Can sweetness be difficult to handle when in excess?

A cement of sticky nectar and pollen on the heads of small sunbirds (*Nectarinia zeylonica* Linn.) would seem frustrating to most, but not to the obligate pollinators of the mangroves *Bruguiera gymnorrhiza* and *B. sexangula* in India. *Bruguiera* flowers are large and long lived. Each flower produces about 40–60 μl of nectar/day, translating to about 1.6–2.0 million of pollen over the life of each flower (15–20 days). While gently probing the flowers, the beaks of the sunbirds come in contact with the anthers of the flower, which triggers an explosive release of pollen (Figure 1). Repetitive visits to the flowers coat beaks of sunbirds with veneers of nectar and spurs accumulation of heavy pollen loads. This perhaps leads to an unpleasant stickiness. To remove this sticky consequence of pollination, sunbirds spend a lot of time cleansing after their floral visits in mangroves, 30 s to well over a minute. The birds clean the excess nectar and pollen from their breasts with their beaks and then they use their toes to cleanse their beaks. Sunbirds are found to scratch their heads so violently in selected spots against trees in the process of cleaning (Figure 2 *a*) that we find distinctive ‘scratching posts’, which are visited two to three times a day. It appears that sunbirds also have impressive memories of spatial landscapes. But, without frequent visits to scratching posts, pollen and nectar loaded on the sides of bills can obstruct tongue movement (Figure 2 *b*). Thus, tongue cleaning also seems to be obligatory!

Figure 1. A sunbird pollinating a Bruguiera flower.

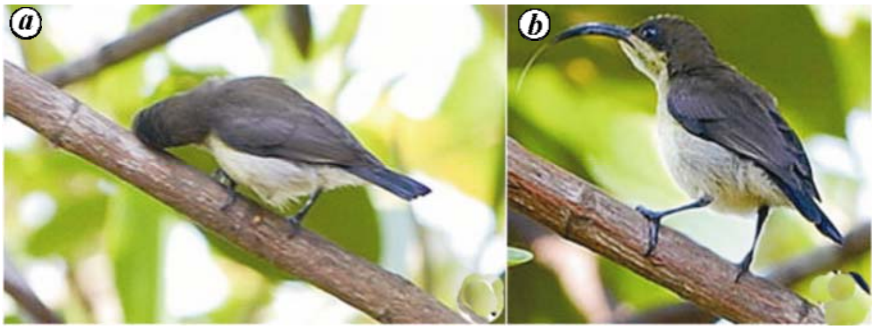

Figure 2. ***a***, Sunbird cleaning its head on a ‘scratching post’. ***b***, A sunbird protruding its tongue to clean.

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Influence of sub-orbital scale climatic variability on monsoons

Das *et al.*[1] have studied clay mineralogy, terrigenous and biogenic components of the sediment core collected from the Ocean Drilling Programme site 728A, northwestern continental margin of the Arabian Sea, off Oman. Their main objectives were to understand palaeoclimatic conditions, such as monsoons fluctuations, weathering processes and transport pathways of sediments from the neighbouring continental areas to the northwestern Arabian Sea and during the late Quaternary period. They discuss climatic changes at coarse-scale – glacial and interglacial cycles. The main conclusion that they draw with regard to temporal variations in the clay mineral assemblages is that the input of terrigenous sediment with the dominance of physically weathered minerals like chlorite and dolomite was higher, while biogenic carbonate was lower because of arid conditions that prevailed during glacial cycles compared to interglacial ones.

However, they have ignored significant variations within the above-mentioned broad cycles. For instance, in figure 5 of Das *et al.*[1], kaolinite/chlorite ratios indicative of the existence of humid climatic conditions are nearly similar for an interglacial sequence around 100 kyrs BP and glacial sequence ~180 kyrs BP. Furthermore, kaolinite/illite ratios and, to some extent, kaolinite/palygorskite ratios are higher for glacial sequences (marine isotopic stages 4 and 6) than interglacial ones. This clearly indicates that the monsoon has been regulated by climatic variability at sub-orbital scales.

Generally, climatic changes seem to occur from short-term sub-decadal scale to the long-term glacial–interglacial scale[2,3]. The main reasons behind the sub-orbital changes in the global climate are related to the evolution of the atomsphere, changes in the lithosphere as well as temperature fluctuations over the North Atlantic region during the late Quaternary[2–4]. The increase in temperature over the North Atlantic had a profound impact not only on ocean circulation in terms of massive inputs of ice bergs[4], increase in glacier-melted water[5] along with supply of dissolved oxygen and nutrients to the global ocean through subduction of North Atlantic deep water[3,6], but also strengthened the atmospheric teleconnections between high-latitude regions and the monsoons[7]. It has been recognized that sub-orbital climatic cycles such as the Dansgaard–Oeschger cycles, Heinrich events, Younger Dryas, etc. are more important for understanding the rapid change in climate compared to glacial/interglacial cycles[8]. Even within the glacial sequence, there were both cold and warm/humid intervals, which are commonly known as stadials and interstadials respectively. Likewise, in the interglacial sequences, e.g., in the Holocene, climate was warm during the medieval period but cold during the Little Ice Age, besides Younger Dryas and climatic optimum during the early Holocene[2,8].

The consequence of temperature changes over the temperate-polar regions of the North Atlantic has not only been noticed in the Arabian Sea, but also in different oceans, including the climate over Antarctica[9]. Some information is available with regard to the sub-orbital/millennial-scale variability in the climate inferred from the Arabian Sea sediments[10–13]. Though Das *et al.*[1] have cited some of these publications, they have ignored climatic oscillations at fine scales. In the light of current knowledge of climatic variability during the Quaternary mentioned above, Das *et al.*[1] have to reinterpret their results by identifying some of the sub-orbital climatic cycles and their significance for a better understanding of the monsoon fluctuations during the late Quaternary.

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Response:

We thank Manjunatha for his suggestions. The reply to his main concerns is given below:

The ratios of clay minerals, kaolinite/chlorite (K/C), kaolinite/illite (K/I) and kaolinite/palygorskite (K/P) considered indicative of humidity are used to discuss monsoonal variations during the late Quaternary. These indices clearly show characteristic monsoonal variations during the large glacial–interglacial cycles. The above ratios also showed few characteristic variations within a broad cycle. Some of them are correlated to the effect of stadial–interstadial cycles (within MIS 5) with support from the oxygen isotope data measured on foraminifers. A few more such peaks are shown by selective humidity index within other broad cycles. Such peaks are in part co-relatable to the stadial/interstadial cycles, but not well supported by all indices and/or by oxygen isotope data, and hence are not highlighted.

In the past, researchers have shown that the monsoon in the northwestern Arabian Sea was not only regulated by long-term glacial–interglacial cycles, but also by the short-term sub-orbital climatic cycles, such as Dansgaard–Oeschger cycles, Younger Dryas, etc.[1–4]. It has also been indicated that teleconnections between the subtropical monsoons and high-latitude climates exist during the last glaciation[5,6]. The Dansgaard–Oeschger events are globally synchronous[7] and occur quasi periodically, with the recurrence time[8] being a multiple of 1470 years. The transition from the last glacial period, which ended at around 16,000 years ago, to the present interglacial period, was punctured by a brief (approximately 1300 ± 70 yrs) and intense return to cold conditions[9] at ~11,000 yrs BP. This episode is now recognized as the Younger Dryas Event and is a prime example of dramatic and rapid climate oscillations. All these smaller-scale variabilities in climate are inferred based on high-resolution data analyses. The present study has been made on a relatively coarse sample interval. The age difference of two successive samples varies between 3000 and 4000 years or more. Moreover, the weathering mineral assemblages and erosional products may not respond immediately and directly to the climatic changes[10]. Sample data of very high resolution are needed to interpret the effect of climatic variability at sub-orbital scales, which is beyond the scope of the present work. However, the suggestions are encouraging to search for such climatic variability based on sub-orbital scale using clay mineralogy as proxy.

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