Seasonal impact on quantitative attributes and vegetation indices of bioresources present in horti-silvi-pasture system of Central Kashmir, Jammu and Kashmir, India

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Bioresources composition in District Budgam (Central Kashmir) revealed the presence of 31 genera having 32 species belonging to 20 families of herb plants and six genera of six species representing three families of trees. Seasonal variation in quantitative attributes explicated dominance of *Cynodon dactylon*. Index of diversity of herbaceous species demonstrated maximum values during summer season. In case of tree diversity, *Malus domestica* was recorded as the most important species revealing an importance value index of 72 in the evaluated agroforestry system.

Keywords: Bioresources, horti-silvi-pasture system, quantitative attributes, seasons, vegetation indices.

BIOLOGICAL diversity is the variation among living organisms from all sources and natural ecosystems of which they are a part. This includes diversity of ecosystems, diversity within species and between species. As the rate of deforestation, land degradation, loss of biodiversity and ecosystem services continue to rise globally, the international community is faced with the challenge of finding land-use interventions that can mitigate or reduce the impact of these environmental issues. There has been a lack of concern about ecosystem restoration compounded with primitive and ineffective forest practices and on-going deforestation[1]. In the past, the conservation of biodiversity has been mostly understood in terms of the management of protected areas and natural forests, ignoring the possible role of farm areas and the ways through which rural communities have promoted biodiversity in their subsistence agricultural production systems[2]. The ability of many intensively used landscapes to support native species suggests that maintaining and creating habitats in human-influenced landscapes can help conserve a large proportion of biodiversity[3]. In the last three decades, there has been a growing interest in agroforestry because of its biodiversity and the ecosystem services it delivers, besides providing the tangible benefits of food, fodder, fuelwood, timber and non-timber forest products (NTFPs). About 50–80% of species from the regional pools typically survive in agroforestry systems; however, many endemic species are lost from the agroforests[4]. Considering the fact that ecosystems and species are disappearing at an alarming rate, the role of agroforestry as a conservation tool needs to be exploited further[5].

The traditional agroforestry systems identified in the Kashmir Valley, Jammu and Kashmir (J&K), India include boundary plantations, agri-silviculture on sloping lands, agri-silviculture in plains, horti-silviculture, horti-silvi-pasture, horti-silvi-agriculture and homegardens[6,7]. These systems have been evaluated in terms of livelihood aspects only and to date, no work has been done to evaluate the biodiversity of these identified agroforestry systems. Thus, a study was undertaken to assess bioresources present in horti-silvi-pasture system of Budgam district, J&K.

The present study was conducted during 2013 and 2014. The experimental site is located between 34°1′12″N lat. and 74°46′48″E long. at an altitude of 1610 m amsl, roughly 15 km southeast of Srinagar city. The topography of Budgam district is mixed with both mountainous and plain areas. The climate is of temperate type with the upper reaches receiving heavy snowfall during winter. The average annual precipitation of the district is 585 mm. Three out of nine tehsils, namely Budgam, Beerwah and Chadoora were selected to carry out the study. Multistage stratified random sampling was used to select the blocks – villages within tehsils and farmers within villages. A total of 252 farmers were selected and interviewed using a pretested questionnaire regarding different land-use patterns (agriculture, agroforestry, horticulture) and their socio-economic status.

In the study area, 10 m × 10 m size quadrats for trees and two 1 m × 1 m quadrats for herbs were laid down and replicated three times respectively.

Herbarium specimens (herbaceous plants) were collected for three consecutive seasons, viz. spring, summer and autumn[8], and identified at the Division of Environmental Sciences, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir and Centre for Biodiversity and Taxonomy, Department of Botany, University of Kashmir. Data on vegetation were quantitatively analysed for density, basal area, frequency and importance value index (IVI) separately for three different life forms, i.e. trees and herb species, according to Curtis and McIntosh[9].

All the datasets were analysed using descriptive statistics (MS Excel worksheet) and the standard procedures followed by Gomez and Gomez[10].

From the reconnaissance, it was estimated that 184 out of 252 farmers in the study area practiced different agroforestry systems, of which 30 farmers carried out horti-silvi-pasture system covering about 5.75 ha area.

Bioresources composition revealed the presence of herb layers representing 31 genera, 32 species of 20 families

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Table 1. Density of different herbaceous plants in horti-silvi-pasture system of the study area (Budgam district, J&K, India)

	Density/m^2					
	Spring		Summer		Autumn	
Plant species	Mean	±SE	Mean	±SE	Mean	±SE
Amaranthus caudatus L.	10.50	2.75	25.50	10.98	6.00	1.73
Anagallis arvensis L.	4.00	0.12	10.83	3.37	2.00	0.81
Anthemis cotula L.	7.50	2.30	21.83	7.40	4.66	1.16
Asparagus officinalis L.	7.83	7.83	24.33	12.18	5.83	0.83
Cannabis sativa L.	20.66	4.91	38.83	11.34	10.00	0.86
Chenopodium album L.	11.83	6.40	37.33	6.48	6.00	2.02
Clinopodium vulgare L.	5.16	0.44	11.66	3.00	2.00	0.15
Convolvulus arvensis L.	5.66	1.96	32.00	1.60	3.66	1.85
Conyza canadensis L. Cronquist	17.66	1.85	37.33	3.60	12.00	1.25
Cynodon dactylon L.	90.33	3.94	103.66	9.40	67.33	9.68
Daucus carota L.	17.66	1.45	37.00	3.51	11.66	1.33
Galinsoga parviflora Cav.	7.00	2.04	12.16	2.94	3.50	1.75
Geranium polyanthes Edgew & Hook	32.66	16.33	54.50	0.28	17.83	1.39
Medicago polymorpha L. (Benth.)	42.83	14.87	62.16	7.83	30.50	5.83
Mentha arvensis L.	3.33	1.33	10.66	3.35	1.33	0.66
Oenothera rosea L. Her. ex Aiton	51.16	1.42	77.50	9.84	37.00	9.25
Plantago lanceolata L.	11.16	3.76	34.66	0.16	7.50	2.46
Plantago major L.	16.16	8.09	35.83	6.45	8.50	1.50
Poa pratense L.	16.33	9.11	23.33	5.10	10.33	1.91
Polygonum hydropiper L.	14.66	4.84	18.5	3.25	–	–
Potentilla reptans L.	10.33	0.16	14.16	3.16	4.66	0.40
Prunella vulgaris L.	6.00	3.21	11.83	1.01	3.00	1.52
Rumex dentatus L.	7.66	4.47	29.83	0.72	3.16	1.58
Scandix pectenveneris L.	21.16	3.83	45.66	2.45	12.33	1.33
Sonchus oleraceus L.	9.00	3.00	29.00	1.60	5.50	1.04
Setaria viridis L.	31.33	1.45	38.70	2.12	–	–
Stellaria media L. (Vill.)	20.83	10.93	36.70	7.94	11.50	1.25
Sysiumbrium irio L.	4.33	2.18	12.70	1.76	–	–
Taraxacum officinale Weber	16.83	3.91	38.34	12.17	10.66	2.04
Trifolium pratense L.	21.33	0.72	25.16	7.48	11.50	0.50
Veronica persica Poiret	12.66	6.33	15.50	2.78	5.16	0.77
Viola odorata L.	12.66	6.34	16.00	2.56	6.00	0.34
Total	568.20	–	1023.18	–	315.94	–

Table 2. Basal area of different herbaceous plants in horti-silvi-pasture system of the study area

	Basal area (cm^2/m^2)					
	Spring		Summer		Autumn	
Plant species	Mean	±SE	Mean	±SE	Mean	±SE
Amaranthus caudatus L.	0.38	0.05	0.52	0.03	0.14	0.01
Anagallis arvensis L.	0.02	0.001	0.13	0.09	0.009	0.004
Anthemis cotula L.	0.19	0.003	0.26	0.07	0.12	0.01
Asparagus officinalis L.	0.98	0.20	1.23	0.62	0.13	0.01
Cannabis sativa L.	1.10	0.25	1.57	0.06	0.48	0.10
Chenopodium album L.	0.14	0.003	0.68	0.29	0.11	0.01
Clinopodium vulgare L.	0.52	0.25	1.10	0.16	0.28	0.06
Convolvulus arvensis L.	0.52	0.10	1.11	0.14	0.27	0.13
Conyza canadensis L. Cronquist	0.76	0.29	1.07	0.01	0.55	0.21
Cynodon dactylon L.	1.93	0.03	2.02	0.03	1.65	0.29
Daucus carota L.	0.76	0.19	1.07	0.01	0.54	0.19
Galinsoga parviflora Cav.	0.57	0.29	0.87	0.06	0.20	0.10
Geranium polyanthes Edgew & Hook	0.65	0.15	0.89	0.03	0.27	0.06
Medicago polymorpha L. (Benth.)	1.42	0.25	1.27	0.22	0.67	0.22
Mentha arvensis L.	0.02	0.001	0.12	0.01	0.008	0.001
Oenothera rosea L. Her. ex Aiton	1.86	0.03	1.98	0.05	1.06	0.01

(*Contd*)

Table 2. (*Contd*)

	Basal area (cm²/m²)					
	Spring		Summer		Autumn	
Plant species	Mean	±SE	Mean	±SE	Mean	±SE
Plantago lanceolata L.	1.22	0.14	1.31	0.04	0.82	0.13
Plantago major L.	1.24	0.62	1.33	0.03	0.93	0.13
Poa pratense L.	1.25	0.62	1.34	0.01	0.98	0.16
Polygonum hydropiper L.	1.32	0.05	1.35	0.02	–	–
Potentilla reptans L.	0.35	0.10	0.51	0.11	0.17	0.08
Prunella vulgaris L.	0.47	0.23	0.81	0.13	0.22	0.02
Rumex dentatus L.	0.68	0.34	1.28	0.34	0.24	0.12
Scandix pectenveneris L.	0.82	0.12	1.33	0.32	0.54	0.14
Sonchus oleraceus L.	0.22	0.07	0.48	0.16	0.03	0.006
Setaria viridis L.	1.05	0.01	1.15	0.04	–	–
Stellaria media L. (Vill.)	0.38	0.03	0.83	0.15	0.25	0.06
Sysiumbrium irio L.	0.25	0.08	0.41	0.06	–	–
Taraxacum officinale Weber	0.71	0.19	1.09	0.08	0.38	0.04
Trifolium pratense L.	0.92	0.40	1.10	0.07	0.69	0.11
Veronica persica Poiret	0.51	0.25	0.90	0.05	0.24	0.006
Viola odorata L.	0.51	0.30	0.91	0.04	0.25	0.004
Total	23.21	–	31.12	–	11.98	–

Table 3. Frequency of different herbaceous plants in horti-silvi-pasture system of the study area

	Frequency (%)					
	Spring		Summer		Autumn	
Plant species	Mean	±SE	Mean	±SE	Mean	±SE
Amaranthus caudatus L.	66.66	16.66	83.33	16.66	50.00	0.11
Anagallis arvensis L.	16.66	5.10	33.33	16.66	15.00	1.63
Anthemis cotula L.	58.33	8.33	66.66	16.66	50.00	0.32
Asparagus officinalis L.	16.66	6.66	33.33	16.66	16.66	6.66
Cannabis sativa L.	66.66	16.66	83.33	16.66	50.00	1.11
Chenopodium album L.	61.11	30.93	66.66	9.62	50.00	0.12
Clinopodium vulgare L.	50.00	1.12	83.33	16.66	33.33	16.66
Convolvulus arvensis L.	50.00	0.023	66.66	16.66	33.33	16.66
Conyza canadensis L. Cronquist	58.33	8.33	66.66	8.33	50.00	0.45
Cynodon dactylon L.	94.44	5.55	100	9.66	83.33	8.33
Daucus carota L.	53.33	3.33	65.00	7.63	46.66	3.33
Galinsoga parviflora Cav.	50.00	18.86	66.66	16.66	33.33	16.66
Geranium polyanthes Edgew & Hook	33.33	16.66	50.00	0.92	33.33	16.66
Medicago polymorpha L. (Benth.)	75.00	14.43	86.11	7.34	58.33	8.33
Mentha arvensis L.	16.66	6.66	33.33	16.66	6.66	0.33
Oenothera rosea L. Her. ex Aiton		14.78	94.44	5.55	58.33	8.33
Plantago lanceolata L.	50.00	10.99	58.33	8.33	58.33	8.33
Plantago major L.	50.00	25	75.00	10.41	50.00	11.09
Poa pratense L.	50.00	18.86	66.66	16.66	50.00	18.86
Polygonum hydropiper L.	50.00	10.11	83.33	16.66	–	–
Potentilla reptans L.	50.00	16.20	66.66	16.66	33.33	16.66
Prunella vulgaris L.	50.00	18.86	53.33	10.11	26.66	16.66
Rumex dentatus L.	33.33	16.66	50.00	9.14	33.33	16.66
Scandix pectenveneris L.	50.00	9.80	66.66	8.33	50.00	10.67
Sonchus oleraceus L.	66.66	16.66	83.33	8.33	50.00	18.86
Setaria viridis L.	83.33	16.66	91.66	8.33	–	–
Stellaria media L. (Vill.)	58.33	10.04	75	14.43	50.00	10.34
Sysiumbrium irio L.	41.66	12.04	66.66	8.33	0	0
Taraxacum officinale Weber	66.66	16.66	75	10.43	50	18.86
Trifolium pratense L.	58.33	8.33	66.66	16.66	50	18.86
Veronica persica Poiret	50	18.86	66.66	16.66	33.33	16.66
Viola odorata L.	51.66	10.08	70.00	11.09	33.33	8.98
Total	1704.90	–	2127.11	–	1211.60	–

Table 4. Importance value index (IVI) of different herbaceous plants in horti-silvi-pasture system of the study area

	IVI					
	Spring		Summer		Autumn	
Plant species	Mean	±SE	Mean	±SE	Mean	±SE
Amaranthus caudatus L.	7.56	1.14	7.96	1.67	7.10	0.62
Anagallis arvense L.	1.81	0.05	2.93	0.81	1.91	0.50
Anthemis cotula L.	5.48	1.01	5.94	1.35	6.59	0.48
Asparagus officinalis L.	5.98	1.28	7.78	4.16	4.06	0.36
Cannabis sativa L.	12.12	0.71	12.37	1.47	11.11	0.67
Chenopodium album L.	6.02	3.27	8.82	2.00	6.91	0.68
Clinopodium vulgare L.	6.10	1.21	8.45	0.80	5.84	0.31
Convolvulus arvensis L.	6.27	1.85	9.59	1.02	6.06	3.10
Conyza canadensis L. Cronquist	9.92	2.40	10.06	0.70	12.75	2.64
Cynodon dactylon L.	29.63	1.70	21.02	0.83	41.92	6.75
Daucus carota L.	9.58	0.69	9.93	0.62	12.22	2.30
Galinsoga parviflora Cav.	6.48	1.86	6.94	1.12	5.34	2.82
Geranium polyanthes Edgew & Hook	10.87	5.95	10.40	0.18	10.65	5.54
Medicago polymorpha L. (Benth.)	17.87	3.53	14.00	1.77	19.52	1.04
Mentha arvensis L.	1.48	0.06	2.98	0.73	1.01	0.08
Oenothera rosea L. Her. ex Aiton	21.44	0.97	18.08	0.82	25.15	3.30
Plantago lanceolata L.	10.05	0.58	10.11	0.25	13.41	3.08
Plantago major L.	10.89	5.76	11.06	0.84	13.75	4.54
Poa pratense L.	10.78	5.75	9.47	1.26	14.56	1.83
Polygonum hydropiper L.	11.04	1.04	9.77	0.86	–	–
Potentilla reptans L.	6.20	0.96	6.01	0.95	5.58	2.90
Prunella vulgaris L.	6.25	0.57	6.10	0.40	4.86	2.55
Rumex dentatus L.	6.01	3.23	9.24	0.99	5.66	2.90
Scandix pectenveneris L.	10.14	1.35	11.64	1.43	12.44	1.05
Sonchus oleraceus L.	6.54	0.98	8.19	1.01	5.80	0.33
Setaria viridis L.	14.85	1.26	11.54	0.29	–	–
Stellaria media L. (Vill.)	9.08	0.20	9.57	1.65	9.79	0.40
Sysiumbrium irio L.	4.12	2.27	5.54	0.53	–	–
Taraxacum officinale Weber	9.78	0.77	10.62	1.03	10.53	0.91
Trifolium pratense L.	11.22	2.06	8.87	1.69	12.58	0.52
Veronica persica Poiret	7.16	3.80	7.32	0.84	6.26	3.22
Viola odorata L.	7.15	3.00	7.54	0.45	6.48	3.00
Total	300	–	300	–	300	–

and tree layers comprising six genera having six species belonging to three families.

Plant diversity and community structure are important attributes correlated with the prevailing environmental as well as anthropogenic variables[11]. Vegetation strata, viz. herbs and trees recorded were lower than those reported by Man *et al.*[12] (80 herb plants in the Lipp–Asrang Wildlife Sanctuary, Himachal Pradesh); Shameem and Kangroo[13] (75 wild herbaceous plants for the forest ecosystem in Dachigam National Park, Kashmir) and Molla and Kewessa[14] (55 tree species in traditional agroforestry practices of Dellomenna district, Southeastern Ethiopia). About 32 herb plant species were recorded which is much lower than those reported by various workers. This low species richness could be due to micro-climate and edaphic conditions, and less diverse agro-geographical conditions prevailing in the Kashmir Valley compared to studies done elsewhere, as also reported by Amjad[15].

Table 1 shows that in the horti-silvi-pasture system, total density (individuals/m^2) of herbs was 568.20 (spring), 1023.18 (summer) and 315.94 (autumn). The highest value was recorded for *Cynodon dactylon* during three seasons, i.e. 90.33 (spring), 103.66 (summer) and 67.33 (autumn), while *Mentha arvensis* recorded the lowest values, viz. 3.33 (spring), 10.66 (summer) and 1.33 (autumn). Density reveals the strength of any species in a landscape[16]. The marked variation among seasons can be attributed to the conducive growth and development conditions, amount of litter and rate of litter decomposition which may be influenced by tree density[17], availability of soil moisture for optimum nutrient flow in soil–plant system and other environmental factors. During autumn, the rate of sprouting of root/seed stock was found to decrease and species number declined owing to adverse climatic conditions, as reported by Sharma *et al.*[18].

Table 2 reveals a marked fluctuation in total based area from 23.21 (spring) to 31.12 (summer) to 11.98 (autumn). Among the plant species, contribution of *C. dactylon* was the highest to the total basal area of herbs in different sampling seasons. Basal area for *C. dactylon* was 1.93

Table 5. Quantitative attributes of trees in horti-silvi-pasture system of the study area

Quantitative attributes →	Density (plants ha^{-1})		Basal area (m^2 ha^{-1})		Frequency (%)		IVI	
Tree species ↓	Mean	±SE	Mean	±SE	Mean	±SE	Mean	±SE
Malus domestica Borkh.	300.00	57.73	4.40	0.63	100.00	50.56	72.00	7.31
Populus deltoides Bart.	200.00	57.73	4.08	1.44	47.00	10.34	40.00	8.63
Populus nigra Bart.	167.00	88.19	2.77	1.40	35.00	13.33	38.00	8.60
Prunus domestica L.	267.00	33.33	4.28	0.32	84.00	33.33	65.47	6.67
Pyrus communis L.	233.33	88.19	4.15	0.20	67.00	50	54.71	8.92
Robinia pseudoacacia L.	34.00	33.33	0.69	0.18	14.00	3.33	12.00	1.42
Salix alba L.	67.00	33.33	1.03	0.53	24.00	4.12	17.24	8.72
Total	1268.33	–	21.40	–	371.00	–	300	–

(spring), 2.02 (summer) and 1.65 (autumn). The lowest value for basal area was recorded for *M. arvensis* as 0.02 in spring, 0.12 in summer and 0.008 in autumn season. One of the reasons for such changes in basal area of the herbs in different seasons could be the corresponding changes in density, and may also presuppose the development of an extensive root system for efficient nutrient absorption for growth to take place, as reported by Pappoe *et al.*[19].

In terms of frequency, the highest value was attributed to *C. dactylon*, i.e. 94.44% in spring, 100% in summer and 83.33% in autumn. The species with lowest frequency value was *M. arvensis*, with 16.66% in spring, 33.33% in summer and 6.66% during autumn (Table 3). The results show high frequency values during summer season, owing to optimum resource availability either through litter already present on the ground surface or through fertilizers that farmers apply to enhance growth and production of fruit crops, good soil-moisture, humidity and temperature.

The high-frequency percentage of species like *C. dactylon* in this agroforestry system highlights their greater ecological amplitude (the degree of adaptation of a living organism to changes in its environment) or niche breadth[20].

Numerical values of IVI of different species revealed that the dominant species with the highest IVI value of 41.92 (autumn season) was *C. dactylon*, which was dominant during summer and spring seasons also (Table 4). High IVI of a few species indicated their dominance and ecological success and their good power of regeneration. The IVI values varied with season. Also, the disappearance of some species may be due to the mechanical damage by humans and animals. Favourable observations in support of our results were also reported by Bijalwan *et al.*[21].

In the horti-silvi-pasture system, the broadleaved trees were characterized by *Populus deltoides*, *Populus nigra*, *Robinia pseudoacacia* and *Salix alba*, while fruit trees by *Malus domestica*, *Prunus domestica* and *Pyrus communis*. Data pertaining to quantitative attributes revealed that *M. domestica* recorded a maximum density of 300 ha^{-1} with basal area of 4.40 m^2 ha^{-1}, 100% frequency and 72 IVI, indicating dominance in this agroforestry system. Minimum values for density, basal area, frequency and IVI of 34 ha^{-1}, 0.69 m^2 ha^{-1}, 14% and 12 respectively, were recorded for *Robinia pseudoacacia* (Table 5).

The higher values for quantitative attributes of certain tree species may be due to ecological/environmental adaptability, farmers' preference for their subsistence requirement fulfilment and a variety of multipurpose uses such as fuelwood, easy propagation and management as cash crops[22].

Horti-silvi-pasture system in District Budgam currently serves as a storehouse of valuable bio-resources like *Mentha arvensis*, *Rumex* sp., *Taraxacum officinale*, *Viola odorata* which are listed as either endangered/vulnerable in IUCN Red Data Book. Plant resources in these agroforestry systems are limited and require efficient and wise use. So, necessary steps should be taken not only to store the original vegetation but also to improve it by acknowledging and rewarding the farmers for the bio-resource conservation services that they provide to the global community. This ensures that they take keen and firm interest to give their best in conserving the nature's unsurpassed gift.

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Identification of *cis*- and *trans*-expression quantitative trait loci using Bayesian framework

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The detection and identification of expression quantitative trait loci (eQTLs) for biological characteristics like gene expression is an important focus of genomics. The existence of *cis*- and *trans*-eQTLs is crucial for establishing their cumulative significance to the desired traits. A crucial aspect of genomics is identifying the *cis*- and *trans*-eQTLs that capture substantial changes in the expression of distant genes. The goal of the present study was to use an integrated hierarchical Bayesian model to identify the *cis*- and *trans*-eQTLS. Molecular approaches are utilized to categorize just the candidate genes when quantitative trait loci or eQTLs are identified. Variations inside or near the gene are hypothesized to determine the genetic variances that reflect transcript levels. The identification of eQTLs has helped us better understand gene regulation and complex trait analysis. The present study focused on barley crops, and only *cis*-eQTLs were identified; no additional eQTL hotspots were determined. Mouse gene expressions were used to study *trans*-eQTLs and substantial *cis*- and *trans*-eQTLs, as well as four eQTL hotspots were identified.

Keywords: Barley, gene expression, hotspots, integrated hierarchical model, quantitative trait loci.

A quantitative characteristic is described in biological research as a quantifiable phenotype, such as yield, disease resistance, etc. that differs numerically and is dependent on the collective activities of numerous genes and the environment. The initial step in quantitative characteristic loci (QTL) mapping is to identify potential genes for detecting chromosomal regions linked with a certain quantitative trait[1]. Recently, expression quantitative trait loci (eQTL) mapping has become a popular and successful approach for detecting regulatory areas for genes using transcriptome and genotyping data[2]. These are the genomic regions that control mRNA or protein expression. The most significant molecular phenotypes are gene expressions, which operate as quantitative qualities that link genetic diversity to phenotypic variance. These differences in gene expression are expected to be important in phenotypic differences and species evolution. As a result, identifying eQTL has become a significant element of biological research[3]. Traditional QTL mapping often finds broad areas

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