EARLY CRETACEOUS CLIMATE CHANGES SUGGESTED ON THE BASIS OF COCKROACH WING VARIATIONS

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Abstract: As indicated by the equal variability within two analysed groups of Lower Cretaceous cockroach forewings, the section of the Siberian Baissa locality (Baissa of the Endandine Formation is the richest fossil insect site of the Lower Cretaceous) is found to be discontinual, thus denying the presence of the only recorded Mesozoic climatic oscillations in the world. Evidence is given that faunistic changes known in the Early Cretaceous (Berriasian- Valanginian) were not reversed.
The top part of the Baissa section (designated herein) is found to be very rich in arthropods and plants, and contains warm and semiarid elements including the largest spider of that age.
Climatic conditions during the Lowermost Berriasian are found to gradient, from wet, through humid up to semiarid. This inference changes the view on the evolution of biota, including insect societies, and angiosperm plants which evolved during that time. The same change from humid to arid conditions is recorded from several localities in China, which supports a Cretaceous rather than a Jurassic age for them. The paper emphasizes the role of cockroaches as a very fine stratigraphical tool.

Key words: Stratigraphy, Climate, Ecology, Cretaceous, Evolution, Insecta, Blattaria, variability, wing venation

Introduction

Understanding the earliest Cretaceous climate conditions is essential for evolutionary studies in paleontology, since it was the time when such groups as flowering plants and social insects evolved (elements that actually created the modern type of Contemporary ecosystems).
Baissa is the richest fossil site of that age, so understanding the stratigraphy of the site is fundamental for the reconstruction of faunistic and climate changes.
For more than 50 years it was thought that the whole section at the site is continual, and since the lowest and the bottom parts of the section are very different from the middle part, it was accepted that Baissa presents evidence for Mesozoic temperature oscillations.
We analyse the faunas of section (in particular the cockroaches), which allow us to suggest a hypothesis, that there must be a tectonic gap within the section. This was confirmed (during AMBA project expedition) and a tectonic zone has been found between layers characterized by more, and less thermophilic faunas.
Our observation changes the view on the climate changes in the lower Cretaceous and erects a hypothesis of steep aridization of the environment, causing relative temperature change.

Material and Methods

All the fossil insect material is deposited in the Paleontological Institute, Moscow, Russia. Statistical analysis was done on more than 1000 fossil cockroaches, using the Statgraphics 6.0 computer program.
Baissa is located in Transbaikalian Russia, on the river Vitim, approximately 60 km from the village of Romanovka. Its age is the beginning of the Cretaceous and is dated as representing the lowermost Berriasian- lower Aptian strata acording to different authors (Zherikhin 1978; Zherikhin et al. 1999). The site is described in detail by Zherikhin et al. (1999), including the energy flow diagram, with some additional comment resulting from this study to be found in Mostovski and Vršanský (2000). We consider the earliest Berriasian- Valanginian dating of the site, corresponding to cca. 130-140Ma.

Results

The Baissa section is divided into 43 layers (Martinson 1961) of which 18 bear significant insect impressions. Concerning the number of specimens collected, each of the insect-bearing layers is comparable to any other lower Cretaceous fossil site. On the basis of the biota present in impressions, the section can be divided into layers that are characterized by relatively cold climate (similar to contemporary subtropical, humid and warm), and warm climate (similar to contemporary warmer subtropical, possibly semiarid).
Insects, among which cockroaches have characteristics that make them useful in modelling biota (partially noted in Vršanský 1997-2000) are dominant in both faunistic complexes (Flora display only minor changes, hence it is not significant for the comparison of cycles.). I) Blattaria specimens comprise 8% of all insects of the "humid" section, and about 6% in "semiarid" layers. II) The state of preservation of the cockroaches is excellent. The species studied also possess microstructural characters, including gut contain (Krassilov, V.A. and Rasnitsyn, A.P. 1982, 1999), and sensillar complexes (Vršanský et al. 2001), which practically allow us to describe them on the same level as living species.
III) They are variable. The cockroach´s forewing is popular for its huge variations, and it was thought to bear no phylogenetic information. Nevertheless, it has been shown that several characters remain stable even if the habitus of the wing strongly differs, and additionally the character of venation and its variation is characteristic for each taxonomic group and stage of evolution (Vršanský 2000). Variations are typical for each population, hence making possible correlation of "fossil populations" in each rhythm. IV) They are temperature-sensitive. Temperature strongly influences the valention of most cockroach species, and cockroach complexes are therefore an excellent model for the temperature cycles. Additionally, its affinity to humidity is depressed, when free water is available.
The cockroach fauna of Baissa includes about 30 species in circa 10 genera and 5 families. The biocenosis may be separated into species inhabiting humid and dry biocenoses. Wet layers are free of Blattaria, which can be caused by a lack of effective temperature (All the species (and genera) currently inhabiting marginal arctic regions are Tertiary or Quarternary in origin.). There are no significant common species recorded for the whole section.
Dry layers have all the common species and their composition is very similar (layer 27 which lies in the transitional zone may appear to be exceptional, but it is poor in fossil impressions). It indicates rather stable and similar condition during the "dry" periods. Analysis was done on *Elisama* sp. (undescribed), showing very fine differences in variability. These may be validated only when the sample size is over 30 in each layer (unpublished materials).
Humid layers. *Piniblattella vitimica* (Vishniakova, 1964) (Insecta, Blattaria, Blattellidae (Piniblattellini)). The species is the most significant cockroach of Baissa, where it is

present in the humid layers (2, 4, 6, 31, 35?), one specimen is found in dry layer 16 (1 of 600 specimens- this find is insignificant according to its markings during the earliest expedition (possibly incompatible)). As an eudominant species with lower thermic preferences, its imago and immature stages comprise about 8% of all terrestrial insects. For comparative studies, more than 400 wings have been used, of which 120 are statistically evaluated.
The two analysed groups (2 (2+4); and 31) are identical, not differing in any character. It is apparent also for x= 0.05. Such correlation of "populations" evidently may have been not reached after a long break, and most probably it reflects continuity of "suprapopulation" of the two groups, in the two layers.
Vitisma rasnitsyni Vršanský, 1999 (Polyphagidae, Vitisminae) (layers 2 and 31). 44 wings analysed. Both groups are identical, not differing in any feature. (Fig.1). It is apparent even for x= 0.05.
Remarks. Even the cockroach wing is highly variable, several features have been shown to be stable, which include fossil species (Vršanský, 1997). The most promising features (total number of veins at the margin, number of R+M veins etc.) have been used for our study. Since the Baissa section was thought to bear evidence of climate changes over more than 400 000 years, we wanted to see how the species changed during that time. No differences were found between the upper and lower analysed layers. This casts doubt on the continuity of the section and/or its age.

Stratigraphy of Baissa
Baissa belong to the Endandine Formation, which is characterized by arid or semiarid condition. It differs from the Southern Transbaikalian which is characterized by humid and temperate climate.
As presumed by cockroach variability, a tectonic active zone has been found between layers 9 (Traditional 11) and 13 (the first of the "dry" layers).
The upright zone of layers 13 and 15 correspond to traditional markings 11, and 13 respectively.
We have collected several dozen specimens of insects in the layer 13. They are evidence of warm, subtropical elements, including the largest Mesozoic arachnid of that age. Flora with mass findings of Czekanowskia and Ginkoites is evidence of a warm and dry climate.
The alluvial sediments found in Butui, which is a little older than Baissa also correspond to the "wet" prehistory of Baissa.

Discussion
The similarity of Lithology at Baissa, combined with the partial destruction of layers by Quarternary sediments did not allow us to distinguish a crack within the Baissa section previously. Therefore the section was described as continual. The new finds show that the section is discontinual and therefore the uppermost layers cannot be defined as the youngest. According to our results, these layers are as old as that near the bottom of the section. Therefore both groups of layers represent the same faunistic and floristic complexes. The conclusion of all previous authors was based on the section differentiation, hence resulting in the scheme cold, warm, cold. Now, the scheme is wet, humid (upper and bottom layers) and dry (central). This changes the basics of both the faunistic and floristic analysis, and according to the significance of the search-area, it changes a view on the Cretaceous biocenogenenesis, with an important evolutionary meaning.

Such analysis may appear fruitful in localities, where numerous materials have been collected without appropriate stratigraphic notes (as Chinese and Brazilian Lower Cretaceous Lagerstätte)

Conclusions

- There are no critical temperature oscillations, resulting in change of faunistic complexes, recorded in the Mesozoic. The direction of fauna change is restricted to direction "cool" ›"warm" which is probably caused by aridization, possibly without external temperature change influence. The change, from wet, humid up to semiarid or arid in the Lower Cretaceous was smooth, and not repeated.
- The climate change influenced only the composition of faunistic complexes, whilst plant societies show only ratio differences. Climate conditions during the Lowermost Cretaceous were more stable than was thought, without stress changes.
- The depth of the Baissa section is reduced to about 40m (preliminary 120m) which decreases the age of the Baissa section to about 150 000 years of continuous record.
- Cockroach wings appear to be a promising indicator of temperature changes and continuity of insect societies, useful in dating and correlation of terrestrial fossil sites. The variability of the isolated forewing is a characteristic precise enough to allow discrimination between different layers of almost the same age. Such detailed study enhances the value of the locality.

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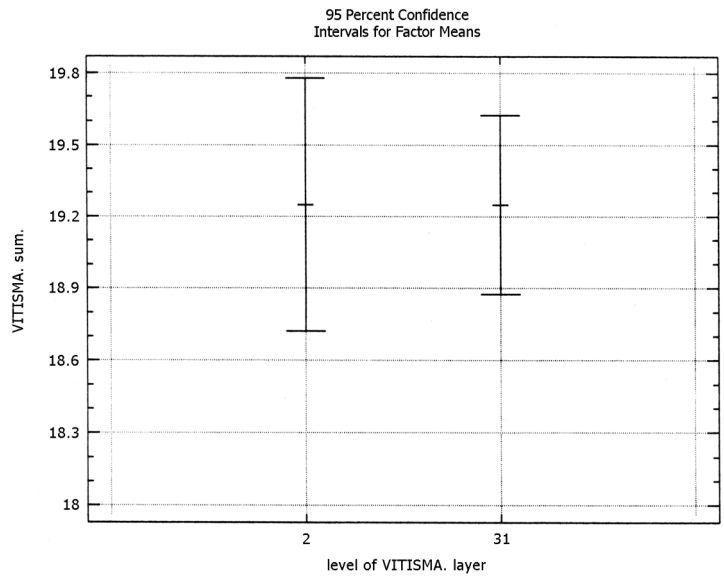
Fig.1. Comparison of layers 2,4 and 31 based on variation of *Vitisma rasnitsyni*. The same results have been obtained for *Piniblattella vitimica* (variability described in Vršanský 1997).



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