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Research Article

ANALYSIS OF GROUND WATER DRAFT PATTERN IN AN AGRICULTURE LAND USE UNDER RAINFED WATERSHED SYSTEM

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Abstract- There has been a significant increase in the demand of groundwater for agriculture, domestic and industrial uses. This has caused over exploitation of groundwater in some areas causing excessive lowering of water levels, sea water intrusion in coastal aquifers and upcoming of saline water in inland areas. To overcome from these problems the ground water draft pattern has been studied in the Patapur micro-watershed, which is located in Raichur district [semi-arid region].In the micro-watershed the main source of irrigation has been supplied from the tube wells. The necessary data[discharge of the tube well (lit/s), irrigation period (hr), irrigation interval (days), number of irrigation, crop details, soil types etc]required for the groundwater investigation was collected from the owners of the tube wells. Parallelly, the groundwater fluctuations during pre-monsoon, monsoon and post-monsoon for 2013-2014 were also measured [3-4 m during the month of June and July]. The total groundwater draft during the investigation period was 228,858.50 m^3. From the study it was concluded that, the micro-watershed prevailed with semi arid agro climatic condition needs groundwater protection to set sustained yield of rain fed crop intermittently.

Keywords- Draft, Groundwater fluctuation, Groundwater investigation, Micro-watershed.

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Introduction

Water level being directly measurable is an important parameter for the study of aquifer systems and their behavior. In order to understand the connectivity of the aquifer especially in hard-rock regions, the spatial and temporal variability of water level should be considered [1]. Being time-variant, water level should be monitored and it could be controlled by recharge/draft of groundwater. Variation of meteorological parameters, tidal phenomena, urbanization, earthquakes, external loads, stress/strain etc due to groundwater recharge, discharge and intensity of rainfall are reflected in groundwater level fluctuation with time[2].

There has been a significant increase in the demand of groundwater for agriculture, domestic and industrial uses. This has caused over exploitation of groundwater in some areas causing excessive lowering of water levels, sea water intrusion in coastal aquifers and upcoming of saline water in inland areas. Parallelly, it resulted in reduction of individual well yield, growth in well population, failure of bore wells, drying up of dug wells and increase in power consumption [3].

The state's annual replenishable groundwater resource is about 16.81 BCM out of which net annual groundwater availability of 14.81 BCM provides draft of 10.01 BCM. The present groundwater development in the state is at about 68 percent of available sources facilitating 0.779 M ha well irrigation. The Raichur district is being under semi-arid climatic conditions, situated over peninsular gneissic complex. Net groundwater availability and gross draft of the district were 82095 ha m, 23525 ha m and as gross domestic and industrial draft of 2757 ha m respectively. The projected domestic and industrial requirement by 2025 would be 4244 ha m where as net groundwater availability for irrigation is 55760 ha m [4].

As groundwater level is concerned, the depth to water level in pre-monsoon and post -monsoon ranges between 0.65-10.70 [mbgl] and 0.05-11 [mbgl] respectively [5]. The 75 percentage groundwater area in the district is safe and the rest 24 percent is denoted as 'over-exploited' and one percent as 'semi-critical' area.

Hence, to prepare a sustainable management strategy for groundwater development, it is important to understand the fluctuation of groundwater levels and its draft with reference to natural or artificial recharge in space and time domain.

Material and methods

The study was conducted in Patapur micro-watershed being located at Manvi taluk of Raichur district, Karnataka and has an area of 541.39 ha. The study area lies between the 16˚07' 35.9" Latitude and 76^0 51' 33.3" Longitudes and 16˚08' 22.3'' Latitude and 76˚53' 27.7" Longitudes with an average elevation of 447 m above the mean sea level (MSL). The study area is falling under the Survey of India toposheet of 56 D/16 [1:50,000].The climate of the region could be termed as semi-arid with mild winters and hot summers. December is the coldest month with mean daily minimum temperature of 17.7 ºC, while May month being the hottest month with mean daily maximum temperature of 39.8 ºC. Relative humidity of around 75 percent observed during monsoon period. Wind speed exceeding 15km/h during the months of June and July. The recorded annual potential evaporation would be 1950 mm [year], maximum [220 mm] in May month and lowest in December [120 mm]. The average annual rainfall of the district is 621 mm.

In the micro-watershed the main source of irrigation has been supplied from the

tubewells. There were 13 tube wells, which have been identified during investigation. The necessary data required for the groundwater investigation was collected from the owner of the tube wells and the crops grown under protective groundwater irrigation during both kharif and rabi seasons were listed in [Table-1]. The discharge of the each tube well in the study area was estimated by direct measurement of the time to fill a container of known volume i.e.Q= V/t[Q = Discharge, lit/s and V = Volume of water, liters].The estimated discharge during both kharif and rabi season are listed in the [Table-2]. Irrigation period[hr]and the irrigation interval[days]were calculated on the basis of availability of 3 phase electricity and the gap between two irrigations respectively [Table-2]. The accessibility of irrigation was analyzed based on the data collected from the farmers and its effect on cropping pattern was studied by tabular analysis. Draft[Table-2] from each tube wells in the micro-watershed was calculated by adding total discharges which were obtained during both kharif and rabi season.

Results and Discussion

As many as thirteen marginal to small farmers [holding size of 0.81-6.3 ha] own the tube wells enforced last 5-15 decades. The depth varies from 18.28-35.50 m in the granite-confined aquifer region. The thirteen number of tube wells can be classified into two clusters, where in the TW_1-TW_4 [cluster-1] located at about 421.48m from the outlet of watershed. Cluster-2 consisting of remaining nine wells are located near outlet. The upper reach of micro-watershed being situated with hillock and upper pediment landform coupled with sandy soils no tube wells have been situated. The tube wells are energized with 3.73 watts submersible pumps, and are in restricted period of power supply [6-24hr]. From all the tube wells the farmers utilize groundwater with possible efficiency to grow both annual [cotton and pigeon pea] and seasonal crops including groundnut, sunflower and vegetables regularly even though paddy being high water consuming crop [daily 6-10 mm] as many as five farmers cultivate in kharif season. However three farmers do cultivate even rabi season also, two farmers[TW_{10} and TW_{11}] are using tube well water for cultivating paddy for both the seasons, six farmers namely TW_2, TW_3, TW_4, TW_7 and TW_{10} undertake two crops in kharif season including paddy and vegetables. Five farmers of TW_2, TW_3, TW_7, TW_9 and TW_{13} grow two crops during rabi seasons including paddy and vegetables. The area during kharif and rabi seasons together would be 38.42 ha during 2013 and 14 [Table-1].

The discharge [Table-2] measured from each well during kharif season varies between 4.1-6.1 lit/s where as it almost remain in the same range during rabi seasons which shows the groundwater potential is good. Further in many situations because of restriction [6 hours] on power availability the pumping output does not get over exploited which could also influenced on uniform output through the year. The irrigation interval [days] generally varies from crop to crop. The existing practice followed in tubewell irrigated farmers would be once in fortnight [15 days] the crop mainly groundnut, cotton and pegionpea where as interval reduce 4-5 days for sensitive and remunerative crops like vegetables. However farmers do pump regularly on daily basis invariably to support paddy crop throughout kharif and rabi season in smaller area. This reflects on farmer's tendency to balance their economics events even though the groundwater is hardpress.

Draft [Table-2] from each tube wells in the micro-watershed was calculated by adding total discharges, obtained during both kharif and rabi season and mathematically it is expressed as:

Draft = Discharge (m^3/sec) X Irrigation period (hr) X Irrigation interval (days) X Crop duration (months).

The total draft estimated during kharif season was 1,19,9,83.24 m^3 including all thirteen wells, where as it was reduced to 1,08,8,75.26 m^3 in rabi season. Together accounting 2,28,8,58.5 m^3 throughout the year. The average depth of water irrigated would be 42 mm as compared to total rainfall received [685mm] during the year 2013. The highest draft output was used for paddy crop which varied from 12,4,41.6 m^3-2,00,55.6 m^3 in kharif as escalated to a range of 13,7,37.6–20,0,55.6 m^3 in rabi season. Among all other crops, vegetables required relative lesser quantity of water, which remained to 1,9,63.44 m^3.

Table-1 *Agricultural land use details in the Patapur micro-watershed.*

Sl no	Wells	Crop details under protective irrigation				Crop duration (days)			
		Kharif season		Rabi season		Kharif season		Rabi season	
		Crop 1	Crop 2	Crop 1	Crop 2	Crop 1	Crop 2	Crop 1	Crop 2
1	TW_1	Sunflower	-	Groundnut	-	120		130	-
2	TW_2	Cotton	Onion	Groundnut	Vegetables	196	90	130	90
3	TW_3	Pegionpea	Paddy	Groundnut	Paddy	180	150	130	150
4	TW_4	Cotton	Chilly	Sunflower	-	196	90	120	-
5	TW_5	Paddy	-	Sunflower	-	150	-	120	-
6	TW_6	Vegetables	-	Vegetables	-	196	150	130	150
7	TW_7	Cotton	Paddy	Groundnut	Paddy	196	150	150	-
8	TW_8	Cotton	Paddy	Paddy	-	196	150	150	-
9	TW_9	Pegionpea		Sunflower	Paddy	180	-	120	150
10	TW_{10}	Cotton	Paddy	Paddy	-	196	150	150	-
11	TW_{11}	Paddy	-	Paddy	-	150	-	150	-
12	TW_{12}	Cotton	-	Groundnut	-	196	-	130	-
13	TW_{13}	Sunflower	-	Paddy	Sunflower	120	-	150	120

Table -2 *Observed groundwater utilities and irrigation scheduling parameters of tube wells in the Patapur micro-watershed.*

Sl no	Wells	Discharge(lit/s)		Irrigation Period (hr)	Irrigation interval(days)				Number of irrigation							
		Kharif season	Rabi season		Kharif season		Rabi season		Kharif season		Rabi season		Kharif season		Rabi season	
					Crop 1	Crop 2	Crop 1	Crop 2	Crop 1	Crop 2	Crop 1	Crop 2	Crop 1	Crop 2	Crop 1	Crop 2
1	TW_1	3.47	4.95	6	15	-	15	-	8	-	9	-	599. 62	-	962.28	-
2	TW_2	3.4	5.05	6	15	5	15	5	14	18	8	18	1028.16	1321.92	827.64	1963.44
3	TW_3	5.2	5.20	6	15	1	15	1	12	150	8	150	1347.84	16848	898.56	16848
4	TW_4	4.06	4.79	6	15	4	15	-	14	8	8	75	1227.74	701.57	827.71	665.24
5	TW_5	3.85	3.85	6	1	-	15	-	150	-	6	-	12474	-	-	-
6	TW_6	3.92	3.96	6	5	-	5	-	18	-	18	-	1524.10	-	1539.65	-
7	TW_7	6.19	6.19	6	15	1	15	1	14	150	9	150	534.82	20055.60	1203.34	20055.60
8	TW_8	5.55	5.55	6	15	1	1	-	14	150	150	-	1678.32	17982	17982	-
9	TW_9	4.89	4.89	6	15	-	15	1	12	-	8	150	1267.48	-	844.99	15843.60
10	TW_{10}	4.24	4.24	6	15	1	1	-	14	150	150	-	366.34	13737.60	13737.60	-
11	TW_{11}	3.84	4	6	-	1	-	1	150	-	150	-	12441.60	-	12960	-
12	TW_{12}	3.82	4.51	6	15	-	15	-	16	-	8	-	1155.17	87.68	87.68	-
13	TW_{13}	4.1	3.98	6	15	-	1	8	8	-	150	8	708.48	12895.20	12895.20	687.75
												Total Draft	36,353.68	83,629.56	52,811.64	56,063.62

The depth to groundwater table [m] contours [with respect to msl] drawn across the micro-watershed during each month of the year 2013-14 indicate situation of two clusters in terms of depth intervals. The spatial maps of pre-monsoon [Fig-1] depicts that the cluster -1 are placed functionally between 428-429 m in March 2013. The rains stretched in June 2013 conspicuously contrary cluster-2 wells which placed between contour 428-429 in march where continuously 426-427m. Which shows cluster-2 were fairly at steady state of pumping. In case of cluster-1 pumping activity might have increased due to enhance protective irrigation continuously for the rabi / summer crops.

During monsoon season [Fg-2][July-October] cluster-1 wells were placed between the range of 427-428 m. whereas cluster-2 wells at the end of October were still in 428-429. In a post-monsoon scenario [Fig-3] [November 2013-February 2014]. There was a steep drawdown realized from cluster-1 wells to TW_{10} of Cluster-2. It shows TW_{10} had been pumped out a large quantity of water and at the same time it was replenished equally so that it performed better replenishment as compared to other wells of cluster- 1.

The groundwater level reached the lowest level in the hottest periods after which it starts rising to reach highest peak, a little the end of rainy seasons. The rise and fall depends upon the amount, duration and intensity of precipitation, depth of weathering, specific yield of the formation etc [6].

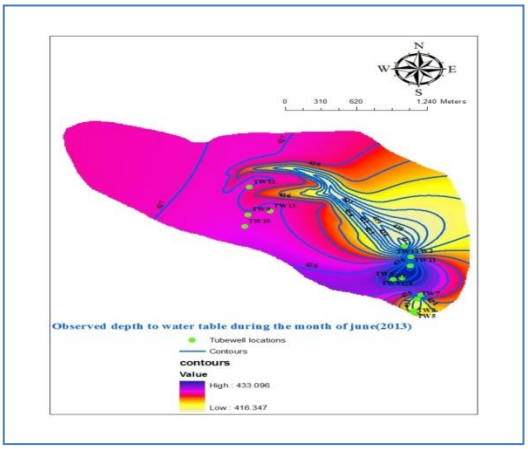
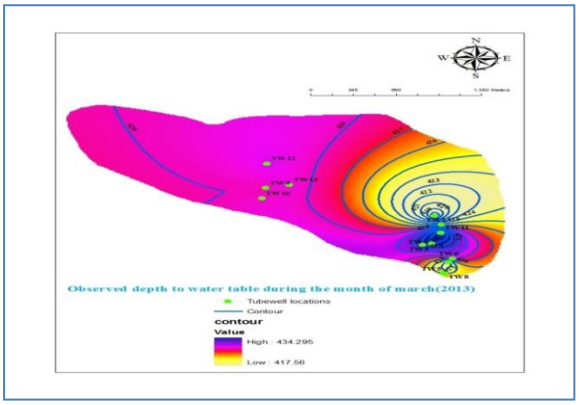
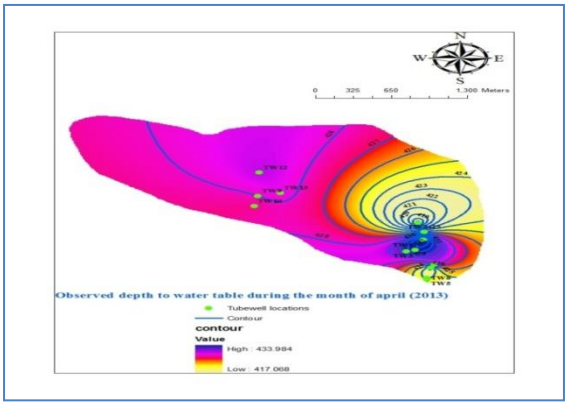
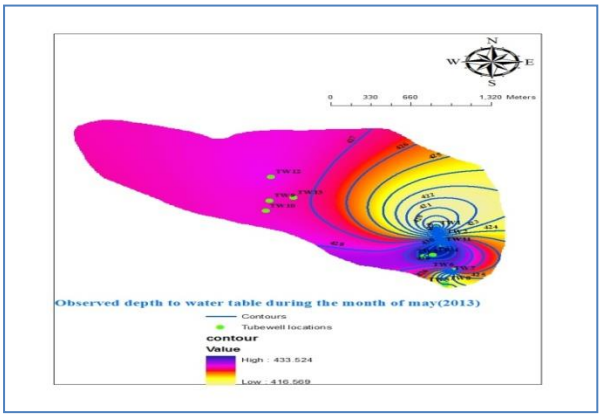
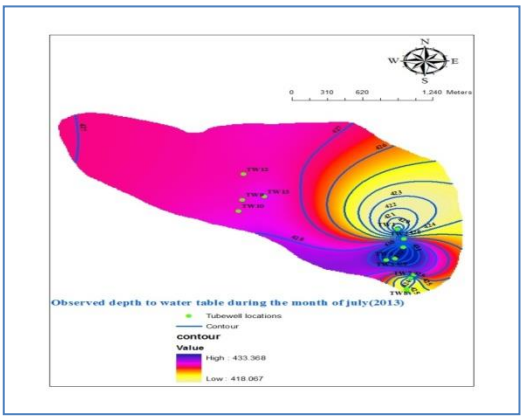


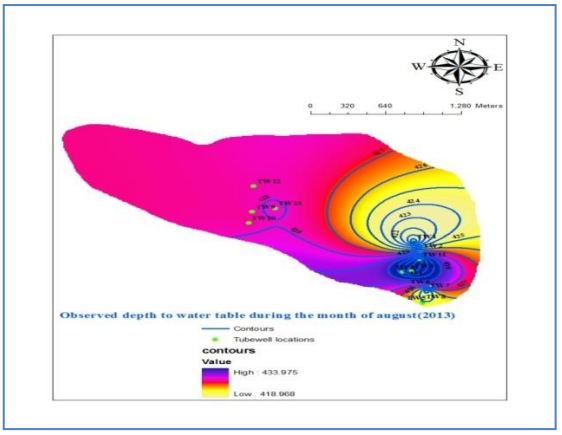
Fig-1 Spatial distribution of depth to water table during March, April, May and June respectively.

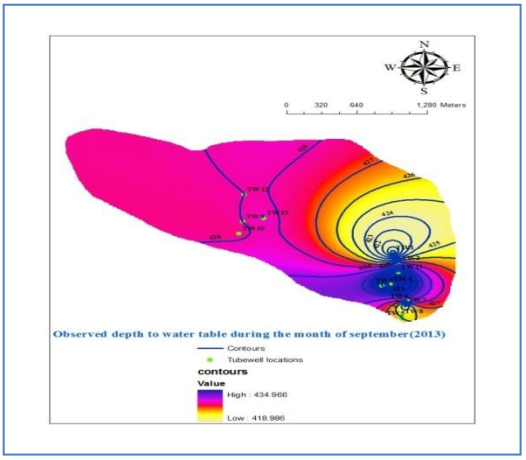












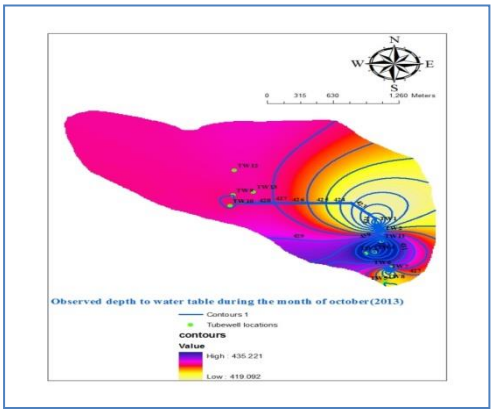
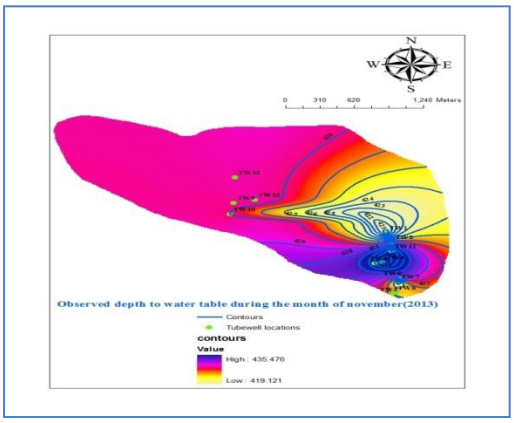
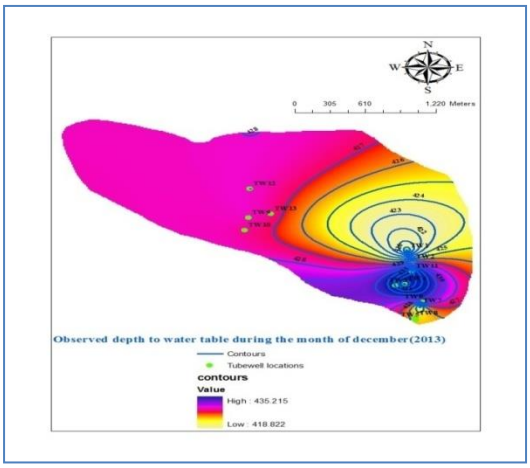
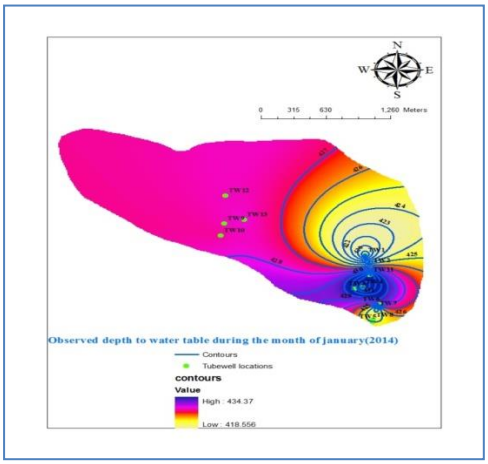


Fig-2 Spatial distribution of depth to water table during July, August and September respectively.







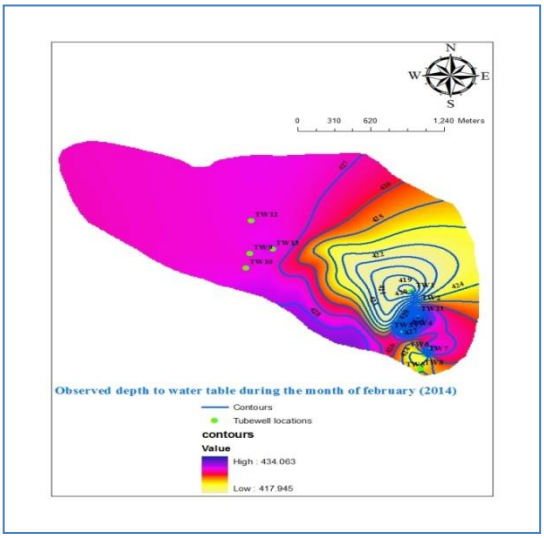


Fig-3 Spatial distribution of depth to water table during November, December, January and February respectively.

Conclusions

The semi-arid tropical climate which prevails in around the Raichur region is very critical from the perspective of groundwater abstraction plan for the purpose of agriculture and domestic requirement. In the study area the observed average groundwater fluctuation would be in the range of 3-4m during the month of June and July. Paddy crop cultivation by tube well was covers about the command area of 38.43 ha due to this groundwater extraction pattern would be affected with additional stress. The calculated groundwater draft during Kharif season was 119983.24 m^3 and in Rabi season was found to be about 108875.26 m^3. The total groundwater draft in micro-watershed during the investigation period was found to be about 22,8,,858.50 m^3 or 42.27 mm of equivalent depth over the watershed area. Spatially, groundwater extraction in micro-watershed affected significantly in the month of June and November. All the results from the investigation revealed that the Patapur micro-watershed prevailed with semi arid agro climatic conditions needs groundwater protection to set sustained yield of rain fed crop intermittently.

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Author Contributions

Savita Seetimani: During my research work I have collected the data of discharge of the tube wells (lit/s), irrigation period (hr), irrigation interval (days), number of irrigation, crop details etc from the owners of the tube wells during field visit. Groundwater levels for the pre-monsoon, monsoon and post-monsoon (2013-2014) were collected for the study.

Satishkumar Umapathy: As a major adviser, during my M.Tech research he has guided, suggested and supported me in each and every step to complete the work satisfactorily.

Maheshwarbabu Banda: He guided to prepare the groundwater contour maps in Arc GIS.

Mallikarjun Ayyangowdar, Nemichandrappa Muddi and Veeresh Hogarnal: As a advisory committee members they gave valuable suggestions in every step to complete the work satisfactorily.

Abbreviations

lit/s – liter per second
hr-hour
m-meter

m^3-meter cube
BCM-Billion Cubic Meter
M ha-Million Hectare
ha m- hectare meter
mbgl-meters below ground level
ha-hectare
MSL-Mean Sea Level
ºC-Degree Celsius
km/h-kilometer per hour
Mm-Million meter
TW_1-Tube Well 1,similarly TW_2 to TW_{13}.

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.

Conflict of Interest: None declared

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