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FORAGE PRODUCTIVITY OF ARID TEMPERATE HARBOI RANGELAND, KALAT, PAKISTAN

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Abstract

Harboi rangeland is an arid temperate highland range. The growing season lasts from April to October with seasonal and annual variation in rainfall and temperature. Monthly sampling over two years period was carried to determine its productivity. The total average dry biomass production was 10772.5 Kg/ha/year. The months of July and August were the most productive months (2120.7 and 2012.7 Kg/ha, respectively). The total dry biomass, biomass contributed by grasses, herbs and shrubs generally increased from April through August and thereafter it progressively decreased till October. The grasses contributed 1269.1 Kg/ha/year, herbaceous species 743.4 Kg/ha/year and shrubs 8760.0 Kg/ha/year towards the total dry biomass production. It was observed that the range is suffering with overgrazing, over exploitation and soil erosion, which must be cared for. It is recommended that a blend of traditional and modern methods of range management with the participation of local communities be tried for its sustainable use.

Introduction

Of the total area of 34.7 million ha of Balochistan, the rangeland cover some 30 million ha. Afzal (1993) classified the rangelands of Balochistan as excellent (3.2%), very good (9.5%), good (8.1%), fair (17%), poor (33.7%) and non-grazable condition (28.5%). Anonymous (1995) stated that the poor productive rangelands cover about 62%, medium productive range cover 25% and high potential productive range cover only 13% of the province.

There are about 20 million small ruminants in Balochistan with 54% sheep and 46% goats as the major livestock (Anonymous, 1998). The livestock system in Balochistan depends on the lifestyle of livestock owner and rangeland property regime. About 30% of small ruminants are owned by nomadic powindahs, 60% by transhumans and only 10% by sedentary livestock owners. Some 60% of the flocks consists of more than 100 animals/herd.

Many studies made for the assessment of forage productivity suggest that the sustainability of the range depends upon a number of factors such as rainfall, edaphic features, grazing system and seasonal availability of forage (Mirzaclinov & Yakovleva, 1990; Prince, 1991; Omar, 1991; Mwalyosi, 1992; Zhao, 1992; Grunzoaldt *et al.*, 1994; Khan, 1996; Makulbelova, 1996; Farooq, 2003; Durrani *et al*., 2005). Said & Hussain (1959), Irshad (1961) and Rafi (1965) observed that protection and proper management increased the total palatable vegetation cover in Maslakh range. Ali (1966) and Irshad (1966) estimated that 200 acres of low productive rangelands of Quetta-Kalat, which are overstocked by almost 20 times, might support only one sheep for one year due to low rainfall and severe overgrazing. Heymel (1989) reported that that grazing reduced total vegetation cover, biomass, density and number of species in Nichara rangeland. Wahid (1990) reported that at Zarchi (Kalat) the total biomass, which was correlated to the amount of rainfall, ranged from 73 to 107 Kg dry matter/ha., including 91-94%

contribution by shrubs. Sardar (1992) estimated that of the total forage production of 2468 Kg/ha in Hazargangi National Park, shrubs contributed 52% and grasses 34%. Mori & Rehman (1997) concluded that protection dramatically increased the number of species, total vegetation cover and biomass in Kanak Valley, Balochistan. Ahmed *et al*., (1998) observed improved vegetation cover due to protection from sheep and goats grazing at Chiltan National Park, Quetta. Similarly, Iskalku rangeland had poor productivity due to overgrazing (Durrani *et al*., 1996).

Recently, Durrani & Hussain (2005) and Durrani *et al*., (2005) reported on the ethnoecology and ecological characteristics of plants from Harboi rangeland. No other reference especially on the productivity of forage from Harboi rangeland is available. It is obvious that any future management planning definitely requires a base line data about the existing rangeland productivity (Mohammad, 1985; Gou *et al*., 1997; Farooq, 2003). The present study was therefore, aimed to assess the existing forage productivity of palatable component to help range managers and ecologists in their future studies and management of this and similar other rangelands.

Materials and Methods

Location and climate: The Harboi rangeland Kalat, lying between 29° N and 66°, 45 to 67° E, covers an area of 22351 ha. It was declared as Protected Forest since January 1967 (Fig. 1). The study area has rugged mountainous terrain of limestone and conglomerates with many small valleys and dry ravines. The altitude varies from 2900 to 3300 m with dry temperate climate. The nearest meteorological station is Kalat which is 30 Km away from the research site. The short summer lasts from May to September. The mean temperature of the hottest months, June and July, rises to over 30°C with maximum hardly reaching up to 35°C at Kalat. The winters are long, cold and dry lasting from October to April. The coldest month, January, has a mean monthly temperature of -4°C that may drop to as low as -16°C (Table 1). The cold spell is quite severe with chilling winds. Wind speed varies from 1.88 to 2.47 mS^{-1} (Table 1). The mean annual air pressure is 1516 MPa that varies from low during May (1443 MPa) to high (1565 Mpa) in November (Table 1). The mean annual relative humidity is 44% with lowest (32.48%) during June and highest (60%) in January (Table 1). The mean value of clouds is 1.87 OKTS. The highest cloud (3.28 OKTS) occur in March and least in October (0.62 OKTS). The mean dew point temperature varies from -5.4°C (January) to 9°C (July). The mean annual rainfall is 28.5 mm that varies from 2.38 mm (September) to 124.77 mm (December). Evapo-transpiration is higher than rainfall that causes aridity. The precipitation is mostly received during winter from western depression. The area receives regular snowfall during winter.

Measurement of productivity

Herbaceous productivity: The above ground foliage of 15 grasses and 7 herbs was determined monthly from April to October for two consecutive years i.e., 1997–1998 by species at ground level using 10, 0.5 m^2 quadrats. The harvested material was packed in paper bags in the field and then oven dried at 65°C for 72 hours in laboratory. The dry weight of all the species was then combined to get the total biomass estimates (Hussain, 1989; Bonham, 1989).

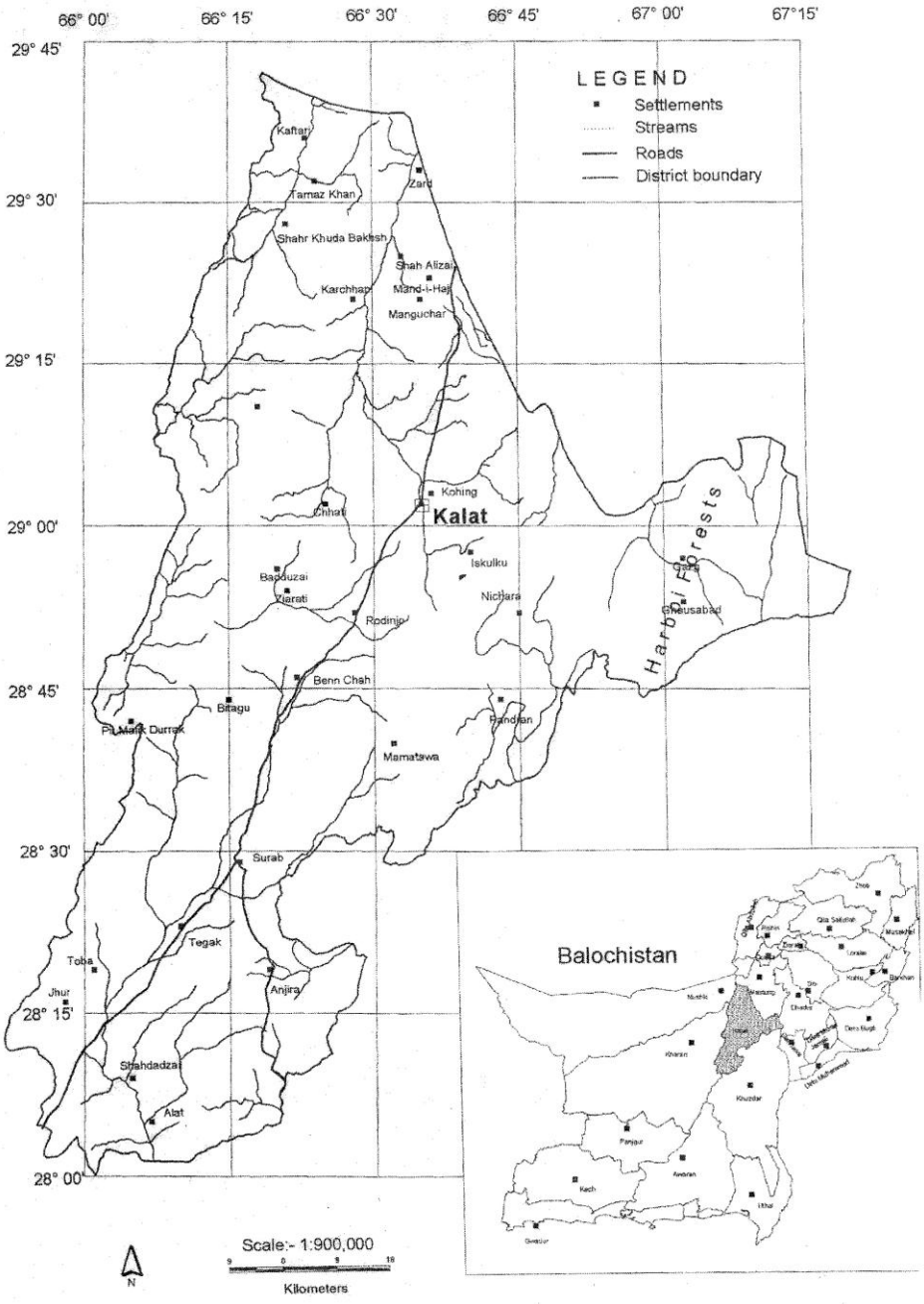

Fig. 1. Map of Kalat showing research area.

Shrub productivity: The biomass of 17 shrubby species was estimated by Reference Unit Technique (Andrew *et al*., 1981; Kirmse & Norton, 1985) by monthly sampling from April to October for two consecutive years i.e. 1997–1998. A small representative part of shoot was designated as reference unit. The size of the reference unit was 10 to 20% of the foliage weight of average plant. The number of reference units of plants were counted and multiplied by average weight of clipped reference unit to estimate shrub biomass production. The plants were stored and dried as above.

Results

Productivity of grasses: It was observed that the maximum dry biomass of 517.9 – 523.2 Kg/ha was provided by *Phacelurus speciosus*, followed by *Pennisetum orientale* (343.5-375.5 Kg/ha) and *Stipa pennata* (94.6-87.9 Kg/ha) during 1997 and 1998, respectively (Table 2). The total grass productivity was slightly better during 1997 (1291.5 Kg/ha) than 1998 (1246.8 Kg/ha). The grass productivity gradually increased from April to July 1997 (83.6 to 247.9 Kg/ha) and thereafter it declined towards October (151.5 Kg/ha) (Fig. 2). Similarly in 1998, the dry biomass of grasses enhanced from 87.7 to 300.1 Kg/ha from April through July and showed decline in the subsequent months till October (51.0 Kg/ha) (Fig. 3). As a whole, the productivity of grasses was 1269.2 Kg/ha/year (Table 2). It increased from 85.7 Kg/ha to its peak production of 274.0 Kg/ha in July, showing slight depression in June (167.5 Kg/ha).

Productivity of herbaceous plants: This included herbs other than grasses. *Eremurus persicus* produced the maximum of 1004.1 Kg/ha during 1997, followed by *Iris tenuifolia* (234.3 Kg/ha). Similarly, during 1998, *Eremerus persicus* and *Iris tenuifolia* once again produced the highest dry matter of 100.4 Kg/ha and 76.2 Kg/ha, respectively. The total herbage productivity was significantly greater during 1997 (1270.0 Kg/ha) than during 1998 (216.8 Kg/ha). The total productivity was the highest (478.3 Kg/ha) during May 1997, which dwindled to 2.4 Kg/ha during October (Fig. 2). Similarly, during 1998, April had the maximum biomass (74.3 Kg/ha), which gradually decreased to 6.9 Kg/ha during September (Fig. 3). In October 1998 no herbage was available. Generally, the month of May produced the highest average dry mass (267.6 Kg/ha) that progressively decreased to only 1.2 Kg/ha in October (Table 2).

Productivity of shrubs: During 1997, *Artemisia maritima* produced the maximum shoot biomass of 1955.9 Kg/ha/year, followed by *Astragalus* (97-8 Spp) (1862.5 Kg/ha/year) and *Sophora griffithii* (1786.9 Kg/ha/year). In 1998, *Astragalus* (97-8 Spp) yielded the maximum (2116.4 Kg/ha/year) dry biomass, followed by *Artemisia* (1986.1 Kg/ha/year) and *Sophora* (1585.9 Kg/ha/year) (Table 2). The total productivity of shrubs was greater during 1998 (8846.5 Kg/ha) compared to 1997 (8673.5 Kg/ha). During 1998, eight shrubs produced more biomass than 1997, while nine shrubs registered low biomass in the same period. The shrub biomass gradually increased from April to July 1997 (667.5 to 1685.1 Kg/ha) and thereafter continuously declined to 549.7 Kg/ha in October (Fig. 2). Similarly in 1998, the biomass increased from April to August (837.5 to 1888.8 Kg/ha) and thereafter declined to 206.5 Kg/ha in October in the subsequent months (Fig. 3). The period from April to August was the most productive months during both the investigated years. However, due to dry spell in 1998, the biomass decreased in September and October as compared to 1997 (Table 2). As a whole, the average biomass of shrubs was 8760.0 Kg/ha/year, which continuously increased from April to July (752. 5, 1253.6, 1591.3 and 1772.4 Kg/ha, respectively) and then followed a continuously declining pattern from August to October (1743.5, 1268.7 and 378.1 Kg/ha, respectively).

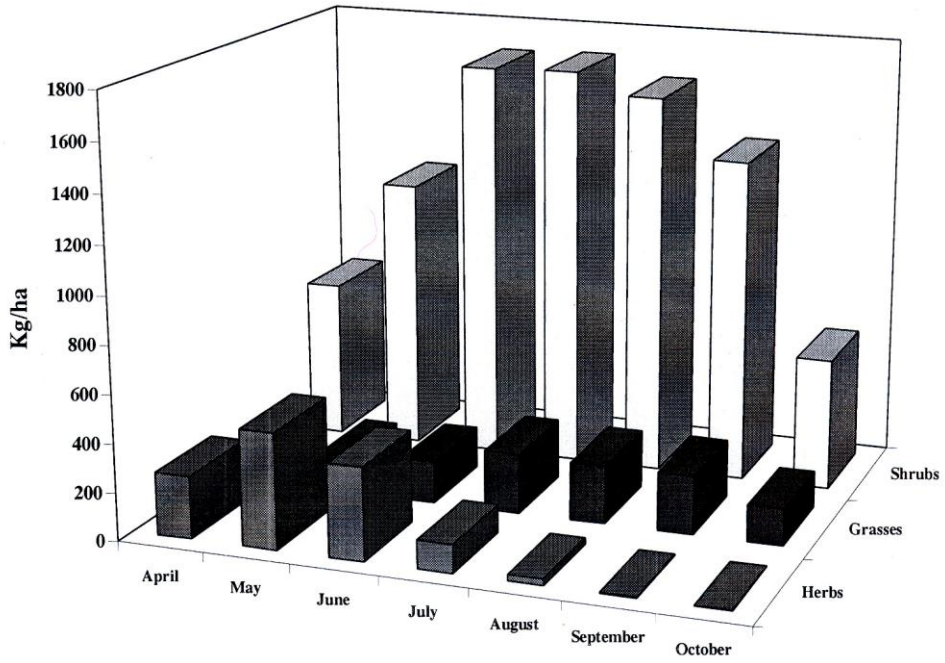

Fig. 2. Productivity of vegetation during different months of 1997.

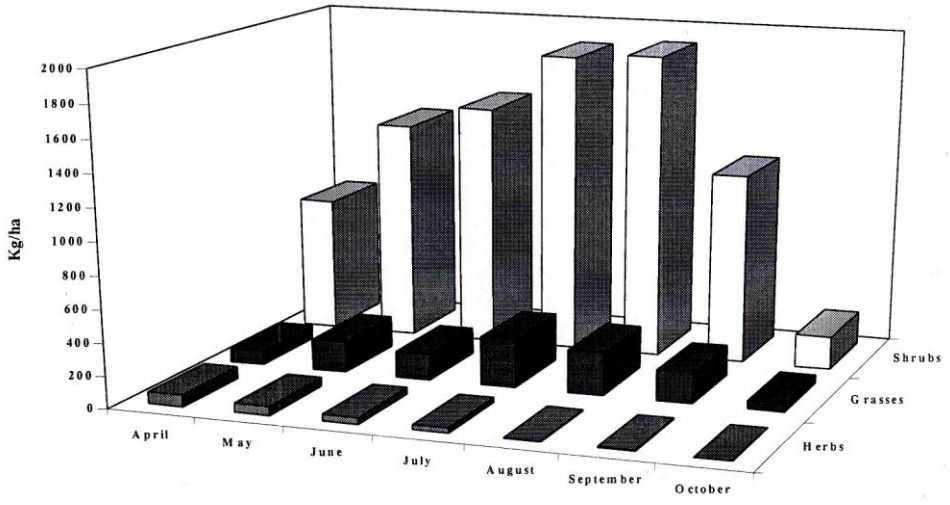

Fig. 3. Productivity of vegetation during different months of 1998.

The overall productivity of forage: The total average dry biomass for both the years was 10772.6 Kg/ha/year with July and August as the most productive months (2120.7 and 2012.7 Kg/ha, respectively). The biomass showed a gradual increase from April to July and thereafter it progressively declined towards October (480.5 Kg/ha).

Discussion

Optimum use of rangeland resources depends on the understanding of the amount and dynamics of seasonal phytomass production as influenced by climatic fluctuations. Dry biomass is a measure of community's resources tied up in different species and is one of the best indicators of species importance within a plant community (Bonham, 1989; Gou *et al.,* 1997). The total dry biomass production of Harboi range for 1997 was 43% greater than productivity during 1998. This was possibly due to high amount of rainfall received during 1977 compared to 1998. Many other studies (Mohammad, 1989; Durrani *et al*., 1996, 2005; Durrani & Hussain, 2005; Farooq, 2003) have also shown that the amount of rainfall severely affects the productivity of rangelands and our findings agree with them. The total amount of forage produced in Harboi range was quite high as compared to annual production of other rangelands in Balochistan (Sardar, 1992; Wahid, 1990; Akbar *et al*., 1994; Mori & Rehman, 1997; Saleem, 1997). This high productivity might be due to protection and highland location of Harboi range compared to other rangelands that are degraded and relatively less protected.

The present study showed that period from June to August had the high productivity during both the investigated years. The contribution of shrubs towards the total productivity was 72.7% and 85.8%, respectively for 1997 and 1998. This was due to response of vegetation to late winter and early spring rains during 1997 (the total annual rainfall for 1997 was 976.9 mm which was the highest recorded during the past six years). The total rainfall during June and July for the 1997 was 146.6 mm that promoted growth of the vegetation and productivity. The life cycle and herbage productivity besides other factors is linearly related to the annual precipitation (Scholes & Baker, 1993; Shanmugavel & Ramarathinam, 1993; Mohammad, 1989; Farooq, 2003, Durrani *et al*., 2005). The present study also concludes that there was also decline in the forage production during dry and winter months. The productivity was greater during 1998 in May (by 19.1%), July (by 4.9%) and August (by 0.3%) as compared to 1997 in the same months. However, differences were greater in dry biomass in both years during October. It was 45.38% higher in 1997 than observed in 1998. The decrease of dry matter during 1998 was due to long dry spell with poor rainfall and high temperature, which caused poor growth of vegetation and early completion of life cycle during late September. Similarly, Akbar *et al.,* (1994) also observed that spring and summer rains increased the dry matter production in Mastung and Tomagh rangelands.

Herbaceous productivity contributed about 11.3% of the total dry matter during 1997. But it was only 2.1% of the total yield during 1998 (216.8 Kg/ha) showing 9.2% decrease in the productivity. The dry biomass of herbaceous components peaked during May (478.3 Kg/ha) that declined to 2.4 Kg/ha in October. The findings are in line with those of Yossef *et al.,* (1996) who also reported maximum production of herbaceous phytomass during May due to moderate temperature and moisture. The annual herbs and bulbous geophytes like tulips were the major contributors to the total productivity during April and May as they are present during this period. Danin (1999) stated that phytomass produced by annuals is low on unfavourable habitats.

A drastic decrease in dry biomass was observed for the year 1998 owing to long dry spell with poor rainfall. The most obvious differences were the decrease in biomass of

Eremurus persicus by 81.8% and *Iris tenufolia* by 50.9%. It has been observed over the years that collection of both these plants along with other species on commercial scale has not only reduced their regeneration but also biomass in the area (Durrani & Hussain, 2005). Bulbs and roots are dug out which result in permanent loss of such plants. Liu *et al.,* (1996) also reported 40 to 60% decrease in biomass for grassland in China due to habitat destruction. Similarly, West (1993), Hussain *et al.* (1997), Hussain & Badshah (1998) and Durrani *et al.* (2005) reported that grazing decreased the productivity, species composition and stability of communities.

The present study envisages that grasses provide about 11 to 12% of total dry matter yield as observed during 1997-1998. The biomass of grasses was 1.8% greater during 1997 than in 1998. There was 2.4 to 11.5% increase during April to August while 49.6% decrease was recorded towards October, 1998.

Although annual grasses such as *Bromus sericeus, B. tectorum, Eragrostis minor* and *Schismus arabicus* were abundant during early spring, yet their biomass contribution was low due to their small size (about 2 to 10 cm height). Eroded thin layered soil with low water holding capacity, low organic matter and low nutrients in Harboi range reduced the size and vigour of plants leading to poor biomass production. Range condition is primarily based on the density and production of native palatable perennial grasses and diversity of palatable forage species.

Generally, 5 to 7 hours/day are required for animal feeding which splits into intensive early morning and late evening feeding period (Nyamangara & Ndlova, 1995). Grazing time and forage intake of grazing animals varies with their body weight and depends on the accessibility, quantity, quality and availability of forage. Availability of good quality forage reduces grazing time. It was observed that about 1000 to 1500 animals in mixed herd graze daily in Harboi rangeland during growing season. According to FAO (Anonymous, 1983) estimate the annual requirement of sheep is 823.00 dry matter Kg/year, goat is 284 dry matter Kg/year and that of camel is 2737.5 dry matter Kg/year. Holechek *et al.* (1998) stated that the range utilization level is 30 to 40% of key species for shrub-steppe vegetation in semi arid regions, which may reach up to 50% during high productive years and decreased during dry period.

It was estimated that Harboi rangeland produces an average of 10772.5 Kg/ha/year. But, with its present stocking rate, the grazing animals require about 832.5 to 1248.75 Kg/ha/day. It is obvious that the available forage is insufficient for the present stocking rate. It was estimated that amount of available forage in Harboi rangeland was approximately sufficient for only for 24 sheep/ha or 25 goats/ha (= 5 AUM's/ha) and for three camels only during growing season (April to October). Wahid (1990) reported that 5 sheep or goats equal to 1 AUM's. Although the stocking rate in Harboi range was better when compared to the findings of Wahid (1990) who reported 0.89 AUM's capacity in Zarchi and Tomagh rangelands, yet the range is suffering from overgrazing which is adversely affecting the productivity and species diversity.

Overgrazing not only removes palatable plant cover but also causes compaction of soil and promotes erosion through out the rangeland. Major factors influencing range-animal nutritional status include stocking rate, grazing system, type of forage species, types of animals and season of use (Holechek *et al.*, 1998; Hussain & Badshah, 1998; Durrani *et al*., 2005). The rural population of adjoining areas depends upon this rangeland for most of the livelihood as no other resources are available. Thus, a proper management is required for the sustainability of this rangeland. It has been reported that

protection and grazing management has increased biodiversity and biomass in other rangelands of Balochistan (Mori & Rehman, 1997; Saleem, 1997; Ahmed *et al.* (1998).

Although, Harboi rangeland is a protected forest yet grazing of livestock and collection of forest resources by locals is a common feature due to lack of implementation of laws. Afzal *et al*, (1993) reported that according to a traditional method of land protection locally called "Pargore" (Pushto) a part of the grazing land is left ungrazed during the growing season to improve vegetation cover and forage production. There is a potential for improving range vegetation, biomass and habitat of Harboi rangeland through blending the traditional and modern methods of range management with the participation of local communities. Furthermore, it is recommended not only to maintain an optimum stocking rate during the growing season but also to replace the existing low yielding livestock with high yielding improved breeds to reduce the grazing pressure, improve range sustainability and enhanced productivity at secondary level.

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