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Improving Performance of Replacement Heifers in Hot Arid Environment Under Intensive Management

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Abstract: Problem statement: Imported Holstein Friesian dairy cattle are exposed to hot arid climate in feedlot management in Kuwait. Desert climate is extreme reaching high 45-50°C in summer and low -4ºC in winter at day and night respectively. High calf mortality, poor reproduction and milk yields were main constraints to viable dairying. The objectives of this study were to assess the magnitude of calf mortality, its causes; implement strategic intervention measures for improving calf survival rates and evaluate dairy herd performance. **Approach:** Two scenarios were used: (1) studying dairy herd performance without applying intervention measures and (2) introducing improved management with interventions. Performance of the herds of situations 1 and 2 were compared. Three classes of dairy herds, pre-weaned calves, heifers and first lactation cows born in Kuwait were used. **Results:** Implementing intervention measures resulted in significant ($p = 0.001$) reduction of crude calf mortality rates from a mean of 43.6% to a low 4.67%. Growth rates of calves and heifers increased significantly, resulting in breeding of locally raised heifers at 15 mo age instead of usual practice of breeding at 18-22 mo. Feed cost was significantly reduced by 14-25% by early breeding of heifers. Herd culling rate was reduced from 62-33% and conception rates increased by 41%. The milk yield was increased by 1.25-1.50 fold through replacing the imported cows by locally born heifers. Adult cattle mortality rates reduced from high 9 to a low 1%. Case study showed that locally born and reared dairy herd formed a mean of 65.8% of total dairy cattle in cooperating farms. **Conclusion:** A systematic applied research studies in the commercial dairy farms had resulted in a visible improvement in the performance of all categories of locally born dairy herds and they were better adapted to the local hostile climate.

Key words: Dairy calf, heifer, feedlot, intervention, performance

INTRODUCTION

Milk yield of imported Holstein Friesian dairy cows exposed to Kuwait's hot feedlot environment ranged from 2,500-4,500 liters milk/cow/lactation. Mean life-time performance of cows was low i.e., 2.3 lactations/cow[1]. The constraints adversely affecting the performance of dairy cattle in Kuwait were assessed[2]. They found that the fundamental problem was that the country did not have traditional local dairy cattle breed adapted to the local harsh arid environment. The calves born from exotic dairy cows had a very high mortality rate[3], therefore, the producers were unable to raise their replacement heifers and adapt them for milk production.

Assessments carried out[4] revealed that nutritional and health management of all classes of dairy herds were inadequate causing poor growth of calves, below standard reproductive efficiency and milk yield of imported cattle. Gwatibaya *et al*.[5] and Amani *et al*.[6] observed that heat stress had a significant adverse effect on milk yield and reproductive efficiency in cows in Zimbabwe and Sudan. However, improved nutritional status of cows in hot arid conditions in Kuwait had resulted in improved milk yield and reduced feed cost[1]. Studies carried out in Arizona, USA by Ray *et al*.[7] found that there was a significant influence of seasons and microclimate on fertility of dairy cows. An eight year duration study was conducted in the commercial dairy farms of Kuwait to

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evaluate the performance of young growing dairy under two situations, with and without interventions.

MATERIALS AND METHODS

Investigations were carried out over a period of 8 years in phases in the commercial dairy farms of Kuwait. The studies concentrated on surveying the Kuwait's dairy farms for assessing the magnitude of pre-weaned calf mortality and identifying its causes, rearing the replacement heifers, adapting them to local environment and evaluating their performance.

Study location and climate: The dairy farms were located in Sulaibiya, 25 km northwest of Kuwait city and managed in feedlot system (zero grazing). Summer season extending from June to early September is mostly dry with extremely hot daytime temperature of 48°C. After last part of July, temperature reaches as high as 50°C for 1-2 weeks with dry air and a low Relative Humidity (RH). RH increases after mid August and September reaching over 90% with simultaneous decline of temperature, reaching 40-43°C during early September. Autumn season extends over October and November, decreasing temperature to 30 and 20°C respectively. Winter season extends from December to February and part of March during which, temperature can reach as low as -4°C at night and high 10-19°C at day. Spring season covers part of March to May temperatures reaching 20-30°C.

Calf mortality and its causes: Retrospective data: Calf mortality data of a complete year were extracted from the database of the PAAFR[8] which included number of calves born, died and sold from all farms of Kuwait. Crude mortality rate was calculated by the formula[9]:

Crude mortality rate = No. of calf deaths divided by average number of calves at risk (opening number of calves + closing number of calves/2) × internal time component

Field survey: For the field survey work, the dairy farms were classified as large (>500 head), medium (250-499 head) and small (<250 head) farms. Twelve farms, 4 from each class were randomly selected from all Kuwait's 29 farms that reared calves. Stratified sampling procedures within herds using proportional allocation were adapted representing 56% of the total 11,760 dairy milking cow population of Kuwait. A survey format was used to record individual calf data for the 1,280 calves[3]. Each dairy farm was visited on a regular basis for data collection of new born calves.

Causes of calf mortality: Survey work involved identification of causes of calf morbidity and mortality from disease histories, clinical symptoms and laboratory microbiological studies. Biological samples from sick calves and from calves after post-mortem examination were collected. Fecal samples were collected from calves showing the symptoms of diarrhea and dehydration. Nasal swabs and blood samples were screened according to standard procedures for respiratory diseases[10].

Strategy for improving herd performance: On completion of the field survey, a strategy was developed to address the key constraints identified during the survey studies. The main strategy elements of the interventions were implemented in dairy farms of Kuwait as shown in Table 1.

Without interventions: In without intervention situation (control) the dairy cattle production system followed the commercial practices of the farms without applying extra management.

Intervention measures: According to the strategy, two scenarios of dairy cattle production systems were compared. In with intervention situation, the calves were housed in newly introduced hutches for feeding and health management. Improved feeding and quick treatment for calf-hood diseases was followed (Table 1).

Calf housing and feeding: Clean environment for calving cows, timely and clean colostrum feeding were ensured. Immune status of calves was monitored through determination of immunoglobulins (IgG, IgM and IgA) of 36 h old calves. One of the elements of the strategy of pre-weaned calf rearing was introduction of individual polyvinyl calf hutches. Hutches had ultra-violet blocking pigments to prevent heat build up and enabling natural ventilation and easy to clean[2]. These hutches were used year-round. Clean sand bedding was used in the hutches to maintain hygiene[2]. Mortality rates were monitored from 90d age till their calving and lactation stages.

Nutrition of dairy herds: Nutritional trial was conducted to compare the performance of heifers fed with commercial diets (control-C), without added supplement and improved supplemented diets (Treatment-T) having balanced nutrients[11]. A total of 168 heifers (72 C and 96 T herds) were used for the study and they were fed diets (Table 2) twice daily with *ad libitum* fresh water supply[11] and their live weight gain and heights were monitored. The heifers were vaccinated against FMD, Rinderpest, Brucellosis, Rift Valley Fever and IBR.

Table 1: Strategy elements and intervention actions for improving pre-weaned calves, heifers and cows

Strategy elements	Intervention actions
Pre-weaned calves	
Recording system for calves	Established a system for individual calf events.
Pre-calving management of heifers and cows	Ensured a clean environment without fecal contamination and contact of late pregnant heifer cows with pathogens.
Colostrum feeding	Implemented colostrum feeding from cows or from colostrum bank.
Calf housing	Provided a clean housing and feeding environment to reduce disease threat. Provided dry and disinfected calf pen or calf hutch.
Calf feeding and weaning	Formulated balanced diet and introduced ideal feeding method for weaning of calves at 3 mo.
Heifers	
Selection of replacement heifers	Selected weaned heifer calves at 3 mo. of age. Recorded weights, heights and vaccinated. Provided balanced ration and adequate dietary fibers.
Heifer management: weaning to 12 mo of age	Fed diets to achieve growth rate, weights, heights and body conditions. Selected and culled heifers to minimize feed/labor costs. Separated the potential heifers and grouped them according to body conditions.
Heifer management: 15-18 mo. of age	Monitored reproductive behavior, synchronized estrus if on-time and mating as planned. Introduced fixed time artificial insemination (AI). Natural breeding through a closed observation.
Cows	
Management during pregnancy and delivery	Applied nutritional practices to meet the requirements of pregnancy.
Management of lactating cows	Formulated rations according to recommended feed composition and requirements. Provided rations according to the milk yield, weight and stage of lactation.
Herd health management and bio-security	Used bio-security measures as per standard farm operating procedures. Ensured veterinarian care of the herd on a routine basis for identification of mastitis cases, laminitis, bloats and sick animals.
Feeds, feeding and nutrition of herds	Selected feed ingredients and mixed feeds based on quality, routine analysis and nutritional evaluation. Avoided drastic changes of rations for all herds.
Body Condition	Maintained body conditions of heifers and cows.

Table 2: Composition* of concentrate mixtures of different classes of dairy herds: Control and treatment herds

	Percentage on dry matter basis					
Classes of dairy herds	DM%	Ash	CP	EE	NDF	ADF
Control (without I)						
Pre-weaned calves	90.4	3.1	12.1	3.3	28.8	9.3
Weaned calves	90.3	4.2	12.4	3.9	31.0	7.1
Growing heifers	92.5	5.3	10.9	3.0	27.7	7.0
Pregnant heifers	94.3	3.6	11.5	2.8	36.9	14.4
Milk cows	90.3	7.5	15.1	2.2	31.7	11.8
Dry cows	90.2	6.8	11.3	2.4	38.8	15.2
Treatment (with I)						
Pre-weaned calves (N6×3)	90.7	5.0	17.4	3.2	29.8	9.2
Weaned calves (N2×3)	90.2	9.6	17.2	2.4	25.9	8.6
Growing heifers (N1×3)	89.9	N/A	16.9	N/A	30.5	10.7
Pregnant heifers (N5×3)	91.2	7.3	17.3	2.8	24.3	6.5
Milk cows (N6×3)	91.2	6.4	17.5	2.8	28.6	12.4
Dry cows (N1×3)	90.0	8.1	17.7	3.3	29.1	7.6

I: Intervention; *: Mean values of triplicate analysis; N/A: Not Analyzed; Pre-weaned calves: 0-3 mo; Weaned heifer calves: 4-6 mo; Growing Heifers: 7-15 mo; Pregnant heifers: 16-24 mo; Milk cows (1st lactation): 25-33 mo

Reproduction and breeding: Heifers attaining the target growth parameters (132 cm height and 385 kg live weight) were assigned to breeding groups to facilitate heat detection and mating. Heat mount detectors were affixed for oestrus detection. Heifers were synchronized with two Prostaglandin F_2 alfa (PGF_{2a}) injections (Preloban produced by Intervet, European Union) 11 d apart[12]. They were Artificially Inseminated (AI) 72 h after the second injection. Pregnancy diagnosis was carried out by rectal palpation on the 40th day. Breeding performance was determined by estrus detection rate (number of animals observed in heat divided by the number of animals in breeding cohort under observation $\times$ 100), estrus intervals (number of days between successive estrus), submission rates (number of animals bred divided by the number of animals due to be bred over the first 20 days after breeding is due to commence, in percentage). First service conception rates (number of animals confirmed pregnant to the 1st service divided by the number of animals serviced $\times$ 100).

Immunization of pregnant cows: Pregnant cows and heifers were administered *Lactovac* vaccine (Intervet UK Ltd) against *E. coli*, *Rotavirus* and *Coronavirus.* They received two injections of 5 mL vaccine during their late pregnancy with an interval of 4 and 5 weeks between the doses and allowing 2 and 3 weeks from the time of the 2nd dose until the planned date of calving. A total of 720 and 357 calves were born from vaccinated and unvaccinated dams respectively. The pregnant heifers or cows were brought to disinfected calving area. A total of 133 calves from their birth to 90 days age were individually recorded for their disease syndromes to identify the causes of diseases.

Feeding trial on lactating cows: First lactation cows were randomly divided into T and C groups. The C herd was provided with commercial concentrate mixers and T herd fed with concentrate mixture formulated according to the NRC[11] standards (Table 2). Herd management was similar for both the groups. The roughage to concentrate ratios were 20: 80 for both C and T herds comprising 10% alfalfa hay 10% wheat straw. Both concentrates and roughages were analyzed[13,14]. Feed intake and costs were compared.

Milk yield and analysis: Daily records of total milk production of first lactation cows of both C and T groups of 65 and 82 cows respectively were recorded. A portable milk analyzer "Lactoscan" (Manufacturer: Milkotronic Ltd, European Union, Bulgaria) was used for determination of fat, protein, Solid Non Fat (SNF), lactose, density and water content.

Serum immunoglobulins: A colostrum bank was established so that the calves receive adequate quantity of clean colostrum on time. The level of Immunoglobulins (Ig) (IgG, IgM and IgA) of blood serum of calves of 3 d old were determined[15,16].

RESULTS

Causes of calf morbidity, mortality and growth rate of Pre-weaned calves: Major disease syndromes of sick calves were diarrhea, pneumonia, pneumo-enteritis (Table 3). Diarrhea was found in calves of ages between 1-15 d; whereas, most cases of pneumonia and pneumo-enteritis were found in calves of ages between 16-60 d. Pneumonia associated with pneumo-enteritis accounted for 68.4% of total disease syndromes. Clinical Laboratory diagnosis showed that main causal agents of diarrhea/enteritis were *Escherichia coli*, *Salmonella*, *Klebsiella*, *Rotavirus*, *Coronavirus*, *Cryptosporidia* and *Coccidia* and that of Pneumonia *Staphylococcus*, *Streptococcus* and *Pasteurella* sp. (Table 4). The risk rates for the diseases caused by these organisms ranged from 20-100%. Parasites detected were *Cryptosporidia* and *Coccidia* sp.

The crude mortality rates of pre-weaned calves born from vaccinated and unvaccinated dams were 12.8% and 12.1% respectively (table not presented). At the start of the study, crude calf mortality rate was as high as 90% (mean 43.63%) and then reduced by introducing intervention measures to as low as 2% (mean 4.67%). Phase-wise reduction of crude mortality was highly significant during 8 year study period (Fig. 1). Improved diet and hutch housing of calves resulted in a significant ($p = 0.01$) improvement in daily gain (Table not presented) compared to control (523 g Vs 115 g gain h^{-1} day^{-1}).

Heifer growth: Heifers of T diet achieved significantly ($p = 0.001$) better growth rates than animals on the C diet (Table 5). The proportion of heifers (89%) reached the target height (127 cm at 12 mo. of age) in T compared to C (15%) and 74% and 30% ($p = 0.001$) of the target weight (336 kg at 12 mo. age) in T and C respectively. Significant differences ($p = 0.001$) in daily live weight gains were observed between T and C herds of farms 2 and 3. Regression analyses showed that there was a significant positive correlation between the weaning weights and weight at 12 mo. of heifers ($r^2 = 6825$, $p = 0.01$).

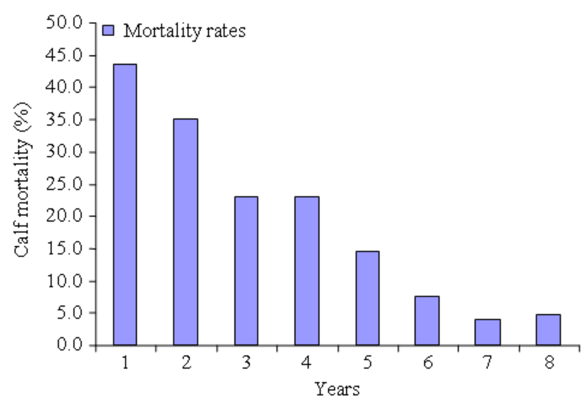

Fig. 1: Phase-wise reduction of crude mortality (%) from years 1-8. (Year 1) Retrospective data; Year 2: Field survey data; (Years 3-8) Intervention measures implemented

Table 3: Disease syndromes and deaths by age groups (numbers) in pre-weaned calves

Age (d)	Colic	Diarrhea	Joint illness	Pneumonia	Pneumo-enteritis	Surgery	Tympani	Total
1-7	0.0	2.0	0.0	1.0	9.0	8.0	0.0	20.0
8-15	2.0	7.0	0.0	1.0	9.0	0.0	0.0	19.0
16-30	1.0	0.0	0.0	6.0	13.0	0.0	1.0	21.0
31-60	0.0	1.0	11.0	14.0	12.0	4.0	1.0	43.0
61-90	2.0	0.0	5.0	14.0	3.0	0.0	0.0	24.0
> 90	0.0	0.0	1.0	5.0	0.0	0.0	0.0	6.0
Totals	5.0	10.0	17.0	41.0	46.0	12.0	2.0	133.0
Proportion (%)	3.8	7.5	12.8	33.8	34.6	9.0	1.5	100.0

Table 4: Laboratory diagnosis of bacterial, viral and parasitic diseases of pre-weaned calves

Microbial species	No. of samples	No. positive	Morbidity risk rate (%)
Diarrhea and enteritis agents			
Escherichia coli	24	10	41.67
Salmonella	34	11	32.35
Klebsiella	28	8	20.57
Rotavirus	5	3	60.00
Coronavirus	10	10	100.00
Cryptosporidia	23	15	65.21
Coccidia	5	1	20.00
Pneumo agents			
Staphylococcus	10	10	100.00
Streptococcus	10	10	100.00
Pateurella	10	10	100.00

Table 5: Heights, Weight and Daily Live Weight Gain of Heifers in three farms

	Farm 1		Farm 2		Farm 3	
Variables	T	C	T	C	T	C
No. heifers	19.00	13.00	38.00	8.00	10.00	4.00
No. reaching height standard	17.00	2.00	11.00	3.00	5.00	0.00
*Proportion (%)	89.00[a]	15.00[b]	31.00[a]	38.00[a]	50.00	0.00
No. reaching weight standard	14.00	3/10	7.00	1.00	1.00	0.00
Proportion (%)	74.00[a]	30.00[b]	19.00[a]	13.00[b]	10.00	0.00
Mean ADG (kg)	1.16[a]	0.94[a]	0.81[a]	0.68[b]	0.67[a]	0.52[b]

Different superscripts [a] and [b] of the same farm are significantly different (p = 0.05). T: Improved feeding management; C: Control: Traditional feeding management as practiced in the commercial farms

Reproductive performance of heifers: Ages of heifers were approximately 13-15 mo while clear cycling occurred. Only those heifers that attained the standard growth value of 132 cm in height and were >380 kg body weight were mated by AI.

Comparing herd performance: In the commercial system of management (without intervention), adult dairy herd crude mortality was found high (Table 6). The mortality rate was significantly reduced 9 Vs 1%. Likewise, an annual culling rate of herd was reduced from 66-33%. Milk yield improved in first lactation cows born in Kuwait by 1.25-1.5 fold.

Contribution of growing locally born and raised dairy cattle to total herd: A case study: As a result of continued applied studies first to third lactation cows formed 32% of the total cows (Table 7), a higher proportion of locally pregnant (59%) and growing heifers (97.8%) contributed to the total young heifers. Above locally born replacement heifers were better adapted to the Kuwait's environment for breeding milk production compared to imported herds.

Table 6: Comparative performance of young and mature dairy herds with and without research interventions

	Interventions		
Variables	With	Without	Improvement level
Calves mortality rate (% 0-3 mo)	4.67[a]	43.63[b]	9.3x
Weight gain calves (0-3 mo g h^{-1} day^{-1})	523[a]	115[b]	4.5x
Heifers standard height (%)	89[a]	15[b]	5.9x
Heifers standard weight (%)	74[a]	30[b]	2.4x
Breeding of heifers (mo)	15[a]	18-22[b]	Saved feed cost by 25%
Calving age of heifers (mo)	24	25-31	Saved feed cost by 14%
Adult herd mortality rate (%)	1[a]	9[b]	9.0x
Herd culling rate/annum (%)	33[a]	62[b]	1.8x
Milk yield Liters/head/day year 1	16.07[a]	10.65[b]	1.5x
Year 2	16.86[a]	21.1[b]	1.25x

Different superscripts [a] and [b] of the same farm are significantly different (p = 0.05)

Table 7: Contributions of locally born and raised dairy herds to total dairy herd after five-year interventions: A case study in Kuwait (numbers)

Herd classes	Local born	Imported	Total	Locally replaced (percent of total herd)
Lactating cows	194	408	602	32.2
Pregnant hers\d (Heifers)	101	70	171	59.0
Growing heifers (6-15 mo old)	400	9	409	97.8
*Growing young calves (3-5 mo old)	75	Nil	75	100.0
*Pre-weaned calves 1-90 day old	176	Nil	176	100.0
Breeding bulls	26	18	44	59.1
Total	972	505	1,477	Mean: 65.80

*: Young growing calves include both males and females (Sex ratio 1:1)

DISCUSSION

Many countries of hot arid region including Kuwait do not have their own adapted dairy cattle breeds, thus depend on temperate origin imported high yielding Holstein Friesian dairy cattle. Systematic relevant studies and data addressing the constraints faced by the dairy farms of Kuwait and similar hot arid countries are scarce. Present investigations addressed some of the constraints of commercial dairy farms of Kuwait.

Causes of calf-hood diseases: Main causes of high mortality rate in pre-weaned calves were identified. Intervention measures (Table 1) were applied and crude calf mortality rate of calves reduced from mean high of 43.6 to low of 4.67%. Most important element of the success was improving on-farm calf health management, housing and nutrition[2,3]. Predominant causal agents of diarrhea, pneumonia and enteritis of day old to 2 weeks calves were quickly identified (Table 3). It was found that calves confined in the metallic crates in intensive closed-type housing system was associated with a higher incidence of pneumonia as a result of combined adverse effects of a built-up high RH % and pathogens. Housing of calves in individual naturally ventilated polyvinyl hutches had reduced crude mortality rate of calves significantly[2]. Immune status of the calves also was vital factor in reducing the disease incidence and death[16].

Weaned heifers: Raising replacement heifers, adapting them to an intensive management under hot arid climate were the main strategic elements (Table 1) in our study. It is worth noting that rearing replacement heifers in the dairy farms of Kuwait had been a very rare practice and elsewhere in many countries due to the high calf losses[1]. Once the results of high calf survival rate were demonstrated recently in the commercial dairy farms, rearing of locally born weaned heifers for herd replacement had been initiated by the dairy producers of Kuwait. It was clear that the weaned heifer calves from their 91 day age had minimum health problem and mortality (Table 6). Disease prevention, nutrition and selection were found to be key strategic elements for improved performance of heifers. Improved dietary management of heifers in two out of the three farms had reflected in their performance parameters (Table 2 and 5). Heights, weights and daily live weight gain of heifers had improved significantly ($p \leq 0.001$) in T compared to C herds, however, farm to farm variations were observed. These differences were associated mainly with incidence of pneumonia in farms 2 and 3 adversely affecting the heifer performance. Our results were consistent with the findings of similar hot climatic zone[17,18]. Improved growth rate of heifers resulted in early breeding them at an average of 15 mo instead of 20 mo. This was a significant achievement resulting in a longer lactation life and saving feed cost by 14-25% (Table 6). Tanaka *et al*.[19] also found that nutritional management was the key factor for improving reproduction and milk yield of dairy herds.

Locally born dairy herd performance: Our medium-term results of 8 year demonstrated that use of USA origin superior frozen semen and AI of imported second to third parity Australian Holstein Friesian cows produced better calves with low mortality rate than that born from the imported pregnant heifers. Upgraded weaned heifers reached the targeted body size for breeding them at earlier age than conventional breeding practice in Kuwait.

The usual practice in Kuwait was importation of pregnant heifers from mainly temperate regions and retain them for an average of 2.3 lactations and then cull them as beef cows. The reason for a short productive life of imported cows was the lack of their adaptation to the hostile local climate [3]. Recently, Razzaque *et al*.[4] observed that there had been economic benefits to the dairy producers in rearing calves in Kuwait. Israeli Holstein Friesian dairy cattle breed was developed over the years by introducing genetic resources obtained from high yield dairy cattle of Europe and USA. Thus, an annual mean milk yield of Israeli cows was 11,281 kg/cow/lactation and the best cow yielded more than 18,700 kg lactation^{-1}[20].

Dairy producers of Kuwait started to implement plan for rearing their locally born heifers using the recommended procedures of the present study and as well as with the financial incentives provided by the Kuwait Government. As a result, the commercial farms made progress during past 5-6 years in replacing their imported dairy herds by locally born herds. Case study (Table 7) demonstrated on-farm progress made in adapting the strategy of replacement heifer rearing.

CONCLUSION

Direct involvement of commercial dairy producers in applied research appeared to be very effective means for phase-wise reduction of calf mortality rates and improvement of performance of heifers and first lactation cows raised under feedlot management in hot arid environment.

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