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Phenotypic and genotypic correlation studies of Mandarins from Northeast India

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Abstract
Mandarins are highly preferred fruit crop in India where maximum genetic diversity is seen in Northeast part of the country. The present investigation was conducted during the year 2018-21 by collecting mandarin genotypes from different parts of Northeast India (Arunachal Pradesh, Assam, Meghalaya, Manipur, Mizoram, Nagaland, Tripura and Sikkim) along with three wild species to evaluate the genetic diversity using morphological markers Correlation studies showed that fruit weight had high significant positive correlation with yield, juice content, vitamin c, number of fruits per tree; shelf life have high positive significant correlation with pH only; number of fruits per tree have positive significant correlation with yield at both genotypic and phenotypic level which denotes the importance of selection of these traits for yield improvement. A direct selection of these traits will lead to simultaneous improvement of the above said characters and yield (kg/tree) in the mandarin breeding programme.

Keywords: Correlation, genotypes, mandarin and phenotypic

Introduction
Rutaceae family consist of the important crops of *Citru*s which are grown all over world for their characteristics flavour, attractive evergreen foliages and flowers as well as the extraordinary fragrance which added aesthetic value of *Citrus* trees (Swingle and Reece, 1967) [12]. Among the entire *Citrus* genus, Mandarins are phenotypically heterogeneous group, consisting of several species together with various interspecific and intergeneric hybrids and mutants. It is fully fledged throughout the tropical and subtropical regions of the world. However, the finest fruit quality is observed under subtropical conditions. Among the different *Citrus* fruits in India, mandarin is placed at first position with respect to area and production followed by sweet oranges and limes. North-Eastern Region of India is a treasure house of *Citrus* germplasms because of the existence of 23 species, 1 subspecies and 68 varieties (Sharma *et al*., 2004) [24].
Citrus decline results in loss of vigour and general health and decreased fruit production by showing symptoms like defoliation of young shoots and dying back of twigs from the tip. This in due course leads to decline of productivity to a greater extent (Yadav *et al.*, 2003) [13]. Khasi Mandarins are grown in all the states of North East India. Maximum area of mandarin cultivation is from Arunachal Pradesh (32.73 thousand hectare) with a production and productivity as 69.74 thousand metric tons and 2.13 MT/ha respectively. Following this Mizoram (16.37 thousand hectare) bags second in area and 44.02 thousand metric tons and 2.69 MT/ha production and productivity respectively. Other states include Assam (14.69 thousand hectare area, 203.72 thousand metric tons production, 13.63 MT/ha productivity); Sikkim (13.08 thousand hectare area, 18.99 thousand metric tons production, 1.45 MT/ha productivity); Meghalaya (9.28 thousand hectare area, 45.24 thousand metric tons production, 4.88 MT/ha productivity); Nagaland (6.52 thousand hectare area, 47.33 thousand metric tons production, 7.26 MT/ha productivity); Tripura (5.62 thousand hectare area, 25.33 thousand metric tons production, 4.51 MT/ha productivity) and Manipur (4.46 thousand hectare area, 39.89 thousand metric tons production, 8.94 MT/ha productivity). However maximum productivity of Mandarin cultivation in North East is seen at Assam (13.63 MT/Ha) followed by Manipur (8.94 MT/Ha) (Anon., 2018) [1].

Materials and Method
The experimental material for the present study comprised of selected mandarin genotypes in which collection and survey was achieved from North-East states of India as wide variability specifically exists all through these particular locations. The morphological characters will be

studied by following IPGRI citrus descriptor (Anon, 1999) [2]. The sampling of fruit, leaves and seed were done in the month of December to February for two consecutive bearing years. The plant samples from each genotypes included tree leaves, fruit and seeds along with the plant characteristics recording with the passport data of the location. The samples collected were further evaluated from the Department of fruit science of College of Horticulture and Forestry, Central Agricultural University, Pasighat. The data evaluated were statistically analysed with SPSS software.

Table 1: Selected genotypes and wild species

Genotypes	Place	State
G1	*Citrus indica*, Sibut (Pagla Nadi)	Arunachal Pradesh
G2	Adi Pasi	Arunachal Pradesh
G3	Wokha, Nagaland	Nagaland
G4	Doribokre, Nokrek,West Garo Hills	Meghalaya
G5	Mandel Noket, Nokrek, West Garo hills	Meghalaya
G6	Jampui Hills	Tripura
G7	Duragre, West Garo hills	Meghalaya
G8	Along	Arunachal Pradesh
G9	Geyzing, West Sikkim	Sikkim
G10	Jengging	Arunachal Pradesh
G11	Mardoloi, Near Nongpoh, Near East Khasi Hills	Meghalaya
G12	Mokokchung	Nagaland
G13	Darechikgre, West Garo hills, Nokrek	Meghalaya
G14	Rengging	Arunachal Pradesh
G15	Ukhrul, Kamjong region	Manipur
G16	Moreh Komla, Chandel District	Manipur
G17	Serchhip	Mizoram
G18	Singtam, East Sikkim	Sikkim
G19	Lhathao, Junapathar, Namsai	Arunachal Pradesh
G20	Jeru village, Upper Siang	Arunachal Pradesh
G21	Nagpur mandarin, Basar	Arunachal Pradesh
G22	Zero point, Near Dambuk	Arunachal Pradesh
G23	Sonapur	Assam
G24	Chani Village, Yazali	Arunachal Pradesh
G25	Miglung, Pasighat	Arunachal Pradesh
G26	Mebo	Arunachal Pradesh
G27	Roing	Arunachal Pradesh
G28	Tamenglong	Manipur
G29	Sikkim Mandarin, Basar	Arunachal Pradesh
G30	Yagrung Village	Arunachal Pradesh
G31	Kinnow Mandarin, Basar	Arunachal Pradesh
G32	Khasi Mandarin, Basar	Arunachal Pradesh
G33	Sissen Village	Arunachal Pradesh
G34	Dambuk	Arunachal Pradesh
G35	Karko	Arunachal Pradesh
G36	Nagpur mandarin, Biswanath Charali	Assam
G37	Bodak village	Arunachal Pradesh
G38	Boleng, Siang	Arunachal Pradesh
G39	Balek	Arunachal Pradesh
G40	Taki Lalung	Arunachal Pradesh
G41	Hill Mandarin, CHF, Pasighat	Arunachal Pradesh
G42	Cleopatra Mandarin, CHF, Pasighat	Arunachal Pradesh

Results and Discussion

Tree height had positive and very high significant phenotypic correlation with total sugar (0.372), peel or rind thickness (0.367), fruit length (0.364), vitamin C (0.353) and fruit width (0.329) respectively. However tree height has medium positive phenotypic correlation significance with number of seeds (0.223), fruit weight (0.204) and yield (0.184). High negative phenotypic correlation was seen in titratable acidity (0.364) followed by seed weight (0.305). However, the present investigation recorded total sugar (0.448), fruit length (0.437), vitamin C (0.419), peel thickness (0.418), fruit width (0.410), number of seed (0.254) and fruit weight (0.229) reported highest positive significant genotypic correlation whereas yield (0.201), juice content (0.188) and number of fruits (0.180) have medium significant positive genotypic correlation. A negative significant genotypic correlation was reported in titratable acidity (0.383) and seed weight (0.349) with respect to tree height. Fruit weight was positively and highly significantly correlated with phenotypic level (rp) with peel weight (0.833), yield (0.688), fruit length (0.579), peel thickness (0.565), fruit width (0.490), juice content (0.426), total sugar (0.387), number of fruit (0.326) and vitamin C (0.312) respectively. However it is positively medium significant correlated with phenotypic level with seed weight (0.187). Fruit weight is negatively significantly phenotypic correlated with titratable acidity (0.382). At the genotypic level had positive and highly significant correlation with peel weight (0.863), yield (0.716), fruit length (0.656), peel thickness (0.604), fruit width (0.5660, juice content (0.446), vitamin C (0.439), total sugar (0.405) and number of fruit

(0.344) but medium significant positively genotypic correlated with seed weight (0.201) was recorded. Fruit weight is highly negatively significant and genotypically correlated with titratable acidity (0.392). Under study it was found that fruit length (mm) had positive highly significant phenotypic correlation with fruit width (0.758), peel weight (0.514), total sugar (0.401), peel or rind thickness (0.363), yield (0.277), vitamin C (0.263) and juice content (0.241). Fruit length is negatively high significant phenotypically correlated to titratable acidity (0.470). At the genotypical level, fruit length is positively high significantly correlated with fruit weight (0.930), peel weight (0.568), TSS (0.447), peel thickness (0.414), vitamin C (0.382), yield (0.315), juice content (0.294) while fruit length is negative significant genotypically correlated with titratable acidity (0.515) only. Observations recorded that fruit width had positive and high significant phenotypic correlation with total sugar (0.495), peel weight (0.323), peel thickness (0.316), yield (0.279), vitamin c (0.247), juice content (0.236) while fruit width is positively medium significant phenotypically correlated with TSS (0.228) and pH (0.193) respectively. There is no negative significant phenotypic correlation with respect to fruit width. It is observed that fruit width is positive significant genotypic correlated with total sugar (0.556), peel weight (0.385), vitamin C (0.364), yield (0.313), juice content (0.263) and TSS (0.255) while medium significant positive genotypic correlated with pH (0.203) and number of fruits/tree (0.186). Fruit width is negative significant high genotypic correlated with titratable acidity (0.502). Fruit size was directly correlated with fruit weight in the research work done by Dorji and Yapwattanaphun (2015) [3] in the mandarin accessions from Bhutan.

Peel weight is positive high significant phenotypic correlated with yield (0.573), juice content (0.466), peel weight (0.456), seed weight (0.319), number of fruits/tree (0.271), vitamin C (0.235). It is having high negative significant phenotypic correlation with titratable acidity (0.301). However, peel weight had high positive significant genotypic correlation with yield (0.585), juice content (0.488), peel weight (0.479), seed weight (0.328), vitamin C (0.310) and number of fruits/tree (0.277) while high negative genotypic correlation with titratable acidity. Number of seeds per fruit showed high positive significant phenotypic correlation with juice content (0.308) and shelf life under room temperature (0.257) while medium significant positive phenotypic correlated with peel thickness (0.180). Meanwhile number of seeds/ fruit is negative highly significant phenotypic correlated with TSS (0.285) and medium significant negative phenotypic correlated with seed weight (0.204), total sugar (0.227) and pH (0.219) respectively in decreasing order of negative phenotypic significance. At genotypic (r_g) level number of seeds per fruit had positive and high significant correlation with juice content (0.334), shelf life under room temperature (0.294) while positive medium significant genotypic correlated with peel thickness (0.191). It is negative high significant genotypic correlation with TSS (0.321), pH (0.246), Total sugar (0.229) and medium significant negative genotypic correlated with only seed weight (0.218). This data shows the role of number of seeds on the final size of the fruit. It was similar to the findings of Kumar *et al*. (2015) [6].

At phenotypic level juice content showed high positive significant phenotypic correlation with peel or rind thickness (0.438), yield (0.397), number of fruits (0.268), seed weight (0.230) and medium positive significant phenotypic correlated with vitamin C (0.186) and shelf life under room temperature (0.177). There is no negative significant phenotypic correlation with respect to juice content (ml). However at the genotypic level, juice content is positive high significant correlation with peel or rind thickness (0.468), yield (0.402), number of fruits/tree (0.293), seed weight (0.246) and vitamin C (0.231) and medium positive genotypic correlation with total sugar (0.177). It is negative significant genotypic correlation with pH (0.177). Seed weight is positively significant phenotypic correlated with yield (0.177) while there was no negative significant phenotypic correlation with seed weight. While at the genotypic level there is positive significant genotypic correlation with yield (0.177) but there was no negative significant genotypic correlation with seed weight similar to that at that phenotypic level.

The role of endogenous hormones in rough skinned (abnormal) and normal thickness of mandarin fruits has been extensively reviewed by Monselise and Goren (1978) [7]. Kumar *et al*. (2015) [6]also reported significant direct effect of seed number and peel thickness in mandarin fruits. In the present investigation, peel or rind thickness is positive high significant phenotypic correlation with yield (0.589), number of fruits (0.428), total sugar (0.346), vitamin c (0.270) and Shelf life under room temperature (0.265) while it is negative high significant phenotypic correlated with titratable acidity (0.280). However, peel or rind thickness is positive high significant positive correlation with yield (0.629), number of fruits/tree (0.462), total sugar (0.368), vitamin C (0.360) and shelf life under room temperature (0.292) but it is observed that the peel or rind thickness is negative high significant with titratable acidity (0.293). TSS had high positive phenotypic significance with pH (0.444), total sugar (0.410) and vitamin C (0.253) but medium positive significant phenotypic correlation with number of fruits (0.190). It observed negative high significant genotypic correlation with titratable acidity (0.541) and shelf life under room temperature (0.369). At the genotypic level, TSS had high positive significant genotypic correlation with pH (0.538), total sugar (0.463) and vitamin C (0.318) but medium positive significant genotypic correlation with number of fruits (0.188). However, it had high negative significant genotypic correlation with titratable acidity (0.587) and shelf life under room temperature (0.440). Similarly Erner *et al.* (1976) [4] reported a direct correlation between the development of rough peel and presence of higher cytokinin and gibberellins levels in the tissues of the fruit. Physical characters are reported to have a positive correlation with each other but negative correlation with the biochemical characteristics (Prasad and Rao; 1989) [9].

Titratable acidity has high positive significant phenotypic correlation with shelf life under room temperature (0.559) although it had high negative significant phenotypic correlation with vitamin C (0.611), total sugar (0.591), pH (0.501), number of fruits (0.443) and yield (0.356). Titratable acidity had high positive significant genotypic correlation with only shelf life under room temperature (0.588) but high negative genotypic correlation with vitamin C (0.783), total sugar (0.618), pH (0.539), number of fruits (0.457) and yield (0.361). Total sugar (%) had high positive significant phenotypic correlation with vitamin C (0.536), number of fruits/tree (0.339), yield (0.331) and pH (0.307) while high negative phenotypic correlation with shelf life under room temperature (0.271). At genotypic level, total sugar had high positive significant genotypic correlation with vitamin C (0.734), number of fruits (0.375), yield (0.349) and pH

(0.337) and high negative significant genotypic correlation with shelf life under room temperature (0.303). Vitamin C had high positive significant phenotypic correlation with number of fruits (0.384), yield (0.348) and high negative phenotypic significant with shelf life under room temperature (0.309). However, vitamin C had high positive significant genotypic correlation with number of fruit (0.487) and yield (0.419) while high negative significant genotypic correlation with shelf life under room temperature (0.453). At phenotypic level, shelf life under room temperature had high positive significant phenotypic correlation with pH (0.413) while no negative significant correlation with any traits was recorded in this. Shelf life under room temperature had high negative significant genotypic correlation with pH (0.453) but no negative significant genotypic correlation with any characters was recorded. In the pH there was no record of any positive or negative significant phenotypic correlation with any characters. Similarly in the genotypic level, pH had not shown any negative or positive significant genotypic correlation with other characters. Number of fruits per tree had high positive significant phenotypic correlation with only yield (0.853) and there was no report of any negative significant phenotypic correlation with number of yield at phenotypic level. At genotypic level also number of fruits per tree was recorded with high positive genotypic correlation with yield (0.879) but no negative significant genotypic correlation was recorded here. Yield trait was recorded with other characters. However to summarize, yield was showing high positive significance phenotypic correlation with number of fruits (0.853), fruit weight (0.688), peel or rind thickness (0.589), juice content (0.397), vitamin C (0.348), total sugar (0.331), fruit width 90.279) and fruit length (0.277) while yield had medium positive significance with tree height (0.184) and seed weight (0.177). Yield was showing high negative significant phenotypic correlation with titratable acidity (0.356). Observations recorded that yield had high positive significant genotypic correlation with number of fruits (0.879), fruit weight (0.716), peel or rind thickness (0.629), peel weight (0.585), vitamin C (0.4190, juice content (0.402), total sugar (0.349), fruit length (0.315) and seed width (0.313) while medium positive significant genotypic correlation with tree height (0.201) and seed weight (0.183) respectively. Yield was found high negative significant genotypic correlation with titratable acidity (0.361) similar to that at the phenotypic level. These findings support the findings of Khandavi (2012) [5] who reported high significant and positive correlation of fruit weight with length and breadth of fruit in sweet oranges and lime. These findings also agree with the findings of Pingle (2011) [8] and Shrestha *et al.* (2012) [11] in kagzi lime and acid lime respectively.

Wide range of variations is present at the morphological, biochemical, yield and shelf life characters of mandarins from North East India from the present investigation. Hence, it is needed to give more emphasis on these characters during selection programme for the improvement of yield and other quality traits as elite mother plants.

Table 2: Phenotypic correlation

Phenotypical Correlation Matrix																	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
1	1.000	0.204*	0.364**	0.329**	0.044	0.223*	0.164	-0.305**	0.367**	0.123	-0.364**	0.372**	0.353**	0.089	-0.019	0.163	0.184*
2		1.000	0.579**	0.490**	0.833**	0.154	0.426**	0.187*	0.565**	0.012	-0.382**	0.387**	0.312**	0.122	0.015	0.326**	0.688**
3			1.000	0.758**	0.514**	0.042	0.241**	0.117	0.363**	0.173	-0.470**	0.401**	0.263**	-0.025	0.145	0.139	0.277**
4				1.000	0.323**	0.008	0.236**	0.050	0.316**	0.228*	-0.434**	0.495**	0.247**	-0.036	0.193*	0.165	0.279**
5					1.000	0.109	0.466**	0.319**	0.456**	-0.055	-0.301**	0.214*	0.235**	0.013	-0.006	0.271**	0.573**
6						1.000	0.308**	-0.204*	0.180*	-0.285**	-0.002	-0.227*	-0.003	0.257**	-0.219*	-0.031	0.094
7							1.000	0.230**	0.438**	-0.114	-0.131	0.167	0.186*	0.177*	-0.172	0.268**	0.397**
8								1.000	0.092	0.068	0.137	-0.077	-0.074	-0.083	0.027	0.056	0.177*
9									1.000	-0.016	-0.280**	0.346**	0.270**	0.265**	0.012	0.428**	0.589**
10										1.000	-0.541**	0.410**	0.253**	-0.369**	0.444**	0.190*	0.043
11											1.000	-0.591**	-0.611**	0.559**	-0.501**	-0.443**	-0.356**
12												1.00	0.536**	-0.271**	0.307**	0.339**	0.331**
13													1.000	-0.309**	0.076	0.384**	0.348**
14														1.00	-0.413**	-0.169	0.058
15															1.000	0.132	-0.007
16																1.000	0.853**
17																	1.000

1= Tree Height (m), 2= Fruit Weight(g), 3= Fruit length(mm), 4= Fruit width(mm), 5= Peel weight(g), 6= No. of seeds/fruit, 7= Juice content (ml), 8= seed weight(g), 9= Peel or rind thickness, 10= TSS, 11= Titratable Acidity (%), 12= Total sugar (%), 13= Vit C (mg/ 100g), 14= Shelf life ambient temperature, 15= pH, 16= No of fruits, 17= Yield (kg/ tree)

Table 3: Genotypic correlation

Genotypical Correlation Matrix																	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
1	1.000	0.229**	0.437**	0.410**	0.040	0.254**	0.188*	-0.349**	0.418**	0.132	-0.383**	0.448**	0.419**	0.117	0.001	0.180*	0.201*
2		1.000	0.656**	0.566**	0.863**	0.166	0.446**	0.201*	0.604**	0.012	-0.392**	0.408**	0.439**	0.125	0.016	0.344**	0.716**
3			1.000	0.930**	0.568**	0.028	0.294**	0.125	0.414**	0.208*	-0.515**	0.447**	0.382**	-0.005	0.153	0.138	0.315**
4				1.000	0.385**	0.010	0.263**	0.053	0.387**	0.255**	-0.502**	0.556**	0.364**	-0.043	0.203*	0.186*	0.313**
5					1.000	0.111	0.488**	0.328**	0.479**	-0.062	-0.306**	0.228*	0.310**	0.024	-0.002	0.277**	0.585**
6						1.000	0.334**	-0.218*	0.191*	-0.321**	0.000	-0.229**	0.003	0.294**	-0.246**	-0.038	0.099
7							1.000	0.246**	0.468**	-0.125	-0.132	0.177*	0.231**	0.168	-0.176*	0.293**	0.402**
8								1.000	0.100	0.062	0.145	-0.080	-0.095	-0.090	0.039	0.057	0.183*
9									1.000	0.008	-0.293**	0.368**	0.360**	0.292**	0.003	0.462**	0.629**
10										1.000	-0.587**	0.463**	0.318**	-0.440**	0.538**	0.188*	0.051
11											1.000	-0.618**	-0.783**	0.588**	-0.539**	-0.457**	-0.361**

12												1.000	0.734**	-0.303**	0.337**	0.375**	0.349**
13													1.000	-0.453**	0.151	0.487**	0.419**
14														1.000	-0.453**	-0.172	0.059
15															1.000	0.135	-0.002
16																1.000	0.879**
17																	1.000

1= Tree Height (m), 2= Fruit Weight (g), 3= Fruit length (mm), 4= Fruit width (mm), 5= Peel weight (g), 6= No. of seeds/fruit, 7= Juice content (ml), 8= seed weight(g), 9= Peel or rind thickness, 10= TSS, 11= Titratable Acidity (%), 12= Total sugar (%), 13= Vit C (mg/ 100g), 14= Shelf life ambient temperature, 15= pH, 16= No of fruits, 17= Yield (kg/ tree)

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Reference

1. Anonymous. Horticulture statistics at a glance, Government of India, Ministry of Agriculture and Farmers welfare, Department of Agriculture, Cooperation and Farmers Welfare, Horticulture statistics Division, New Delhi, 2018.
2. Anonymous. Descriptors for *Citrus*. International Plant Genetic Resources Institute (IPGRI), Rome, Italy, 1999.
3. Dorji K, Yapwattanaphun C. Assessment of the genetic variability amongst mandarin (*Citrus reticulata* Blanco) accessions in Bhutan using AFLP markers. BMC Genetics. 2015;16:39.
4. Erner Y, Goren R, Monselise SP. The rough fruit condition of the shamouti orange connection with the endogenous hormonal balance. Journal of Horticulture Science. 1976;52:367-74.
5. Khandavi RS. Survey for selection of superior kagzi lime (*Citrus aurantifolia* Swingle) strains in Beed district. M.Sc. (Ag.) Thesis Submitted to M.K.V., Parbhani, Maharashtra, India, 2012,
6. Kumar A, Avasthe RK, Pandey B, Lepcha B, Rahman H. Correlation studies for effect of fruit grade on fruit quality and seed traits of mandarin variants in North East India. Indian Journal of Horticulture. 2015;72(2):162-166. doi:10.5958/0974-0112.2015.00032.8.
7. Monselise SP, Goren R. The role of internal factors and exogenous control in flowering, peel growth and abscission in Citrus. Scientia Horticulture. 1978;13:134-39.
8. Pingle SN. Survey for selection of superior kagzi lime (*Citrus aurantifolia* Swingle) strains in Latur district. M.Sc. (Ag.) Thesis Submitted to M.K.V., Parbhani, Maharashtra, India, 2011,
9. Prasad MBNV, Rao GSP. Genetic variability, correlations and path-coefficient analysis for some morphological and biochemical constituents of acid lime fruits. Scientia Horticulture. 1989;41(1&2):43-53.
10. Sharma BD, Hore DK, Gupta SG. Genetic resources of *Citrus* of north-eastern India and their potential use. Genetic Resources and Crop Evolution. 2004;51:411-418.
11. Shrestha RL, Dhakal DD, Durga GM, Paudyal KP, Shrestha S. Study of fruit diversity and selection of elite acid lime (*Citrus aurantifolia* Swingle) genotypes in Nepal. American Journal of Plant Science. 2012;3:1098-1104.
12. Swingle WT, Reece PC. The botany of *Citrus* and its wild relatives. In: Reuther, W., Batchelor, L.D., Webber, H.J. (eds). The *Citrus* Industry. University of California Press, Berkeley, 1967, 190-340.
13. Yadav DS, Patel RK, Rai N, Dubey AK. Physico-chemical status and yield of fruits of declined Khasi Mandarin orchards in Meghalaya. Agriculture Science Digest. 2003;23(1):71-72.