one experiment. The essential qualitative features such as formation of rings and their subsequent breakdown, along with the evolution of streamwise structures, are observed very clearly in the present simulation. The distinct advantage of such simulations is that, unlike in experiments, we are able to obtain accurate instantaneous pictures of the entire flow field.

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Commercial exploitation—A threat to Indian orchids?

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To understand the impact of commercial exploitation on the endangered status of orchids, we analysed the data on a large set of Indian orchid species. In this article we show commercial exploitation to be a major cause in driving them to the status of rare/endangered/threatened (RET) species. Orchid species bearing large and showy flowers are shown to be more commercially exploited and thus more vulnerable for extinction. Here we suggest a few strategies to conserve these species.

ORCHIDS form the largest group among flowering plants comprising of over 18,000 species in the world[1]. India harbours a rich orchid flora owing to its geographical diversity. It is estimated that nearly 1,300 species exist in India, of which about 200 can be commercially exploited[2]. Despite their commercial value both locally and internationally, mass multiplication techniques have not been popularized in India. Therefore, orchid dealers in the country depend mostly on collections from wild to meet a large part of their foreign and local demands[3]. Besides, collections of native-rare orchid species for botanical studies, orchidoriums and sanctuaries also contribute to the depletion of the orchid stocks in the wild. As a consequence of such indiscriminate collections, many orchid species have been pushed to the state of rare/endangered/threatened[4] (RET) and have become vulnerable for extinction. According to an estimate by Arora[3] it is feared that nearly fifty native species of orchids including popular species such as jewel orchids and lady slippers are on the verge of extinction.

However, so far, no attempts have been made to understand the impact of commercial exploitation on orchid populations. In this article, by developing data base on a large set of orchid species, we analyse the impact of commercial exploitation on the endangered status of orchids. Further, we bring out patterns of preference for floral features among commercial orchids and its consequence to the RET status. Based on our results, we suggest a few strategies to conserve orchids.

For a set ($N = 746$) of Indian orchid species, data on their place of occurrence, floral features such as flower size (width and length) and colour were collected from various published sources (flora of various regions of India[5–10], books[11–13], several research articles[14], etc.), crosschecking atleast from two sources. Information on the endangered status of a species and whether it is commercially exploited was obtained from the lists of IUCN Plant's Threatened Committee, *Red Data Book* of IUCN[15] and lists or books published by various taxonomists (for instance, Mukherjee[2] listed over 100 commercially exploited species of orchids).

To analyse the association between commercial exploitation and the RET status, two-way contingency tables were constructed and subjected to χ^2 test[16]. While assessing the preference of flower/petal colour for commercial exploitation, various shades of a related colour were grouped into one category (for instance, orange, pink and red were classified as red).

A significantly higher proportion (40.77%) of commercially exploited orchid species are in RET group compared to those in noncommercial group (19.48%; $P < 0.01$; Table 1; Figure 1), implying that commercial exploitation of orchids is likely to render them the RET status. North India harboured larger proportion (86.76%) of commercially exploited orchid species compared to South India (13.24%; Table 2). It is interesting to note that significantly more than expected number of commercially exploited orchid species of North India are in RET group. In contrast, among the South Indian orchid flora, significantly more than expected number of noncommercial orchid species are in RET group ($P < 0.05$; Table 2). From these results it may be concluded that among the North Indian flora, commercial exploitation appears to be a major factor driving the orchid species to the status of RET while in South India, reasons other than commercial exploitation such as habitat destruction, deforestation, conversion of forest land to agriculture, etc. might be responsible.

Since orchids are highly priced for their aesthetic value, it is likely that those with attractive floral features such as large size (length and width) and bright colours are more exploited commercially, making them vulnerable for extinction. Therefore, we tested for the difference among various categories for such floral features (Table 3).

Orchid species with yellow (25.59%), white (24.33%) and green (19.78%) flowers were more frequently

Table 1. Distribution of orchid species into categories of endangered status and commercial exploitation

Status	Commercial	Noncommercial	Total
RET	53 (40.77)	120 (19.48)	173
Common (Non-RET)	77 (59.23)	496 (80.52)	573
Total	130	616	746

χ^2 value = 27.74; $P < 0.01$; $df = 1$.
RET = Rare/Endangered/Threatened.
Values in parentheses are percentages calculated for each column total.

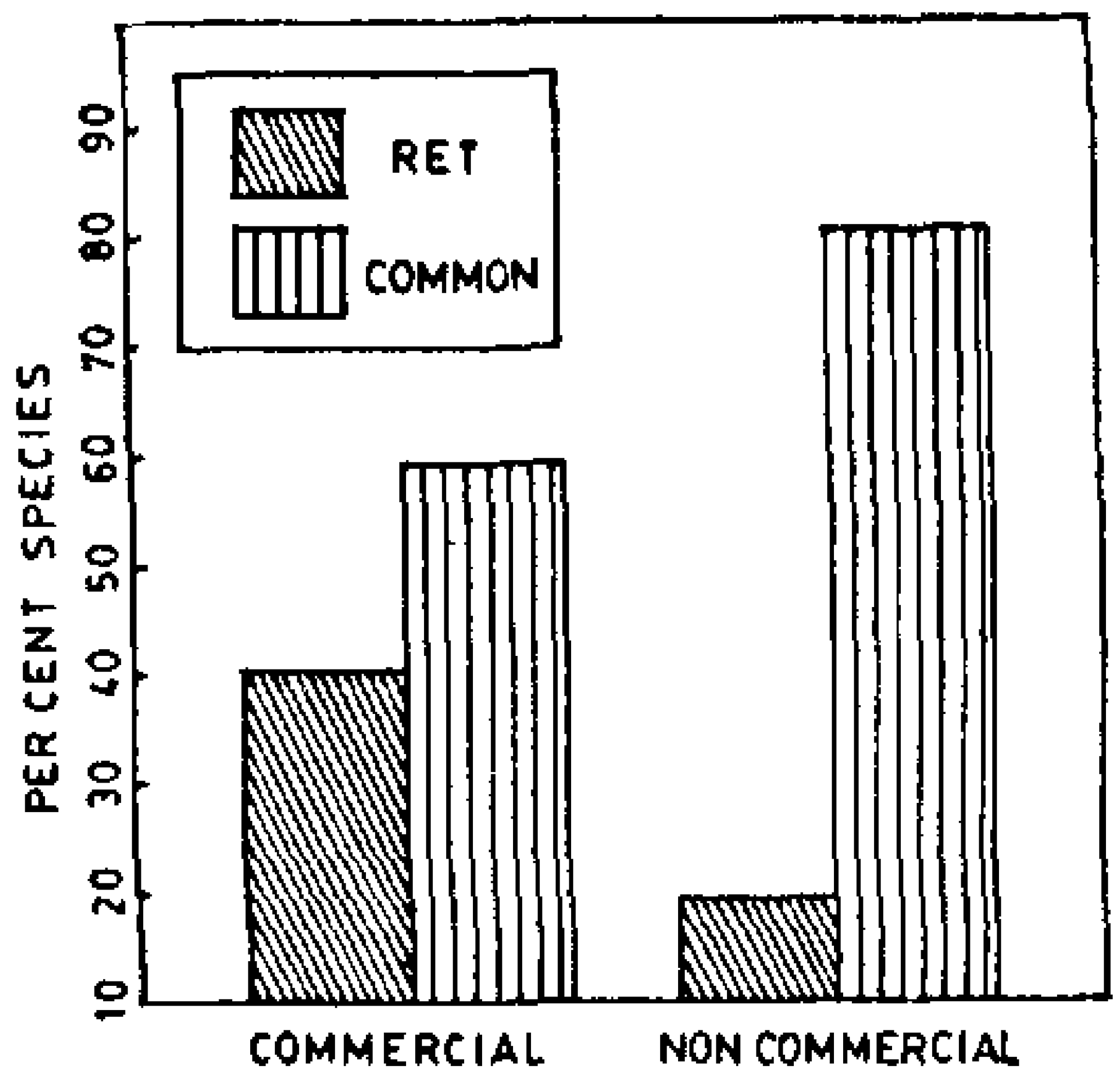

Figure 1. Percentage of species in RET and common group among commercial and noncommercial orchids.

Table 2. Distribution of orchid species into categories of endangered status, commercial exploitation and latitudinal regions

Latitudinal region	Commercial		Noncommercial		Total
	RET[a]	Common[b]	RET[c]	Common[d]	
North India	51 (44)	67 (65)	92 (101)	423 (421)	633
South India	4 (11)	14 (16)	34 (25)	100 (102)	152
Total	55	81	126	523	785

χ^2 value = 9.97; $P < 0.05$; $df = 3$.
[a]Two species overlap in both the regions; [b]Four species overlap in both the regions; [c]Six species overlap in both the regions; [d]27 species overlap in both the regions.
Values in parentheses are those expected from a random distribution.

Table 3. Distribution of orchid into flower colour classes and categories of commercial exploitation

Colour category	Commercial	Noncommercial	Total	Per cent
Yellow	36 (33)	127 (130)	163	25.59
White	42 (32)	113 (123)	155	24.33
Green	10 (26)	116 (100)	126	19.78
Red	20 (16)	59 (63)	78	12.40
Purple/blue	13 (15)	63 (61)	76	11.93
Brown	9 (8)	29 (30)	38	5.97
Total	130	507	637	

χ^2 value = 14.19; $P < 0.01$; $df = 4$ (calculated only for values under 'commercial' column)
Values in parentheses are those expected from a random distribution.

Table 4. Comparison of floral features between/among categories of endangered status and commercial exploitation

Character	N	Mean ± SE	N	Mean ± SE	t test Significance
		Commercial		**Noncommercial**	
Flower width (mm)	125	37.23 ± 2.34	535	16.39 ± 0.70	$P < 0.01$
Flower length (mm)	102	36 95 ± 2.69	507	18.92 ± 0 80	$P < 0.01$
		RET		**Common**	
Flower width	161	26.94 ± 1.96	498	18.23 ± 0 81	$P < 0 01$
Flower length	146	32.32 ± 2.50	462	18.67 ± 0.73	$P < 0.01$
		Commercial–RET		**Commercial–common**	
Flower width	52	45.32 ± 3.85	72	31.76 ± 2.76	$P < 0 05$
Flower length	44	46.52 ± 1.26	57	29.94 ± 2.54	$P < 0.05$
		Noncommercial–RET		**Noncommercial–common**	
Flower width	109	18 18 ± 1.69	426	15.94 ± 0 77	NS
Flower length	102	26.20 ± 2 66	405	17.09 ± 0.72	$P < 0 05$

NS, non significant.
Differences in N for the two characters are due to lack of data on flower length.

encountered than those with other colours. Significantly, more than the expected number of species with white, red and yellow (in that order) coloured flowers are exploited commercially while those with green and other colours are not ($P < 0.01$; Table 3).

Commercial orchid species had significantly larger mean flower size (width, w = 37.23 mm and length, l = 36.95 mm) compared to those not commercially exploited (w = 16.39 mm and l = 18.92 mm; $P < 0.01$; Table 4). The RET species also had significantly larger mean flower size (w = 26.94 mm and l = 32.32 mm) compared to the common (non RET) (w = 18.23 mm and l = 18.67 mm; $P < 0.01$; Table 4). Further, among the commercial orchid species, those in RET group had a larger flower size (w = 45.32 mm and l = 46.52 mm) compared to those in the common group (w = 31.76 mm and l = 29.94 mm; $P < 0.05$; Table 4). But, among the noncommercial orchid species, the RET and common group differed significantly only for flower length ($P < 0.05$; Table 4).

As shown in Figure 2*a* and *b*, flowers of a higher proportion of noncommercial orchids are smaller in size while those of a higher proportion of commercial orchids are larger. This is true for both length and width of the floral features.

From this study it appears that orchid species with large and bright coloured flowers are more exploited leading to their greater vulnerability for extinction. It is unfortunate that commercial exploitation instead of facilitating the conservation of the species, is in fact rendering them vulnerable for extinction. This calls for an urgent need to plan the conservation of these species. We suggest that mass multiplication of orchids through advanced *in vitro* techniques be initiated for export and other commercial purposes. Further, setting up of orchid sanctuaries in orchid-rich wilderness could be the major thrust in their conservation *in situ*. It is also preferred if collection of such species from the wild is completely banned.

a

b

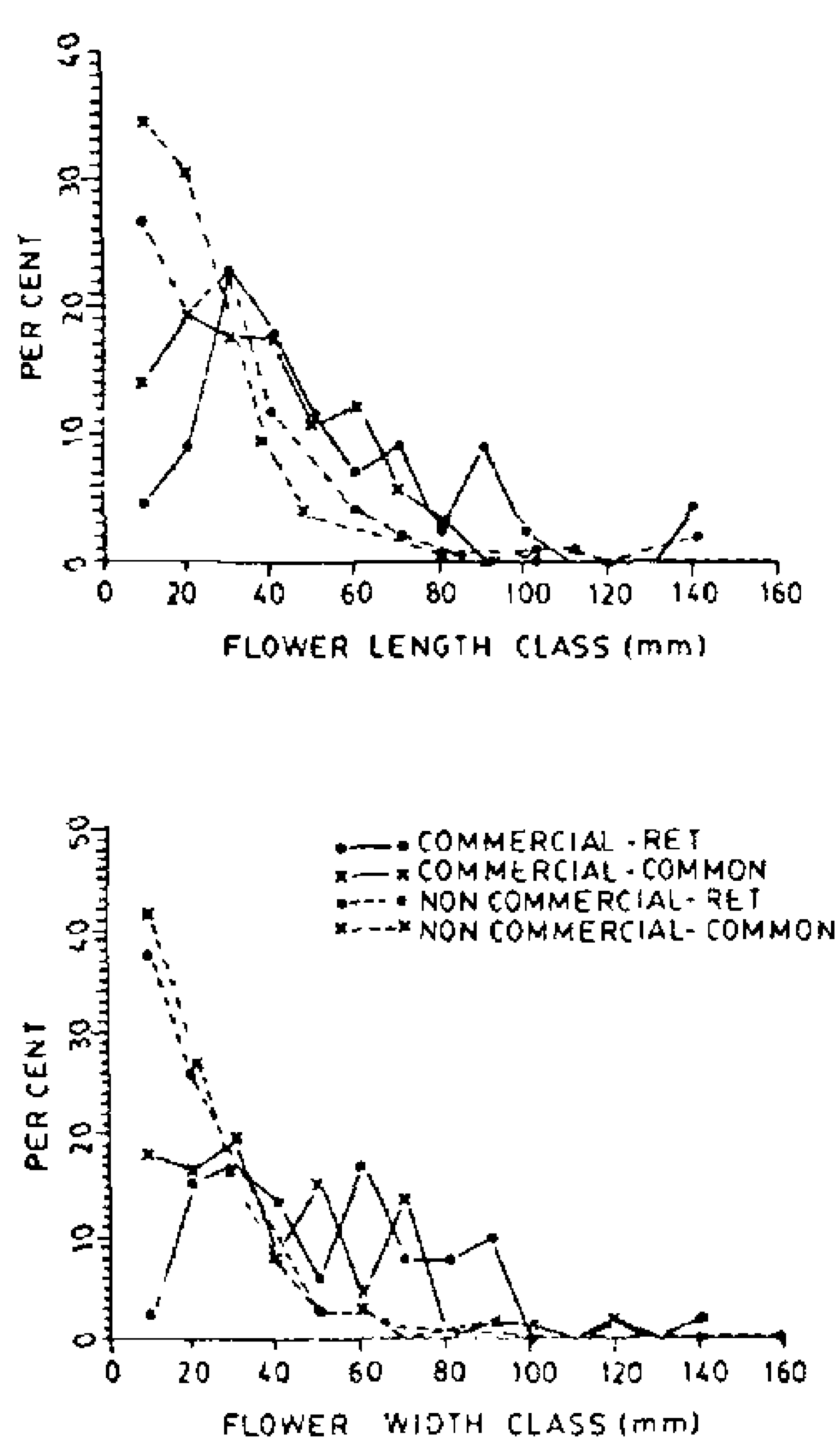

Figure 2. Distribution of orchid species into (*a*) flower length and (*b*) flower width classes

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RESEARCH COMMUNICATIONS

NMR chemical shielding tensors as a tool for probing molecular environment: Carbon-13 NMR and X-ray studies on malonic acid

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An empirical correlation proposed earlier[1] between the σ_{22} component of the chemical shielding tensor and the O−C−O bond angle at the carboxyl carbon in several dicarboxylic acids and related compounds, formed the basis for the reinvestigation of the X-ray structure of malonic acid. The X-ray analysis provides a striking confirmation of the correlation proposed and establishes the fact that the chemical shielding tensors can provide a sensitive tool for determining the local molecular geometry.

THE magnetic shielding tensors σ determined by proton enhanced rare spin NMR methods have provided a wealth of structural information about solid state conformation of molecules[2–5]. This information is more detailed than that obtained from NMR experiments involving the liquid state since it enables the determination of the principal values of the shielding tensor rather than just the trace of the tensor, thus providing more information on the chemical environment. A knowledge of the individual components of σ, which are likely to be more sensitive to geometrical changes than their isotropic counterparts, should lead to a better understanding of the mechanisms responsible for the chemical shift.

It has often been reported in the literature that the σ component of the carboxylic carbon tensor is extremely sensitive to the local structure[3]. Recently, a linear correlation was proposed between the σ_{22} component of the carboxyl carbon tensor and the O−C−O bond angle at this carbon atom[1]. Figure 1 shows such a correlation for a group of organic compounds containing carboxyl carbon as one of their functional groups, with a correlation coefficient of 0.94. The points of the curve could be fitted to a linear function of the form $y=mx+c$ with $m=-11.3$ and $c=1566$. For compounds with a known bond angle, this equation could be used to obtain an approximate estimate of the σ_{22} value of the tensor or vice versa. Malonic acid whose X-ray structure is known[6], was excluded from the above calculations, since application of this relationship to malonic acid using the conformational parameters (i.e., O−C−O = 128° for both carboxyl groups) reported in the X-ray studies, yields a value of 120 ppm for σ_{22} for both the carboxyl carbons which is very much at variance with the value of 178 and 175 ppm observed (indicated by □ in Figure 1) from NMR experiments. Consequently, we decided to reinvestigate the X-ray structure of malonic acid, primarily to improve the accuracy of the X-ray analysis and also to test the potential utility of the empirical relationship established between the σ_{22} and the O−C−O bond angle.

Complete three-dimensional CuK_α intensity data (to