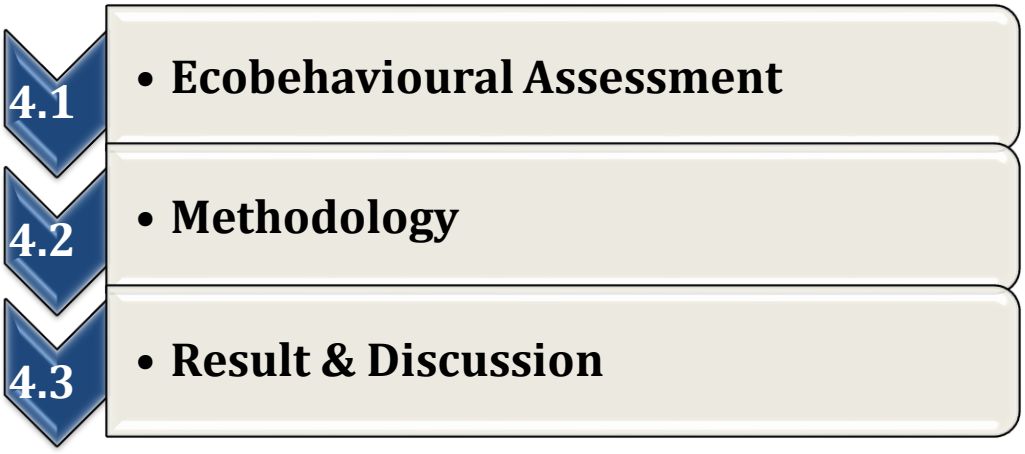
CHAPTER 4

ECOBEHAVIOURAL ASSESSMENT IN *ILYOPLAX SAYAJIRAOI*



4.1 Ecobehavioural assessment

Heavy metal pollution is of ubiquitous concern for the ecological management of aquatic ecosystems (Iwasaki et al., 2009; Bentum et al., 2011). Its properties like environmental persistence, toxicity, and ability to be incorporated into food webs make it more hazardous (Demirbas, 2008). The concentration of heavy metals is more toxic in hard water than soft water as cations such as calcium and magnesium compete with metal ions for active sites within an organism's tissues, thereby reducing the potential toxicity of the metals (Kelly, 1988). Anthropogenic pressures (e.g. industrial activities, mining, and urban runoff) and natural processes (e.g. weathering) also add on heavy metals in aquatic ecosystems (Carpenter, 1925; Iwasaki et al., 2009; Bentum et al., 2011). The release of heavy metals waste in wetlands through natural processes of weathering is highly dependent on the geology of that area (Gupta and Banerjee, 2012). Mining activity

introduces a significant source of mercury (Hg), lead (Pb), and other heavy metals contamination in the environment (Hanson et al., 2007; Obiri, 2007; Singh et al., 2007). Post mining, olivine, orthopyroxene, and other metallic minerals buried deep into the earth's crust are removed out and heaped as waste outside. When exposed to weathering, it releases toxic chemicals like lead, cadmium, iron, and mercury (Bentum et al., 2011).

Sediment samples are extensively used in analysing heavy metal levels and accumulation because they act as sinks and process historical evidence of natural and anthropogenic fluxes of heavy metals (Hseu et al., 2002; Aksoy et al., 2005; Nguyen et al., 2005; Boamponsem et al., 2010). Contaminated sediments are hazardous to benthic macroinvertebrates, which expose high trophic organisms to hazardous heavy metals (Begum et al., 2009; Bentum et al., 2011).

Biological Monitoring Working Party (BMWP) and the Average Score per Taxon (ASPT); (Armitage et al., 1983) respectively were applied for quality assessment of river on benthic invertebrates (Korte et al., 2009). The major problem for biodiversity conservation is lack of knowledge about its tremendous varieties along the captive area and presence of hotspots (Barbosa and Callisto, 2000). Also less attention is given on pressure that is created by anthropogenic activities on biodiversity. Establishing fauna of flora habituated at that place as bio monitoring tool can fill up this gap.

Physical and chemical evaluation of river and oceans are costlier than bio monitoring (Resh, 1995; Dudgeon, 2003; Barbour et al., 2004). Reliable and accurate signals are obtained by benthic invertebrates about anthropogenic activities and effect of stressors over long time durations. This gives a strong linkage between pollutants and benthic fauna. Hard water have more percentage in making heavy metal significantly toxic as cations

calcium magnesium compete with metal ions for active sites in an organism's tissues (Kelly, 1988). In 1959 Normal behaviour was studied by Altevogt in *Uca tangeri*, and observed that adult males hide five to fifteen times longer than juveniles and females as males were caught regularly by locals as its chela is used as delicacy.

4.2 Methodology

- DSLR camera attached to tripod stand was set, focused on crabs of *Ilyoplax sayajiraoi*.
- Two different types of treatments were applied to analyse the behavioural difference in crabs of *Ilyoplax sayajiraoi*.
- Each treatment was divided into three seasons, summer, monsoon and winter. Each video was divided into initial, medial and final according to the specific time interval.
- Quadrats were marked (Chemically treated, fertilizer treated and normal behaviour)
- According to the type of quadrates, 1. Chemically treated- 10% solution of $CoCO_3$ was sprayed evenly covering all burrows of *Ilyoplax sayajiraoi* and allowed to react for six hours in-situ. 2. Fertilizer was evenly sprayed on quadrate.
- Video recording of their behaviour was carried out and noted in particular format sheet after comparing all the behavioural videos in the laboratory.

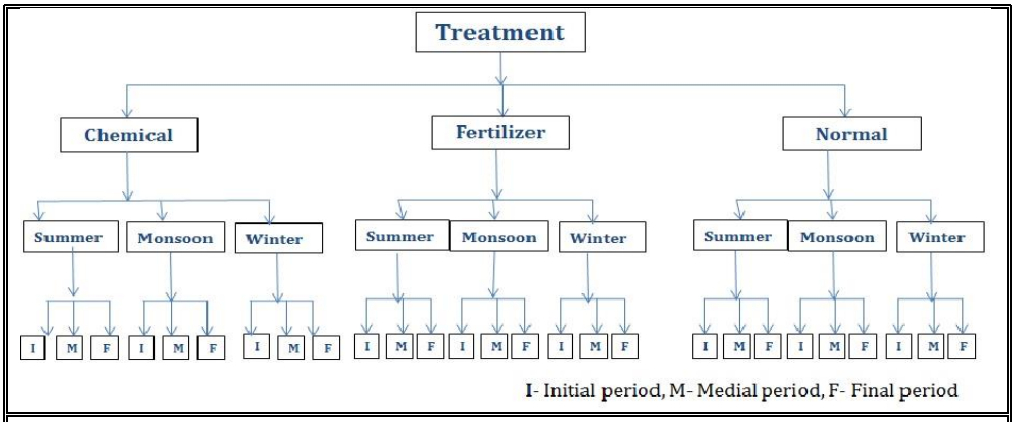


Figure 4.1 Methodology for eco behavioural assessment

4.3 Observation and Result

4.3.1 Analysis for untreated burrows

4.3.1a Seasonal variation in activities of crab

Behaviour analysis for untreated crab burrows is illustrated further. Foraging, popping out, feeding, time spent inside (TSI), mudballing and plugin behaviour are shown in three different time duration i.e. 1. Initial, 2. Middle and 3. Final shown from figure 4.2 to figure 4.10. In summer season plugin behaviour reaches higher values in initial phase, in middle and final phases it spends complete time inside the burrow (TSI). Time spent for popping out activity was higher in initial than any other phase. In winter season maximum time spend was inside the burrow in initial phase and it was plugged in middle phase. In final phase no activity was observed. Time spent for popping out activity was higher in initial and middle as compared to final phase. In monsoon season maximum mudballing was observed from initial to final phase no plugin behaviour was observed, no popping out behaviour was seen as crab stayed outside for period. Foraging and feeding activity was in its peak during initial phase for all the three seasons, then after it decreased to zero.

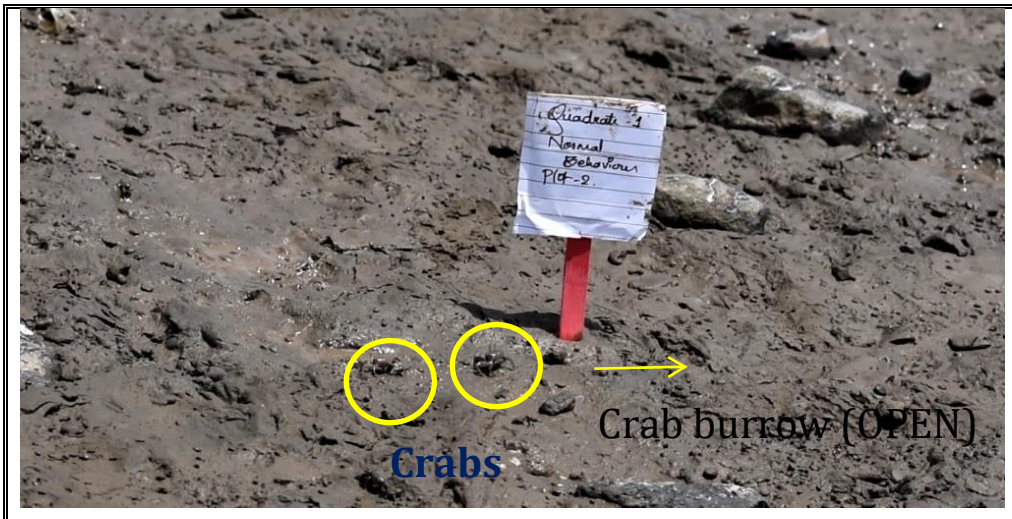


Figure 4.2 Shows crab outside the burrow performing different activities in its initial phase of untreated burrows of summer season

Figure 4.3 Shows closed crab burrow in its middle phase in untreated burrows of summer season

Figure 4.4 Shows final phase with zero activity in untreated burrows of summer season

Figure 4.5 Shows crabs performing different activities in initial phase of untreated burrows of winter season

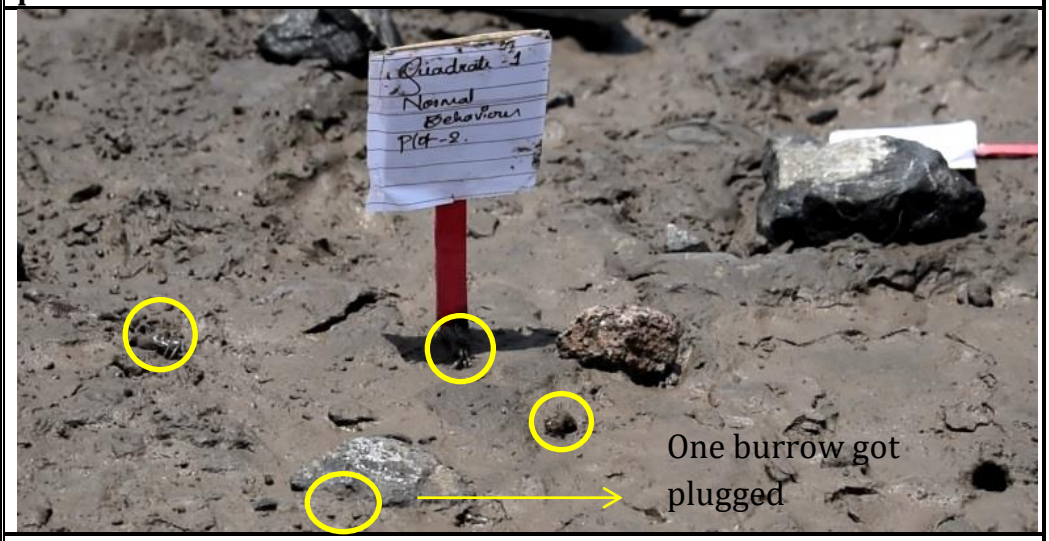


Figure 4.6 Shows crabs performing different activities with one burrow plugin for untreated burrows of winter season

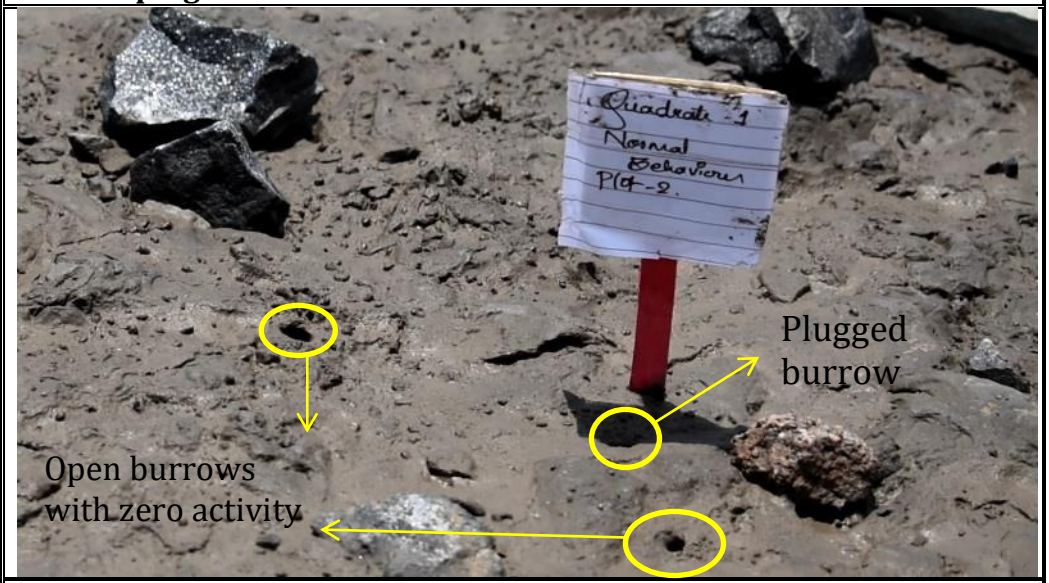


Figure 4.7 Shows plugged burrows in final phase of untreated burrows of winter burrows

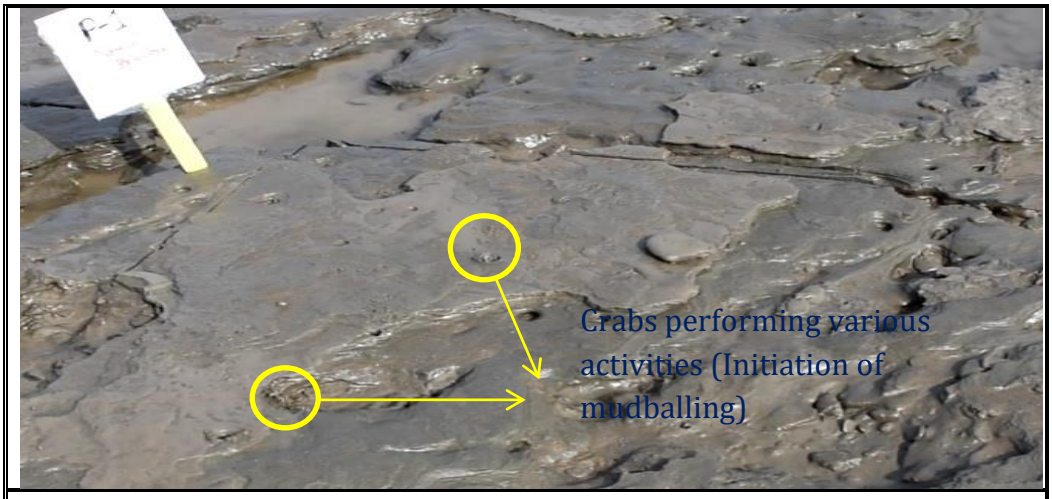


Figure 4.8 Crabs performing various activities in initial phase of untreated burrows of monsoon season

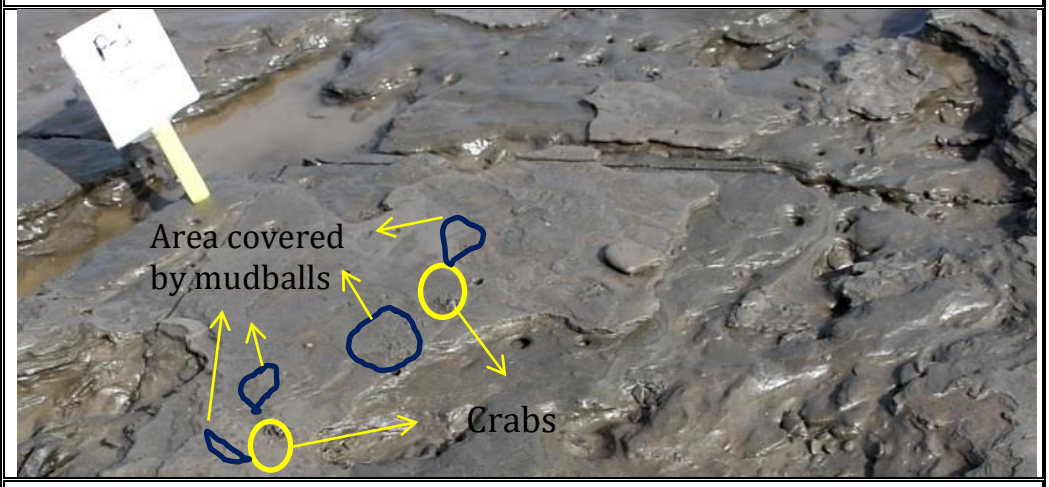


Figure 4.9 Crabs performing mudballing in middle phase of untreated burrows of monsoon season

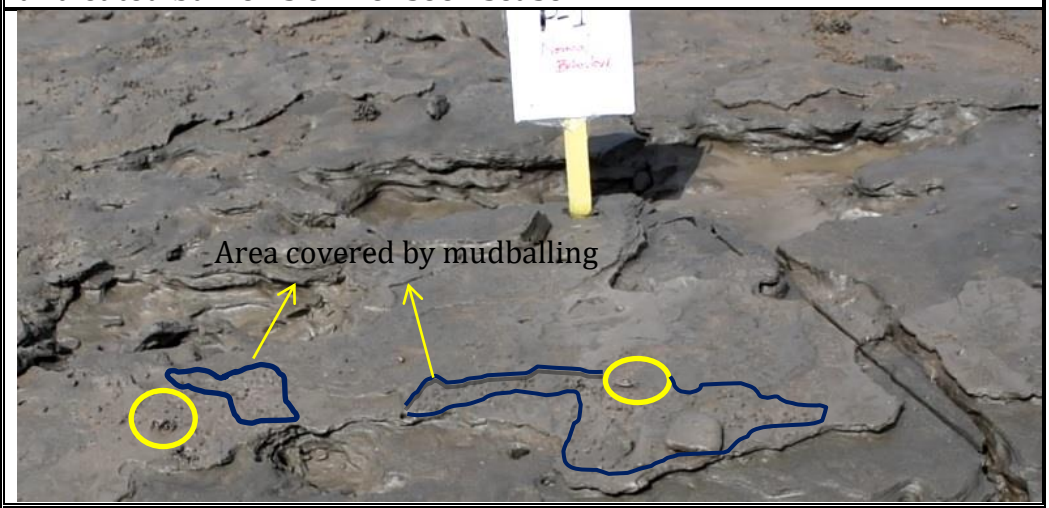


Figure 4.10 Crab covering a larger area performing mudballing in final phase of untreated burrows of monsoon season

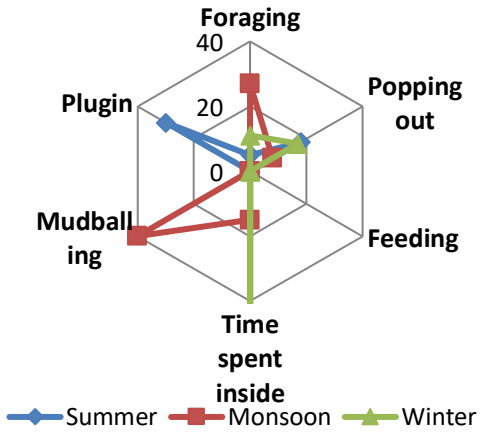


Figure 4.11 Radar diagram of untreated burrow (Initial phase)

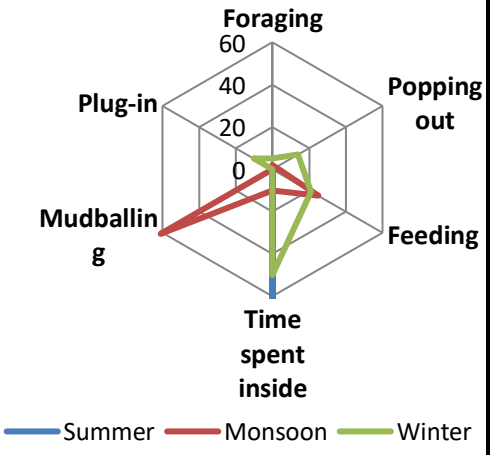


Figure 4.12 Radar diagramof untreated burrow (Middle phase)

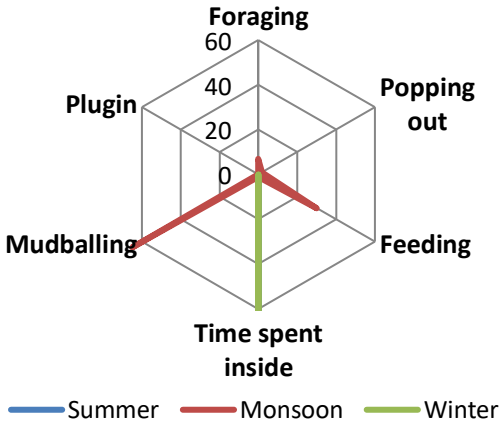


Figure 4.13 Radar diagram of untreated burrow (Final phase)

4.3.1b Interrelationship between activities of crab in winter season

Pearson correlation amongst Foraging, popping out, feeding, time spent inside (TSI), mudballing and plugin behaviour was analysed for evaluating the relationship between activities of crab in winter season for untreated crab burrows (Table 4.1). Feeding was significantly correlated with foraging (r = 0.639; p=0.05%), TSI (r = -1.00; p = 0.01%), popping (r = -0.904; p=0.01%), cleaning (r = -0.750; p = 0.05%), waving (r = -0.904; p= 0.01%) and plugin (r = -0.996; p = 0.01%). Foraging was significantly correlated with TSI (r = -0.639; p = 0.05%), popping (r = -0.904; p = 0.01%), TSO (r = -0.865; p = 0.01%), (r = -0.829; p = 0.01%), mudballing (r = -0.529; p = 0.05%), cleaning (r=0.984; p = 0.01%), waving (r = -0.904; p = 0.01%), plugin (r=0.567; p = 0.05%). TSI was correlated with popping (r= 0.896; p = 0.01%), cleaning (r = -0.750; p = -0.01%), waving (r = 0.896; p = 0.01%) and plugin (r = 0.997; p = 0.01%). Popping is correlate with TSO (r = 0.581 p = 0.01%), fighting (r = 0.524; p = 0.05%), cleaning (r = 0.964; p = 0.01%), waving (r = 0.896; p = 0.01%), plugin (r = 0.997; p = 0.01%). TSO is having significant correlation between fighting (r = 0.998; p = 0.01%), mudballing (r = 0.881; p = 0.01%) and cleaning (r = 0.784; p = 0.01%). Fighting is correlated with mudballing (r = 0.912; p = 0.01%) and cleaning (r = 0.739; p = 0.01%). Cleaning is correlated with waving (r = 0.961; p = 0.01) and waving is highly correlated with plugin (r = 0.862; p = 0.01).

Table 4.1 Correlation between different behavioural activities of crab for untreated burrows winter season

	Feeding	Foraging	TSI	Popping	TSO	Fighting	Mudballing	Cleaning	Waving	Plugin
Feeding	1									
Foraging	.639	1								
TSI	-1.000**	-.625	1							
Popping	-.904**	-.904**	.896**	1						
TSO	-.177	-.865**	.159	.581	1					
Fighting	-.110	-.829**	.091	.524	.998**	1				
Mudballing	.309	-.529	-.326	.127	.881**	.912**	1			
Cleaning	-.750*	-.984**	.738*	.961**	.784*	.739*	.397	1		
Waving	-.904**	-.904**	.896**	1.000**	.581	.524	.127	.961**	1	
Plugin	-.996**	-.567	.997**	.862**	.087	.019	-.394	.687*	.862**	1

** Correlation is significant at the 0.01 level (2 –tailed). * Correlation is significant at the 0.05 level (2-tailed).
TSI- Time Spent Inside the burrow, TSO- Time Spent Outside the burrow

Table 4.2 Component Matrix[a] for untreated burrows winter season		
Activities	**Component**	
	1	2
Feeding	-.840	.542
Foraging	-.952	-.296
TSI	.830	-.558
Popping	.991	-.132
TSO	.683	.731
Fighting	.631	.776
Mudballing	.257	.966
Cleaning	.989	.149
Waving	.991	-.132
Plugin	.787	-.616

Table 4.3 Total Variance for untreated burrows winter season						
Component	**Initial Eigenvalues**			**Extraction Sums of Squared Loadings**		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.794	67.944	67.944	6.79	67.944	67.944
2	3.199	31.987	99.931	3.19	31.987	99.931

Scree plot shown in figure 4.14 shows data has two major components as shown in table.4.2. Per cent variance for component 1 is 67.944%, 2 is 31.987%. Cumulative percentage for component 1 is 67.944%, component 2 is 99.931%. For winter season two major clusters are formed, 1. Mudballing: Fighting: TSO and 2. TSI and Plugin Feeding and foraging are not related with any of these clusters and present in two different quadrates figure.4.15.

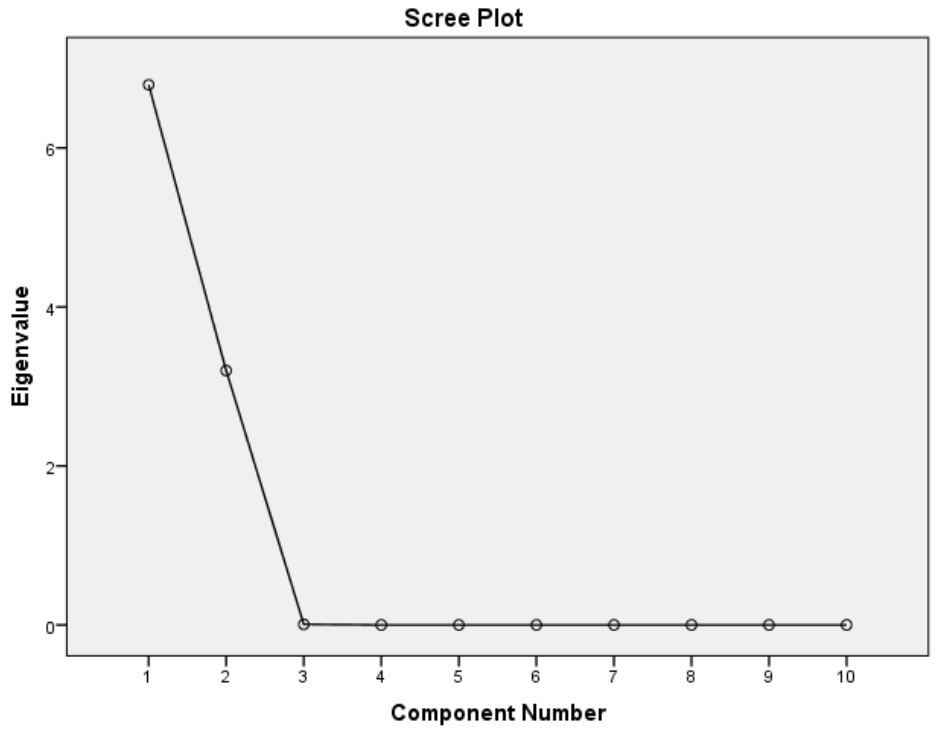


Figure 4.14 Scree plot indicating major two plots for untreated burrows winter season

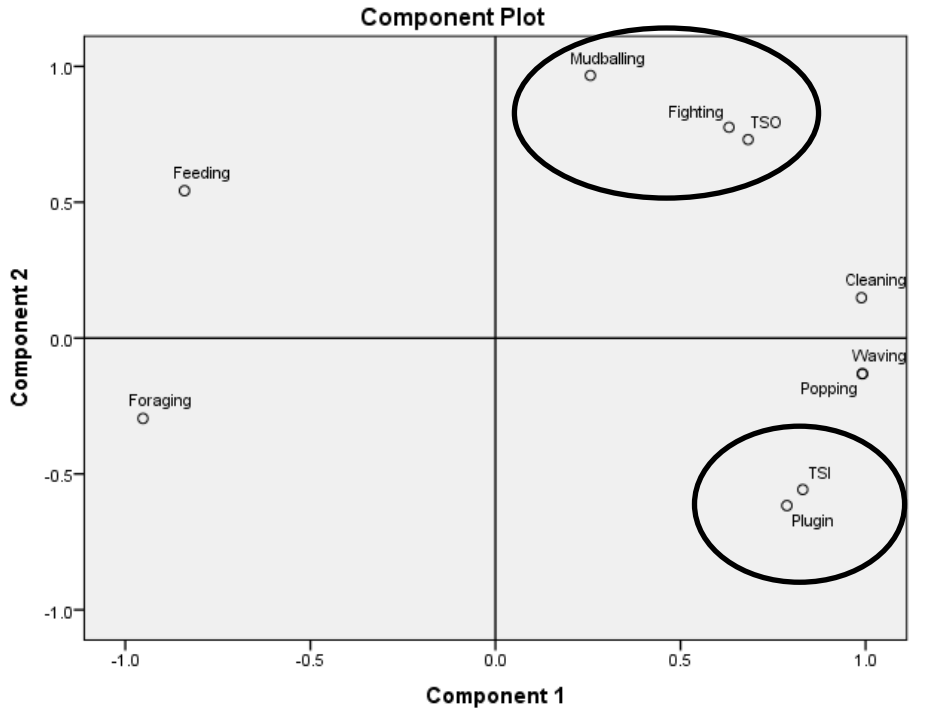


Figure 4.15 PCA analysis indicating two major clusters for winter season
TSO: Time Spent Outside the burrow; TSI: Time Spent Inside the burrow

4.3.1c Interrelationship between activities of crab in summer season

Pearson correlation amongst Foraging, popping out, feeding, time spent inside (TSI), mudballing and plugin behaviour was analysed for evaluating the relationship between activities of crab in summer season for untreated crab burrows (Table 4.4). Feeding was significantly correlated with TSO (r = 0.973; p=0.01%), fighting (r = 0.827.00; p = 0.01%), mudballing (r = 0.856; p=0.01%) and waving (r = 0.829; p = 0.01%). Foraging was significantly correlated with TSI (r = -0.923; p = 0.01%), popping (r = -0.834; p = 0.01%), fighting (r = -0.859; p = 0.01%), cleaning (r=0.994; p = 0.01%), plugin (r = -0.922; p = 0.01%). TSI was correlated with popping (r= 0.982; p = 0.01%), cleaning (r = -0.959; p = 0.01%), waving (r = -0.526; p = 0.05%) and plugin (r = 1; p = 0.01%). Popping is correlate with cleaning (r = -0.890; p = 0.01%), plugin (r = 0.983; p = 0.01%). TSO is having significant correlation between fighting (r = 0.935; p = 0.01%), mudballing (r = 0.712; p = 0.05%) Fighting is correlated with cleaning (r = -0.797; p = 0.05%). Mudballing is correlated with waving (r = 0.999; p = 0.01%). Cleaning is correlated with waving (r = -0.959; p = 0.01)

Table 4.4 Correlation between different behavioural activities of crab for untreated burrows summer season

	Feeding	Foraging	TSI	Popping	TSO	Fighting	Mudballing	Cleaning	Waving	Plugin
Feeding	1									
Foraging	-.422	1								
TSI	.040	-.923**	1							
Popping	-.147	-.834**	.982**	1						
TSO	.973**	-.621	.271	.087	1					
Fighting	.827**	-.859**	.595	.434	.935**	1				
Mudballing	.856**	.107	-.482	-.637	.712*	.417	1			
Cleaning	-.320	.994**	-.959**	-.890**	-.532	-.797*	.215	1		
Waving	.829**	.158	-.526	-.676*	.676*	.371	.999**	.265	1	
Plugin	.038	-.922**	1.000**	.983**	.269	.593	-.484	-.959**	-.528	1

**** Correlation is significant at the 0.01 level (2 –tailed). * Correlation is significant at the 0.05 level (2-tailed).**
TSI- Time Spent Inside the burrow, TSO- Time Spent Outside the burrow

Table 4.5 Component Matrix[a] for untreated burrows summer season		
Activities	Component	
	1	2
Feeding	.276	.961
Foraging	-.988	-.156
TSI	.972	-.237
Popping	.910	-.414
TSO	.492	.871
Fighting	.768	.640
Mudballing	-.261	.965
Cleaning	-.999	-.047
Waving	-.310	.951
Plugin	.971	-.239

Table 4.6 Total Variance for untreated burrows summer season						
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.761	57.60	57.605	5.76	57.605	57.605
2	4.239	42.39	100.000	4.23	42.395	100.000

Scree plot shown in figure 4.16 shows data has two major components as shown in table.4.5. Per cent variance for component 1 is 57.60%, 2 is 42.39%. Cumulative percentage for component 1 is 57.605%, component 2 is 100%. For winter season two major clusters are formed, 1. Mud balling: Waving: and 2. TSI : Popping and Plugin. Feeding and foraging are not related with any of these clusters and present in two different quadrates Cleaning is related with foraging as both the activities are negligible in this season figure.4.17.

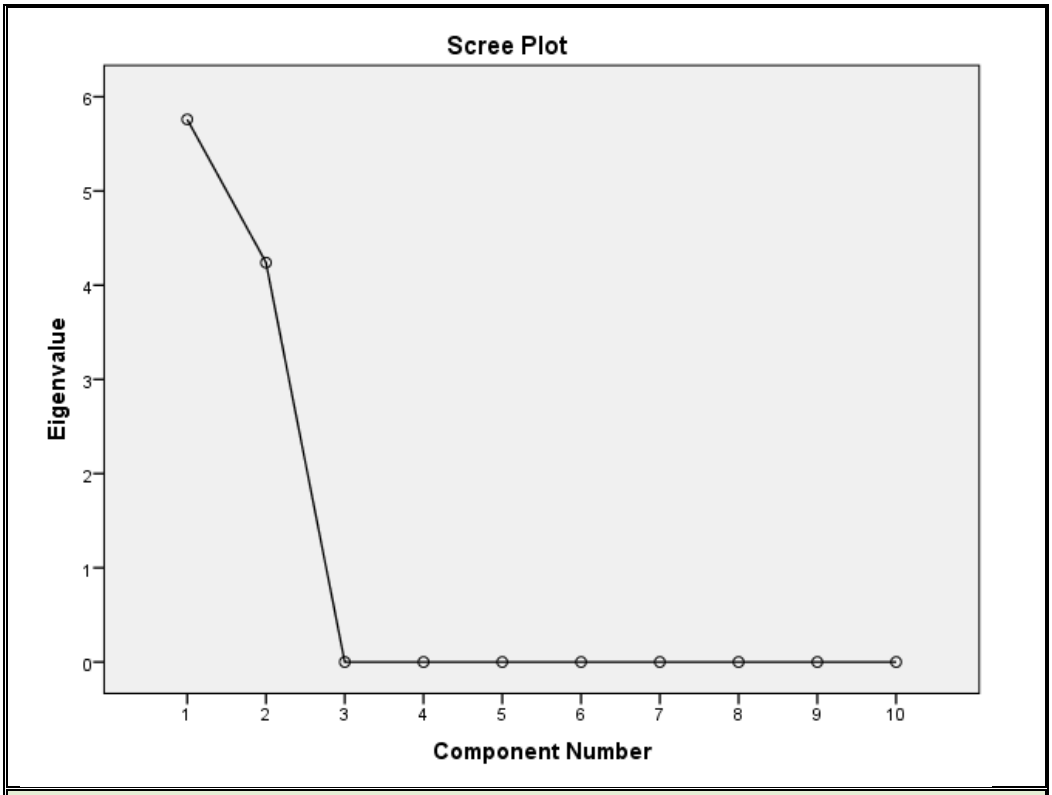


Figure 4.16 Scree plot indicating major two plots for untreated burrows summer season

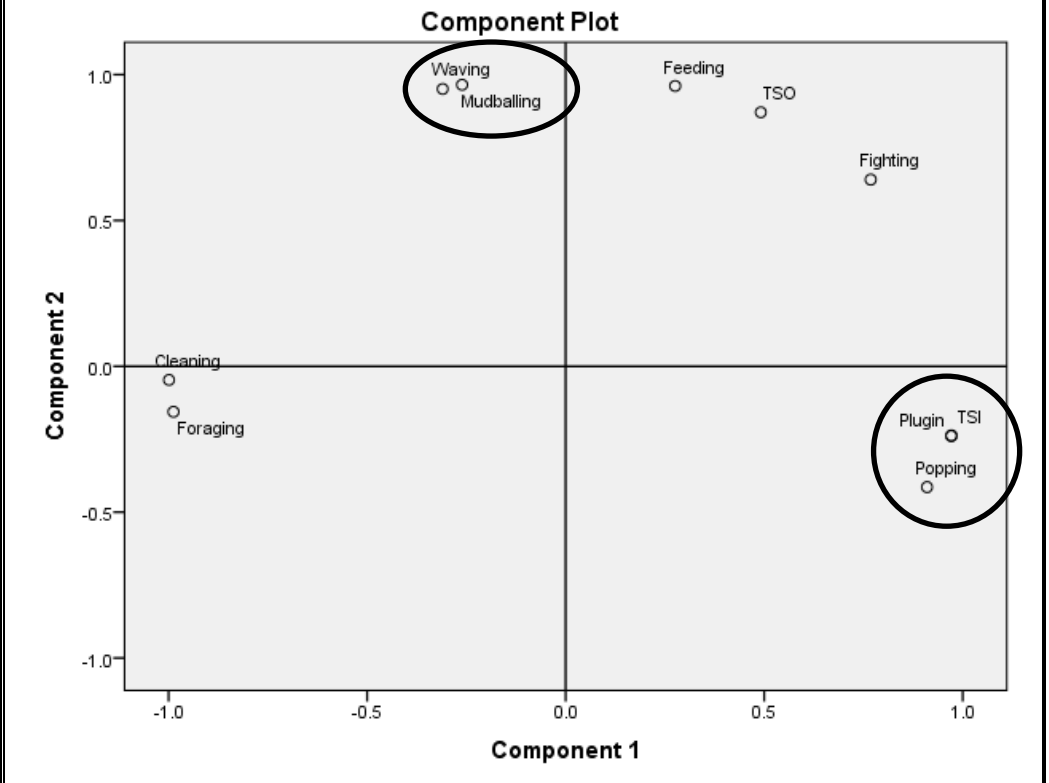


Figure 4.17 PCA analysis indicating one major cluster for summer season
TSO: Time Spent Outside the burrow; TSI: Time Spent Inside the burrow

4.3.1d Interrelationship between activities of crab in monsoon season

Pearson correlation amongst Foraging, popping out, feeding, time spent inside (TSI), mudballing and plugin behaviour was analysed for evaluating the relationship between activities of crab in monsoon season for untreated crab burrows (Table 4.7). Feeding was significantly correlated with foraging (r = 1; p=0.01%), TSI (r = -0698.00; p = 0.05%), and plugin (r = 0.673; p = 0.05%). Foraging was significantly correlated with TSI (r = -0.688; p = 0.05%), plugin (r = 0.684; p = 0.05%). TSI was correlated with popping (r= 0.930; p = 0.01%), TSO (r = 0.-0.716; p =0.05%), fighting (r = 0.974; p = 0.01%), mudballing (r = -0.811 p = 0.01%), cleaning (r = -0.794; p = 0.05%), waving (r = 0.955; p = 0.01%). Popping is correlate with TSO (r = 0.-0.923; p =0.01%), fighting (r = 0.989; p = 0.01%), mudballing (r = -0.970 p = 0.01%), cleaning (r = -0.962; p = 0.01%), waving (r = 0.997; p = 0.01%). TSO is having significant correlation between fighting (r = -0.856; p = 0.05%), mudballing (r = 0.989; p = 0.01%) cleaning (r = 0.993; p = 0.01%), waving (r =-0.891; p = 0.01%) plugin (r = -0.739; p = 0.05%). Fighting is correlated with mudballing (r = -0.923; p = 0.01%) cleaning (r = -0.912; p = 0.01%), waving (r =-0.997; p = 0.01%) Mudballing is correlated with cleaning (r = 1; p = 0.01%) waving (r = -0.948; p = 0.01%). Cleaning is correlated with waving (r = -0.939; p = 0.01) and plugin (r = -0.653; p = 0.05%)

Table 4.7 Correlation between different behavioural activities of crab for untreated burrows monsoon season

	Feeding	Foraging	TSI	Popping	TSO	Fighting	Mudballing	Cleaning	Waving	Plugin
Feeding	1									
Foraging	1.000**	1								
TSI	-.698*	-.688*	1							
Popping	-.386	-.373	.930**	1						
TSO	.000	-.014	-.716*	-.923**	1					
Fighting	-.518	-.506	.974**	.989**	-.856**	1				
Mudballing	.148	.134	-.811**	-.970**	.989**	-.923**	1			
Cleaning	.120	.106	-.794*	-.962**	.993**	-.912**	1.000**	1		
Waving	-.454	-.441	.955**	.997**	-.891**	.997**	-.948**	-.939**	1	
Plugin	.673*	.684*	.059	.422	-.739*	.284	-.632	-.653	.353	1

**** Correlation is significant at the 0.01 level (2 –tailed). * Correlation is significant at the 0.05 level (2-tailed).**
TSI- Time Spent Inside the burrow, TSO- Time Spent Outside the burrow

Table 4.8 Component Matrix[a] for untreated burrows monsoon season		
	Component	
	1	2
Feeding	-.392	.920
Foraging	-.379	.925
TSI	.932	-.362
Popping	1.000	.007
TSO	-.920	-.392
Fighting	.990	-.141
Mudballing	-.968	-.251
Cleaning	-.960	-.279
Waving	.998	-.068
Plugin	.416	.909

Table 4.9 Total Variance for untreated burrows monsoon season						
Component	**Initial Eigenvalues**			**Extraction Sums of Squared Loadings**		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.02	70.205	70.205	7.02	70.205	70.205
2	2.98	29.795	100	2.98	29.795	100

Scree plot shown in figure 4.18 shows data has two major components as shown in table 4.8. Percent variance for component 1 is 70.20%, 2 is 29.795%. Cumulative percentage for component 1 is 70.205%, component 2 is 100%. For winter season two major clusters are formed, 1. Mudballing: Cleaning: TSO and 2. TSI: Popping waving: Fighting. Feeding and foraging are not related with any of these clusters and present in two different quadrates Cleaning is related with foraging as both the activities are negligible in this season figure 4.19

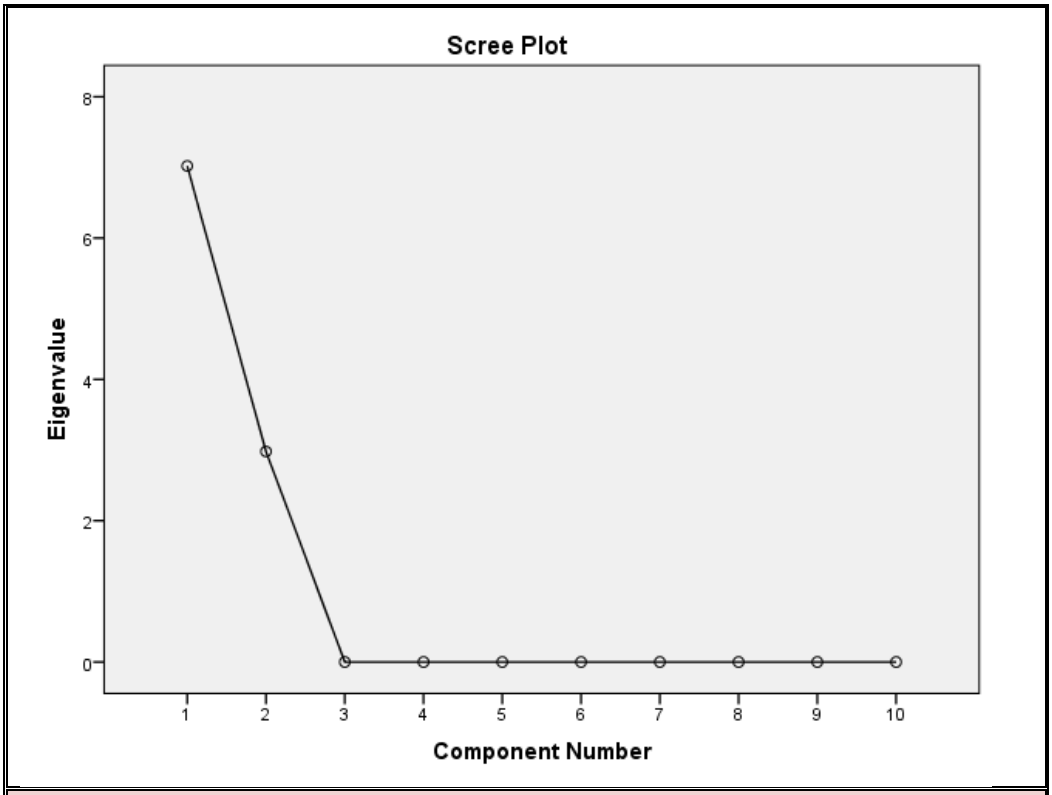


Figure 4.18 Scree plot indicating major 2 plots for untreated burrows monsoon season

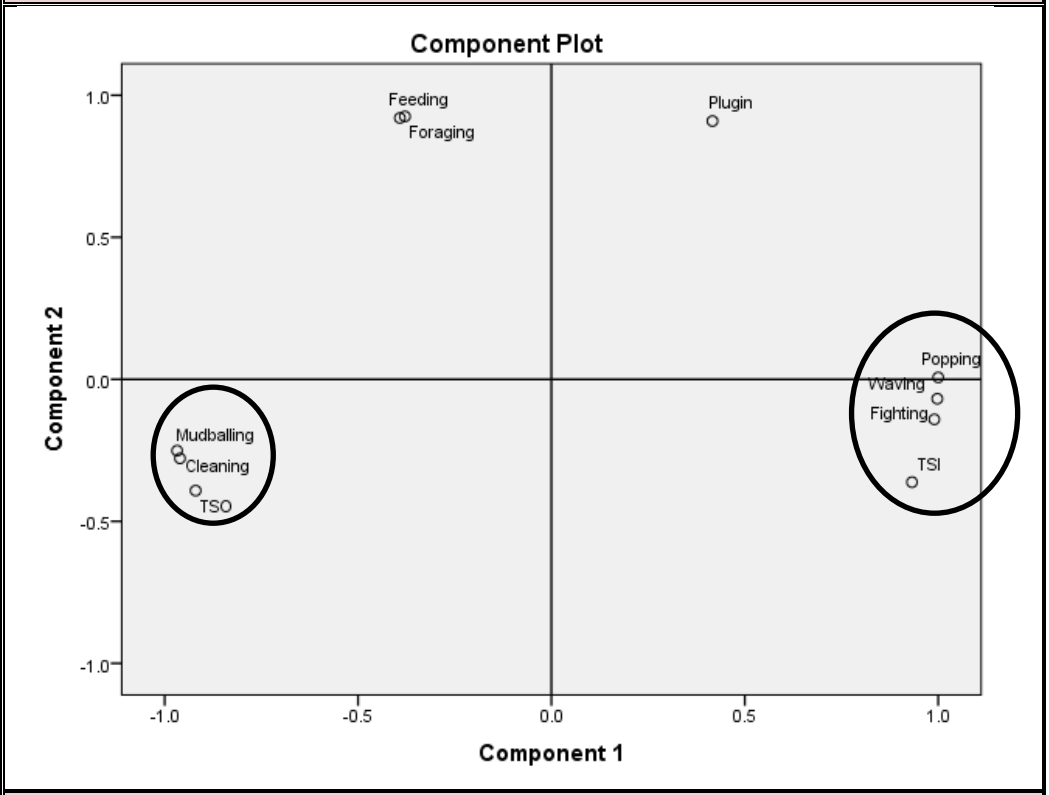


Figure 4.19 PCA analysis indicating two major cluster for monsoon season
TSO: Time Spent Outside the burrow; TSI: Time Spent Inside the burrow

4.3.2 Analysis for chemically treated burrows

4.3.2a Seasonal variation in activities of crab

Behaviour analysis for chemically treated crab burrows is illustrated further. Foraging, popping out, feeding, time spent inside (TSI), mudballing and plugin behaviour are shown in three different time duration i.e. 1. Initial 2. Middle and 3. Final shown from figure 4.20 to figure 4.28. Chemically treated burrows showed no plugin behaviour in both summer and winter seasons. In summer season, initial time phase was spend inside the burrow and remaining time was spent in popping. in middle final phases crab was seen popping out and remaining time inside the burrow. Time spent for popping out activity was higher in initial than any other phase. In winter season maximum time spend was inside the burrow in initial phase. In final phase no activity was observed. Time spent for popping out activity was higher in initial and middle as compared to final phase. In monsoon season maximum mudballing was observed from initial to final phase no plugin behaviour was observed, no popping out behaviour was seen as crab stayed outside for period. Foraging and feeding activity was in its peak during initial phase for all the three seasons, then after it decreased to zero.

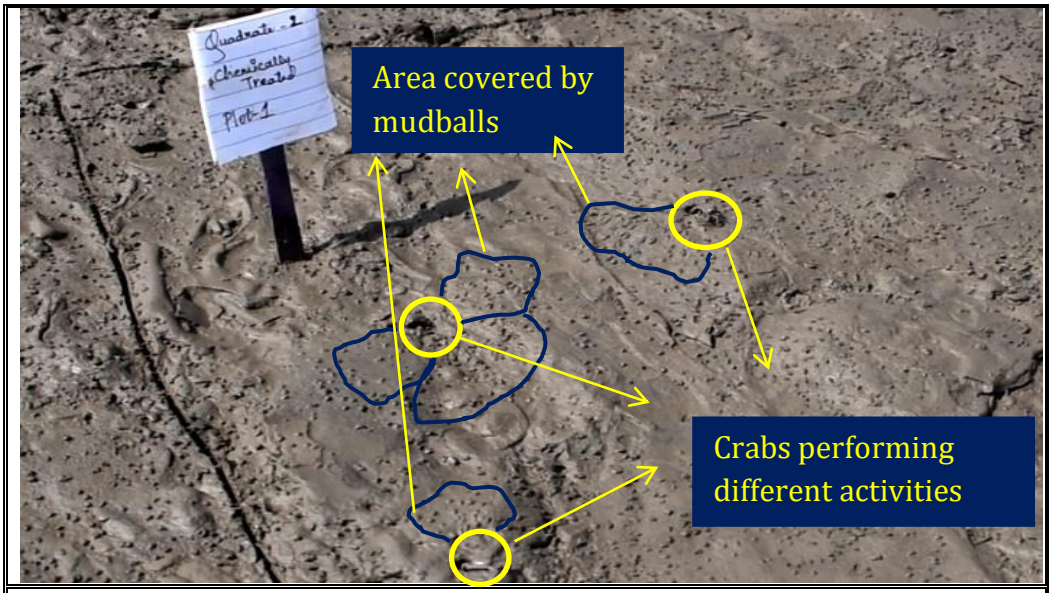


Figure 4.20 Crabs performing various activities in initial phase of chemically treated burrows summer season

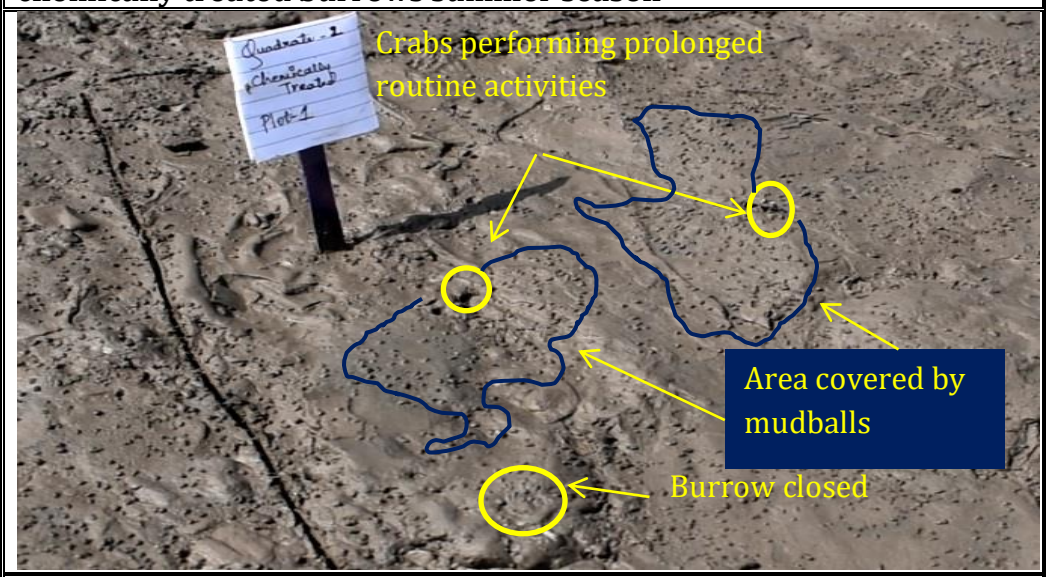


Figure 4.21 Crabs performing prolonged routine activities in middle phase of chemically treated burrows summer season

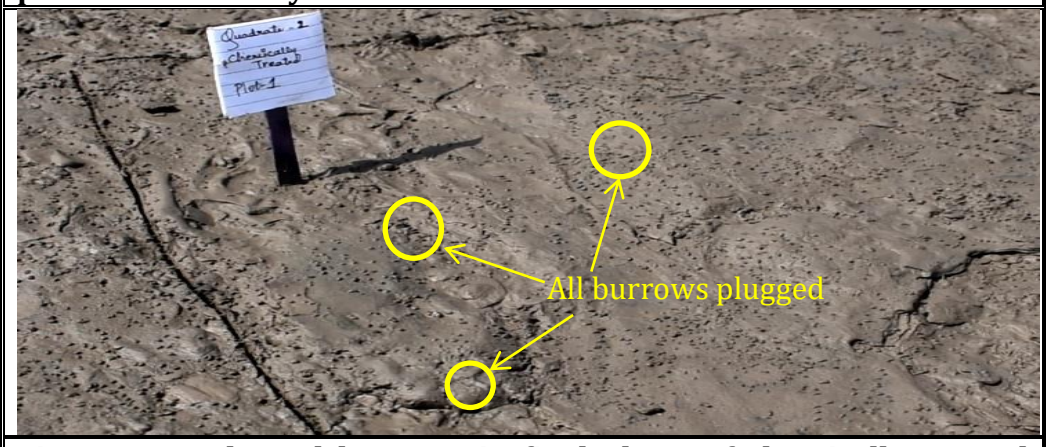


Figure 4.22 Plugged burrows in final phase of chemically treated burrows summer season

Figure 4.23 Zero activity of crabs in initial phase of chemically treated burrows winter season

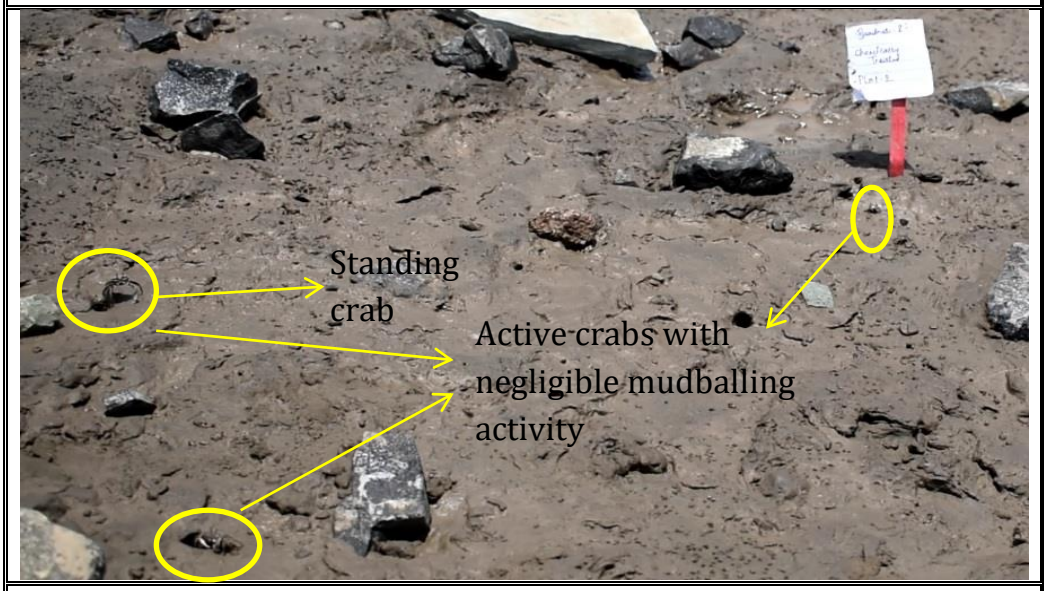


Figure 4.24 Crabs performing various routine activities with negligible mudballing in middle phase of chemically treated burrows winter season

Figure 4.25 Zero crab activity in final phase of chemically treated burrows winter season

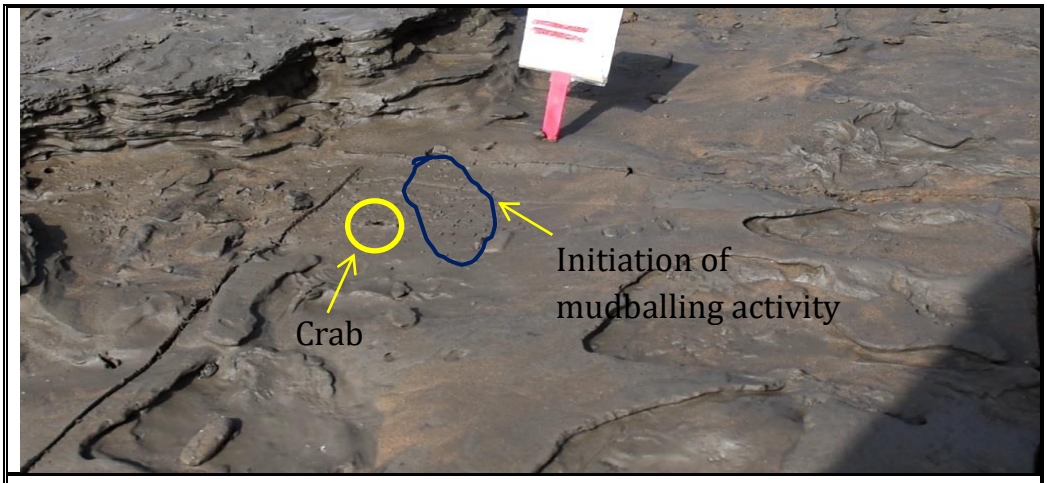


Figure 4.26 Shows crab initiating mudballing activities in initial phase of chemically treated burrows monsoon season

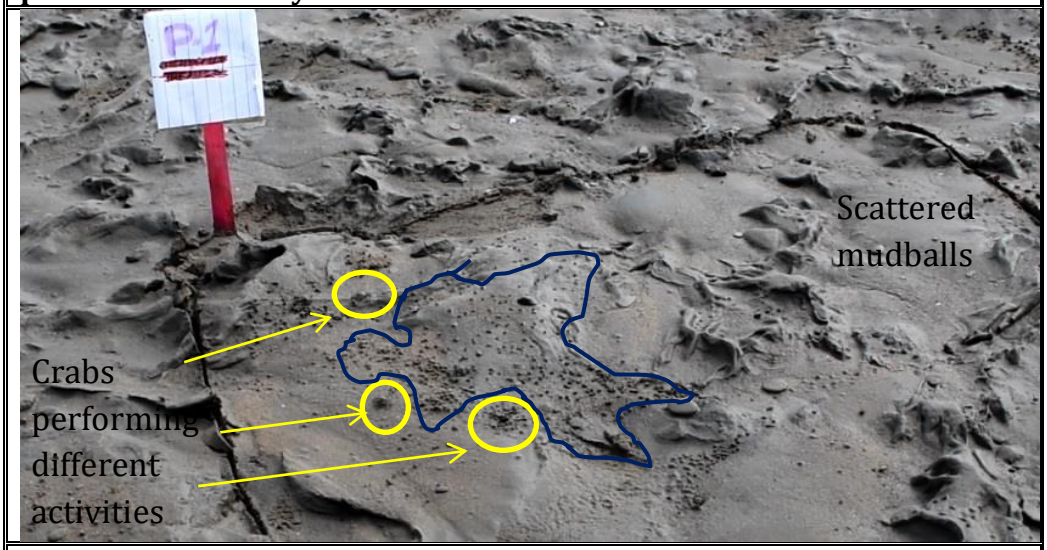


Figure 4.27 Shows excessive mudballing activity in middle phase of chemically treated burrows monsoon season

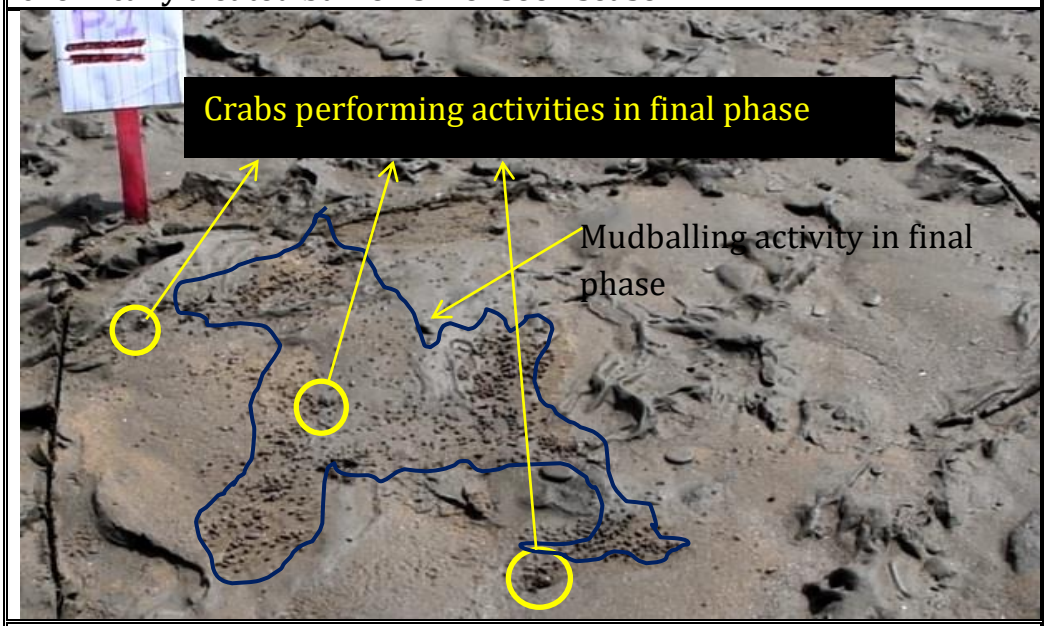


Figure 4.28 Shows crabs performing mudballing in final phase of chemically treated burrows monsoon season

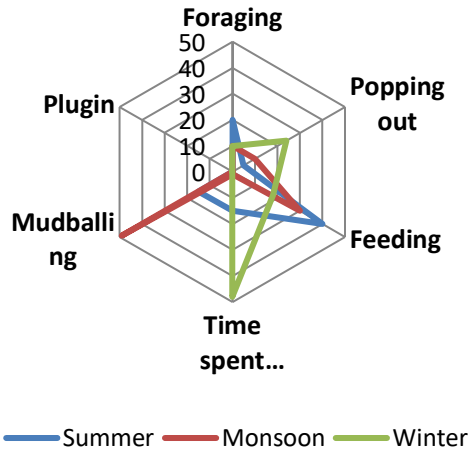


Figure 4.29 Radar diagram of chemically treated burrow (Initial phase)

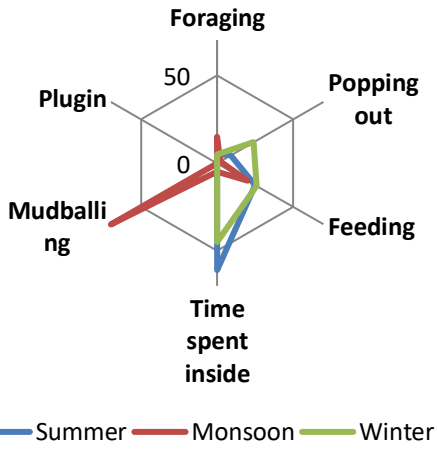


Figure 4.30 Radar diagramof chemically treated burrow (Middle phase)

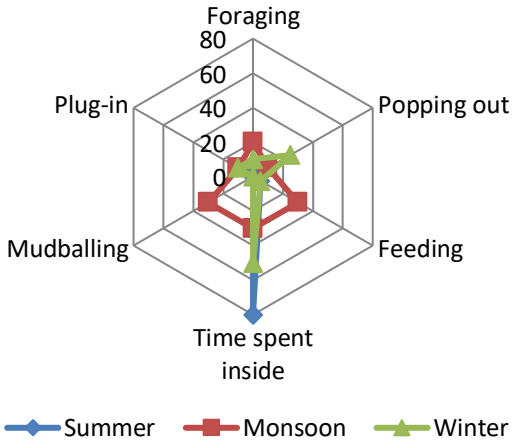


Figure 4.31 Radar diagram of chemically treated burrow (Final phase)

4.3.2b Interrelationship between activities of crab in winter season

Pearson correlation amongst Foraging, popping out, feeding, time spent inside (TSI), mudballing and plugin behaviour was analysed for evaluating the relationship between activities of crab in winter season for chemically treated crab burrows (Table 4.10). Feeding was significantly correlated with foraging (r = 0.639; p = 0.05%), TSI (r = -1.00; p = 0.01 %), popping (r = -0.904; p = 0.01%), cleaning (r = -0.750; p = 0.05%), waving (r = -0.904; p = 0.01%) plugin (r = 0.996; p = 0.01%). Foraging was significantly correlated with foraging (r = 1; p = 0.01%), TSI (r = -0.625; p = 0.05%), popping (r = -0.904; p = 0.01%), TSO (r = -0.865; p = 0.05%), fighting (r = -0.829; p = 0.01%), cleaning (r = -0.984; p = 0.01%) waving (r = -0.904; p = 0.01%). TSI was correlated with popping (r = 0.896; p = 0.01%), cleaning (r = 0.738; p = 0.05%), waving (r = 0.896; p = 0.01%), Plugin (r = -0.996; p = 0.01%). Popping is correlate with cleaning (r = 0.961; p =0.05%), waving (r = 1; p = 0.01%), plugin (r = 0.862; p = 0.01%). TSO is having significant correlation between fighting (r = -0.998; p = 0.01%), mudballing (r = 0.881; p = 0.01%) cleaning (r = 0.784; p = 0.01%). Fighting is correlated with mudballing (r = 0.912; p = 0.01%) cleaning (r = -0.739; p = 0.01%). Cleaning is correlated with waving (r = 961; p = 0.01%). Waving is correlated with plugin (r = 0.862; p = 0.01).

Table 4.10 Correlation between different behavioural activities of crab for chemically treated burrows winter season

	Feeding	Foraging	TSI	Popping	TSO	Fighting	Mudballing	Cleaning	Waving	Plugin	
Feeding	1										
Foraging	.639	1									
TSI	-1.000**	-.625	1								
Popping	-.904**	-.904**	.896**	1							
TSO	-.177	-.865**	.159	.581	1						
Fighting	-.110	-.829**	.091	.524	.998**	1					
Mudballing	.309	-.529	-.326	.127	.881**	.912**	1				
Cleaning	-.750*	-.984**	.738*	.961**	.784*	.739*	.397	1			
Waving	-.904**	-.904**	.896**	1.000**	.581	.524	.127	.961**	1		
Plugin	-.996**	-.567	.997**	.862**	.087	.019	-.394	.687*	.862**	1	

** Correlation is significant at the 0.01 level (2 –tailed). * Correlation is significant at the 0.05 level (2-tailed).
TSI- Time Spent Inside the burrow, TSO- Time Spent Outside the burrow

Table 4.11 Component Matrix[a] for chemically treated burrows winter season		
	Component	
	1	2
Feeding	1.000	-.015
Foraging	.366	.917
TSI	-1.000	-.003
Popping	-.895	.434
TSO	.882	.467
Fighting	.848	.525
Mudballing	.335	-.872
Cleaning	.984	-.172
Waving	.895	-.434
Plugin	-.998	-.057

Table 4.12 Total Variance for chemically treated burrows winter season						
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.308	73.083	73.083	7.308	73.083	73.083
2	2.504	25.038	98.121	2.504	25.038	98.121

Scree plot shown in figure 4.32 shows data has two major components as shown in table 4.11. Per cent variance for component 1 is 73.083%, 2 is 25.038%. Cumulative percentage for component 1 is 73.083%, component 2 is 98.121%. For winter season two major clusters are formed, 1. Feeding: Cleaning: waving and 2. TSI: Plugin 3. Fighting: TSO: Popping and foraging are not related with any of these clusters and present in two different quadrates figure 4.33.

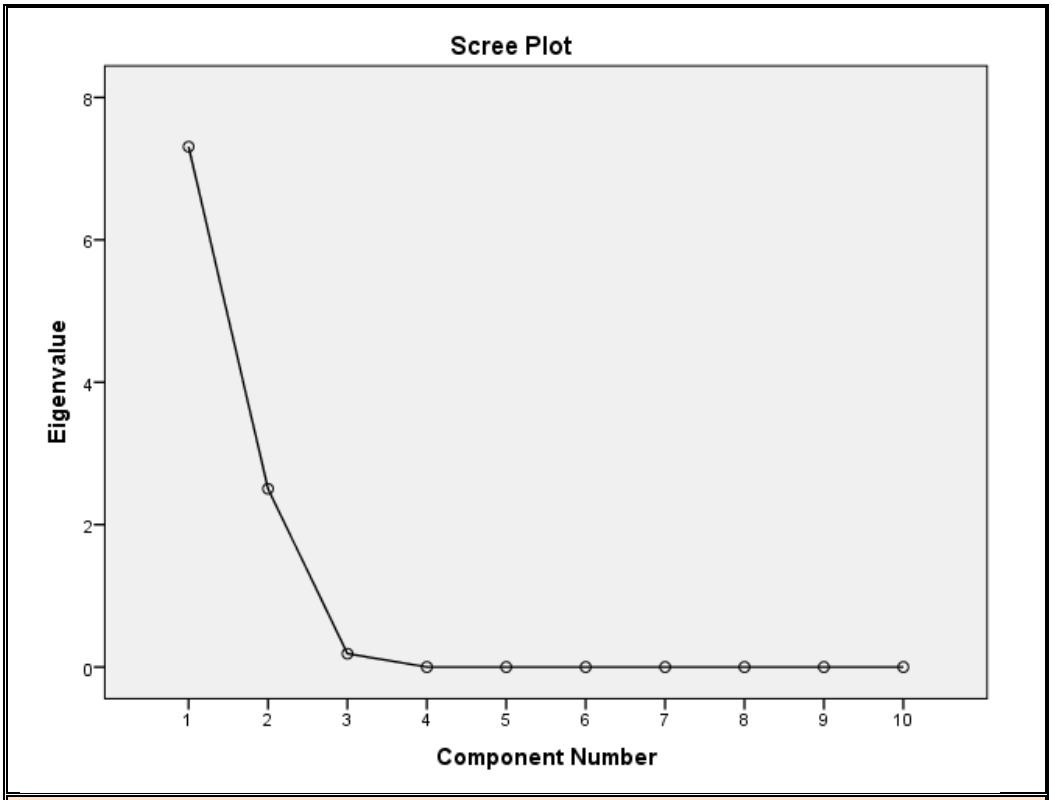


Figure 4.32 Scree plot indicating major two plots for chemically treated burrows winter season

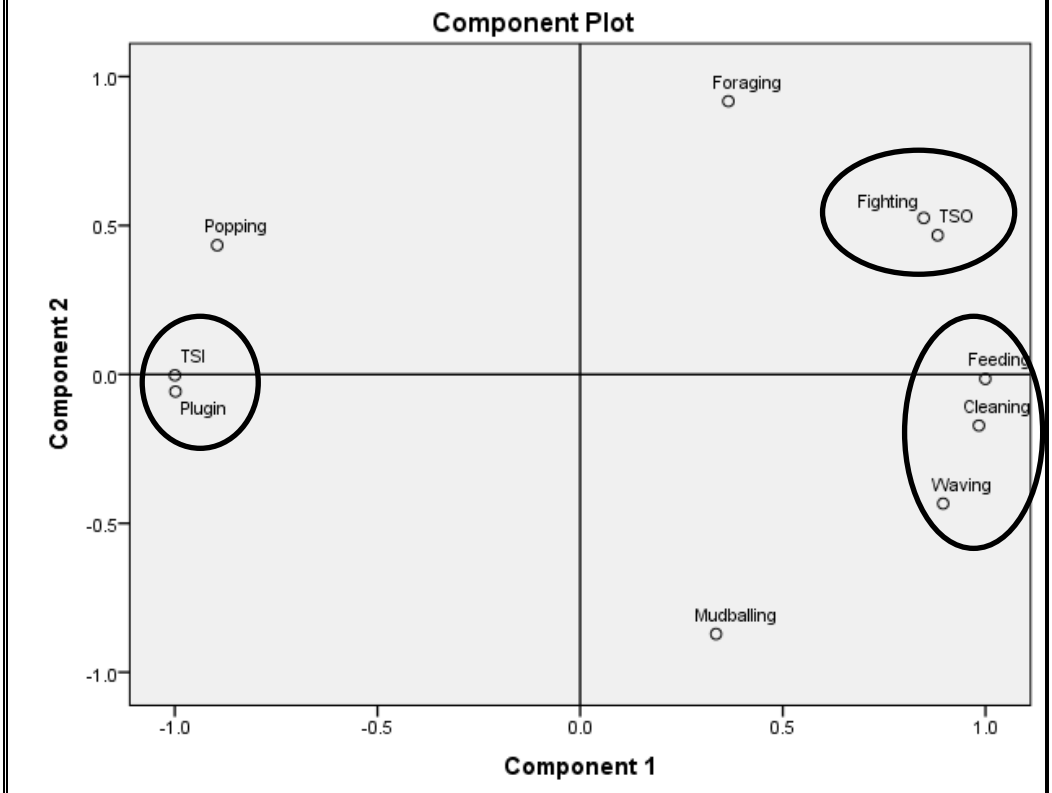


Figure 4.33 PCA analysis indicating three major clusters for winter season
TSO: Time Spent Outside the burrow; TSI: Time Spent Inside the burrow

4.3.2c Interrelationship between activities of crab in summer season

Pearson correlation amongst Foraging, popping out, feeding, time spent inside (TSI), mudballing and plugin behaviour was analysed for evaluating the relationship between activities of crab in summer season for chemically treated crab burrows (Table 4.13). Feeding was significantly correlated with TSI (r = -1; p = 0.01%), popping (r = -0.904; p = 0.01 %), TSO (r = 0.873; p = 0.01%), fighting (r = 0.837; p = 0.01%), cleaning (r = 0.979; p = 0.01%) plugin (r = -0.997; p = 0.01%). Foraging was significantly correlated with TSO (r =0.761; p = 0.01%), fighting (r = 0.804; p = 0.05%), cleaning (r = 0.979; p = 0.01%), TSO (r = -0.865; p = 0.05%), fighting (r = -0.829; p = 0.01%), cleaning (r = 0.979; p = 0.01%). TSI was correlated with popping (r = 0.896; p = 0.01%), TSO (r = -0.882; p = 0.01%), Fighting (r = -0.847; p =0.01%), cleaning (r = -0.546; p = 0.05%), waving (r = -0.896; p = 0.01%), plugin (r = 0.998; p = 0.01%). Popping is correlate with cleaning (r = 0.961; p =0.05%), waving (r = 1; p = 0.01%), plugin (r = 0.862; p = 0.01%). TSO is having significant correlation between fighting (r = -0.998; p = 0.01%), mudballing (r = 0.887; p = 0.01%) cleaning (r = 0.784; p = 0.01%). Fighting is correlated with cleaning (r = 0.908; p = 0.01%), plugin (r = -0.875; p = 0.01%). Cleaning is correlated with waving (r = 961; p = 0.01%). Waving is correlated with plugin (r = 0.862; p = 0.01).

Table 4.13 Correlation between different behavioural activities for chemically treated burrows summer season

	Feeding	Foraging	TSI	Popping	TSO	Fighting	Mudballing	Cleaning	Waving	Plugin
Feeding	1									
Foraging	.348	1								
TSI	-1.000**	-.365	1							
Popping	-.904**	.086	.896**	1						
TSO	.873**	.761*	-.882**	-.581	1					
Fighting	.837**	.804**	-.847**	-.524	.998**	1				
Mudballing	.338	-.620	-.324	-.642	-.089	-.147	1			
Cleaning	.531	.979**	-.546	-.118	.877**	.908**	-.487	1		
Waving	.904**	-.086	-.896**	-1.000**	.581	.524	.642	.118	1	
Plugin	-.997**	-.416	.998**	.870**	-.906**	-.875**	-.280	-.592	-.870**	1

** Correlation is significant at the 0.01 level (2 –tailed). * Correlation is significant at the 0.05 level (2-tailed).
TSI- Time Spent Inside the burrow, TSO- Time Spent Outside the burrow

Table 4.14 Component Matrix[a] for chemically treated burrows summer season		
	Component	
	1	2
Feeding	**.981**	**-.187**
Foraging	**.520**	**.845**
TSI	**-.985**	**.169**
Popping	**-.806**	**.583**
TSO	**.950**	**.311**
Fighting	**.926**	**.374**
Mudballing	**.189**	**-.906**
Cleaning	**.683**	**.723**
Waving	**.806**	**-.583**
Plugin	**-.993**	**.115**

Table 4.15 Total Variance for chemically treated burrows summer season						
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.75	67.507	67.507	6.751	67.507	67.507
2	3.05	30.509	98.016	3.05	30.509	98.016

Scree plot shown in figure 4.34 shows data has two major components as shown in table 4.14. Per cent variance for component 1 is 67.507%, 2 is 30.509%. Cumulative percentage for component 1 is 67.507%, component 2 is 98.016%. For summer season two major clusters are formed, 1. Foraging: Cleaning: fighting: TSO and 2. TSI: Plugin. Popping and mudballing, waving are not related with any of these clusters and present in two different quadrates figure 4.35.

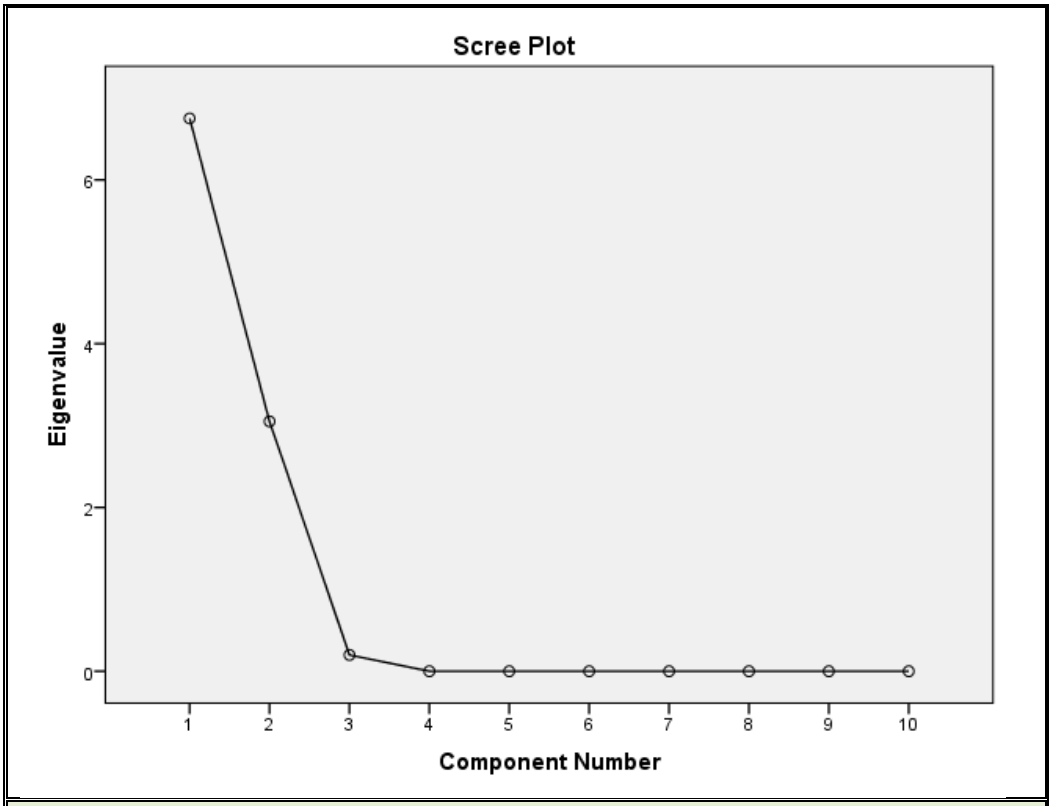


Figure 4.34 Scree plot indicating major two plots for chemically treated burrows summer season

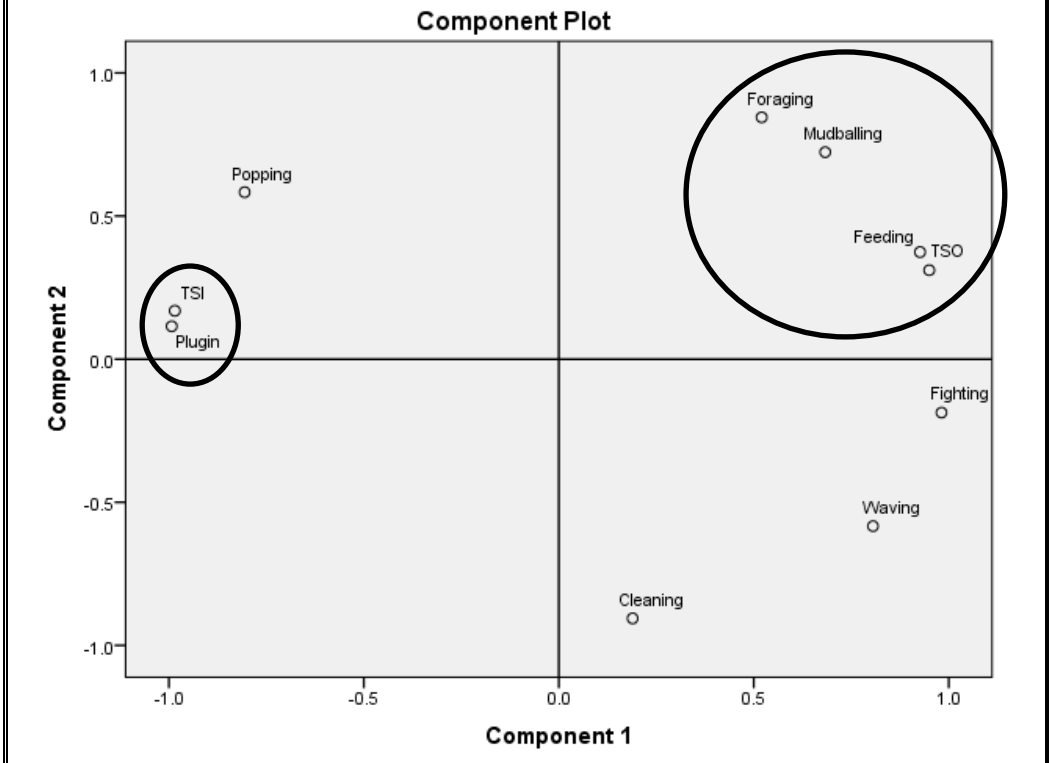


Figure 4.35 PCA analysis indicating two major cluster for summer season
TSO: Time Spent Outside the burrow; TSI: Time Spent Inside the burrow

4.3.2d Interrelationship between activities of crab in monsoon season

Pearson correlation amongst Foraging, popping out, feeding, time spent inside (TSI), mudballing and plugin behaviour was analysed for evaluating the relationship between activities of crab in monsoon season for chemically treated crab burrows (Table 4.16). Feeding was significantly correlated with foraging (r = 0.913; p = 0.01%), popping (r = 0.700; p = 0.01 %), TSO (r =-0.922; p = 0.01%), mudballing (r = -0.854; p = 0.01%), cleaning (r = -0.868; p = 0.01%) plugin (r = 0.926; p = 0.01%). Foraging was significantly correlated with TSO (r =-0.683; p = 0.05%) . TSI was correlated with popping (r = 0.930; p = 0.01%), TSO (r = -0.716; p = 0.01%), mudballing (r = -0.811; p =0.01%), cleaning (r = -0.794; p = 0.05%), waving (r = 0.955; p = 0.01%), plugin (r = 0.707; p = 0.01%). Popping is correlate with TSO (r =-0.923; p =0.05%), fighting (r = 0.989; p = 0.01%), mudballing (r = -0.970; p = 0.01%), cleaning (r = -0.962; p = 0.01%), plugin (r = 0.918; p = 0.01%). TSO is having significant correlation between fighting (r = -0.-856; p = 0.01%), mudballing (r = 0.989; p = 0.01%) cleaning (r = 0.993; p = 0.01%). Fighting is correlated with cleaning (r = 0.912; p = 0.01%), plugin (r = -0.849; p = 0.01%). Cleaning is correlated with waving (r = 961; p = 0.01%). Waving is correlated with plugin (r = 0.862; p = 0.01).

Table 4.16 Correlation between different behavioural activities of crab for chemically treated burrows monsoon season

	Feeding	Foraging	TSI	Popping	TSO	Fighting	Mudballing	Cleaning	Waving	Plugin
Feeding	1									
Foraging	.913**	1								
TSI	.388	-.021	1							
Popping	.700*	.349	.930**	1						
TSO	-.922**	-.683*	-.716*	-.923**	1					
Fighting	.587	.206	.974**	.989**	-.856**	1				
Mudballing	-.854**	-.568	-.811**	-.970**	.989**	-.923**	1			
Cleaning	-.868**	-.591	-.794*	-.962**	.993**	-.912**	1.000**	1		
Waving	.645	.277	.955**	.997**	-.891**	.997**	-.948**	-.939**	1	
Plugin	.926**	.692*	.707*	.918**	-1.000**	.849**	-.987**	-.991**	.885**	1

**** Correlation is significant at the 0.01 level (2 –tailed). * Correlation is significant at the 0.05 level (2-tailed).**
TSI- Time Spent Inside the burrow, TSO- Time Spent Outside the burrow

Table 4.17 Component Matrix[a] for chemically treated burrows monsoon season		
	Component	
	1	2
Feeding	**.844**	**-.536**
Foraging	**.552**	**-.834**
TSI	**.822**	**.570**
Popping	**.974**	**.227**
TSO	**-.986**	**.166**
Fighting	**.930**	**.368**
Mudballing	**-1.000**	**.018**
Cleaning	**-.999**	**.047**
Waving	**.954**	**.300**
Plugin	**.984**	**-.179**

Table 4.18 Total Variance for chemically treated burrows monsoon season						
Component	**Initial Eigenvalues**			**Extraction Sums of Squared Loadings**		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	8.354	83.542	83.542	8.354	83.542	83.542
2	1.646	16.458	100.000	1.646	16.458	100.000

Scree plot shown in figure 4.36shows data has two major components as shown in table 4.17. Per cent variance for component 1 is 83.542%, 2 is 16.458%. Cumulative percentage for component 1 is 83.542%, component 2 is 100%. For monsoon season two major clusters are formed, 1. TSI: Fighting: Waving: Popping and 2. TSO: Cleaning: Mudballing. Foraging,

feeding and plugin are not related with any of these clusters and present in two different quadrates figure 4.37.

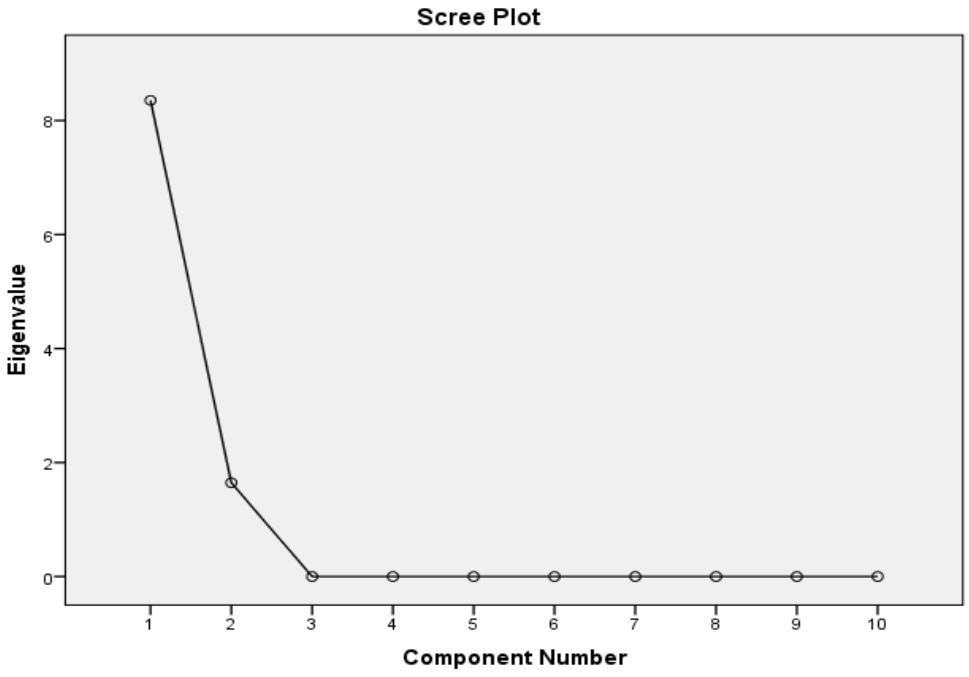


Figure 4.36 Scree plot indicating major two plots for chemically treated burrows monsoon season

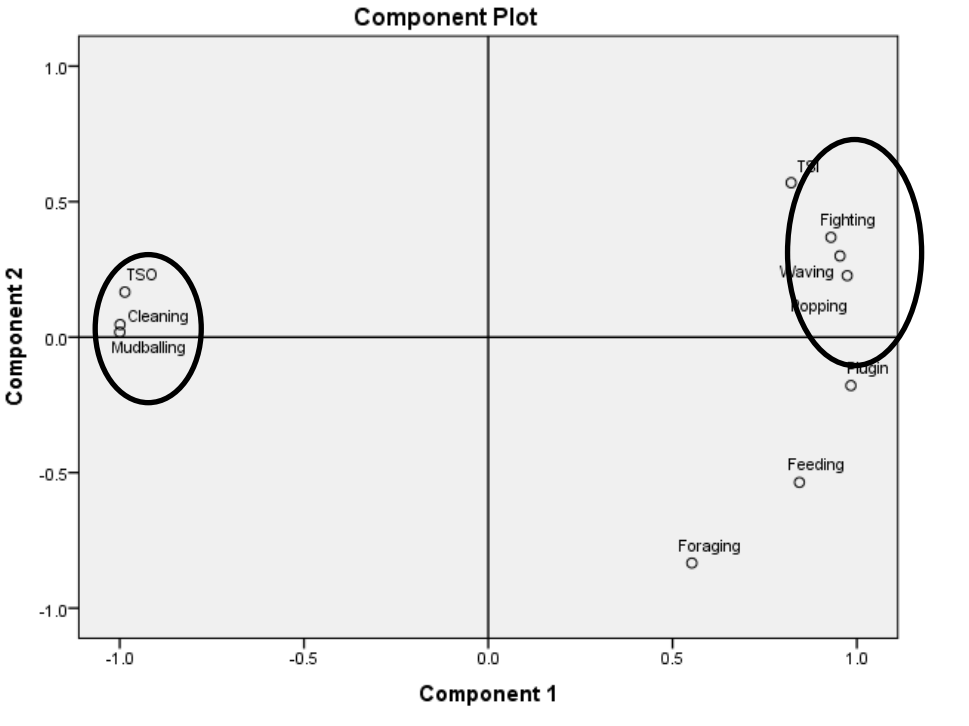


Figure 4.37 PCA analysis indicating two major cluster for monsoon season
TSO: Time Spent Outside the burrow; TSI: Time Spent Inside the burrow

4.3.3 Analysis for fertilizer treated burrows

4.3.3a Seasonal variation in activities of crab

Behaviour analysis for fertilizer treated crab burrows is illustrated further. Major difference between untreated crab burrow and fertilizer treated burrow was not observed. Foraging, popping out, feeding, time spent inside (TSI), mudballing and plugin behaviour are shown in three different time duration i.e. 1. Initial 2. Middle and 3. Final shown from figure 4.38 to figure 4.46. In summer season plugin behaviour was observed in initial phase same as in untreated crab burrows. In middle and final phases it spends complete time inside the burrow (TSI). Time spent for popping out and foraging activity was higher in initial than any other phase. Same as in untreated crab burrows in fertilizer treated burrows too crab showed plugin behaviour in middle phase. In final phase no activity was observed. Time spent for foraging feeding and popping out activity was higher in initial and middle as compared to final phase. In monsoon season maximum mudballing was observed from initial to final phase no plugin behaviour was observed, no popping out behaviour was seen as crab stayed outside for period. Foraging and feeding activity was in its peak during initial phase for all the three seasons, then after it decreased to zero.

Figure 4.38 Shows active crab burrow in initial phase of fertilizer treated summer season

Figure 4.39 Shows crab performing various activities in middle phase of fertilizer treated burrows in summer season

Figure 4.40 Shows plugged in behaviour in final phase of fertilizer treated burrows summer season

Figure 4.41 Shows crab performing various activities in initial phase of fertilizer treated burrows winter season

Figure 4.42 Early plugged in behaviour seen in middle phase of fertilizer treated burrows winter season

Figure 4.43 Shows zero activity in final phase of fertilizer treated burrows winter season

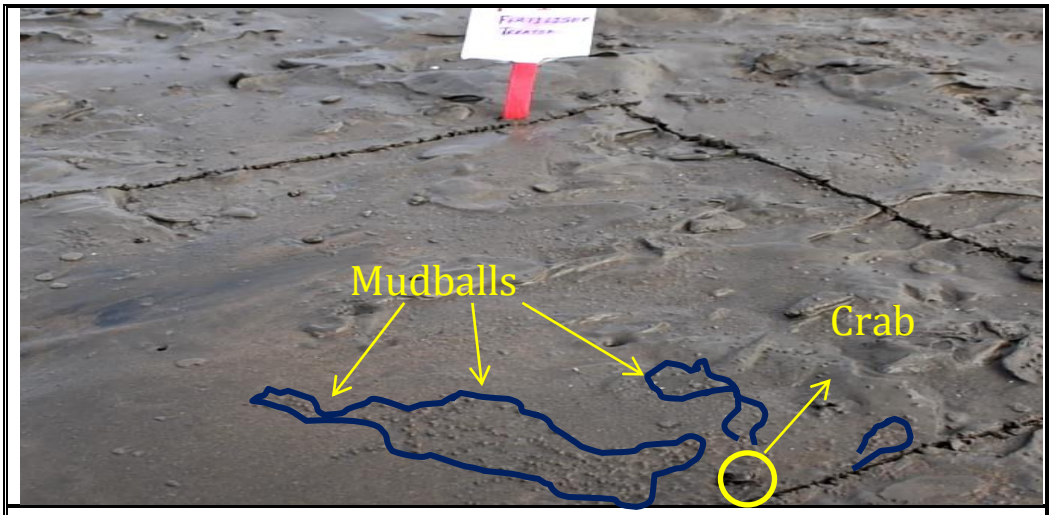


Figure 4.44 Mudballing in initial phase of fertilizer treated burrows monsoon season

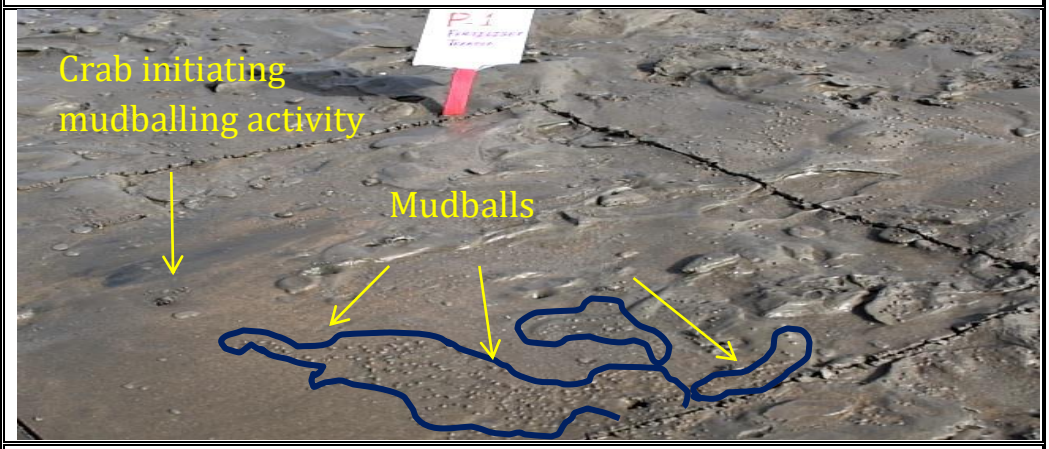


Figure 4.45 Muballing in middle phase of fertilizer treated burrows monsoon season

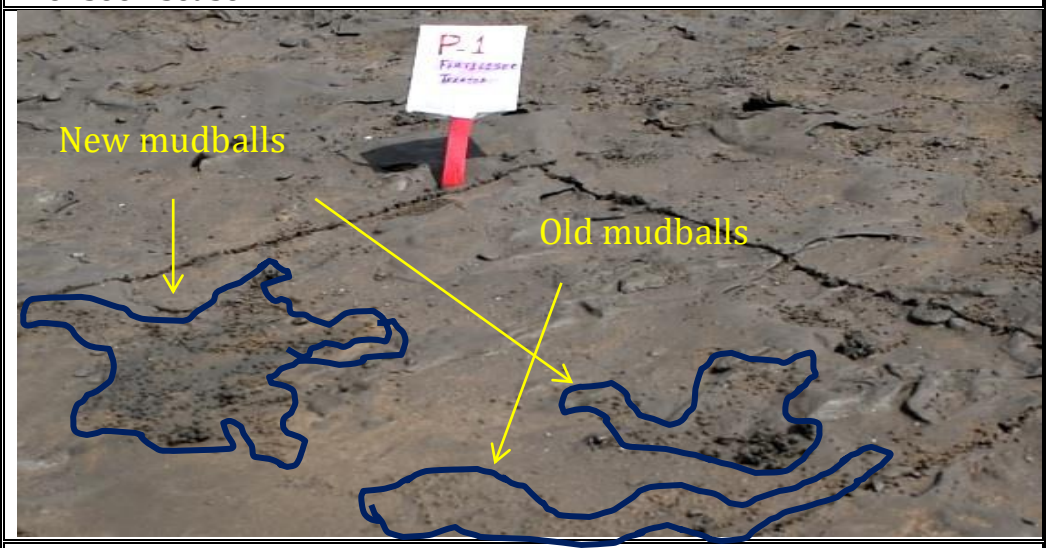


Figure 4.46 High amount of mudballing activity in final phase of fertilizer treated burrows monsoon season

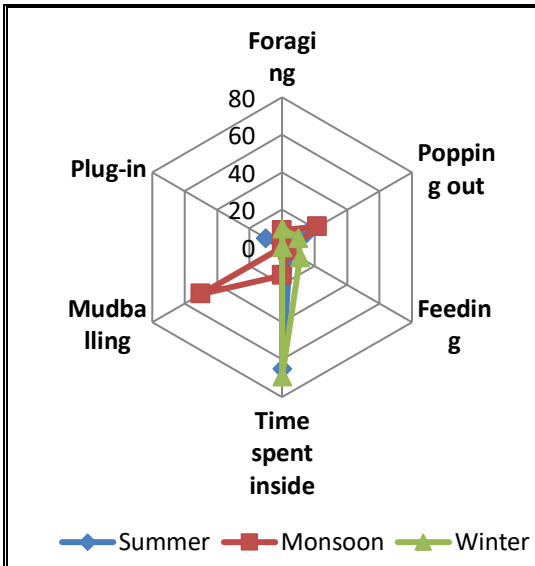


Figure 4.47 Radar diagram of fertilizer treated burrow (Initial phase)

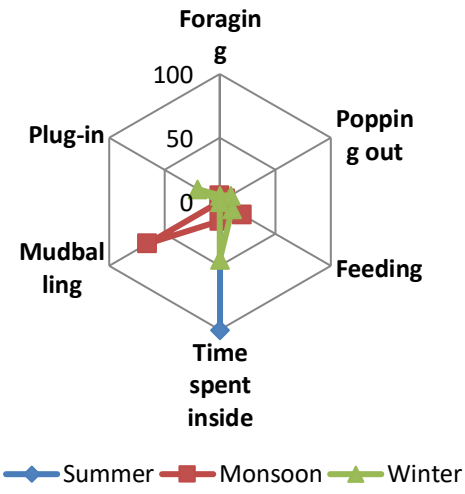


Figure 4.48 Radar diagramof fertilizer treated burrow (Middle phase)

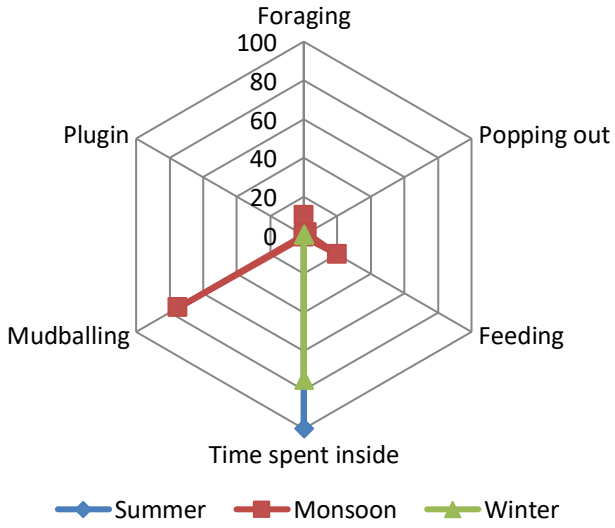


Figure 4.49 Radar diagram of fertilizer treated burrow (Final phase)

4.3.3b Interrelationship between activities of crab in winter season

Pearson correlation amongst Foraging, popping out, feeding, time spent inside (TSI), mudballing and plugin behaviour was analysed for evaluating the relationship between activities of crab in winter season for fertilizer treated crab burrows (Table 4.22). Feeding was significantly correlated with foraging (r = 1; p = 0.01%), TSI (r = -0.993; p = 0.01 %), popping (r = -0.838; p = 0.01 %), cleaning (r =-0.993; p = 0.01%), plugin (r = -0.999; p = 0.01%), cleaning (r = -0.868; p = 0.01%) plugin (r = 0.926; p = 0.01%). Foraging was significantly correlated with TSI (r =-0.990; p = 0.01%) TSO (r = -0.716; p = 0.01%), popping (r = -0.826; p =0.01%), cleaning (r = -0.990; p = 0.01%), waving (r = -0.998; p = 0.01%), TSI was significantly correlated with popping (r = 0.896; p = 0.01%). cleanning (r = 1; p = 0.01%), plugin (r = 0.997; p =0.01%),. Popping is correlate with cleanig (r = 0.896; p =0.05%), plugin (r = 0.862; p = 0.01%). TSO is having significant correlation between fighting (r = 0.998; p = 0.01%), mudballing (r = 0.881; p = 0.01%) waving (r = 1; p = 0.01%). Fighting is correlated with mudballing (r = 0.912; p = 0.01%), waving (r = 0.996; p = 0.01%). Cleaning is correlated with plugin (r = 967; p = 0.01%).

Table 4.22 Correlation between different behavioural activities of crab for fertilizer treated burrows winter season

	Feeding	Foraging	TSI	Popping	TSO	Fighting	Mudballing	Cleaning	Waving	Plugin
Feeding	1									
Foraging	1.000**	1								
TSI	-.993**	-.990**	1							
Popping	-.838**	-.826**	.896**	1						
TSO	-.043	-.021	.159	.581	1					
Fighting	.025	.048	.091	.524	.998**	1				
Mudballing	.434	.454	-.326	.127	.881**	.912**	1			
Cleaning	-.993**	-.990**	1.000**	.896**	.159	.091	-.326	1		
Waving	-.062	-.040	.178	.596	1.000**	.996**	.872**	.178	1	
Plugin	-.999**	-.998**	.997**	.862**	.087	.019	-.394	.997**	.106	1

** Correlation is significant at the 0.01 level (2 –tailed). * Correlation is significant at the 0.05 level (2-tailed).
TSI- Time Spent Inside the burrow, TSO- Time Spent Outside the burrow

Table 4.23 Component Matrix[a] for fertilizer treated burrows winter season		
	Component	
	1	2
Feeding	-.977	.214
Foraging	-.972	.236
TSI	.995	-.098
Popping	.936	.353
TSO	.256	.967
Fighting	.189	.982
Mudballing	-.231	.973
Cleaning	.995	-.098
Waving	.274	.962
Plugin	.985	-.171

Table 4.24 Total Variance for fertilizer treated burrows winter season						
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.95	59.553	59.553	5.95	59.553	59.553
2	4.04	40.447	100.000	4.04	40.447	100.000

Scree plot shown in figure 4.50 shows data has two major components as shown in table 4.23. Per cent variance for component 1 is 59.553%, 2 is 40.447%. Cumulative percentage for component 1 is 59.553%, component 2 is 100%. For summer season three major clusters are formed, 1. Fighting: TSO: Waving and 2. Feeding: Foraging, waving and 3. Cleaning: TSI: Plugin Popping and mudballing are not related with any of the other activity and present in two different quadrate figure 4.51.

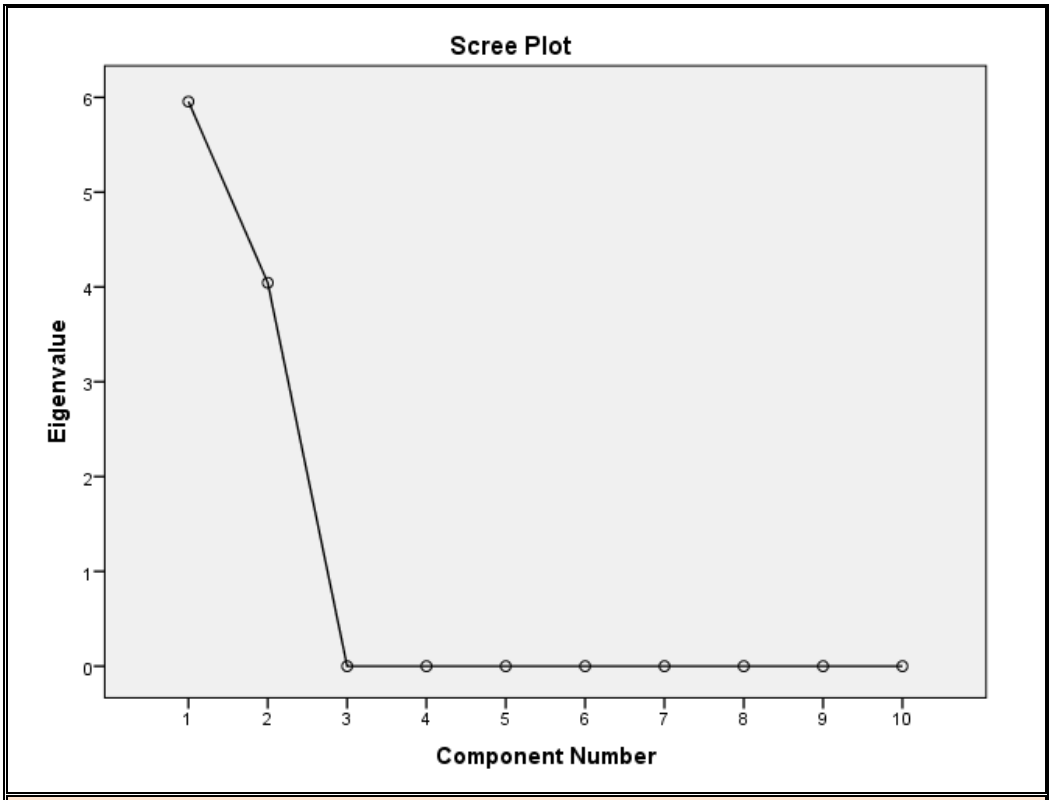


Figure 4.50 Scree plot indicating major two plots for fertilizer treated burrows winter season

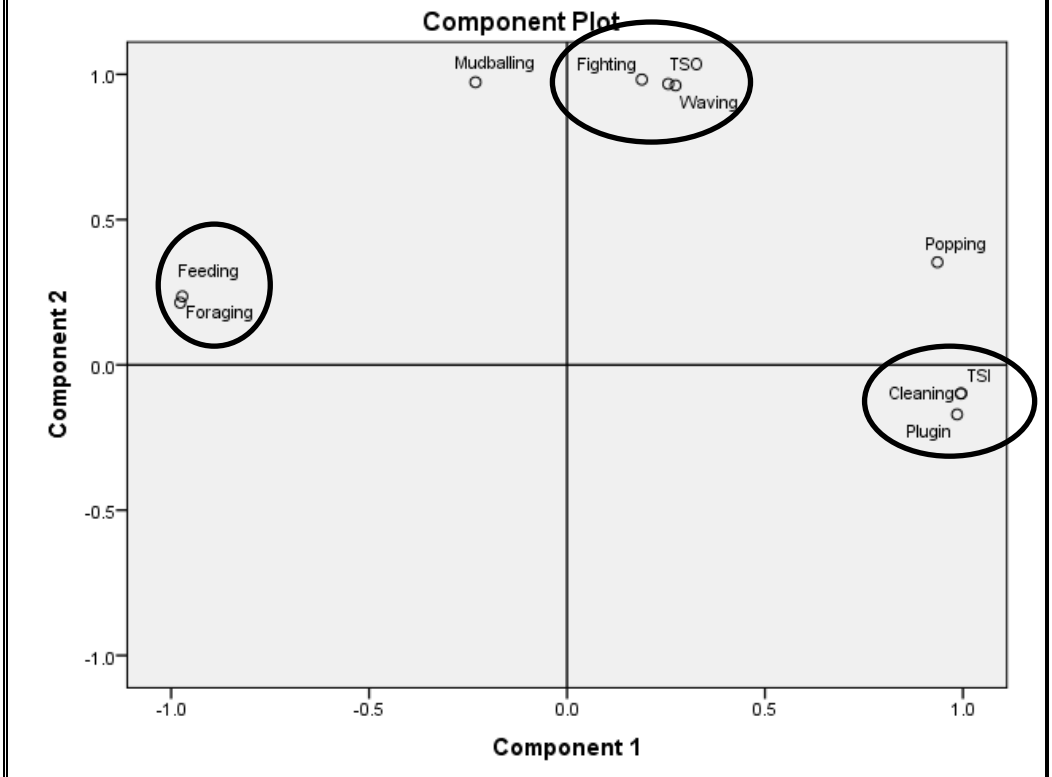


Figure 4.51 PCA analysis indicating three major clusters for winter season
TSO: Time Spent Outside the burrow; TSI: Time Spent Inside the burrow

4.3.3c Interrelationship between activities of crab in summer season

Pearson correlation amongst Foraging, popping out, feeding, time spent inside (TSI), mudballing and plugin behaviour was analysed for evaluating the relationship between activities of crab in summer season for fertilizer treated crab burrows (Table 4.25). Feeding was significantly correlated with TSO (r = 0.973; p = 0.01%), fighting (r = 0.827; p = 0.01 %), mudballing (r = 0.856; p = 0.01 %), waving (r = 0.829; p = 0.01%).). Foraging was significantly correlated with TSI (r =-0.923; p = 0.01%) TSO (r = -0.621; p = 0.05%), popping (r = -0.834; p =0.01%), fighting (r = -0.859; p = 0.01%), cleaning (r = 0.994; p = 0.01%), TSI was significantly correlated with popping (r = 0.982; p = 0.01%). cleanning (r = 0.959; p = 0.01%), plugin (r = 1; p =0.01%),. Popping is correlate with cleanig (r = -0.890; p =0.05%), plugin (r = 0.983; p = 0.01%). TSO is having significant correlation between fighting (r = 0.935; p = 0.01%), mudballing (r = 0.712; p = 0.01%) waving (r = 0.676; p = 0.05%). Fighting is correlated with cleaning (r = -0.797; p = 0.01%). Cleaning is correlated with plugin (r = -0.959; p = 0.01%).

Table 4.25 Correlation between different behavioural activities of crab for fertilizer treated burrows summer season

	Feeding	Foraging	TSI	Popping	TSO	Fighting	Mudballing	Cleaning	Waving	Plugin
Feeding	1									
Foraging	-.422	1								
TSI	.040	-.923**	1							
Popping	-.147	-.834**	.982**	1						
TSO	.973**	-.621	.271	.087	1					
Fighting	.827**	-.859**	.595	.434	.935**	1				
Mudballing	.856**	.107	-.482	-.637	.712*	.417	1			
Cleaning	-.320	.994**	-.959**	-.890**	-.532	-.797*	.215	1		
Waving	.829**	.158	-.526	-.676*	.676*	.371	.999**	.265	1	
Plugin	.038	-.922**	1.000**	.983**	.269	.593	-.484	-.959**	-.528	1

** Correlation is significant at the 0.01 level (2 –tailed). * Correlation is significant at the 0.05 level (2-tailed).
TSI- Time Spent Inside the burrow, TSO- Time Spent Outside the burrow

Table 4.26 Component Matrix[a] for fertilizer treated burrows summer season		
	Component	
	1	2
Feeding	.276	.961
Foraging	-.988	-.156
TSI	.972	-.237
Popping	.910	-.414
TSO	.492	.871
Fighting	.768	.640
Mudballing	-.261	.965
Cleaning	-.999	-.047
Waving	-.310	.951
Plugin	.971	-.239

Table 4.27 Total Variance for fertilizer treated burrows summer season						
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.761	57.605	57.605	5.761	57.605	57.605
2	4.239	42.395	100.000	4.239	42.395	100.000

Scree plot shown in figure 4.52 shows data has two major components as shown in table 4.26. Per cent variance for component 1 is 57.605 7%, 2 is 42.395%. Cumulative percentage for component 1 is 57.605%, component 2 is 100%. For summer season two major clusters are formed, 1. Waving: mudballing and 2. TSI: Plugin: Popping. Feeding, foraging and TSO doesn't form a cluster but present in same quadrate figure 4.53.

Figure 4.52 Scree plot indicating major two plots for fertilizer treated burrows summer season

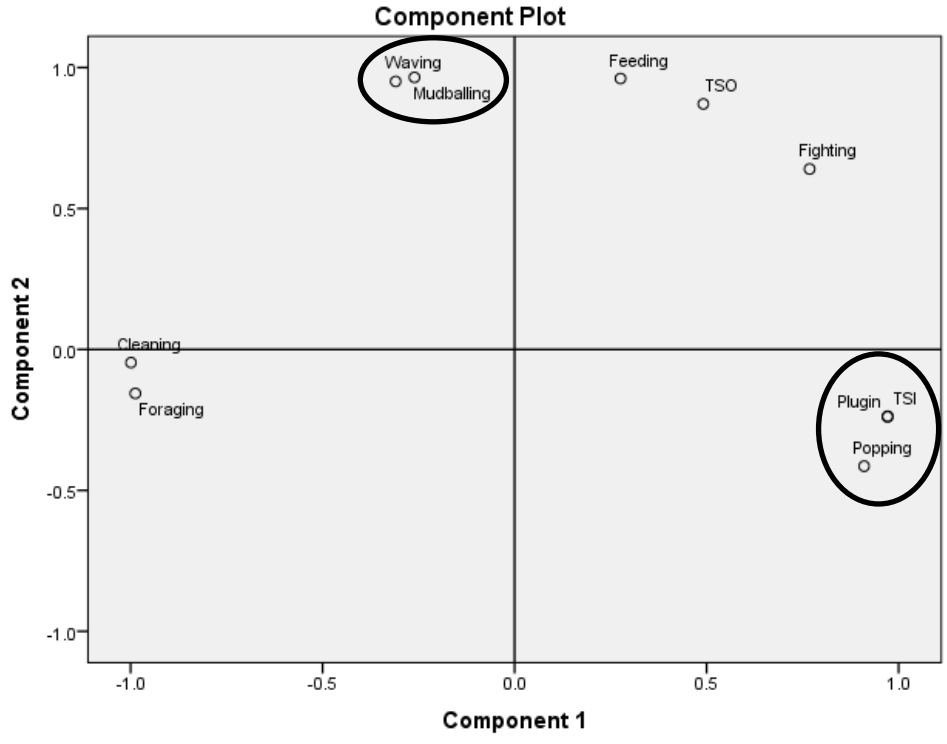


Figure 4.53 PCA analysis indicating two major clusters for summer season
TSO: Time Spent Outside the burrow; TSI: Time Spent Inside the burrow

4.3.3d Interrelationship between activities of crab in monsoon season

Pearson correlation amongst Foraging, popping out, feeding, time spent inside (TSI), mudballing and plugin behaviour was analysed for evaluating the relationship between activities of crab in monsoon season for fertilizer treated crab burrows (Table 4.28). Feeding was significantly correlated with forging (r = -0.878; p = 0.01%), TSI (r = -0.698; p = 0.05 %), fighting (r = -0.518; p = 0.05%), plugin (r = 0.673; p = 0.05 %). Foraging was significantly correlated with TSI (r =0.956; p = 0.01%) TSO (r = -0.665; p = 0.05%), popping (r = 780; p =0.01%), fighting (r = -0.864; p = 0.01%), cleaning (r = -0.623; p = 0.01%), waving (r = 825; p = 0.01%).TSI was significantly correlated with popping (r = 0.930; p = 0.01%), TSO (r = -0.855; p = 0.01%), mudballing (r = -0.811; p = 0.01%), waving (r = 0.955 ; p =0.01%), plugin (r = ; p =0.01%). Popping is correlate with TSO (r = -0.986; p =0.01%), fighting (r = -0.989; p =0.01%), mudballing(r = -0.970; p =0.01%), cleaning (r = -0.975; p =0.01%). TSO is having significant correlation between fighting (r = -0.951; p = 0.01%), cleaning (r = 0.932; p = 0.01%), mudballing (r = 0.970; p = 0.01%), waving (r = -0.971; p = 0.01%). Fighting is correlated with mudballing (r = -0.923; p = 0.01%), cleaning (r = -0.932; p = 0.01%), waving (r = 0.997; p = 0.01%). Cleaning is correlated with waving (r = -0.956; p = 0.01%).

Table 4.28 Correlation between different behavioural activities of crab for fertilizer treated burrow monsoon season

	Feeding	Foraging	TSI	Popping	TSO	Fighting	Mudballing	Cleaning	Waving	Plugin
Feeding	1									
Foraging	-.878**	1								
TSI	-.698*	.956**	1							
Popping	-.386	.780*	.930**	1						
TSO	.227	-.665	-.855**	-.986**	1					
Fighting	-.518	.864**	.974**	.989**	-.951**	1				
Mudballing	.148	-.603	-.811**	-.970**	.997**	-.923**	1			
Cleaning	.172	-.623	-.825**	-.975**	.998**	-.932**	1.000**	1		
Waving	-.454	.825**	.955**	.997**	-.971**	.997**	-.948**	-.956**	1	
Plugin	.673*	-.237	.059	.422	-.568	.284	-.632	-.613	.353	1

**** Correlation is significant at the 0.01 level (2 –tailed). * Correlation is significant at the 0.05 level (2-tailed).**
TSI- Time Spent Inside the burrow, TSO- Time Spent Outside the burrow

Table 4.29 Component Matrix[a] for fertilizer treated burrows monsoon season		
	Component	
	1	2
Feeding	-.455	.890
Foraging	.826	-.564
TSI	.955	-.296
Popping	.997	.076
TSO	-.970	-.242
Fighting	.997	-.072
Mudballing	-.948	-.318
Cleaning	-.955	-.295
Waving	1.000	.001
Plugin	.352	.936

Table 4.30 Total Variance for fertilizer treated burrows monsoon season						
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.668	76.675	76.675	7.668	76.675	76.675
2	2.332	23.325	100.000	2.332	23.325	100.000

Scree plot shown in figure 4.54 shows data has two major components as shown in table 4.29. Per cent variance for component 1 is 57.605 7%, 2 is 42.395%. Cumulative percentage for component 1 is 57.605%, component 2 is 100%. For monsoon season two major clusters are formed, 1. Waving: fighting: waving: TSI: Foraging: Popping and 2. TSO: Cleaning: mudballing. Feeding, plugin doesn't form a cluster figure 4.55.

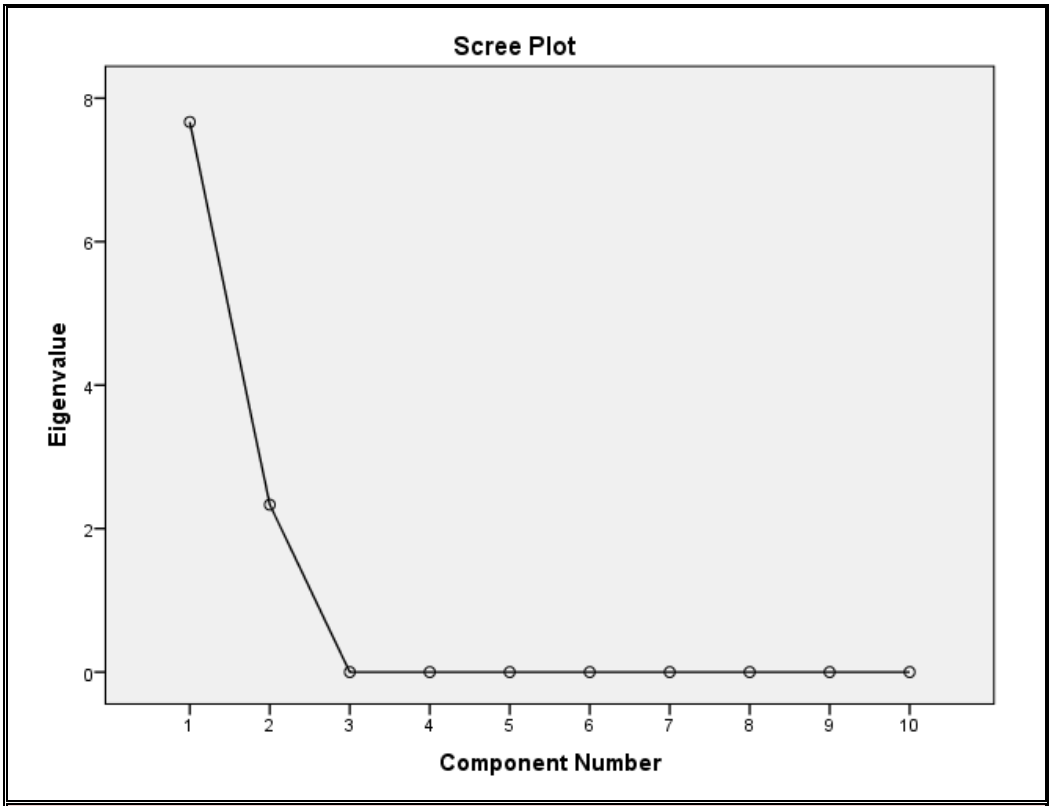


Figure 4.54 Scree plot indicating major two plots for fertilizer treated burrows monsoon season

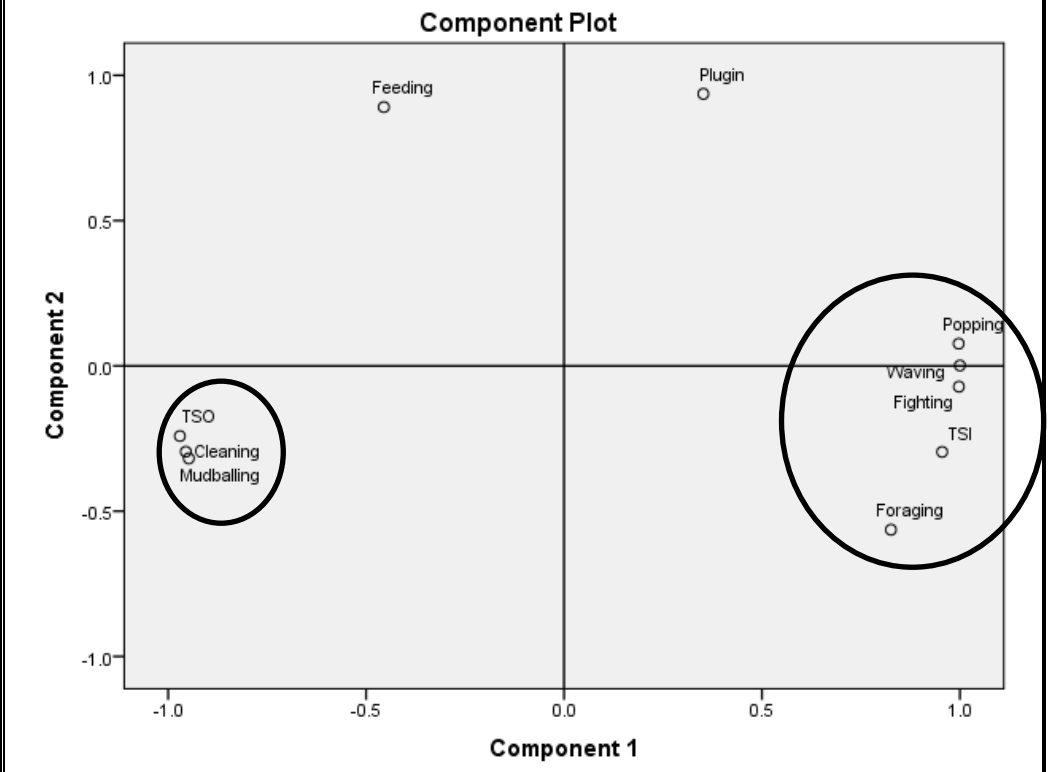


Figure 4.55 PCA analysis indicating two major clusters for monsoon season
TSO: Time Spent Outside the burrow; TSI: Time Spent Inside the burrow

4.4 Discussion

This study confirms that various behaviour patterns (with and without treatment) of *Ilyoplax sayajiraoi* (e.g., feeding, foraging, plugged-in, waving and fighting) can be analysed on mudflats of Kamboi.

Normal behaviour of crab in summer season shows feeding, foraging, mudballing and plugging behaviour shown in figure 4.2 in its initial phase because of vigorous heat outside (40^0C ±1). While burrow temperatures dropped to (28^0C ±1) maximum depth. So, it prefers to rest inside the burrows (Braithwaite & Talbot, 1972; Christy, 1982). Monsoon season shows foraging, feeding and mudballing in all the three phases, it reciprocates behaviour of summer season, as shown in PCA chart figure 4.19. This is because temperatures are optimum outside also because of rainy season their burrows are sometimes filled with water. In winter initial phase had zero activity as temperatures are low outside and as time passes more activity is seen in middle phase and it gradually decrease in final phase. In 2017 behavioural study was carried out in a similar type of experiment at Royal Burger's Zoo, Netherlands. Interference of human causing alteration in normal behavioural pattern of fiddler crab *Uca rapax* and *Uca tangeri* were video -graphed and analysed. There was no significant impact on abundance of crab by visitors density. It is reported that regularly disturbed fiddler crab get easily accustomed to consecutive disturbances (Van et al., 2019). When approached by possible predator they tend to seek refuge in their burrows (Crane, 1975).

Chemically exposed (Cobalt carbonate (10%) solution) burrows of crab in summer season showed a major difference with respect to normal behaviour. Heavy metal when mixed with water releases its metal ions very rapidly and are very active and motile. Chemoreceptors present on crab's antennae and

hairs of mouthpart sense presence of some unusual item (metal ions of Cobalt). This might have increased its feeding foraging and TSO time duration shown in PCA chart figure 4.35 and radar diagrams from figure 4.29 to 4.31.

Fertilizer treated burrows (G5-Foliar) had no influence on normal behaviour of crabs. Shown in PCA chart figure 4.51, 4.53 and 4.55 forming considerably same clusters as it was in untreated one. This could be because it sensed nothing new in the fertilizer as it contained algae and sea weed extracts, humic acid and amino acids. It is a normal substance that crabs usually feed on.