; front part with AME strongly convex — in shape of another cephalic lobe — covered with short scattered



Figs. 1–4: *Ceraticelus sibiricus* Eskov. 1 Male carapace, lateral view; 2 Male carapace, dorsal view; 3 Female carapace, lateral view; 4 Male right palp, mesal view; 5 Male left palp, lateral view; 6 Epigyne. Scale lines = 0.1 mm.