Climate change and its impact on the Himalayan glaciers

In 2004, I visited the Chorabari Glacier on an expedition under the leadership of M. Kuhle. Thus, I have read the paper by R. K. Chaujar with great interest[1]. In agreement with Chaujar[1], we also recognized different latero-frontal moraines around Kedarnath. Because younger glacial history was not the primary aim of our expedition, we did not differentiate the moraine loops in detail. However, as visible in figure 3 in the article[1] as well as in my photos, Chaujar's geomorphological differentiation into an oldest stage 1 and three younger glacier stages seems to be correct.

According to Chaujar[1], the glacier terminated during stage 1 at 3160 m asl. Because the recent glacier snout lies at 3835 m asl the ELA-depression (ΔELA) calculated by any TSAM-method ([recent glacier terminus – former terminus]/2) was 338 m. Neither for any region in the Himalayas nor for other mountain ranges do I know of such high ΔELAs attributed to a climatically induced Little Ice Age (LIA) glacier advance. According to my field work in the Himalayas (to be published soon) and authors like Kuhle[2], Shiraiwa and Watanabe[3] and Yang *et al.*[4], the maximum ΔELAs during the LIA in the Himalayas and Southern Tibet varied from 50 to 200 m. Derived from other climate records[5,6] and visible in figure 7 in Chaujar[1], the LIA minimum temperatures in High Asia were ca. 1°C lower than recently. In the Himalayas such temperature lowerings usually go with ΔELAs of around 90 m (ref. 7).

The crests of the highest lateral moraines run 150 m higher than the approximately 3000-year-old temple of Kedarnath. Following Chaujar[1], these crests indicate the LIA maximum (stage 1). That means during stage 1 (ca. AD 1748) as well as stages 2 (AD 1766) and 3 (AD 1827), the temple withstood a continuously down moving ice body up to 150 m high. According to the author, altogether 400 years of submerging are further documentated by glacier striations at some rock walls of the temple (Chaujar[1], figure 8). These striations are 1–2 mm deep and run parallel across several decimetres with an interspace of some centimetres. Taking into account this regularity and the fact that the striations do not cut but surround some porphyroblasts, they seem to be the result of different weathering of a gneissic foliation and hence are no indication of glacier submerging.

The above given dates for the glacier stages were determined by lichenometry. Chaujar[1] measured the growth rate of *Rhizocarpon geograficum* directly of seven lichen thalli between 2004 and 2007. Reasoned by nonlinear growth curves of lichens and by non-steady growth rates under changing climatic conditions, this method is not useful for lichenometric dating. Directly measured growth rates just refer to the measurement period and cannot be assigned to the past[8].

Keeping in mind the methodical problems, the high ΔELA values and the well-preserved Kedarnath temple, it is more likely that the glacier stages 1–3 are not of historical but of neoglacial age. It seems to be interesting that different dating methods used for clearing up the glaciation history in the Himalayas produce widely ranging results. Derived from OSL datings carried out by Richards *et al.*[9], for example, the Pheriche stage at the Khumbu Glacier indicates a ΔELA of 200–300 m, 18–25 ka ago. Due to those findings (e.g. Richards *et al.*[9] compared with Chaujar[1]) it must be questioned, if such big variations in timing of glaciation given by absolute dating techniques were caused by the completely different climate history of the particular Himalayan valleys or if they are possibly reasoned by methodical misleading.

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Response:

ΔELA-depression. ΔELA is not fixed. It depends upon the factors like size, orientation, topography, debris cover, etc., and cannot be fixed by studying 2–3 glaciers in the Himalaya or by satellite data. These values are by actual field work and measurements. Three glaciers are studied in detail where L1 values of Chota Shigri[1], Dokriani[2] and Chorabari glaciers are 3750, 3380 and 3160 m asl, snout position 4050, 3910 and 3835 m asl and ΔELA values are 150, 265 and 338 m respectively. Thus, a simple model of ΔELA cannot be derived at least in the Himalayan conditions.

Regarding striations. I reiterate that these are striations clearly seen passing through the augens of feldspars. Even their continuity can be seen on three slabs made up of pieces of different rocks. Had it been a case of differential weathering, this continuity would not have been there. Moreover, the feldspar augen should have been weathered/kaolinized first than the groundmass. These are basically high-grade metamorphic gneissic rocks, and the gneissic texture is superimposed by glacier movement and is clearly distinguishable here.

Nonlinear growth curves of lichens. This is true under the changing climate but in a particular area, except for seasonal variations, climatic conditions remain the same. It varies with different areas as in the Dokriani[2] (0.66 mm) and Chorabari (1.0 mm) glaciers. Therefore, this is the only species that is being used to determine the age of a particular activity as it has uniform growth rate.

The glacier stages 1–3. It appears that Achenbach has not noticed the glacial landforms particularly the moraines. Continuity of L1 on both sides of the glacier around the snout still exists. Then how they can be of neoglacial age? Moreover L2, L3 and L4 are present within the loop of lateral and terminal moraine of L1.

OSL dating. There are various limitations in sampling techniques for OSL. In their paper, SK4, SK5 and SK6 are the sample sites from the same moraine, deposited at the same time, and showing the age difference 9.9 ± 1.8 (10.1 ± 1.5 ka), 9.3 ± 1.8 and 1.1 ± 0.2 ka respectively. Even in these ages, ± 1.8 ka means an uncertainty factor of 3.6 ka years. Besides, SK9 and ABU147 are the same samples analysed in two different labs and the results are 21.9 ± 3.0 and 20.5 ± 1.4 ka years respectively. Radiocarbon dates, also referred to in the paper, from moraines close to modern glaciers in the Khumbu Himalayas are 480 ± 80 (Muller), 550 ± 85 (Benedict) and 410 ± 100 (Fushimi). If an older slide material in the area is transported and deposited by the glacier as one of its landforms, and a sample taken from that will give a misleading age.

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From ornamental to detrimental: plant invasion of *Leucanthemum vulgare* Lam. (Ox-eye Daisy) in Kashmir valley, India

In the contemporary world, biological invasions represent a major contributory factor to the global biodiversity crisis[1,2]. In fact, the theme of the International Day of Biological Diversity, 2009 was 'invasive alien species' in an effort to raise awareness and focus attention on this grave but hitherto least appreciated threat to biodiversity[3].

Since the historical past, humans have been introducing alien plant species from other biogeographic regions of the world for food, fodder, fibre, fuel, etc. However, the number of such introductions during recent times, particularly for ornamental purposes, has increased manifold. Such introductions are either intentional or unintentional. Majority of the alien introduced species are benign, however some of these species escape from cultivation, spread slowly and silently at initial stage, but become dominant and widespread at later stages to attain an invasive status in the introduced range and prove detrimental for the native biodiversity[4]. Many studies[5–8] have shown that trade in ornamental species, in particular, represents one of the most important pathways of introduction of invasive species. Several of these species are presently ranked among the world's 100 worst weeds, e.g. *Lantana camara*. About half of the 300 most invasive plants in North America, and more than 70% of the New Zealand's invasive weeds, were intentionally introduced to gardens and parks as ornamental plants[9].

Kashmir valley, nestled in the northwestern extremity of Himalayan biodiversity hotspot, is bestowed with an incredible plant wealth[10]. However, over the last few decades, flora of the valley faces a multitude of threats. Being historically a global tourist destination, the valley has witnessed intentional introductions of several alien species for ornamental purposes, particularly in the public gardens, private parks and tourist spots[11]. One such ornamental species with European origin[12] has been *Leucanthemum vulgare* (Ox-eye Daisy), which was introduced in Kashmir during the British era for its beautiful white blooms. However, our field observations and continuous monitoring of alien plant species over a decade have indicated that this species has escaped from cultivation and is now growing profusely in the wild. Presently, it shows restricted distribution in the peripheries of tourist spots such as Gulmarg, Tangmarg, Pahalgam and Duksum, and gardens such as Harwan, Shalimar and Kashmir University Botanical Garden. At these sites, it grows abundantly in the forest openings (Figure 1), meadows, public lands, and along the periphery of wetlands and degraded slopes of roadsides.

L. vulgare is a perennial herb. Belonging to the family Asteraceae, it bears white ray florets and yellow disc florets. Though primarily cultivated in the areas of aesthetic importance but with each passing year, the species is expanding its geographical extent much away from the source populations and increasing its population abundance to form pure stands. Its seeds have efficient mechanism of dispersal by wind, and potential to spread throughout the sub-alpine and alpine landscape of the region. Because species is not grazed by domestic livestock and/or wild animals, it is a serious threat to the sustainable use of alpine pastures in the region which sustain huge livestock population. Road construction and other developmental activities create forest gaps and disturbed habitats in alpine meadows that provide ideal sites for the species to form monospecific stands thereby drastically reducing the occurrence and abundance of native diversity.

As a part of the present study, we did field sampling studies in the coniferous forests dominated by *Pinus wallichaina* (Blue Pine) at Gulmarg (2600 m amsl) during 2009. The sampling unit used was 1 m^2 quadrat. We selected three different sites for sampling: (i) Highly invaded site, where the visual cover percentage of *L. vulgare* was more than 70; (ii) Moderately invaded site, where the visual cover percentage of *L. vulgare* was less than 50, and (iii) Un-invaded site, where there was no invasion of *L. vulgare*. At each site, 10 quadrats were laid down randomly.