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# Thamar University Journal of Natural & Applied Sciences

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# Thamar University Journal of Natural & Applied Sciences

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**Part A**  
**Papers in English**  
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## The Prevalence of Hepatitis B Surface Antigen (HBsAg) Among Blood Donors in Some Hospitals of Thamar, Yemen

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### ABSTRACT

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Viral hepatitis is a general term meaning inflammation of the liver and can be caused by a variety of viruses such as hepatitis B virus.

Hepatitis B is a serious transfusion-transmissible disease affecting millions of people throughout the world.

This study was designed to evaluate the prevalence of HBsAg and the risk factors for HBV infection among blood donors in Thamar governorate/Yemen, and to focus upon the importance of blood transfusion in spreading the hepatitis B virus.

A total of 200 blood donors at the blood bank of Thamar hospital and Al-Wehda teaching hospital, during the period of January 2009 to October 2009, and January 2010 to July 2010, were screened for the presence of hepatitis B surface antigen (HBsAg). Each patient filled a questionnaire including age, sex, dental visit, blood transfusion ..etc. The donors were all male adult (age: 17-45 years).

Four out of 200 (2%) donors were found to be HBsAg positive by an enzyme-linked immunosorbent assay (ELISA) using monoclonal antibodies to HBsAg. Two of the four (50%) HBsAg-positive donors have relative symptoms of HBV (i.e jaundice) while the other two HBsAg-positive donors were asymptomatic. Questionnaires revealed that: The four positive donors were all married. The two asymptomatic HBsAg-positive donors were army soldiers. The other two symptomatic donors were civil workers.

One of the two asymptomatic donors has donated a blood a year ago and found to be HBsAg negative.

One of the symptomatic positive donors has had two previous surgical operations and received several pints of blood.

This study emphasizes the need for an accurate detection of this virus, and the need for using confirmatory tests for HBsAg detection and also the need to undertake serious measures to control the spread of HBV among Yemeni people.

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## **INTRODUCTION**

Viral hepatitis is a general term meaning inflammation of the liver and can be caused by a variety of different viruses such as hepatitis A, B, C, D and E. Since the development of jaundice is a characteristic feature of liver disease, a correct diagnosis can only be made by testing patient's sera for the presence of specific anti-viral antigens or antibodies<sup>(1, 2, 3)</sup>.

Hepatitis B is a serious and common infectious disease of the liver, affecting millions of people throughout the world.<sup>(2, 3, 4, 5, 6)</sup>

The severe pathological consequences of persistent HBV infections include the development of chronic hepatic insufficiency, cirrhosis, and hepatocellular carcinoma (HCC). In addition, HBV carriers can transmit the disease for many years<sup>(2, 3, 5)</sup>. Infection occurs very often in early childhood when it is asymptomatic and often leads to the chronic carrier state<sup>(7)</sup>. More than 2000 million people alive today have been infected with HBV at some time in their lives. Of these, about 350 million remain infected chronically and become carriers of the virus<sup>(2, 3, 5, 6)</sup>. Three quarters of the world's population live in areas where there are high levels of infection. Every year there are over 4 million acute clinical cases of HBV, and about 25% of carriers, 1 million people a year, die from chronic active hepatitis, cirrhosis or primary liver cancer<sup>(8)</sup>.

Following HBV infection, HBV DNA is the first detectable marker in acute HBV infection (i.e. before HBsAg)<sup>(9)</sup>, then HBsAg, which is evident 2 to 8 weeks before the appearance of jaundice and biochemical evidence of liver damage. Next to appear are the markers of the virion, such as the soluble antigen, HBeAg<sup>(10)</sup>. In acute infections, clearance of the virus is marked by the disappearance of HBeAg and the appearance of anti-HBe. Later during convalescence, HBsAg also disappears with the appearance of anti-HBs<sup>(11)</sup>.

Levels of several hepatitis markers found in the blood can confirm hepatitis B infection and differentiate acute from chronic infection. The diagnosis of acute hepatitis B is based upon the presence of the hepatitis B surface antigen (HBsAg) and hepatitis B core IgM antibody (HBcIgM). The diagnosis of chronic hepatitis B is based on the presence of the HBsAg marker for at least six months; HBcIgM antibody is usually negative.

Based on the prevalence of HBV chronic carriers (individuals positive for hepatitis B surface antigen, HBsAg) amongst adults in the general population, countries are classified as having low endemicity (< 2%), intermediate endemicity (2%–5%), or high endemicity (> 5%) of infection<sup>(12)</sup>. In most areas of the world (East and South Europe, South America, the Middle East, Middle Asia, Japan, and Turkey), HBV infection is of intermediate endemicity with HBsAg carriage rate of 2% to 7%<sup>(7, 13, 14, 15, 16)</sup>. Studies in the Middle East show the prevalence of HBsAg to range from 3% to 11% in Egypt, 4% to 5% in Iraq, 2.6% to 10% in Jordan, 2% to 6% in the Libyan Arab Jamahiriya, 2.3% to 10% in Oman, 5% to 6% in Palestine, 7.4% to 17% in Saudi Arabia, 16% to 20% in Sudan, 6.5% in Tunisia, 2% to 5% in UAE and 12.7% to 18.5% in the Republic of Yemen<sup>(17)</sup>. These surveys have been conducted on a variety of different population groups with the intention of giving a representative estimate of the prevalence of carriers in the general population. The endemicity of infection is considered high in Yemen where prevalence of positive HBsAg ranges from 8% to 20%, and up to 50% of the population generally have serological evidence of previous HBV infection<sup>(18, 19, 9)</sup>.

The hepatitis B virus can be transmitted in many ways. The main route of HBV transmission is via blood and blood products. Needle-stick injuries in health personnel, haemodialysis, shared needles in drug abusers, dental surgery, receiving blood or blood products, ear and nose piercing practices, tattooing, sexual contact and contact with body

fluid or mucosa of HBV carriers (e.g., workers in clinical laboratories) have been associated with increased risk of transmission<sup>(7)</sup>.

### **Aims**

The aim of this study is to:

- 1- evaluate the prevalence of HBsAg and risk factors for HBV infection among blood donors in Thamar hospital and Al-Wehda teaching hospital /Yemen
- 2- Focus upon the importance of blood transfusion in spreading the hepatitis virus and the importance of accurate detection of this virus.

### **MATERIAL & METHODS**

#### **Material**

The blood of the donors were collected in white tubes (without anticoagulant). Sera collected by centrifugation and subjected to this study. Blood collected by venipuncture, allowed to clot naturally and completely. Care was taken to ensure that the serum samples are clear. Any visible particulate matters in the sample were removed by centrifugation at 3000 RPM for 20 minutes at room temperature or by filtration. Highly lipaemic or haemolysed samples were excluded as they can give false results in the assay. Blood donors were also asked to answer questionnaires, which were used to obtain informations about risk factors associated with HBV infection.

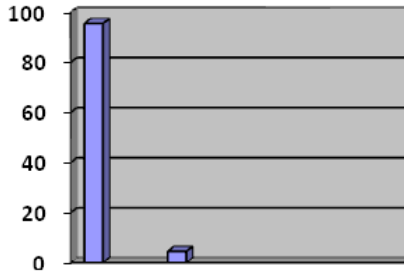
#### **Methods**

The blood samples of 200 donors were subjected to ELISA technique (sandwich method) for the detection of HBsAg using PARAMAX LABO diagnostic kit (USA). Controls were included in each test run. With monoclonal antibodies specific to HBsAg. Patient's serum sample is added to the microwell together with a second antibody conjugated with horseradish peroxidase (HRP) and directed against a different epitope of HBsAg. During incubation, the specific immunocomplex formed in case of presence of HBsAg in the sample, is captured on the solid phase. After washing to remove sample serum proteins and unbound HRP-conjugate, Chromogen solutions containing tetramethylbenzidine (TMB) and urea peroxide are added to the wells. In presence of the antibody-antigen-antibody (HRP) "sandwich" immunocomplex, the colorless Chromogens are hydrolyzed by the bound HRP-conjugate to a blue colored product. The blue color turns yellow after stopping the reaction with sulfuric acid. The amount of color measured and is proportional to the amount of antigen in the sample. Wells containing samples negative for HBsAg remain colorless.

### **RESULTS**

The donors were all male adult (age: 17-45 years). Of the 200 blood donors subjected to this study, four were found to be HBsAg positive i.e , 2% of the blood donors have HBsAg. The results are presented in the following figure (figure; 1).

Figure (1): HBsAg positive donors (95.5%) & HBsAg negative donors (4.5%)



All positive samples were within age group 26-35 years (Table; 1).

Table (1): No. of HBsAg positive blood donors according to age

| Age   | No. Examined | No. positive | % |
|-------|--------------|--------------|---|
| 17-25 | 50           | 0            | 0 |
| 26-35 | 110          | 4            | 4 |
| 36-45 | 40           | 0            | 0 |
| Total | 200          | 4            | 2 |

Two of the four (50%) HBsAg-positive donors have relative symptoms of HBV (i.e jaundice) while the other two HBsAg-positive donors have no symptoms (asymptomatic).

Questionnaires revealed that:

1-The four positive donors were all married (age 26-35 years).

2- The two asymptomatic HBsAg-positive donors were army soldiers. The other two symptomatic donors were civil workers.

3- One of the two asymptomatic donors has donated blood a year ago and found to be HBsAg negative .

4- One of the symptomatic positive donors has had two previous surgical operations and received several pints of blood.

The results are tabulated in the following table:

Table (2): Results of the questionnaires of the HBsAg positive donors

| Patients | Age | Occupation   | Symptoms     | History                                |
|----------|-----|--------------|--------------|--|
| 1        | 26  | army soldier | asymptomatic | nothing significant                    |
| 2        | 29  | army soldier | asymptomatic | blood donation                         |
| 3        | 32  | civil worker | jaundice     | 2 surgical operations & received blood |
| 4        | 35  | civil worker | jaundice     | nothing significant                    |

## DISCUSSION

While transfusion-transmissible diseases, including AIDS and viral hepatitis, continue to spread especially in developing countries, the issue of safeguarding the community's blood

supply is of paramount importance. Blood banks at Tamar hospital and Al-Wehda teaching hospital receive many donations daily, and thus their blood supply has the potential to affect the community.

Four out of 200 donors were found to be positive for HBsAg. Two of the four positive donors were asymptomatic.

The two asymptomatic donors are either in the early stage of the infection or may be chronic carriers. Their condition is unknown because no further investigations were made (e.g. anti-HBcIgM, HBeAg) as these investigations are not available.

One of the asymptomatic donors had donated blood a year ago at Taiz medical center and found to be HBsAg negative using chromatography method. This indicates that either this donor was not infected at that period or that the negative result of Taiz medical center was false as the screening method (chromatography) is not as sensitive as ELIZA. In addition, no confirmatory test used. Researchers in Turkey <sup>(20)</sup> recommend that asymptomatic HBsAg positive blood donors should be followed-up for signs of hepatitis. They found, after long follow up of asymptomatic HBsAg positive blood donors, that 15% of HBsAg positive blood donors have chronic hepatitis.

Our data showed that the two asymptomatic donors were Army soldiers. Hepatitis B is an expanding health problem in the Army<sup>(23, 24)</sup>. Military personnel are one of many core populations at increased risk for acquiring sexually-transmitted diseases and HBV infection<sup>(25, 26)</sup>. Further studies are needed to clarify associations between Army soldiers and HBV infection.

The other two positive cases in this study were symptomatic donors (jaundice). One of them has had two previous surgical operations suggesting that he might have been infected during operation (using contaminated tools) or from blood transfusion during or after operation.

In this study 98% of blood donors were HBsAg negative. Transmission by blood components negative for HBsAg can still occur in the acute phase of infection during the seronegative window period, or during chronic stages of infection ("occult" HBV infection, OHB). OHB is defined as the presence of HBV DNA in blood or liver tissues in patients negative for HBsAg, with or without any HBV antibodies<sup>(9, 27)</sup>.

Acute HBV infection is self-limiting in approximately 97% of immunocompetent adults leading to recovery and immunity. However, in 3% of cases, individuals remain chronically infected (i.e. carrier state), usually testing HBsAg positive and anti-HBc positive. Some of these chronically infected individuals can, however, have very low and/or intermittently detectable levels of HBV DNA and, on testing, are found to be HBsAg negative<sup>(9, 27)</sup>. In a study by El-Sherif, et al <sup>(21)</sup>, HBV DNA was detected in 3.3% of blood donors negative for HBsAg and HBsAb. Because of limitations in current blood screening practices, OHB is an overlooked source of HBV transmission. Liu et al, <sup>(9)</sup> indicated that nucleic acid amplification test (NAT) or new HBsAg tests of enhanced sensitivity would be effective in the screening of blood donors for OHB in highly endemic countries.

In this study 2% of blood donors at Tamar hospital and Al-Wehda teaching Hospital were found to be HBsAg positive. This incidence is lower than that reported in Egypt, for instance, as the frequency of HBsAg in Egyptian blood donors was found to be 4.3%<sup>(21)</sup> and much lower than that reported in Saudi Arabia's blood donors (13.9%)<sup>(14)</sup>. We attributed the differences in the carrier rates to the use of different measurement techniques. Also the results of this study is much lower than the carrier rates of the middle east countries <sup>(17)</sup>.

These surveys have been conducted on a variety of different population groups. Higher rates may be observed in community-based studies than in studies conducted amongst blood donors<sup>(17)</sup>. Blood donors may not be representative of the general population. In some settings, blood donors tend to be healthier than individuals in the general population and consequently are more willing and capable of donating blood. In Saudi Arabia, blood donors appeared to have a lower prevalence of HBsAg (13.9%) when compared to the general population (16.7%)<sup>(14)</sup>. On the other hand, in Yemen, Scott et al.<sup>(22)</sup> found blood donors to have a significantly higher prevalence of HBsAg (20.6%) than non-donor (12.1%) apparently healthy individuals. Therefore, one cannot generalize findings based on studies conducted on blood donors. The 2% of the HBsAg positive cases presented here underestimate the number of hepatitis B infections transmitted by transfusion as infection is often asymptomatic and not all acute infections are diagnosed. Nevertheless, these data show that transmission of hepatitis B by transfusion does occur and emphasizes the need for improving the detection of HBV in all blood banks to reduce the chance of getting hepatitis B from a blood transfusion. Also mandatory reporting of the disease allows state health care workers to track people who have been exposed to the virus. Giving the hepatitis B vaccine or a hepatitis B immune globulin (HBIG) shot to those who have not yet developed the disease may help prevent hepatitis B infection if it is given within 24 hours of exposure. In recent years, blood centers in Yemen have tried to improve the nation's blood safety. Although a progress has already been made, many difficulties remain. Other developing countries face the same challenges as Yemen.

#### **ACKNOWLEDGMENT**

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## فايروس الكبد (ب) بين متبرعي الدم في بعض مستشفيات ذمار- اليمن

مها الالوسي، عبدالسلام المقداد و عرفات الجرفي

كلية الطب والعلوم الصحية - جامعه ذمار

### ملخص

يعتبر التهاب الكبد الفايروسي من أخطر الأمراض المعدية التي تنتقل عن طريق الدم والذي يؤثر على ملايين الناس في جميع أنحاء العالم. ويسبب هذا الالتهاب أنواع مختلفة من الفايروسات ومنها فايروس ب. أجريت هذه الدراسة للتعرف على مدى انتشار فايروس الكبد ب بين متبرعي الدم في بعض مستشفيات محافظة ذمار وكذلك لمحاولة معرفه الأسباب التي أدت للإصابة بهذا المرض. تمت هذه الدراسة على 200 متبرع للدم تتراوح أعمارهم 17-45 سنة في بنك الدم لمستشفى ذمار العام ومستشفى الوحدة التعليمي في محافظه ذمار خلال الفترة من يناير 2009 إلى أكتوبر 2009 ومن يناير 2010 إلى يوليو 2010 ولقد تم الطلب من كل متبرع بعض المعلومات مثل العمر، الجنس، زيارات لأطباء الأسنان، عمليات جراحية، نقل دم ... الخ.

المتبرعين كانوا كلهم ذكور تتراوح أعمارهم بين 17 إلى 35 سنة. ولقد تم فحص المتبرعين لوجود فايروس الكبد ب بواسطة اختبار الامتصاصية المناعية المرتبطة بالانزيم ( تقنيه الأليزا) ولقد وجد ان أربعة منهم (2%) ايجابيين لفايروس الكبد ب. اثنين من الحالات الموجبة ابدوا بعض الأعراض (مثل الصفار)، البقية بدون أعراض. كل المرضى المصابين كانوا متزوجين، اثنان منهم جنود(أحدهم تبرع بالدم قبل سنة وكان فحصه سالب. الاثنان الاخران الذي كان فحصهم موجب مدنيين، احدهم خضع لعمليتين جراحيتين في السابق وأستلم عدة قناني من الدم. هذه الدراسة تؤكد الحاجة لاستخدام فحوصات أكثر دقة لكشف هذا الفايروس والحاجة الى فحوصات توكيدية للفايروس واتخاذ اجراءات مشدده للسيطرة على انتشار هذا الفايروس في أوساط المجتمع اليمني.



## Biochemical Compositions of Urolithiasis among Yemeni Patients

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### ABSTRACT

**Objectives:** Since the chemical composition of calculi is very important for the purpose of determining both the origin and etiology, the present study was therefore done to perform the chemical analysis of stones to know the pattern of biochemical composition of stones among Yemeni patients.

**Methodology:** Kidney stones were sent to Central Laboratory; in Sana'a, the capital of the Republic of Yemen for chemical analysis. The stones were washed in distilled water grinded and powdered in a mortar and were analyzed by samiquantitative method. The powdered stones and standard both were analyzed for uric acid, cystine, oxalate, carbonates, phosphates; ammonia, calcium and magnesium contents. Data extracted from the records included age, sex, occupation and place of residence. The software SPSS 13.0 for Windows was used for data entry and analysis. Chi-Square test was used to compare between different results. P values < 0.05 were considered significant.

**Results:** One hundred eight (108) stones were analyzed chemically during the period from 1st January, 2010 to 30th October 2011. All patients were Yemeni from different part of the country working in the military and their families were included in the study. The mean age of the participants included in the analysis was  $29.65 \pm 11.36$ . There were 94 (87%) stones belonged to males, while 14 (13%) stones to female. The male to female ratio was 6:1. Out of a total of 108 stones, 60 stones (55.6%) were calcium oxalate, 30 (27.8%) were uric acid mixed with calcium oxalate and 5 (4.6%) stones were phosphate mixed with calcium oxalate. The association between gender and biochemical composition of renal stones were positive and statistically significant ( $\chi^2 = 19.072$ , P s= 0.025).



Conclusions: Renal stone disease in Yemeni was not uncommon. The majority were calcium oxalate, followed by uric acid stones. The relative increased frequency of stones in Yemen, which is a part of Mediterranean region, indicates that nutritional, environmental and genetic factors play a role in the occurrence of stones.

Keywords: urolithiasis, biochemical composition, Yemen.

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## **INTRODUCTION**

Urolithiasis is the first most common urological disease affecting both males and females; it is predominant among males in a proportion of approximately 2:1 [1, 2].

Urolithiasis incidence varies in different parts of the world, high incidence areas are Scandinavian Countries, Mediterranean Countries, British Isles, Northern Australia, central Europe, portion of the Malayan Peninsula, China, Pakistan and northern India, whereas the incidence of kidney stones formation is lower in areas like Central and South America and some parts of Africa.

In Asia stone-forming belt has been reported to stretch across Saudi Arabia, the United Arab Emirates, the Islamic Republic of Iran, Pakistan, India, Myanmar, Thailand Indonesia and Philippines [3]. Yemen lies in the south of Saudi Arabia.

The peak incidence is observed in the 2<sup>nd</sup> and 3<sup>rd</sup> decades of life. Renal Calculi are characterized clinically by renal colic as they pass down along the ureter and manifest as haematuria [4].

Both genetic and environmental factors contribute to stone formation. Factors believed to predispose to sporadic urinary lithiasis include hygienic-dietic issues, occupation, geographic and climatic aspects, as well as the special characteristics of drinking water. [5,6].

The biochemical aspects of the disease have centered on the metabolic activity of the patient including certain enzyme disorders. Winer [7], listed seven factors that may contribute to the formation of calculi:

- Metabolic disturbance such as gout
- Endocrinopathies
- Urinary obstruction
- Infectious
- Mucosal metaplasia
- Intrinsic conditions such as dehydration
- Dietary excess, drug excess, or hemotherapy
- Isohydruria

Analysis of urinary calculi is an essential step in the examination and initial treatment of the patient with kidney stones (urolithiasis). Knowledge of the composition of calculi yield fundamental information concerning the pathogenesis of the disease, including metabolic abnormalities, presence of infection, possible artifacts and even drug metabolism [8].

Most stones, approximately 75% are calcium containing largely of calcium oxalate mixed with calcium phosphate. Another 15% are called triple phosphate stones or struvite

stones composed of magnesium ammonium phosphate. 6% are uric acid stone and 1-2% is made up of cystine stones [9, 10].

Since the chemical composition of calculi is very important for the purpose of determining both the origin and etiology, the present study was therefore done to perform the chemical analysis of stones to know the pattern of biochemical composition of stones among Yemeni patients.

## METHODOLOGY

Kidney stones were sent to Central Lab; in Sana'a, the capital of the Republic of Yemen for chemical analysis. These stones were removed surgically from the patients exposed to surgical treatments between 1<sup>st</sup> January, 2010 to 30<sup>th</sup> October 2011, in the "48 Model Hospital" in Sana'a, which is one of the major Teaching Hospitals in the Republic Of Yemen. A request form having a brief history was sent with the patient's stone.

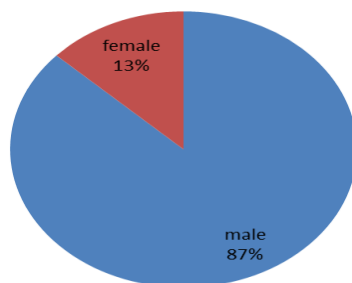
The stones were washed in distilled water grinded and powdered in a mortar and were analyzed by samiquantitative method [11]. The kits supplied by Mascia Brunell S.P.A (Italy) were used for chemical analysis of stones. The synthetic standard available in the form of fine powder was analyzed along with the test samples to serve as a control. The powdered stones and standard both were analyzed for uric acid, cystine, oxalate, carbonates, phosphates; ammonia, calcium and magnesium contents. Data extracted from the records included age, sex, occupation and place of residence.

The software SPSS 13.0 for Windows was used for data entry and analysis. Chi-Square test was used to compare between different results. P values < 0.05 were considered significant.

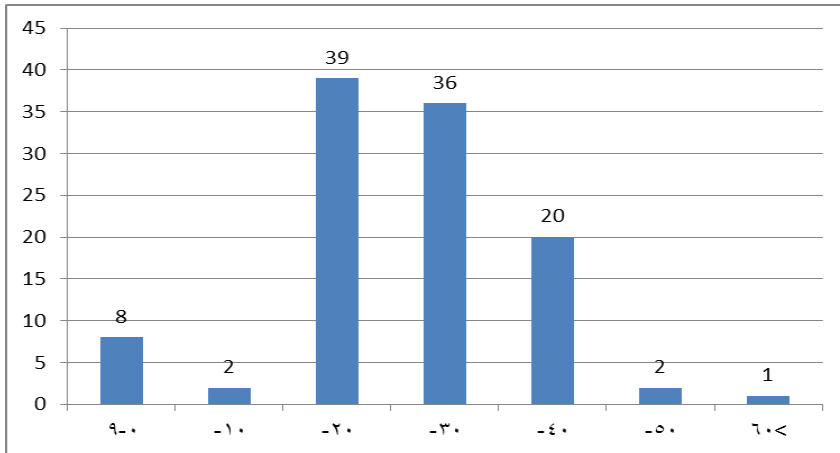
## RESULTS

One hundred eight (108) stones were analyzed chemically during the period from 1<sup>st</sup> January, 2010 to 30<sup>th</sup> October 2011. All patients were Yemeni from different part of the country working in the military and their families were included in the study.

The mean age of the participants included in the analysis was  $29.65 \pm 11.36$ . There were 94 (87%) stones belonged to males, while 14 (13%) stones to female (graph 1 & 2). The male to female ratio was 6:1.



Graph.1: distribution of urolithiasis according to the gender



Graph2. Distribution of urolithiasis according to the age groups

Out of a total of 108 stones, 60 stones (55.6% ) were calcium oxalate, 30(27.8%) were uric acid mixed with calcium oxalate and 5 (4.6%) stones were phosphate mixed with calcium oxalate . Table1.Type of stones.

Table 1: urolithiasis according to the types of stones

| Type of stones                   | frequency | %    |
|----------------------------------|-----------|------|
| uric acid                        | 2         | 1.9  |
| calcium+oxalate                  | 60        | 55.6 |
| calcium+oxalate+phosphate        | 5         | 4.6  |
| magnisium+calcium+oxalate        | 2         | 1.9  |
| calcium+oxalate+amonia+uric acid | 3         | 2.8  |
| calcium+oxalate+uric acid        | 30        | 27.8 |
| calcium+oxalate+ammonia          | 1         | .9   |
| amonia+uric acid+oxalate         | 1         | .9   |
| calcium+phosphate+uric acid      | 2         | 1.9  |
| cabonate+calcium+uric acid       | 2         | 1.9  |

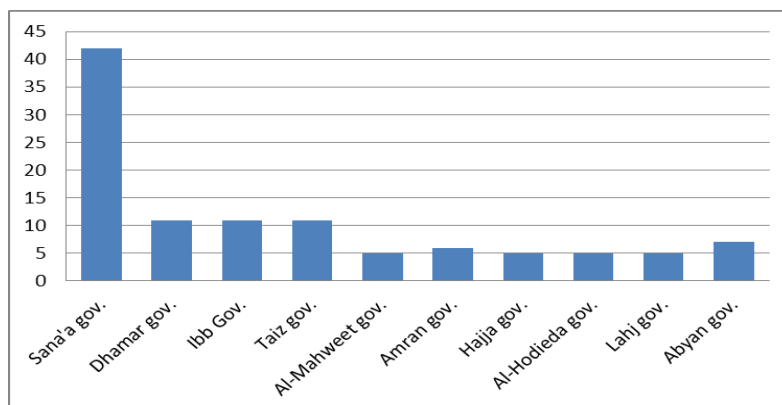
The association between gender and biochemical composition of renal stones were positive and statistically significant ( $\chi = 19.072, P = 0.025$ ). Table2.

Table2. Relation between gender and biochemical compositions of renal stones

|   |   | biochemical compositions of renal stones*** |                  |                            |                            |                                    |                            |                          |                            |                              |                              | T      | $\chi$ | p. |
|---|---|---|------------------|----------------------------|----------------------------|------------------------------------|----------------------------|--------------------------|----------------------------|------------------------------|------------------------------|--------|--------|----|
|   |   | Uric acid                                   | Calcium+ oxalate | Calcium+ oxalate+phosphate | Magnesium+ calcium+oxalate | Calcium+oxalate +ammonia+uric acid | Calcium+ oxalate+uric acid | Calcium+ oxalate+ammonia | Ammonia+ uric acid+oxalate | Calcium+ phosphate+uric acid | Carbonate+ calcium+uric acid |        |        |    |
| M | 1 | 54  | 5                | 0                          | 2                          | 26                                 | 1                          | 1                        | 2                          | 2                            | 94                           |        |        |    |
| F | 1 | 6   | 0                | 2                          | 1                          | 4                                  | 0                          | 0                        | 0                          | 0                            | 14                           |        |        |    |
| T | 2 | 60  | 5                | 2                          | 3                          | 30                                 | 1                          | 1                        | 2                          | 2                            | 108                          | 19.072 | 0.025  |    |

\*\*\* M = Male, F = Female, T = total,  $\chi$  = Chi square test, P = p – value < 0.05 significant.

Most patients were from Sana'a governorate 38.9% as shown in the graph 3.



Graph3. Distribution of urolithiasis according to the patient's place of residence

## DISCUSSION

Analysis of urinary calculi is an essential step in the examination and initial treatment of the patient with kidney stones (urolithiasis). Knowledge of the composition of calculi yield fundamental information concerning the pathogenesis of the disease, including metabolic abnormalities, presence of infection, possible artifacts and even drug metabolism [8].

The present study shows that majority of stones were composed of calcium oxalate (55.6% ) followed by uric acid (27.8%) . Almost similar observations were made from studies done in Saudi Arabia and Sudan [12, 13, and 14]. This might be due to the large consumption of meat and poultry by the people here. These types of food tend to increase the amount of acid in the urine. These stones are formed in acid urine called primary stones. On other hand secondary stones are formed in alkaline urine as a result of infection and compromise of magnesium ammonium phosphate [9]. In our study 4.6% of stones

composed of calcium oxalate mixed with phosphate followed by magnesium mixed with calcium oxalate 1.9 %.

The exact pathogenesis of urolithiasis is not known. A number of promoters, inhibitors and predisposing factors can contribute to the development of stone formation. From the above results it appears that nutritional and environmental factors play a role in the pathogenesis of urolithiasis in Yemen.

The male to female ratio in this study was 6:1. Most studies reported that it is 5 times more in male than females [15]. Alhadramy MS has reported that, it is 2-4 times more in males as compared to females [15,16]. These findings are in close proximity to our reports

The disease affected all age groups from less than 1 year old to more than 70; however the increased incidence of recurrence in patients in the older age may be contributed to the influence of aging and diet. In our study the mean age of the participants included in the analysis was  $29.65 \pm 11.36$  and these findings support other observations done in the literatures [ 3,12,13,15,17].

Increased incidence in males has been attributed to increased dietary protein intake ,which increases urinary excretion of phosphates and magnesium and reduced urinary citrate concentration . The lower risk of stone formation in women was attributed initially to increased urinary citrate concentrations due to the lower urinary saturation of stone forming salts ,while later reports indicated that endogenous estrogen and estrogen treatment in postmenopausal women may decrease the risk of stone recurrence by lowering urinary calcium and calcium oxalate saturation [3]. In this study there were 94 (87%) stones belonged to males and 14 (13%) stones to female. This finding indicate positive association between gender and biochemical compositions of renal stones ( $\chi = 19.072$ ,  $P = 0.025$ ).

The effect of geography on the incidence of stone formation may be direct, through its effect on temperature,high temperatures increase perspiration ,which may result in concentrated urine ,which in turn promotes increased urinary crystallization .In our study 87% of participants were from different part of the country working in the military in different local environment - extreme heat and dryness, lack of rehydration , dietary habits, etc. These findings support other observations done in the previous studies [ 3, 4,6, 10, 17].

## **CONCLUSION**

From the study we can conclude that:

- Renal stone disease in Yemeni was not uncommon .The majority were calcium oxalate, followed by uric acid stones.
- The relative increased frequency of stones in Yemen, which is a part of Mediterranean region, indicates that nutritional, environmental and genetic factors play a role in the occurrence of stones.

## **RECOMMENDATION**

It is stated that nutritional and environmental factors seem to play a role in stone formation. Hence dietary intervention on a large scale and health education in this regard may be helpful on the preventive side.

**Ethics consideration:** no need

**Funding:** no funding

**Competing interests**

The authors declare that they have no competing interests.

**Authors' contributions:**

All authors attest to having contributed substantially to conception and design and acquisition of data and drafting the article and revising it critically for important intellectual content. All authors give approval of the final version to be published.

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## التركيبية الكيميائية لحصوات المسالك البولية

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كلية الطب – جامعة ذمار

### ملخص

المداخلة – معرفة تركيب حصوات الكلى والمسالك البولية مهمة جدا لمعرفة الوقاية والعلاج. وهذه الدراسة هي لتحليل الحصوات ومعرفة التركيبية الكيميائية في اوساط المرضى اليمنيين طرق التحليل. ارسلت الحصوات الى مختبرات الصحة المركزية ومختبرات مستشفى 48 في صنعاء العاصمة اليمنية وتم تحليلها للمركبات الكيميائية التالية. 1. يوريك اسيد 2. سيستين 3. اكسالات 4. كوربونات 5. فوسفات 6. امونيا 7. كالسيوم 8. ماغنيسيوم. وتم تحديد الجنس—العمر—العمل—و مكان الإقامة واستخدمت احدث طرق الحاسوب spss وغيرها للوصول الى ادق النتائج النتائج. تم اجراء تحاليل ل 108 حصوات خلال الفترة 1 يناير 2010 - 30 اكتوبر 2011 م وكان جميع المرضى يمنيون ومن مناطق مختلفة وصلنا الى النتائج التالية .. الذكور 94 = 87% الاناث 14 = 13% أي بنسبة 6 الى 1 اما التركيبية الكيميائية ظهرت كالتالي.. 60حصوة = 55,6% كالسيوم اكسالات و 30 حصوة = 27,8% يوريك اسيد مع كالسيوم اكسالات و كذلك 5 حصوات = 4,6% فوسفات مع كالسيوم اكسالات. الخلاصة. حصوات الكلى والمسالك البولية شائعة في اوساط اليمنيين وغالبيتها كالسيوم اكسالات يتبعها يوريك اسيد انتماؤنا الى شرق البحر الابيض المتوسط من حيث البيئة . التغذية وعوامل الجينات التي تلعب دورا في ظهور الحصوات.



## Preliminary Study on Hard Ticks ( Acari: Ixodidae) of Sheep in Some Areas of Thamar Governorate, Yemen

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### ABSTRACT

The objective of this study was to identify and determine the prevalence of tick species infesting sheep in some areas of Thamar governorate, Yemen. A total of 392 indigenous sheep breeds of either sex and different age were randomly selected and examined for presence of ticks using standard parasitological techniques from December, 2010 to May, 2011. The results revealed that the overall prevalence of tick infestations on sheep was 43.37 %. Of total 875 ticks collected, Seven species of ixodid ticks were identified. The species on hierarchy of overall prevalence abundance were *Rhipicephalus sanguineus* (13.01%), *Rhipicephalus (Boophilus) decoloratus* (9.69%), *Rhipicephalus evertsi evertsi* (5.87 %), *Hyalomma marginatum* (4.59 %), *Amblyomma variegatum* (4.34%), *Rhipicephalus (Boophilus) annulatus* (3.06%), *Haemaphysalis sulcata* (2.04%). *Rhipicephalus (Boophilus) decoloratus* species is recorded for first time in Thamar governorate and Yemen as well as. Statistically, there was significance difference ( $P < 0.05$ ) in the prevalence among different species identified. The highest prevalence rate of ticks infestations was recorded in month of May (62.90%); whereas the lower rate in the month of December (26.67 %). Prevalence of tick infestations was influenced significantly ( $P < 0.05$ ) by Month variation (season). The effect of associated risk factors (determinants) i.e. age, sex, breed of host and area in distribution of ticks was non-significant. Attention should be given to the control and prevention of tick infestations on sheep reared under traditional management in study areas.

**Keywords:** Preliminary study, Prevalence, Sheep, Thamar, Tick.

### INTRODUCTION

The livestock sector represents a significant part of the global economy, particularly in the developing world. Thus, livestock provide energy, food, raw materials, and manure for crops. It is therefore not surprising that the livestock sector has emerged as an important economic source for a vast majority of the rural population



and a target for agribusiness in the dairy, meat, and various other products in the processed foods sector [ 1, 2, 3, 4].

The livestock sector contributes about 16% of the total National Gross Domesticated Product (GDP) and over 23.3% of the Agricultural GDP [5 ]. The current population of livestock in Yemen is estimated as 19.7 million and is predicted to increase 3.2 % per year to reach 30 million by 2025 [ 6].

The livestock sector has increasingly become eminent in terms of its contribution to household nutrition and food security. However, sustainability of this sector has been negatively affected by the high prevalence and incidence of animal diseases and pests [ 7].

Tick infestation presents a serious challenge to farmers of small ruminants in developing countries like Yemen. They exert a major hindrance to improving animal production and livestock industry. Economically, ticks impact the availability of good quality hides and skins to the leather industry. Severe irritation, allergy, and toxicosis often plague livestock growers. In addition, in both small and large ruminants, ticks reduce milk production, increase mortality, and transmit serious diseases such as babesiosis, theileriosis, and anaplasmosis [8, 9, 10].

The control of ticks and tick borne diseases is a major component of animal health programme for the protection of livestock and enhances global food security. Successful control strategy of ticks and the diseases they transmit depends on improving our understanding on the epidemiology, distribution and dynamics of the ticks in the field [11, 12].

Since the previous surveys on ticks infesting livestock in some agro-ecological zones of Yemen [13,14,15,16], to our best knowledge, no work has been carried out on tick infestation on sheep and other ruminants in Thamar. Therefore, this study aimed to identify, determine the prevalence of tick species infesting sheep and associated risk factors (determinants) in some areas of Thamar governorate, Yemen.

## **MATERIALS AND METHODS**

### **Study area**

The study was carried out in some areas of Thamar governorate in the period from December, 2010 to May, 2011. Geographically, Thamar is located at 14.58'N latitude, 44 43'E longitude and at an altitude of 2425 meter above sea level (m. a. s. l). It enjoys a temperate, rainy summer and a cool, moderately dry winter with temperatures occasionally dipping below 0°C . The mean minimum and maximum annual temperatures for the area are 8.8°C and 25.05°C respectively. The area receives an average annual rainfall of about 22.27 mm and relative humidity of about 44.33%.

### **Study population**

The study population constitutes indigenous sheep (Thamari and Ainsi/Boni)

breeds kept under traditional management system. The animals depend on grazing for their feed sources, the flocks are regularly moved to pasture for daytime grazing in the morning and are brought back to the villages in the evening. In house, animals are occasionally supply with crop residues and house-wastes.

### **Study design and sampling strategy**

A cross-sectional study design was employed to address the objective of this study. Multistage cluster random sampling was used as described by Thrusfield [ 17] to select a total of 392 sheep of either sex and different age from five localities of Thamar, namely, Da`r Alhanash, Livestock Market, Manqadha, Mawahep and Yafa`a. All selected animals were examined thoroughly for the presence of ticks.

### **Tick collection and identification**

The selected animals were restrained; all visible ticks were collected from whole body of animal. Ticks were removed carefully and gently from body surface of animal with forceps. The collected ticks were preserved in universal bottles containing 70% ethyl alcohol and labeled with the date of collection (months), age, sex and breed of the hosts. The specimens were brought to laboratory, Department of Veterinary Parasitology, College of Agriculture & Veterinary Medicine, Thamar University, for counting and identification. The ticks were counted and subsequently identified to species level using stereomicroscope according to identification keys given by Urquhart et al. [18 ] and Walker et al. [ 19].

### **Data analysis**

The data obtained were uploaded into Microsoft Excel spreadsheet and summarized by using tables. Statistical analyses were performed by using SPSS 17.1[20]. Descriptive statistics like prevalence, percentages, counts and Ratio were calculated to display the status of ticks relative to some considered variables. Chi-square was used for comparison of binary variables. *P* value less than 0.05 was considered significant.

## **RESULTS**

Out of a total 392 sheep examined for presence of the hard ticks, 170 were found to be infested by one or more tick species. The overall prevalence of ticks recorded was 43.37 %. Ticks have shown a permanent presence through the study period.

Table 1. The overall prevalence of tick infestation on sheep in Thamar governorate

| Animal species | No. of animals examined | No. of animals infested | Percentage % |
|----------------|-------------------------|-------------------------|--------------|
| Sheep          | 392                     | 170                     | 43.37        |

Table 2. The prevalence of tick species identified on sheep in Thamar governorate

| Species                          | No. of animals infested (n=392) | Prevalence (%) | P value |
|----------------------------------|---------------------------------|----------------|---------|
| <i>A. variegatum</i>             | 17                              | 4.34           | 0.000   |
| <i>H. marginatum rufipes</i>     | 18                              | 4.59           |         |
| <i>H. sulcata</i>                | 8                               | 2.04           |         |
| <i>R. evertsi evertsi</i>        | 23                              | 5.87           |         |
| <i>R. sanguineus</i>             | 54                              | 13.78          |         |
| <i>R.(Boophilus) decoloratus</i> | 38                              | 9.69           |         |
| <i>R. (Boophilus)annulatus</i>   | 12                              | 3.06           |         |

Table 3. Sex ratio and distribution of ticks on body of sheep

| Site of attachment        | Ear         | Sternum & flank | Hand leg & udder | Other Body parts | Total of ticks | Female ticks | Male ticks  | Ratio    |
|---------------------------|-------------|-----------------|------------------|------------------|----------------|--------------|-------------|----------|
| No. of Ticks & Percentage | 331 (36.9%) | 136 (15.1%)     | 282 (26.9%)      | 149 (16.6%)      | 875            | 523 (59.8%)  | 352 (40.2%) | 1.3: 0.9 |

Of total 875 ticks collected from sheep, Seven species of ticks were identified, which they are belonging to four genera, namely, *Rhipicephalus*, *Hyalomma*, *Amblyomma* and *Haemaphysalis*. The species on hierarchy of overall prevalence abundance were *R. sanguineus* (13.01%), *R.(Boophilus) decoloratus* (9.69 %), *R. evertsi evertsi* (5.87 %), *H. marginatum* (4.59 %), *A. variegatum* (4.34%), *R.(Boophilus) annulatus* (3.06 %), *H. sulcata* (2.04%) as indicated in Table 2. Statistically, there was significant difference ( $p < 0.05$ ) in the prevalence among the different species of ticks collected from sheep. *R.( Boophilus) decoloratus* species is recorded for first time in study areas of Thamar governorate and Yemen.

The sex ratio ( female/ male) and distribution of the ticks on body parts of sheep are presented in Table 3. As shown, females ticks were dominant on sheep compared to males. Various body sites were categorized based on attachment preference. The ears (36.9 %), were primary sites of attachment, followed by hand leg & udder (26.9 %), sternum & flank ( 15.1 %) and other parts of the body (16.60%), as depicted in Table 3.

Considering the analyses of the prevalence of tick infestation on sheep and associated risk factors, namely, Month variation (season,), age, sex, breed of host and area. The effect of month variation (season) on distribution of tick infestation is presented in Table 4. As shown, the higher prevalence rate was recorded in month of May (62.90%); whereas the lower rate in month of December (26.67%).

Significant difference ( $p < 0.05$ ) was observed between prevalence of ticks and month variation (season).

Table 4. Risk factors (determinants) influencing prevalence of tick infestation on sheep

| Risk factors |                 | No. of animals examined | No. of animals infested | Prevalence | P value |
|--------------|-----------------|-------------------------|-------------------------|------------|---------|
| Month        |                 |                         |                         |            |         |
|              | Dec             | 75                      | 20                      | 26.67      | 0.000   |
|              | Jan             | 60                      | 20                      | 33.33      |         |
|              | Feb             | 60                      | 22                      | 36.67      |         |
|              | Mar             | 75                      | 33                      | 44.00      |         |
|              | Apr             | 60                      | 36                      | 60.00      |         |
|              | May             | 62                      | 39                      | 62.90      |         |
| Age          |                 |                         |                         |            |         |
|              | 1 yr <          | 55                      | 29                      | 52.73      | 0.209   |
|              | 1 yr            | 136                     | 64                      | 47.06      |         |
|              | 2 yrs           | 77                      | 25                      | 32.47      |         |
|              | 3 yrs           | 71                      | 32                      | 45.07      |         |
|              | 4 yrs           | 32                      | 11                      | 34.38      |         |
|              | 5 yrs and above | 20                      | 29                      | 145.0      |         |
| Sex          |                 |                         |                         |            |         |
|              | Female          | 279                     | 119                     | 42.65      | 0.654   |
|              | Male            | 113                     | 51                      | 45.13      |         |
| Breed        |                 |                         |                         |            |         |
|              | Thamari         | 211                     | 87                      | 41.23      | 0.357   |
|              | Ainsi/Boni      | 181                     | 83                      | 45.86      |         |
| Area         |                 |                         |                         |            | 0.777   |
|              | Da`r Alhanash   | 75                      | 35                      | 46.67      |         |
|              | Livestock M     | 92                      | 37                      | 40.22      |         |
|              | Manqadh         | 90                      | 36                      | 40.00      |         |
|              | Mawahep         | 60                      | 26                      | 43.33      |         |
|              | Yafa`a          | 75                      | 36                      | 48.00      |         |

The results of age-wise showed that, the higher prevalence rate of tick infestation was recorded in young animals below one year ( 52.73 %), whereas the lower rate (32.9%) was recorded in animal groups with two-year old ( 32.47 %), as presented in Table 4.

Sex-wise results revealed that, sheep males (45.13%) were found to be more prone to tick infestation compared to females ( 42.65 %). No significance

difference ( $P < 0.05$ ) was observed between prevalence of tick infestation and sex of sheep (Table 4).

Ainsi sheep breed was more susceptible to tick infestation compared to Thamari breed. The prevalence rate recorded in both breeds was 45.86% and 41.23 % respectively.

The distribution of ticks in different localities (areas) of Thamar governorate included in this study are presented in Table 4. The higher prevalence rate was recorded in Yafa`a (48.0%), whereas the lower rate in Manqadh (40.0 %).

Statistically, analyses showed that no significant association ( $P < 0.05$ ) was observed between prevalence of tick infestation and hypothesized risk factors Viz. age, sex, breed and area.

## DISCUSSION

An attempt was carried out to identify, determine the prevalence of tick species infesting sheep and associated risk factors in Thamar governorate. The problem of ticks on sheep in the study area seems to be very important as they are widely distributed, poor management and poor level of awareness of sheep owners regarding the effect of ticks are believed to be the main causes for wide spreading of ticks. In the present study, the overall prevalence of tick infestation was 43.37%. The results of this study are in agreement with findings of other workers [3, 4, 8, 21, 22] who studied the tick infestations in sheep and other domestic ruminants and reported the prevalence rate ranged from 12.8 to 89.90%. The higher prevalence rate reported by some of above workers could be attributed to size of samples, environmental conditions and topo- geography of study area.

Seven species of ticks were identified, which are belonging to four genera, namely, *Rhipicephalus*, *Hyalomma*, *Amblyomma* and *Haemaphysalis*. The species identified were *R. sanguineus*, *R.(Boophilus) decoloratus*, *R. evertsi evertsi*, *H. marginatum rufipes*, *A. varigatum*, *R. (Boophilus) annulatus*, *H. sulcata*. All species identified were previously reported by many workers in some geographical areas of Yemen [13,14,15,16] and other regions of the world [3, 8, 23, 24, 25]. Furthermore, these results support the findings of Friedhoff [26], who reported that majority of tick species belong to *Rhipicephalus*, *Haemaphysalis*, *Amblyomma* and *Hyalomma* genera are the most common tick species infesting domestic animal in the Middle East. The absence of some species reported by above workers in current study may be due to the fact, the present study was limited to Thamar city and surrounding areas; whereas in previous studies different animal species from different geographical areas of Yemen and world were subjected to examination for the presence of ticks.

*R.( Boophilus) decoloratus* species is recorded for first time in study areas of Thamar governorate and Yemen. This could be attributed to importing live animals from Africa, for the purposes of meat consumption and scarifies during religious festivals, where is this species more prevalent [ 3, 12, 22, 27].

*R. sanguineus* tick was the most predominant species in sheep. These results are in line with findings of Shemshad et al [10], who studies species diversity and geographic distribution of hard ticks infesting domestic ruminants in Iran and reached to similar results. This could be explained that, the *R. sanguineus*, have ability to enjoy wide host range in domestic animals and high adapted to climatic condition of study area.

In general, the number of ticks collected from sheep was very low compared to similar studies [21, 22, 28] carried out in other regions of the world. This could be attributed to complicated interplay factors such as climate, vegetation, host density, host resistance and animal husbandry practices. The sex-ratio results showed that, female ticks were more compared to males. This may be due to sampling efficacy and male ticks are difficult to find on host compared to female [29].

Ticks are known to be distributed on different parts of the host body. In this study, the highest number of ticks were seen in ears of sheep, while their distribution on other body parts were with varying percentages. Solomon [30] suggested that factors such as host density, interaction between tick species, time and season and inaccessibility for grooming determine the attachment site of ticks.

As far as could be ascertained, no or a limited amount of literature is available on the tick infesting livestock and associated risk factors in Yemen [15, 16]. Such factors influencing prevalence of tick infestation on sheep are studied for first time in Thamar. As shown in Table 4, the prevalence infestation rate was the highest in May and the lower in December. The results of this study are in accordance with findings reported by other workers [ 2, 15, 23, 25, 31], who studied the relationship between the prevalence of tick infestations and month variation (season). The high prevalence rate of tick infestation in May, could be attributed to environmental conditions which were conducive for survival, development and breeding of ticks in study area.

The current study revealed that younger animals showed high susceptibility to tick infestations compared to adults. This could be explained as resistance in adult animals are building up as the age advance and the animals become more adaptable than in younger. In addition, the soft skin and tissue of younger animals may be easy to penetrated by mouth parts of ticks during feeding [9 ].

Sex-wise data revealed that males were slightly more infested by ticks compared to females. No significant difference was observed between prevalence rate and sex of animal. The higher prevalence rate recorded on males may be due to managerial factors.

In the present study, Anisi breed showed slightly more susceptible to tick infestation compared to Thamari breed. This could be attributed to genetical factors or may be due to the fact that, the farmers in study area have more interest in Thamari breed; thus, taking more care about this breed compared to Ainsi breed.

The highest prevalence rate of tick infestation was recorded in Yafa`as area; whereas the lower rate in Manqadh area. No significant difference was observed in prevalence rate of tick infestations among different areas surveyed. The higher

prevalence rate recorded in Yafa`a locality may be due to moving of livestock, animal husbandry practice and microclimate conditions of Yafa`a locality (area).

In conclusion, hard tick species are prevalent in Thamar governorate. The conducive environmental factors, poor veterinary infrastructure services and lack appropriate knowledge on tick impact on livestock are suggested to be the main causes for abundance of ticks. Further studies on epidemiology of ticks, tick-borne diseases and related factors are recommended as these may provide a valuable basis for designing and launching an all-round control programme in Thamar and other regions with similar environmental conditions.

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## دراسة أولية عن القراد الصلب في الأغنام في بعض مناطق محافظة ذمار

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### ملخص

أجريت هذه الدراسة للتعرف على أنواع القراد الصلب التي تصيب الأغنام ومعدل انتشارها في بعض مناطق ذمار في الفترة من ديسمبر 2010 إلى مايو 2011. تم اختيار 392 رأس من الأغنام عشوائيا من كلا الجنسين وبأعمار متفاوتة من مناطق مختلفة من محافظة ذمار. خضع كل حيوان للفحص العياني بحثا عن القراد الصلب في كل أجزاء الجسم و المختبري للتعرف على أنواع القراد. كشفت الدراسة إن معدل انتشار القراد الصلب في الأغنام ( 43.37%). تم التعرف على سبعة أنواع من القراد الصلب وهي: *Rhipicephalus sanguineus* (13.01%), *Rhipicephalus* (*Boophilus*) *decoloratus* (9.69%), *Rhipicephalus evertsi evertsi* (5.87%), *Hyalomma marginatum* (4.59%), *Amblyomma variegatum* (4.34%) *Rhipicephalus* (*Boophilus*) *annulatus* (3.06%), *Haemaphysalis sulcata* (2.04%). معنوية ( $p < 0.05$ ) بين نسب معدل انتشار الأنواع التي تم التعرف عليها. النوع (*Rhipicephalus* (*Boophilus*) *decoloratus* سجل لأول مرة في محافظ ذمار و اليمن بشكل عام. كشفت الدراسة إن لاختلاف الموسم (الشهور) معنويا ( $p < 0.05$ ) في معدل انتشار القراد. يوصى بعمل برامج مكافحة للقراد الصلب والسيطرة عليها في منطقة الدراسة و المناطق المشابه لها جغرافيا و بيئيا.



## Recent Foraminifera from Socotra Island, Indian Ocean, Yemen

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### ABSTRACT

Twenty five samples were collected from the beach sand of Socotra Island. These samples are covered the northern shoreline of the island. They were treated for extracting the foraminiferal content. Eighty Six foraminiferal species have been identified from the collected samples. These species belonging to 52 genera, 22 subfamilies, 35 families, 16 superfamilies and 6 suborders.

The systematic classification of the recorded species is mentioned and then they were compared with the type- species.

Key words: Key words: Recent foraminifera, Socotra Island, Indian Ocean, Yemen.

### INTRODUCTION

Socotra island is the largest Yemeni Island, located between the longitudes  $53^{\circ} 19'$  and  $54^{\circ} 33'$  E, and latitudes  $12^{\circ} 18'$  and  $12^{\circ} 42'$  N (Fig.1). This island has been living in isolation with the three nearby small islands (Abd Al-Kouri, Samhah and Darsa) to form the Socotra Archipelago in the Indian Ocean off the Horn of Africa, some 380 km S-SE of Ras Fartaq, the nearest point on the south Arabian coast. The length of Socotra Island is about 135 km from east to west with a maximum N-S breadth of 42 km. This archipelago rests on a shelf platform that is attached to the horn of Africa, some 250 km E-NE of cape Gaurdafui at the north-east tip of Somalia (Samuel et al., 1997).

The geography of the area is very interest and variable, there are mountains ground, littoral, fluvial and aeolian plains. Different sedimentary environments such as valleys, coasts, lagoons, brackish water lakes....etc. are widely distributed in the island. All of these environments are distinguished by their own particular environmental conditions which controlling the endemic faunal assemblages inhabiting them.

At the surface of the island, four kinds of relief can be distinguished, these including: (1) The central plateau: It occupies most of the island area



and is divided into two main parts: the eastern and the western plateaus, which overlooking gradually the coastal plains., (2) Coastal Plains: The coastal plains are situated in the northern and southern parts of the island and are non-existent in the eastern or western parts of the island due to the extension of drifts to the coast. The coastal plains are divided into two parts, the northern coastal plain named Hadibo plain and the southern plain named Nawgeed., (3) The Mountains: The most important of which are the mountainous range of Haggier Mountains, which are located at the eastern part of the island (Fig. 1). and (4) The Wadis (valleys): Wadis are interspersed and pour at the northern and southern parts of the island. Some of these valleys springing out from the Haggier mountainous range which are characterized by the running water all the year.

Geology and Stratigraphy of Socotra Island was introduced in detailed by Beydoun and Bichan, 1970, Morrison et al., 1997, Birse et al., 1997 and Samuel et al., 1997. Pre-Cambrian basement rocks are distributed at the eastern part of the island (Haggier Mountains) and in a narrow strip along much of the northern coastline at the base of the cliffs and in the west around Qalansiyah and Ras Shu'ab areas.

Thick sedimentary sequence rests on the Pre-Cambrian basement rocks and exposed in different areas of the island. This sedimentary sequence consists mainly of sandstone (Triassic) and carbonate rocks (Jurassic–Tertiary). The carbonate sequence is highly karstified and cliff-forming massive limestone varies considerably in thickness, from 30m up to 600m (Samuel et al., 1997). Pleistocene and Holocene sediments formed on older rocks in inland depressions, valleys and on coastal plains. The Quaternary deposits of the island include marine, fluvial and continental facies (Flettmaan et al., 2004).

In the studied areas marine deposits are generally horizontal terraces of sandy conglomeratic limestone and heterogeneous calcareous and cemented conglomerates with a variety of marine organisms. The most common amongst them being corals and bivalves. Other marine deposits include pebble banks, beaches, spits and bars giving rise to lagoons or damming up the mouths of streams and wadis to result in the formation of seasonal fresh and brackish water lakes. Marine deposition grades inland into continental and fluvial conditions.

The island lies on the margins of sub-equatorial and northern tropical climate belts. Therefore; the climate is characterized by marked seasonal, spatial–altitudinal and inter-annual variability. The local climate is influenced by large-scale weather phenomena, particularly the seasonally reversing Monsoons, the El Nino-southern oscillation and the Indian Ocean Dipole, and the episodic passage of tropical cyclones.

The diverse topography of the islands creates various micro-climates which cause marked changes in Socotra weather patterns, sea and air temperatures and rainfall. The Nawgeed plains is typical of extremely arid conditions, while parts of the Haggier are in a humid cloudy zone and may experience substantial rainfall occasionally in excess of 100mm per day during the rainy season where the total annual rainfall on the north coast measured is 125-175mm. The annual average temperature in Hadibo attains 28-31°C and the average annual humidity is approximately 65-76%.

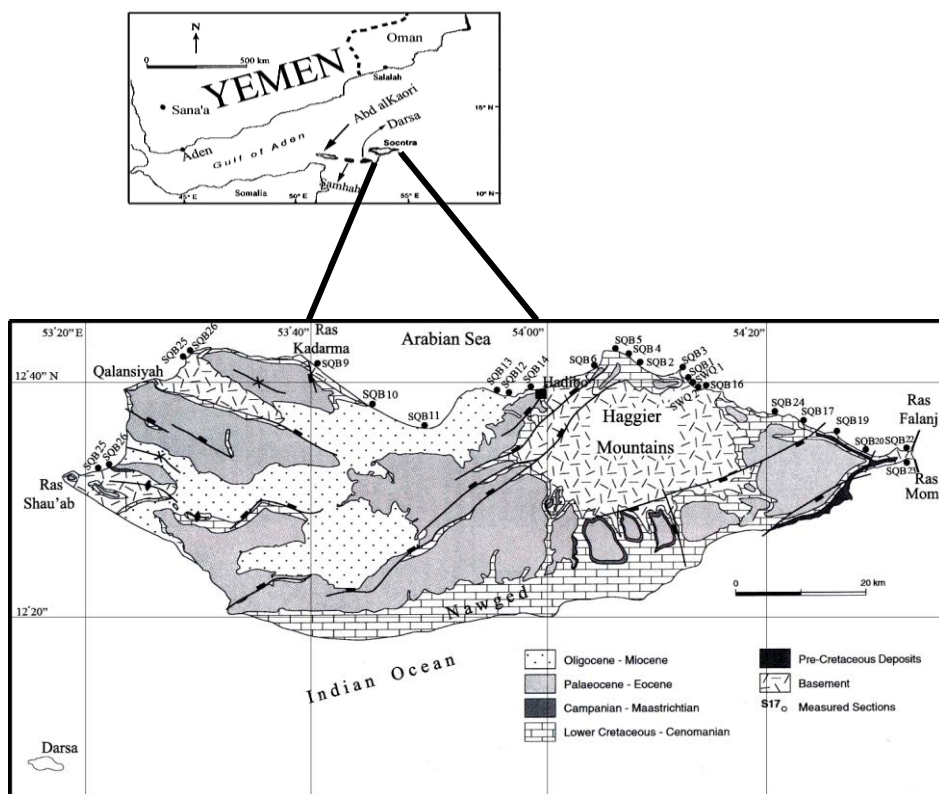


Figure 1: Geological map of Socotra Island including positions of collected samples

## METHODOLOGY

Fieldwork was carried out along the northern coastline of Socotra Island during November 2007. Twenty five samples from the surface sediments of the selected area (Fig. 1) were collected for detail study and separation the foraminiferal tests from sediments which depends on the difference in density between saline water and the shells, which composed of calcium carbonate. The samples were washed by running distilled water using a (200-mesh) sieve. Shells of foraminifera were concentrated and extracted from the sediments by using turbulent movement to the salt water and the sediments inside a plastic container. The carbonate shells were separated and floated on the surface of water according to the low density of the calcium carbonate. The floating materials were separated from the saline solution and concentrated in a plastic sieve. Foraminiferal tests were picked by using double zero (00) size brush and arranged in micropaleontological slides. This fauna were studied and identified by using light binocular microscope. Photos of identified foraminiferal species were taken by Scanning Electronic Microscope (SEM) but some of them taken by 12 Mega Pixel digital camera.

Foraminiferal species from Socotra Island did not study before. Therefore, the present work is considered the first contribution on the foraminiferal assemblages from surface sediments of the Island.

The foraminiferal species are recorded and assessed in the present study. The classification of recorded foraminifera based primarily on characters of the shells. The differences between the type species and our identified species are mentioned and the unknown species will describe here.

Based on the classification of foraminiferal genera by Loeblich and Tappan, 1988, an assemblage of 86 foraminiferal species is recorded. These recorded species belong to 52 genera, 22 subfamilies, 35 families, 16 superfamilies and 6 suborders. The described specimens are deposited in the Department of Earth and Environmental Sciences, Faculty of Science, University of Sana'a.

## TAXONOMY AND SYSTEMATIC PALEONTOLOGY

Order : Foraminiferida EICHWALD, 1830

Suborder: Textularina EHRENBERG, 1839

Superfamily: Textulariacea EHRENBERG, 1838

Family: Eggerellidae CUSHMAN, 1937

Subfamily: Eggerellinae CUSHMAN, 1937

Genus: *Martinottiella* CUSHMAN, 1933

*Martinottiella communis* D'ORBIGNY, 1846

Pl. I, Fig. 1

Remarks: This species was recorded from Maldives Ridge and south eastern Arabian Sea (Sarkar *et al.*, 2009). In this study, *Martinottiella communis* D'orbigny was found as a rare form in SQB12 (Table 1).

*Martinottiella sp.*

Pl. I, Figs. 2-3

Description: Test free, elongate, uniserial, ovate; periphery lobulate, sub-angular; suture flash, curved; wall finely agglutinated, aperture arcuate slit-like, terminal.

Remarks: in this study, *Martinottiella sp.* was found as rare form in SQB12 (Table 1).

Subfamily: Textulariinae EHRENBERG, 1838

Genus: *Textularia* DEFRANCE, 1824

*Textularia agglutinans* D'ORBIGNY, 1839

Pl. I, Figs. 4-9

Remarks: This species was recorded from several areas such as southern Thailand (Jumnongthai, 1980) and East Coast of India (Gandhi *et al.*, 2002). In this study, it recorded as a common and rare form from several samples (Table 1).

*Textularia conica* D'ORBIGNY, 1839

Pl. I, Figs. 10-11.

Remarks: Chambers of this species are increasing gradually in size. This species was recorded from different regions such as south Maldives Ridge, Arabian Sea and from the north-west Indian coastline by Srinath, 2002 and Sarkar *et al.*, 2009. In this study, this species was found with a huge numbers of up to more than 500 specimens in many samples (Table 1).

*Textularia foliacea* HERON-ALLEN and EARLAND, 1915

Pl. I, Fig. 12.

Remarks: This species was distinguished from recent deposits of the Red Sea and the Gulf of Aqaba (Hottinger *et al.*, 1993). In the present study, this form is distinguished from SQB26 as an abundant and as frequent form in SQB25 and rarely form in SQB3 (Table 1).

Suborder: Spirillinina HOHENEGGER and PILLER, 1975

Family: Spirillinidae REUSS and FRITSCH, 1861

Genus: *Sejunctella* LOEBLICH and TAPPAN, 1957

*Sejunctella* sp.

Pl. I, Figs. 13-14.

Description: Test discoidal to enrolled tubular, globular to ovate; complete and rounded Periphery; wall hyaline, numerous prominent perforations on one side, and opposite side imperforate; aperture terminal, rounded at the end of the tube.

Remarks: In this study, this form is distinguished from SQB25, SQB26 as a rare form (Table 1).

Suborder: Miliolina DELAGE and HEROUARD, 1896

Superfamily: Cornuspiracea SCHULTZE, 1854

Genus: *Vertebralina* D'ORBIGNY, 1826

*Vertebralina striata* D'ORBIGNY, 1826

Pl. I, Figs. 15-18.

Remarks: *Vertebralina striata* D'orbigny was recorded from different regions such as East Coast of India (Gandhi *et al.*, 2002), Maldives Ridge and south eastern Arabian Sea (Sarkar *et al.*, 2009) and from Turkey (Meriç *et al.*, 2009).

In this study, this form is distinguished from SQB25 as a frequent and as a rare form in SQB3, SQB13 and SQB26 (Table 1).

Superfamily: Miliolacea EHRENBERG, 1839

Family: Spiroloculinidae WIESNER, 1920

Genus: *Spiroloculina* D'ORBIGNY, 1826

*Spiroloculina aequa* CUSHMAN, 1917

Pl. II, Figs. 2-3.

Remarks: This species was recorded from the beach sands along Saurashtra coast in north-west India (Rao and Srinath, 2002) and Indian coast (Devi and Rajashekhar, 2009). In the present study, this form was found as a common form in SQB25 and SQB26 (Table 1).

*Spiroloculina depressa* D'ORBIGNY, 1826

Pl. I, Fig. 19.

Remarks: This species is very similar to the type species which was described by D'orbigny, 1826. It was recorded several regions such as Florida (Buzas and Severin, 1982), France (Debenay *et al.*, 2001), Thailand Gulf (Melis and Violanti, 2006) and Turkey (Meriç *et al.*, 2009).

In this study, it was recorded as rare form in SQB3, SQB13, SQB25 and SQB26 (Table 1).

*Spiroloculina laevigata* CUSHMAN and TODD, 1944

Pl. I, Fig. 20.

Remarks: This species was recorded in beach sands along Saurashtra coast in north-west India (Rao and Srinath, 2002). This form was recorded as a rare form from the Red Sea coastline (Hudaydah, Mukha and Zabeed) by El-Nakhal, 1980. In this study, *Spiroloculina laevigata* Cushman and Todd was recorded as rare form in SQB25 (Table 1).

*Spiroloculina ornate* D'ORBIGNY, 1839

Pl. II, Fig. 1.

Remarks: In this study, *Spiroloculina ornate* D'orbigny has been recorded as a rare form in SQB12 and SQB25 (Table 1).

*Spiroloculina sp.*

Pl. II, Figs. 4-5.

Description: Test ovate in outline, biconvex; tube-shaped; milioline; complete and semi-rounded periphery; suture lines curved, depressed; surface smooth; wall porcelaneous, imperforate; aperture terminal, rounded at the end of the final chamber with simple tooth.

Remarks: In this study, *Spiroloculina sp.* has been recorded as rare form in SQB12 and SQB26 (Table 1).

Family: Hauerinidae SCHWAGER, 1876

Subfamily: Hauerinae SCHWAGER, 1876

Genus: *Hauerina* D'ORBIGNY, 1839

*Hauerina bradyi* CUSHMAN, 1917

Pl. II Figs. 6-10.

Remarks: This species is similar to the type species. It was recorded in southern Thailand (Jumnongthai, 1980). In the study samples *Hauerina bradyi* Cushman was recorded as an abundant form in SQB25 and SQB26 and rarely from SQB3 and SQB13 (Table 1).

Genus: *Massilina* SCHLUMBERGER, 1893

*Massilina granulocostata* GERMERAAD, 1946

Pl. II, Figs. 11-12.

Remarks: *Massilina granulocostata* was recorded from different regions such as Challenger Station in Papua New Guinea, Gulf of Mexico, Mediterranean Sea, New Zealand and from USA. In the present study, this species was distinguished as a frequent form in samples SQB3, SQB25 and SQB26 (Table 1).

Genus: *Quinqueloculina* D'ORBIGNY, 1826

*Quinqueloculina flavescens* D'ORBIGNY, 1826

Pl. II, Fig. 13.

Remarks: *Quinqueloculina flavescens* was originally described from Madagascar (D'Orbigny, 1826). It was recorded from the coastline of Yemen by El-Nakhal, 1984. In this study, this species was recorded from samples SQB2, SQB19 and SQB25 (Table 1).

*Quinqueloculina poeyana* D'ORBIGNY, 1839

Pl. II, Figs. 14-15.

Remarks: The present species was described from the recent deposits of Cuba and Jamaica (D'Orbigny, 1839). In Yemen, this species was recorded by El-Nakhal, 1980. Also, it was recorded in different regions such as Florida (Buzas and Severin, 1982), Western Australia (Glover *et al.*, 2003) from Thailand (Melis and Violanti, 2006). In this study, it occurs in samples SQB10, SQB12, SWQ1 and SWQ2 as a common form (Table 1).

*Quinqueloculina parkeri* BRADY, 1881

Pl. II, Figs. 16-17

Remarks: This form was described by Brady, 1881. It was identified from different regions such as southern Thailand (Jumnongthai, 1980) and East Coast of India (Gandhi *et al.*, 2002), beach sands along Saurashtra coast in north-west India (Rao and Srinath, 2002) and from Indian coast (Devi and Rajashekhar, 2009). In this study, *Quinqueloculina parkeri*

Brady was occurred as rare form in samples SQB1, SQB4, frequently from samples SQB25 and SQB26 (Table 1).

*Quinqueloculina subdecorata* CUSHMAN, 1918

Pl. II, Fig. 18.

Remarks: This species was recorded by El-Nakhal, 1984 From the Red Sea coastline of Yemen. In this study, *Quinqueloculina subdecorata* was recorded as a rare form in sample SWQ2 (Table 1).

*Quinqueloculina* sp.

Pl. II, Fig. 19.

Description: Test ovate in outline, biconvex; chambers shape tube, milioline; complete and sub-rounded periphery; suture lines curved, slightly depressed; wall porcelaneous, imperforate; surface striated lines; aperture terminal, rounded with a bifid tooth.

This species has recorded here as a commonly from sample SQB26, as a frequent form in sample SQB3, and as rare form in sample SQB19 (Table 1).

Subfamily: Miliolinellinae VELLA, 1957

Genus: *Biloculina* WIESNER, 1931

*Biloculina labiata* SCHLUMBERGER, 1891

Pl. II, Fig. 20.

Remarks: *Biloculina labiata* Schlumberger was recorded from Turkey (Meriç *et al.*, 2009). In this study, it has been recorded as a frequent form in samples SQB25 and SQB26 and as a rare form in samples SQB3 and SWQ2 (Table 1).

Genus: *Triloculina* D'ORBIGNY, 1826

*Triloculina bertheliana* BRADY, 1884

Pl. III, Figs. 14-15.

Remarks: In this study, *Triloculina bertheliana* was identified rarely form in sample SQB2 and frequently from sample SQB25 (Table 1).

*Triloculina longidentata* BANDY, 1953

Pl. III, Figs. 3-5.

Remarks: El-Nakhal, 1993 recorded *Triloculina longidentata* Bandy from Hudaydah and Zabeed, Salif and Mukha areas. In this study, it was identified as an abundant form in sample SQB26, as a common form in sample SQB25 and as a rare form in samples SQB13, SQB14, SQB23 and SQB27 (Table 1).

*Triloculina mindenensis* HOWE, 1939

Pl. III, Figs. 6-7.

Remarks: Howe, 1939 described *Triloculina mindenensis* from the Eocene of Louisiana, U.S.A. It was identified by El-Nakhal, 1980, 1984 and 1993 from Yemen (Hudaydah, Zabeed and Mukha). In this study, this species was recorded form as an abundant form in sample SWQ2 and as a frequent form in samples SQB3 and SQB13 (Table 1).

*Triloculina oblonga* MONTAGU, 1803

Pl. III, Figs. 8-10.

Genus: *Coscinospira* EHRENBERG, 1839

*Coscinospira hemprichii* EHRENBERG, 1839

Pl. IV, Figs. 1-3.

Remarks: This species was recorded by El-Nakhal, 1984 from Mukha area. In this study it was recorded as a rare form in sample SQB1 and SQW 1 (Table 1).

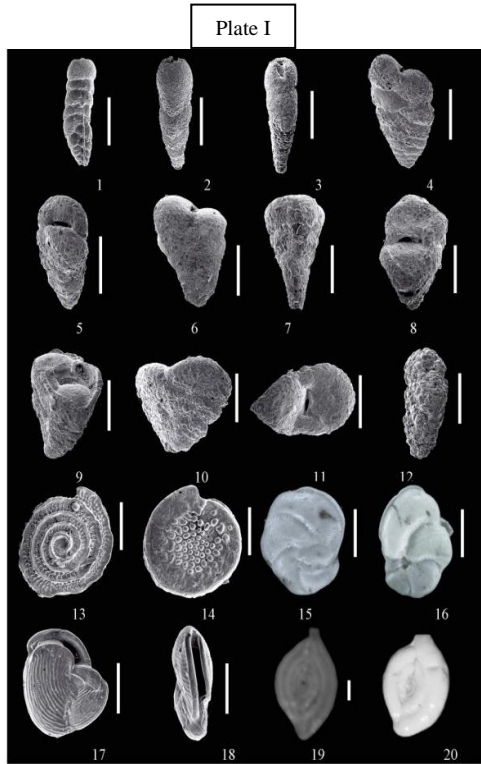


Plate I

1- *Martinottiella communis* D'orbigny, side view, scale bar 320 $\mu$ m., 2- *Martinottiella* sp., side view, scale bar 220 $\mu$ m., 3- *Martinottiella* sp., apertural view, scale bar 315 $\mu$ m., 4- *Textularia agglutinans* D'orbigny, side view, scale bar 510 $\mu$ m. 5- *Textularia agglutinans* D'orbigny, apertural view, scale bar 485 $\mu$ m., 6- *Textularia agglutinans* D'orbigny, side view, scale bar 420 $\mu$ m. 7- *Textularia agglutinans* D'orbigny, edge view, Scale bar 175 $\mu$ m., 8- *Textularia agglutinans* D'orbigny, apertural view, scale bar 120  $\mu$ m., 9- *Textularia agglutinans* D'orbigny, edge view, scale bar 290 $\mu$ m., 10- *Textularia conica* D'ORBIGNY, side view, scale bar 160 $\mu$ m., 11- *Textularia conica* D'orbigny, apertural view, scale bar 135 $\mu$ m., 12- *Textularia foliacea* Heron-Allen and Earland, edge view, scale bar 680 $\mu$ m., 13- *Sejunctella* sp., spiral side, scale bar 230 $\mu$ m., 14- *Sejunctella* sp., umbilical view, scale bar 255 $\mu$ m., 15- *Vertebralina striata* D'orbigny, spiral side, scale bar 325 $\mu$ m., 16- *Vertebralina striata* D'orbigny, spiral side, scale bar 395 $\mu$ m., 17- *Vertebralina striata* D'orbigny, umbilical view, scale bar 165 $\mu$ m., 18- *Vertebralina striata* D'orbigny, apertural view, scale bar 173 $\mu$ m., 19- *Spiroloculina depressa* D'orbigny, side view, scale bar 100 $\mu$ m., and 20- *Spiroloculina laevigata* Cushman and Todd, side view, X60.

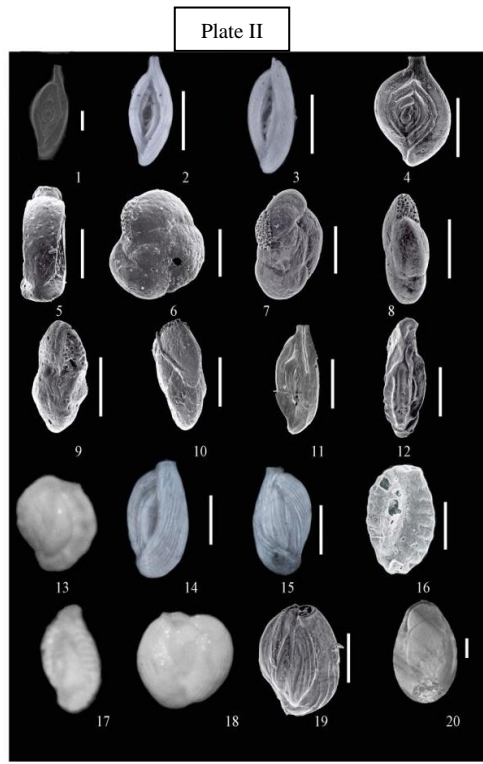


Plate II

1- *Spiroloculina ornate* D'orbigny, side view, scale bar 100 $\mu$ m., 2- *Spiroloculina aequa* Cushman, side view, scale bar 460 $\mu$ m., 3- *Spiroloculina aequa* Cushman, side view, scale bar 405 $\mu$ m., 4- *Spiroloculina* sp., side view, scale bar 190 $\mu$ m., 5- *Spiroloculina* sp., edge view, Scale bar 185 $\mu$ m., 6- *Hauerina bradyi* Cushman, spiral side, scale bar 260 $\mu$ m., 7- *Hauerina bradyi* Cushman, 1917, scale bar 285 $\mu$ m., 8- *Hauerina bradyi* Cushman, edge view, scale bar 260 $\mu$ m., 9- *Hauerina bradyi* Cushman, apertural view, scale bar 270 $\mu$ m., 10- *Hauerina bradyi* Cushman, edge view, scale bar 295 $\mu$ m., 11- *Massilina granulocostata* Germeraad, side view, scale bar 370 $\mu$ m., 12- *Massilina granulocostata* Germeraad, apertural view, scale bar 310 $\mu$ m., 13- *Quinqueloculina flavescens* D'orbigny, side view, X60, 14- *Quinqueloculina poeyana* D'orbigny, side view, scale bar 230 $\mu$ m. 15- *Quinqueloculina poeyana* D'orbigny, side view, scale bar 265 $\mu$ m., 16- *Quinqueloculina parkeri* Brady, side view, scale bar 100 $\mu$ m., 17- *Quinqueloculina parkeri* Brady, side view, X60, 18- *Quinqueloculina subdecorata* Cushman, side view, X60, 19- *Quinqueloculina* sp., side view, scale bar 155 $\mu$ m. and 20- *Biloculina labiata* Schlumberger, side view, scale bar 50 $\mu$ m.

Remarks: This species was recorded from the beach sands along Saurashtra coast in north-

west India (Rao and Srinath, 2002) and Indian coast (Devi and Rajashekhar, 2009). It was recorded by El-Nakhal, 1980 and 1993 from sea shores of Yemen. In this study, *Triloculina oblonga* was occurred as an abundant form in sample SQB12, as frequent form in samples SQB3, SQB14 and SQB25 and as a rare form in samples SQB1 and SQB19 (Table 1).

*Triloculina peroblonga* CUSHMAN, 1922

Pl. III, Fig. 11.

Remarks: This form was recorded by El-Nakhal, 1980 and 1993 from sea shores of Yemen. In this study, *Triloculina peroblonga* Cushman was distinguished as a common form in samples SQB3, SQB13 and SQB25, as a frequent form in sample SQB25 and as a rare form in sample SQB14 (Table 1).

*Triloculina quadrata* COLLINS, 1958

Pl. III, Figs. 12-13.

Remarks: Collins, 1958 described *Triloculina quadrata* from the recent deposits of the Great Barrier Reef of Australia. This species was recorded by El-Nakhal, 1980 and 1993 from sea shores of Yemen. In this study, it was recorded as a common form in sample SQB3, as a frequent form in samples SQB25 and SQB26 and as a rare form in samples SQB13 and SQB19 (Table 1).

*Triloculina trihedra* LOEBLICH and TAPPAN, 1953

Pl. III, Figs. 1-2.

Remarks: This species was recorded by Michelsen, 1967 from island of Læsø in Denmark. *Triloculina trihedra* Loeblich and Tappan was recorded by El-Nakhal, 1980 and 1984 from the Red sea coastline of Yemen. In this study, It was found as an abundant form in samples SQB26 and SWQ2, as a common form in samples SQB1 and SQB13, as a frequent form in sample SQB3 and as rare form in samples SQB12, SQB25 and SWQ1 (Table 1).

*Triloculina* sp.

Pl. III, Fig. 16.

Description: Test ovate in outline, biconvex; chambers shape tube; milioline, three chambers visible from the exterior; complete and sub-rounded periphery; suture lines curved, depressed; wall porcelaneous, imperforate; surface smooth; aperture terminal, rounded at the end of the final chamber with a short bifid tooth.

Remarks: This species was found as rare form in SQB25 (Table1).

Subfamily: Tubinellinae RHUMBLER, 1906

Genus: *Articulina* D'ORBIGNY, 1826

*Articulina antillarum* CUSHMAN, 1922

Pl. III, Fig. 17.

Remarks: This species was recorded in Gulf of Mexico. In this study, *Articulina antillarum* was occurred as rare form (two shells only) in SQB3.

*Articulina carinata* WIESNER, 1923

Pl. III, Figs. 18-20.

Remarks: *Articulina carinata* Cushman was recorded from the recent sediments of Queensland, Australia. In this study it was recorded frequently from SQB25 and rarely from SQB26 (Table 1). It is very similar to the type species but the ornamentation is more clear in our specimens.

Superfamily: Soritacea EHRENBERG, 1839

Family: Peneroplidae SCHULTZE, 1854

Genus: *Peneroplis* DE MONTFORT, 1808  
*Peneroplis planatus* FICHTEL and MOLL, 1798

Pl. IV, Figs. 4-6.

Remarks: This species is very similar to the type species that was described by Fichtel and Moll, 1798, but our specimens characterized that their chambers are increasing slowly in size. It was recorded from southern Thailand (Jumnongthai, 1980), East Coast of India (Gandhi *et al.*, 2002) and from Turkey (Meriç *et al.*, 2009). In this study, it was recorded frequently from samples SQB2 and SQB26 and as a rare form in samples SQB1, SQB13, SQB19 and SQB25 (Table 1).

*Peneroplis pertusus* D'ORBIGNY, 1839

Pl. IV, Figs. 7-8.

Remarks: This species is similar to the species *Dendritina ambigua* Fichtel and Moll, but it has different in the aperture type. It was recorded in Florida (Buzas and Severin, 1982) and Turkey (Meriç *et al.*, 2009). In this study, this species was recorded as an abundant form in samples SQB13 and SQB25, frequently form in samples SQB2 and SQB7 and as a rare form in samples SQB1, SQB4, SQB8, SQB14, SQB19 and SQB26 (Table 1).

Family: Soritidae EHRENBERG, 1839

Subfamily: Soritinae EHRENBERG, 1839

Genus: *Sorites* EHRENBERG, 1839

*Sorites orbiculus* FORSKAL, 1775

Pl. IV, Figs. 9-10.

Remarks: In Yemen *Sorites orbiculus* Forskal recorded as an abundant form at the Yemeni Red Sea coastline by El-Nakhal, 1980 and 1993. In this study, this form was distinguished abundantly from many samples (Table 1). This species was recorded in East Coast of India (Gandhi *et al.*, 2002) and Turkey (Meriç *et al.*, 2009).

Suborder: Lagenina DELAGE and HEROUARD, 1896

Superfamily: Nodosariacea EHRENBERG, 1838

Family: Nodosariidae EHRENBERG, 1838

Subfamily: Nodosariinae EHRENBERG, 1838

Genus: *Dentalina* RISSO, 1826

*Dentalina inornata* D'ORBIGNY, 1846

Pl. IV, Fig. 11.

Remarks: This species was recorded in Maldives Ridge in south eastern Arabian Sea (Sarkar *et al.*, 2009). It is similar to the *laeidentalina aphelis* which was described in Loeblich and Tappan, 1986; but the surface of our specimens smooth. In this study, this species was found as a rare form in sample SQB26 (Table 1).

Genus: *Amphimorphina* NEGEBOREN, 1850

*Amphimorphina butonensis* KEYZER, 1953

Pl. IV, Fig. 12.

Remarks: This species is too similar to the type species of *Amphimorphina haueriana* Negeboren, 1850, but it differs by its rounded aperture. In this study, it was recorded as a rare form in sample SQB25 (Table 1).

Family: Vaginulinidae REUSS, 1860

Subfamily: Marginulininae WEDEKIND, 1937

Genus: *Amphicoryna* SCHLUMBERGER, 1893

*Amphicoryna* sp. 1971

Pl. IV, Fig. 13.

Plate III

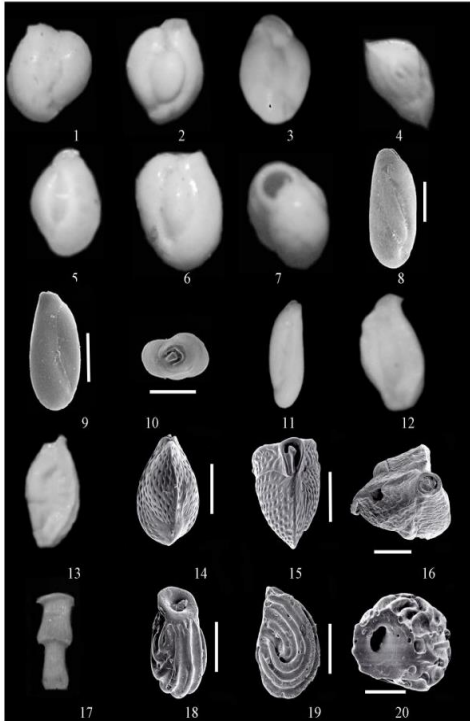


Plate III

1- *Triloculina trihedra* Loeblich and Tappan, side view, X60., 2- *Triloculina trihedra* Loeblich and Tappan, side view, X60., 3- *Triloculina longidentata* Bandy, side view, X60., 4- *Triloculina longidentata* Bandy, apertural view, X60., 5- *Triloculina longidentata* Bandy, side view, X60., 6- *Triloculina mindenensis* Howe., side view, X60., 7- *Triloculina mindenensis* Howe., apertural view, X60., 8- *Triloculina oblonga* Montagu, side view, scale bar 100µm., 9- *Triloculina oblonga* Montagu, side view, scale bar 100µm., 10- *Triloculina oblonga* Montagu, apertural view, scale bar 100µm., 11- *Triloculina peroblonga* Cushman, side view, X60., 12- *Triloculina quadrata* Collins, side view, X60., 13- *Triloculina quadrata* Collins, side view, X60., 14- *Triloculina bertheliana* Brady, side view, scale bar 230µm., 15- *Triloculina bertheliana* Brady, apertural view, scale bar 205µm., 16- *Triloculina* sp., apertural view, scale bar 170µm., 17- *Articulina antillarum* Cushman, side view, X60., 18- *Articulina carinata* Wiesner, edge view, scale bar 170µm., 19- *Articulina carinata* Wiesner, side view, scale bar 160µm., 20- *Articulina carinata* Wiesner, apertural view, scale bar 120µm.

Plate IV

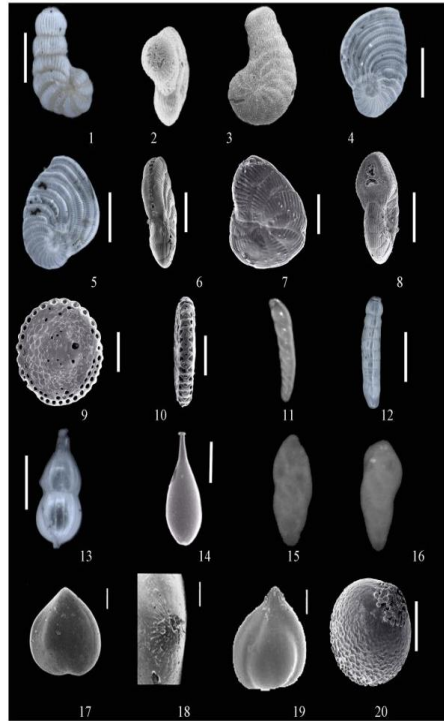


Plate IV

1- *Coscinospira hemprichii* Ehrenberg, spiral view, scale bar 375µm., 2- *Coscinospira hemprichii* Ehrenberg, apertural view, X100., 3- *Coscinospira hemprichii* Ehrenberg, spiral side, X60., 4- *Peneroplis planatus* Fichtel and Moll, spiral side, scale bar 665µm., 5- *Peneroplis planatus* Fichtel and Moll, spiral side, scale bar 575µm., 6- *Peneroplis planatus* Fichtel and Moll, apertural view, scale bar 430µm., 7- *Peneroplis pertusus* D'orbigny, spiral side, scale bar 325µm., 8- *Peneroplis pertusus* D'orbigny, apertural view, scale bar 340µm., 9- *Sorites orbiculus* Forskal, spiral side, scale bar 280µm., 10- *Sorites orbiculus* Forskal, edge view, scale bar 260µm., 11- *Dentalina inornata* D'orbigny, side view, X60., 12- *Amphimorphina butonensis* Keyzer, side view, scale bar 560µm., 13- *Amphicoryna* sp. side view, scale bar 190µm., 14- *Procerolagena clavata* D'orbigny, side view, 300µm. 15- *Pseudopolymorphina hanzawai* Cushman and Ozawa, side view, X60., 16- *Pseudopolymorphina hanzawai* Cushman and Ozawa, side view, X60., 17- *Sigmoidella elegantissima* Parker and Jones, side view, scale bar 100µm., 18- *Sigmoidella elegantissima* Parker and Jones, apertural view, scale bar 100µm., 19- *Sigmoidella elegantissima* Parker and Jones, side view, scale bar 100µm. and 20- *Oolina* sp., apertural view, scale bar 105µm.

Description: Test elongate, uniserial and rectilinear, consist of two global chambers, base commonly apiculate; semi-lobulate and angular periphery; suture lines curved, depressed; wall hyaline, perforate; surface longitudinally striate; aperture terminal, rounded at the end of neck.

Remarks: In this study, it was recorded as a rare form in SQB25 (Table 1).

Family: Lagenidae REUSS, 1862

Genus: *Procerolagena* R. W. JONES, 1984

*Procerolagena clavata* D'ORBIGNY, 1826

Pl. IV, Fig.14.

Remarks: This species was identified by D'orbigny, 1826, from The Hebridean shelf, west of Scotland (Murray, 2003). In this study, it was distinguished as a rare form in SQB25 (Table 1).

Family: Polymorphinidae D'ORBIGNY, 1839

Subfamily: Falsoguttulininae LOEBLICH and TAPPAN, 1986

Genus: *Pseudopolymorphinoides* VAN BELLEN, 1946

*Pseudopolymorphina hanzawai* CUSHMAN and OZAWA, 1928

Pl. IV, Figs. 15-16.

Remarks: *Pseudopolymorphina hanzawai* Cushman and Ozawa was originally described from Sado Island, Japan (Loeblich and Tappan, 1988). In this study, it was recorded as a rare form in QB3 and SQB12 (Table 1).

Subfamily: Polymorphininae D'ORBIGNY, 1839

Genus: *Sigmoidella* CUSHMAN and OZAWA, 1928

*Sigmoidella elegantissima* PARKER and JONES, 1865

Pl. IV, Figs. 17-19.

Remarks: In this study, *Sigmoidella elegantissima* Parker and Jones was found as a common form in SQB25 and SQB26 (Table 1).

Family: Ellipsolagenidae SILVESTRI, 1923

Sub Family: Oolininae LOEBLICH and TAPPAN, 1961

Genus: *Oolina* D'ORBIGNY, 1839

*Oolina* sp.

Pl. IV, Fig. 20.

Description: Test unilocular; chamber shape globular to ovate; complete, sub-rounded periphery; wall calcareous, hyaline, radial, surface with very fine longitudinal striate; aperture terminal, rounded.

Remarks: In this study, it was found two shells only. *Oolina* sp. was found as a rare form in SQB25 (Table 1).

Subfamily: Ellipsolageninae A. SILVESTRI, 1923

Genus: *Fissurina* REUSS, 1850

*Fissurina lacunata* BURROWS and HOLLAND, 1895

Pl. V, Figs.1-2.

Remarks: *Fissurina lacunata* Burrows and Holland was recorded from different regions such as Gulf of Mexico, and New Zealand. In this study, it was recorded frequently from sample SQB25 and as a rare form in SQB26 (Table 1).

*Fissurina* sp.

Pl. V, Fig. 3.

Description: Test ovate in outline with short neck, unilocular; complete and sub-angular periphery; wall calcareous, hyaline, finely perforate; surface smooth, with random or regularly aligned punctae; aperture terminal, ovate.

Remarks: In this study, this species was found as a rare form in SQB26 and frequently from in SQB25 (Table 1).

Genus: *Palliolatella* PATTERSON and RICHARDSON, 1987

*Palliolatella bradii* SILVESTRI, 1902

Pl. V, Fig. 4.

Remarks: *Palliolatella bradii* Silvestri was identified from the Gulf of Aqaba. In this study, this species was recorded as an abundant form in sample SQB25, as a common form in sample SQB26, as a frequent form in sample SQB13 and as a rare form in sample SQB12 (Table 1).

*Palliolatella* sp.

Pl. V, Figs. 5-6.

Description: Test elongate ovate, unilocular; complete and subangular periphery; wall calcareous, hyaline, surface smooth, surrounded with three costae; aperture terminal, rounded on a small neck.

Remarks: In this study, this present species was recorded as a rare form in SQB25 and SQB26 (Table 1).

Suborder: Globigerinina DELAGE and HEROUARD, 1896

Superfamily: Globorotaliacea CUSHMAN, 1927

Family: Globorotaliidae CUSHMAN, 1927

Genus: *Globorotalia* CUSHMAN, 1927

*Globorotalia mendardii* PARKER, JONES and BRADY, 1865

Pl. V, Figs. 7-9.

Remarks: In umbilical view, the suture lines are depressed and curved, but they are flush and curved in spiral view. This species was distinguished as an abundant form in sample SQB26, as a frequent form in samples SQB3 and SQB25 and as a rare form in samples SQB12 and SWQ2 (Table 1).

Family: Candeinidae CUSHMAN, 1927

Subfamily: Globigerinitinae BERMUDEZ, 1961

Genus: *Globigerinita* BRÖNNIMANN, 1951

*Globigerinita* sp.

Pl. V, Figs. 10-11.

Description: Test coiled, subglobular, trochospiral; chambers globular to ovate; sutures curved, depressed; rounded lobulate and sub-rounded periphery; wall calcareous, microperforate; surface pitted; aperture in the early stage a low interiomarginal, extraumbilical-umbilical arch.

Remarks: In this study, this species was recorded as a frequently form in SQB13 and SQB25 (Table 1).

Family: Globigerinidae CARPENTER, PARKER, and JONES, 1862

Subfamily: Globigerinae CARPENTER, PARKER, and JONES, 1862

Genus: *Globigerina* D'ORBIGNY, 1826

*Globigerina bulloides* D'ORBIGNY, 1826

Pl. V, Figs. 12-13.

Remarks: The initial chamber larger than the subsequent chambers. It was recorded from different regions such as East Coast of India (Gandhi *et al.*, 2002) and Indian coast (Devi and Rajashekhar, 2009). In this study, this species was found as a common form in samples SQB3 and SQB25 and as a frequent form in samples SQB26 and SWQ2 (Table 1).

*Globigerinoides rubber* D'ORBIGNY, 1839

Pl. V, Figs. 14- 15

Remarks: *Globigerinoides rubber* D'orbigny, was recorded from different regions such as South Africa, Gulf of Mexico, Kenya, Mediterranean Sea, west and east coasts of India, New Zealand Exclusive Economic Zone and European waters (Devi and Rajashekhar, 2009). In this study, this species was distinguished as a common form in samples SQB3 and SQB26, as a frequent form in sample SWQ2 and as a rare form in sample SQB25 (Table 1).

*Globigerinoides sacculifer* BRADY, 1884

Pl. V, Figs. 16-17.

Remarks: chambers of this form is increasing gradually in size. *Globigerinoides sacculifer* Brady, was recorded from Indian coast (Devi and Rajashekhar, 2009). In this study, this form was recorded abundantly from samples SQB25 and SQB26, as a common form in sample SWQ2, as a frequent form in sample SQB3 and as a rare form in samples SQB1 and SQB27 (Table 1).

Suborder: Rotalina DELAGE and HEROUARD, 1896

Superfamily: Bolivinacea GLAESSNER, 1937

Family: Bolivinidae GLAESSNER, 1937

Genus: *Bolivinellina* SAIDOVA, 1975

*Bolivina pseudopunctata* HÖGLUND, 1947

Pl. V, Figs. 18-19.

Remarks: This species was recorded in Hebridean Shelf west of Scotland (Murray, 2003), Island of Læsø in Denmark (Michelsen, 1967) and Disko Bugt, West Greenland (Lloyd, 2006). In this study, this species form was recorded abundantly from samples SQB25 and SQB26, as a common form in sample SWQ2, as a frequent form in samples SQB3 and SQB12 and as a rare form in samples SQB1 and SQB27 (Table 1).

*Bolivina seminuda* CUSHMAN, 1911

Pl. V, Fig. 20.

Remarks: This species was recorded in shelf of Congo in tropical west Africa (Mojtahid *et al.*, 2006). In this study, *Bolivina seminuda* Cushman was recorded as an abundant form in sample SQB10, as a frequent form in samples SQB3, SQB7, SQB8 and SQB25 and as a rare form in samples SQB9 and SQB26 (Table 1).

*Bolivinella folia* PARKER and JONES, 1865

Pl. VI, Fig. 1.

Remarks: *Bolivinella folia* Parker and Jones was originally described from South Australia by Parker and Jones, 1865. In this study, this species was found as a rare form in study area, in SQB25 and SQB26 (Table 1).

Superfamily: Bolivinitacea CUSHMAN, 1927

Family: Bolivinitidae CUSHMAN, 1927

Genus: *Abditodentrix* PATTERSON, 1985

*Abditodentrix rhomboidalis* MILLETT, 1899

Pl. VI, Figs. 2-4.

Plate V

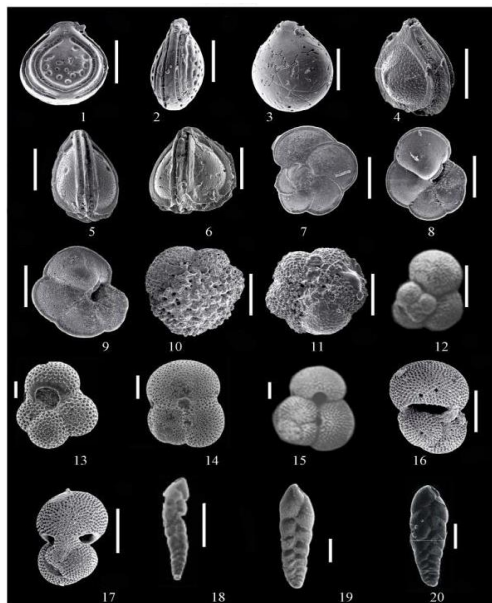


Plate V

1-*Fissurina lacunata* BURROWS and HOLLAND, side view, Scale bar= 155µm., 2- *Fissurina lacunata* BURROWS and HOLLAND, edge view, Scale bar= 145µm., 3- *Fissurina* sp., side view, Scale bar= 115µm., 4- *Palliolatella bradii* SILVESTRI, edge view, Scale bar= 180µm., 5- *Palliolatella* sp., side view, Scale bar= 160µm., 6- *Palliolatella* sp., side view, Scale bar= 160µm., 7- *Globorotalia mendardii* Parker, JONES and BRADY, spiral side, Scale bar= 290µm., 8- *Globorotalia mendardii* Parker, JONES and BRADY, umbilical view, Scale bar= 265µm., 9- *Globorotalia mendardii* Parker, JONES and BRADY, apertural view, Scale bar= 220µm., 10- *Globigerinita* sp., spiral side, Scale bar= 130µm., 11- *Globigerinita* sp., umbilical view, Scale bar= 128µm., 12- *Globigerina bulloides* D'ORBIGNY, spiral side, Scale bar= 100µm., 13- *Globigerina bulloides* D'ORBIGNY, apertural view, Scale bar= 100µm., 14- *Globigerina bulloides* D'ORBIGNY, apertural view, Scale bar= 100µm., 15- *Globigerinoides rubber* D'ORBIGNY, spiral side, Scale bar= 190µm., 16- *Globigerinoides sacculifer* BRADY, aperture view, Scale bar= 290µm., 17- *Globigerinoides sacculifer* BRADY, edge view, Scale bar= 275µm., 18- *Bolivina pseudopunctata* HÖGLUND, side view, Scale bar= 200µm., 19- *Bolivina pseudopunctata* HÖGLUND, side view, Scale bar= 100µm., 20- *Bolivina seminuda* Cushman, edge view, Scale bar= 100µm., 19-20, side views, Scale bar= 100µm.

Plate VI

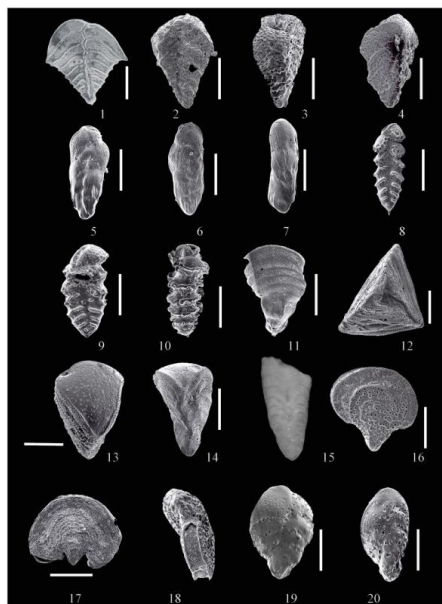


Plate VI

1-*Bolivinella folia* PARKER and JONES, Side View, scale bar= 100µm., 2- *Abditodentrix rhomboidalis* MILLETT, side view, Scale bar= 130µm., 3- *Abditodentrix rhomboidalis* MILLETT, apertural view, Scale bar = 120µm., 4- *Abditodentrix rhomboidalis* MILLETT, edge view, Scale bar= 140µm., 5- *Loxostomina limbata* BRADY, side view, Scale bar = 215µm., 6- *Loxostomina limbata* BRADY, side view, Scale bar = 290µm., 7- *Loxostomina limbata* BRADY, side view, Scale bar= 190µm., 8- *Sagrinella lobata* BRADY, side view, Scale bar=165µm., 9- *Sagrinella lobata* BRADY, side view, Scale bar= 175µm., 10- *Sagrinella lobata* BRADY, side view, Scale bar= 190µm., 11- *Chrysalidinella dimorpha* BRADY, side view, Scale bar= 255 µm., 12- *Chrysalidinella dimorpha* BRADY, side view, Scale bar = 180 µm., 13- *Chrysalidinella dimorpha* BRADY, apertural view, Scale bar = 190 µm., 14- *Chrysalidinella dimorpha* BRADY, edge view, Scale bar = 355 µm., 15- *Chrysalidina pacific* UCHIO, side view, x60, 16- *Pavonina flabelliformis* D'ORBIGNY, side view, Scale bar = 225µm., 17- *Pavonina flabelliformis* D'ORBIGNY, side view, Scale bar= 420µm., 18- *Pavonina flabelliformis* D'ORBIGNY, apertural view, Scale bar= 210µm., 19- *Sigmavirgulina tortuosa* BRADY, side view, Scale bar= 155µm., 20- *Sigmavirgulina tortuosa* BRADY, side view, Scale bar = 165µm.

Remarks: This species was recorded from different regions such as European waters and Mediterranean Sea. In this study, *Abditodentrix rhomboidalis* Millett was found as a rare form in samples SQB3, SQB12 and SQB13 (Table 1).

Superfamily: Buliminacea JONES, 1875

Family: Siphogenerinoididae SAIDOVA, 1981

Subfamily: Siphogenerinoidinae SAIDOVA, 1981

Genus: *Loxostomina* SELLIER DE CIVRIEUX, 1969

*Loxostomina limbata* BRADY, 1881

Pl. VI, Figs. 6-7

Remarks: This species was recorded from beach sands along Saurashtra coast in north-west India (Rao and Srinath, 2002) and East Coast of India (Gandhi *et al.*, 2002). In this study, this species was found as a frequent form in samples SQB10 and SQB12 and as a rare form in samples SQB3 and SQB13 (Table 1).

Genus: *Sagrinella* SAIDOVA, 1975

*Sagrinella lobata* BRADY, 1881

Pl. VI, Figs. 8-10.

Remarks: In Yemen, El-Nakhal, 1984 recorded this species from Salif area. In this study, *Sagrinella lobata* Brady was distinguished as an abundant form in sample SQB12, as a frequent form in sample SQB13 and as a rare form in samples SQB14 and SQB25 (Table 1).

Family: Reussoidae CUSHMAN, 1933

Subfamily: Angulogerininae GALLOWAY, 1933

Genus: *Chrysalidinella* SCHUBERT, 1908

*Chrysalidinella dimorpha* BRADY, 1881

Pl. VI, Figs. 11-14.

Remarks: This species was recorded from southern Thailand (Jumnonghai, 1980). In this study, this species was recorded as an abundant form in samples SQB25 and SQB26 and as a rare form in samples SQB13 and SWQ2 (Table 1).

*Chrysalidina pacific* UCHIO, 1952

Pl. VI, Fig. 15.

Remarks: : *Chrysalidina pacific* Uchio seems as *Chrysalidinella dimorpha* Brady, 1881, but it is taller. In this study, it was recorded in samples SQB25 and SQB26 as a rare form (Table 1).

Family: Pavoninidae EIMER and FICKERT, 1899

Genus: *Pavonina* D'ORBIGNY, 1826

*Pavonina flabelliformis* D'ORBIGNY, 1826

Pl. VI, Figs. 16- 18.

Remarks: In this study, *Pavonina flabelliformis* D'Orbigny was recorded as an abundant form in samples SQB25 and SQB26 (Table 1).

Superfamily: Fursenkoinacea LOEBLICH and TAPPAN, 1961

Family: Fursenkoinidae LOEBLICH and TAPPAN, 1961

Genus: *Sigmavirgulina* LOEBLICH and TAPPAN, 1957

*Sigmavirgulina tortuosa* BRADY, 1881

Pl. VI, Figs. 19-20 and Pl. VII, Figs. 1-2.

Remarks: This species was recorded from Florida (Buzas and Severin, 1982), Maldives Ridg in south eastern Arabian Sea (Sarkar *et al.*, 2009). In Yemen, it was recorded by El-Nakhal, 1993 from Hudaydah, Mukha and Zabeed Sea shores. In this study, it was found

frequently from samples SQB3, SQB12 and SQB25 and a rare form in samples SQB13 and SQB14 (Table 1).

Superfamily: Discorbacea EHRENBERG, 1838

Family: Eponididae HOFKER, 1951

Subfamily: Eponidinae HOFKER, 1951

Genus: *Eponides* DE MONTFORT, 1808

*Eponides cribroripandus* ASANO and UCHIO, 1951

Pl. VII, Figs. 3-4.

Remarks: In initial stages, this species is trochospiral. The aperture extends from the umbilicus to the outer edge on the umbilical side and may be cribrate (Nobes and Uthicke, 2008). In this study, it was found as a frequent form in samples SQB25 and SQB26 and as a rare form in samples SQB1, SQB2 and SQB13 (Table 1).

*Eponides repandus* FICHTEL and MOLL, 1798

Pl. VII, Fig. 5.

Remarks: It was recorded from different regions such as southern Thailand (Jumnongthai, 1980), Florida (Buzas and Severin, 1982), beach sands along Saurashtra coast in north-west India (Rao and Srinath, 2002) and from Indian coast (Devi and Rajashekhar, 2009). In this study, it was recorded as a common form in sample SQB25 and as a rare form in samples SQB5 and SQB13 (Table 1).

Family: Pegidiidae HORN-ALLEN and EARLAND, 1928

Genus: *Neoeponides* REISS, 1960

*Neoeponides schreibersii* D'ORBIGNY, 1846

Pl. VII, Figs. 6-7.

Remarks: In this study, this species was distinguished as a common form in sample SQB13, as a frequent form in samples SQB20, SQB26 and SWQ2 and as a rare form in samples SQB2, SQB14 and SQB25 (Table 1).

Genus: *Schaferina* MC CULLOCH, 1977

*Schaferina annamaryae* MC CULLOCH, 1977

Pl. 7, Fig. 8.

Remarks: In this study, *Schaferina annamaryae* McCulloch was recorded as a rare form in samples SQB3, SQB25, SQB26 and SWQ2 (Table 1).

Family: Rosalinidae REISS, 1963

Genus: *Rosalina* D'ORBIGNY, 1826

*Rosalina bradyi* CUSHMAN, 1915

Pl. VII, Figs. 9-13.

Remarks: This species was recorded in several regions such as France (Debenay *et al.*, 2001), Marmara Sea (Kaminski *et al.*, 2002), Australia marines (Nobes and Uthicke, 2008), Turkey (Meriç *et al.*, 2009), and Indian coast (Devi and Rajashekhar, 2009). In this study, this species was found as an abundant form in samples SQB25 and SQB26, as a common form in sample SQB3, as a frequent form in sample SQB10 and as a rare form in samples SQB12 and SWQ2 (Table 1).

Superfamily: Glabratellacea LOEBLICH and TAPPAN, 1964

Family: Glabratellidae LOEBLICH and TAPPAN, 1964

Genus: *Discorbinoides* SAIDOVA, 1975

*Discorbinoides minogasiformis* UJIIÉ, 1992

Pl. VII, Figs. 14-17.

Remarks: In this study, this species was occurred as an abundant form in samples SQB13, SQB25 and SQB26 and as a rare form in samples SQB20 and SWQ2 (Table 1).

Family: Buliminoididae SEIGLIE, 1970

Genus: *Buliminoides* CUSHMAN, 1911

*Buliminoides williamsoniana* BRADY, 1881

Pl. VII, Fig. 18.

Remarks: It was recorded from Maldives Ridge in south eastern Arabian Sea (Sarkar *et al.*, 2009). In this study, this species was found as a rare form in sample SQB26 (Table 1).

Superfamily: Siphoninacea CUSHMAN, 1927

Family: Siphoninidae CUSHMAN, 1927

Subfamily: Siphoninoidinae LOEBLICH and TAPPAN, 1984

Genus: *Siphoninoides* CUSHMAN, 1927

*Siphoninoides cf. laevigatus* HOWCHIN, 1889

Pl. VII, Fig. 19.

Remarks: In this study, this species was found as abundant form in samples SQB25 and SQB26 (Table 1).

*Siphoninoides echinatus* BRADY, 1879

Pl. VII, Fig. 20 and Pl. 8, Figs.1- 2.

Remarks: This species was recorded from Yemen (Hudaydah, Salif, Zabeed and Mukha) by El-Nakhal, 1993. In this study, *Siphoninoides echinatus* Brady was found as abundant form in samples SQB25 and SQB26 and as a rare form in samples SQB13 and SWQ2 (Table 1).

*Siphoninoides* sp.

Pl. IIX, Figs. 3-4.

Description: Test sub-globular, irregularly trochospiral; periphery sub-lobulate, sub-rounded; wall calcareous, hyaline, thin in the early stage, later much thickened and coarsely perforate; surface pustulose; aperture elevated on a short neck, rounded.

Remarks: In this study, this species was occurred as a common form in samples SQB25 and SQB26 (Table 1).

Family: Cibicididae CUSHMAN, 1927

Subfamily: Cibicidinae CUSHMAN, 1927

Genus: *Cibicides* DE MONTFORT, 1808

*Cibicides refulgens* MONTFORT, 1808

Pl. IIX, Fig. 5-8.

Remarks: *Cibicides refulgens* Montfort, 1808 was recorded from different regions such as France (Debenay *et al.*, 2001), Marmara Sea (Kaminski *et al.*, 2002), beach sands along Saurashtra coast in north-west India (Rao and Srinath, 2002), Hebridean Shelf in west of Scotland (Murray, 2003), Maldives Ridge in south eastern Arabian Sea (Sarkar *et al.*, 2009), Indian coast (Devi and Rajashekhar, 2009), and Mediterranean Sea in Italy (Dias *et al.*, 2010). In this study, It was found as an abundant form in samples SQB13, SQB25, SQB26 and SWQ2, as a common form in sample SQB20, as a frequent form in sample SQB1 and as a rare form in samples SQB2, SQB10, SQB12, SQB19 and SQB24 (Table 1).

Genus: *Montfortella* LOEBLICH and TAPPAN, 1963

*Montfortella bramlettei* LOEBLICH and TAPPAN, 1963

Pl. IIX, Fig. 9.

Remarks: In this study, this species was found as a rare form in samples SQB25, SQB6, SQB27 and SWQ2 (Table 1).

Plate VII

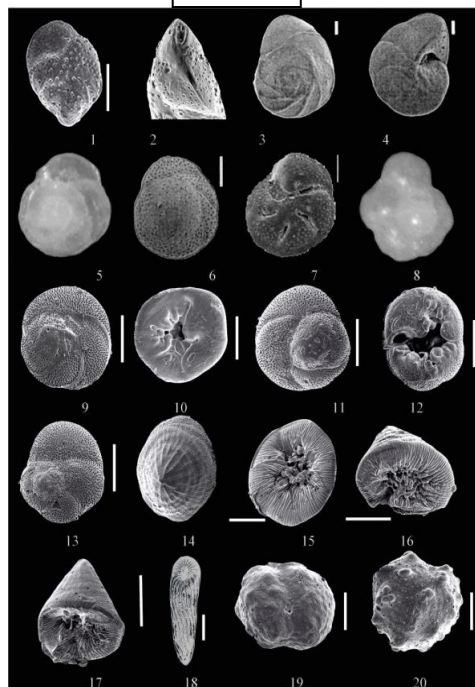


Plate VII

1- *Sigmavirgulina tortuosa* Brady, side view, scale bar 115 $\mu$ m., 2- *Sigmavirgulina tortuosa* Brady, apertural view, scale bar 135 $\mu$ m., 3- *Eponides cribrorepandus* Asano and Uchio, spiral view, scale bar 100 $\mu$ m., 4- *Eponides cribrorepandus* Asano and Uchio, umbilical view, scale bar 100 $\mu$ m., 5- *Eponides repandus* Fichtel and Moll, spiral view, X60., 6- *Neoeponides schreibersii* D'orbigny, spiral view, scale bar 100 $\mu$ m., 7- *Neoeponides schreibersii* D'orbigny, umbilical view, scale bar 100 $\mu$ m., 8- *Schaferina annamaryae* Mc Culloch, spiral view, X60., 9- *Rosalina bradyi* Cushman, spiral view, scale bar 130 $\mu$ m., 10- *Rosalina bradyi* Cushman, umbilical view, scale bar 135 $\mu$ m., 11- *Rosalina bradyi* Cushman, spiral view, scale bar 170 $\mu$ m., 12- *Rosalina bradyi* Cushman, umbilical view, scale bar 185 $\mu$ m., 13- *Rosalina bradyi* Cushman, spiral view, scale bar 215 $\mu$ m., 14- *Discorbinoides minogasiformis* Ujiie, spiral view, scale bar 145 $\mu$ m., 15- *Discorbinoides minogasiformis* Ujiie, umbilical view, scale bar 140 $\mu$ m., 16- *Discorbinoides minogasiformis* Ujiie, side view, scale bar 135 $\mu$ m., 17- *Discorbinoides minogasiformis* Ujiie, scale bar 160 $\mu$ m., 18- *Buliminoides williamsoniana* Brady, apertural view, scale bar 100 $\mu$ m., 19- *Siphoninoides* cf. *laevigatus* Howchin, scale bar 155 $\mu$ m. and 20- *Siphoninoides echinatus* Brady, scale bar 125 $\mu$ m.

Plate IIX

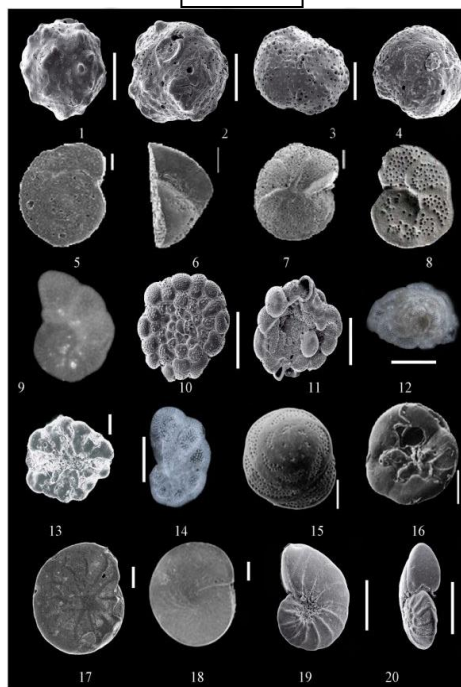


Plate IIX

1- *Siphoninoides echinatus* Brady, side view, scale bar 160 $\mu$ m., 2- *Siphoninoides echinatus* Brady, side view, scale bar 123 $\mu$ m., 3- *Siphoninoides* sp., side view, scale bar 120 $\mu$ m., 4- *Siphoninoides* sp., side view, scale bar 120 $\mu$ m., 5- *Cibicides refulgens* Montfort, spiral view, scale bar 100 $\mu$ m., 6- *Cibicides refulgens* Montfort, edge view, scale bar 100 $\mu$ m., 7- *Cibicides refulgens* Montfort, spiral view, scale bar 100 $\mu$ m., 8- *Cibicides refulgens* Montfort, spiral view, scale bar 100 $\mu$ m., 9- *Montfortella bramlettei* Loeblich and Tappan, spiral view, X60., 10- *Planorbulina mediterraneensis* D'orbigny, spiral view, scale bar 435 $\mu$ m., 11- *Planorbulina mediterraneensis* D'orbigny, umbilical view, scale bar 380 $\mu$ m., 12- *Cymbaloporella tabellaeformis* Brady, spiral view, scale bar 320 $\mu$ m., 13- *Cymbaloporella tabellaeformis* Brady, apertural view, scale bar 100 $\mu$ m., 14- *Epistomaroides punctulatus* Parker and Jones, spiral view, scale bar 230 $\mu$ m., 15- *Asterigerinata mamila* Williamson, spiral view, scale bar 50 $\mu$ m., 16- *Asterigerinata mamila* Williamson, umbilical view, scale bar 50 $\mu$ m., 17- *Amphistegina vulgaris* D'orbigny, spiral view, scale bar 100 $\mu$ m., 18- *Amphistegina radiata* Fichtel and Moll, spiral view, scale bar 100 $\mu$ m., 19- *Nonion tennerbankense* Mc Culloch, spiral view, scale bar 220 $\mu$ m. and 20- *Nonion tennerbankense* Mc Culloch, edge view, apertural view, scale bar 205 $\mu$ m.

Family: Planorbulinidae SCHWAGER, 1877  
 Subfamily: Planorbulinae SCHWAGER, 1877  
 Genus: *Planorbulina* D'ORBIGNY, 1826  
*Planorbulina mediterraneensis* D'ORBIGNY, 1826  
 Pl. IIX, Figs. 10-11.

Remarks: this species was recorded indifferent regions such as Florida (Buzas and Severin, 1982), France (Debenay *et al.*, 2001), Marmara Sea (Kaminski *et al.*, 2002), Guadiana Shelf in southwestern Iberia (Mendes *et al.*, 2004) and from Mediterranean Sea in Italy (Dias *et al.*, 2010). In Yemen, *Planorbulina mediterraneensis* D'Orbigny was recorded from Hudaydah, Salif and Zabeed Sea shore by El-Nakhal, 1993. In this study, this species was identified as a rare form in samples SQB25 and SQB26 (Table 1).

Family: Cymaloporidae CUSHMAN, 1927  
 Subfamily: Cymbaloporinae CUSHMAN, 1927  
 Genus: *Cymbaloporella* CUSHMAN, 1927  
*Cymbaloporella tabellaeformis* BRADY, 1884  
 Pl. IIX, Figs. 12-13.

Remarks: This species was identified from Maldives Ridge in south eastern Arabian Sea (Sarkar *et al.*, 2009). In this study, this species was found as abundant form in sample SQB3 and as a rare form in sample SQB13 (Table 1).

Superfamily: Asterigerinacea D'ORBIGNY, 1839  
 Family: Alfredinidae S. N. SINGH and KALI, 1972  
 Genus: *Epistomaroides* UCHIO, 1952  
*Epistomaroides punctulatus* PARKER and JONES, 1865  
 Pl. IIX, Fig. 14.

Remarks: In this study, *Epistomaroides punctulatus* Parker and Jones was found as rare form in samples SQB25, SQB26, SQB27 and SWQ2 (Table 1).

Family: Asterigerinidae D'ORBIGNY, 1839  
 Genus: *Asterigerina* D'ORBIGNY, 1839  
*Asterigerinata mamila* WILLIAMSON, 1858  
 Pl. IIX, Figs. 15-16.

Remarks: This species was recorded in different regions such as France (Debenay *et al.*, 2001), Marmara Sea (Kaminski *et al.*, 2002), Guadiana Shelf in southwestern Iberia (Mendes *et al.*, 2004) and Turkey (Meriç *et al.*, 2009). In this study, this species was found as a common form in sample SQB13 and as a rare form in samples SQB12 and SWQ2 (Table 1).

Family: Amphisteginidae D'ORBIGNY, 1839  
 Genus: *Amphisteginida* D'ORBIGNY, 1826  
*Amphistegina vulgaris* D'ORBIGNY, 1839  
 Pl. IIX, Fig. 17.

Remarks: *Amphistegina vulgaris* D'Orbigny was recorded as a frequent form in samples SQB22 and SQB25, and as a rare form in samples SQB2, SQB26 and SWQ2 (Table 1).

*Amphistegina radiata* FICHTEL and MOLL, 1798  
 Pl. IIX, Fig. 18.

Remarks: It was recorded from different regions such as beach sands along Saurashtra coast in north-west India (Rao and Srinath, 2002), East Coast of India (Gandhi *et al.*, 2002) and Indian coast (Devi and Rajashekhar, 2009). In this study, the present species was found as an abundant form in samples SQB2, SQB23, SQB26 and SQB27, as a common form in

samples SQB20 and SWQ2, as a frequent form in sample SQB1 and SQB7 and as a rare form in samples SQB4, SQB8, SQB13, SQB14, SQB22 and SQB25 (Table 1).

Superfamily: Nonionacea SCHULTZ, 1854

Family: Nonionidae SCHULTZ, 1854

Subfamily: Nonioninae SCHULTZ, 1854

Genus: *Nonion* DE MONTFORT, 1808

*Nonion tennerbankense* MC CULIOCH, 1977

Pl. IIX, Figs. 19-20.

Remarks: In this study, *Nonion tennerbankense* was found as a rare form in samples SQB1, SQB2, SQB13, SQB25 and SQB26 (Table 1).

Superfamily: Rotaliacea EHRENBERG, 1839

Family: Rotaliidae EHRENBERG, 1839

Subfamily: Pararotaliinae EHRENBERG, 1839

Genus: *Pararotalia* Y. LE CALVEZ, 1949

*Pararotalia calcar* D'ORBIGNY, 1839

Pl. IX, Figs. 1-3.

Remarks: *Pararotalia calcar* D'orbigny was recorded in East Coast of India (Gandhi *et al.*, 2002). In this study, this form was found as an abundant form in samples SQB25 and SQB26 and as a rare form in samples SQB2, SQB19, SQB23 and SWQ2 (Table 1).

*Pararotalia* sp. NOBES and UTHICKE, 2008

Pl. IX, Figs. 4-5.

Remarks: *Pararotalia* sp. was recorded in Australia marines by (Nobes and Uthicke, 2008). In this study, It was found as abundant form in samples SQB25 and SQB26 and as a rare form in samples SQB 12 and SQB13 (Table 1).

Subfamily: Ammoniinae SAIDOVA, 1981

Genus: *Ammonia* BRÜNNICH, 1772

*Ammonia beccarii* CUSHMAN, 1926

Pl. IX, Figs. 6-7.

Remarks: *Ammonia beccarii* Cushman, was recorded from different regions such as southern Thailand (Jumnongthai, 1980), Florida (Buzas and Severin, 1982), France (Debenay *et al.*, 2001), beach sands along Saurashtra coast in north-west India (Rao and Srinath, 2002), East Coast of India (Gandhi *et al.*, 2002), Marmara Sea (Kaminski *et al.*, 2002), Western Australia (Glover *et al.*, 2003), and from Guadiana Shelf in southwestern Iberia (Mendes *et al.*, 2004). In Yemen, *Ammonia beccarii* Cushman was recorded as an abundance form in Hudaydah, Mukha Salif and Zabeed Sea shores by El-Nakhal, 1993. In this study, this species was found as abundant form in samples SQB2, SQB10, SQB12, SQB25, SQB26, SWQ1 and SWQ2, as a common form in sample SQB20, as a frequent form in samples SQB1, SQB11, SQB16 and SQB22 and as a rare form in samples SQB13, SQB17, SQB19 and SQB24 (Table 1).

*Ammonia convexa* NOBES and UTHICKE, 2008

Pl. IX, Figs. 8-9.

Remarks: This species was recorded in Australia marines (Glover *et al.*, 2003) and (Nobes and Uthicke, 2008). In this study, this species was found as abundant form in samples SQB10, SQB12, SQB25, SQB26, SWQ1 and SWQ2 (Table 1).

Family: Calcarinidae SCHWAGER, 1876

Genus: *Elphidiella* CUSHMAN, 1936

*Elphidium macellum* FICHTEL and MOLL, 1798

## Pl. IX, Figs. 10-11.

Remarks: This species was recorded from different regions such as Island of Laesø in Denmark (Michelsen, 1967), Marmara Sea (Kaminski *et al.*, 2002), Maldives Ridge in south eastern Arabian Sea (Sarkar *et al.*, 2009), Indian coast (Devi and Rajashekhar, 2009) and from Turkey (Meriç *et al.*, 2009). In this study, *Elphidium macellum* Fichtel and Moll was found as an abundant form in samples SQB25, SQB26 and SWQ2, as a common form in sample SQB2 and as a frequent form in samples SQB1, SQB13, SQB14, SQB20 and SQB23 (Table 1).

*Elphidium gerthi* VAN VOORTHUYSEN, 1957

## Pl. IX, Figs. 12-13.

Remarks: this species was recorded in Island of Laesø in Denmark (Michelsen, 1967). In this study, *Elphidium gerthi* Van Voorthuysen was found as an abundant form in samples SQB26 and SWQ2, as a common form in sample SQB25, as a frequent form in sample SQB12 and as a rare form in samples SQB1, SQB2, SQB3, SQB13 and SQB19 (Table 1).

*Elphidium jenseni* CUSHMAN, 1924

## Pl. IX, Figs. 14-15.

Remarks: This species was recorded from different regions such as Marmara Sea (Kaminski *et al.*, 2002) and Indian coast (Devi and Rajashekhar, 2009). In this study, it was found as a common form in sample SQB25, as a frequent form in samples SQB3 and SQB26 and as a rare form in samples SQB2, SQB8, SQB12, SQB13 and SWQ2 (Table 1).

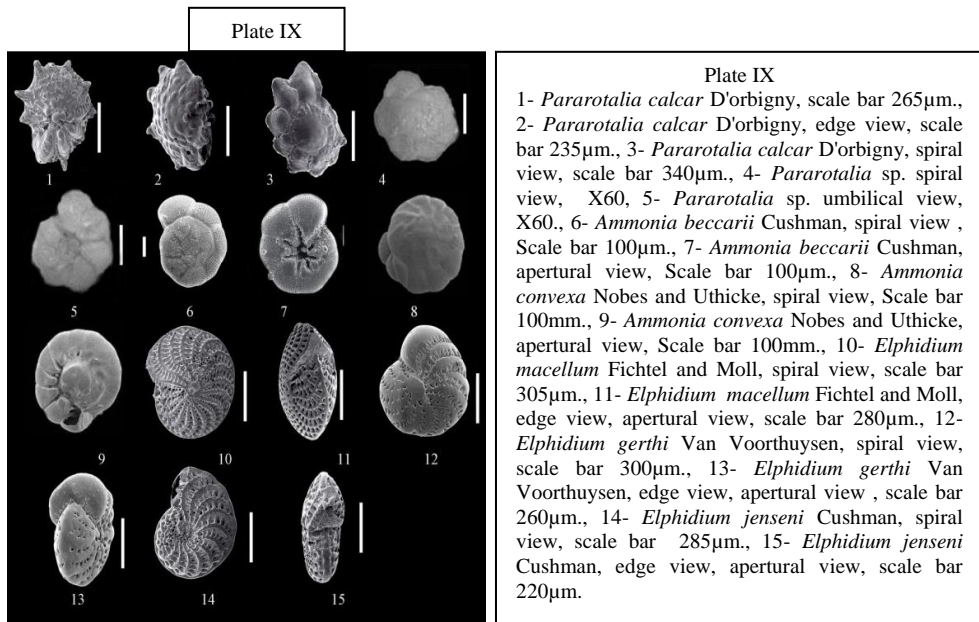


Table 1: Distribution of recorded foraminiferal species in collected samples

| NO | Recorded Species                   | SAMPLES |      |      |      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |      |      |   |
|----|------------------------------------|---------|------|------|------|------|------|------|------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------|------|---|
|    |                                    | SQB1    | SQB2 | SQB3 | SQB4 | SQB5 | SQB6 | SQB7 | SQB8 | SQB9 | SQB10 | SQB11 | SQB12 | SQB13 | SQB14 | SQB16 | SQB17 | SQB19 | SQB20 | SQB22 | SQB23 | SQB24 | SQB25 | SQB26 | SWQ1 | SWQ2 |   |
| 1  | <i>Martinottiella communis</i>     |         |      |      |      |      |      |      |      |      |       |       | R     |       |       |       |       |       |       |       |       |       |       |       |      |      |   |
| 2  | <i>Martinottiella</i> sp.          |         |      |      |      |      |      |      |      |      |       |       | R     |       |       |       |       |       |       |       |       |       |       |       |      |      |   |
| 3  | <i>Textularia agglutinans</i>      | R       |      | R    |      |      |      |      |      |      |       |       |       |       |       |       |       | R     |       |       |       |       |       | C     | A    |      |   |
| 4  | <i>Textularia conica</i>           | R       | R    | F    |      |      |      |      |      |      |       |       | F     |       |       |       |       | R     | R     | R     |       |       |       | A     | A    |      | F |
| 5  | <i>Textularia foliacea</i>         |         |      | R    |      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       | F     | A    |      |   |
| 6  | <i>Sejunctella</i> sp.             |         |      |      |      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       | R     | R    |      |   |
| 7  | <i>Vertebralina striata</i>        |         |      | R    |      |      |      |      |      |      |       |       | R     |       |       |       |       |       |       |       |       |       |       | F     | R    |      |   |
| 8  | <i>Spiroloculina depressa</i>      |         |      | R    |      |      |      |      |      |      |       |       | R     |       |       |       |       |       |       |       |       |       |       | R     | R    |      |   |
| 9  | <i>Spiroloculina laevigata</i>     |         |      |      |      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       | R     |      |      |   |
| 10 | <i>Spiroloculina ornate</i>        |         |      |      |      |      |      |      |      |      |       |       | R     |       |       |       |       |       |       |       |       |       |       | R     |      |      |   |
| 11 | <i>Spiroloculina aequa</i>         |         |      |      |      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       | R     | R    |      |   |
| 12 | <i>Spiroloculina</i> sp.           |         |      |      |      |      |      |      |      |      |       |       | R     |       |       |       |       |       |       |       |       |       |       |       | R    |      |   |
| 13 | <i>Hauerina bradyi</i>             |         |      | R    |      |      |      |      |      |      |       |       | R     |       |       |       |       |       |       |       |       |       |       | A     | A    |      |   |
| 14 | <i>Massilina granulocostata</i>    |         |      | R    |      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       | F     | F    |      |   |
| 15 | <i>Quinqueloculina flavescens</i>  |         | R    |      |      |      |      |      |      |      |       |       |       |       |       |       |       |       | F     |       |       |       |       | A     |      |      |   |
| 16 | <i>Quinqueloculina poeyana</i>     |         |      |      |      |      |      |      |      |      | A     |       | F     |       |       |       |       |       |       |       |       |       |       |       |      | F    | R |
| 17 | <i>Quinqueloculina parkeri</i>     | R       |      |      | R    |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |      | F    | F |
| 18 | <i>Quinqueloculina subdecorata</i> |         |      |      |      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |      | R    |   |
| 19 | <i>Quinqueloculina</i> sp.         |         |      | F    |      |      |      |      |      |      |       |       |       |       |       |       |       | R     |       |       |       |       |       |       | C    |      |   |
| 20 | <i>Biloculina labiata</i>          |         |      | R    |      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       | F     | C    |      | R |
| 21 | <i>Triloculina trihedra</i>        | C       |      | F    |      |      |      |      |      |      |       |       | R     | C     |       |       |       |       |       |       |       |       |       | R     | A    | R    | A |
| 22 | <i>Triloculina longidentata</i>    |         |      |      |      |      |      |      |      |      |       |       | R     | R     |       |       |       |       |       |       | R     |       |       | C     | A    |      |   |
| 23 | <i>Triloculina mindenensis</i>     |         |      | F    |      |      |      |      |      |      |       |       | F     |       |       |       |       |       |       |       |       |       |       |       |      |      | A |
| 24 | <i>Triloculina oblonga</i>         | R       |      | F    |      |      |      |      |      |      |       |       | A     | F     |       |       |       | R     |       |       |       |       |       | F     |      |      |   |
| 25 | <i>Triloculina peroblonga</i>      |         |      | C    |      |      |      |      |      |      |       |       |       | C     | R     |       |       |       |       |       |       |       |       |       | C    | F    |   |
| 26 | <i>Triloculina quadrata</i>        |         |      | C    |      |      |      |      |      |      |       |       |       | R     |       |       |       |       | R     |       |       |       |       |       | F    | F    |   |





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## مقبات حديثة من جزيرة سقطرى، المحيط الهندي، اليمن

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### ملخص

تم استخلاص 68 نوعا من أنواع الفورامنيفرا من خمس وعشرين رملية جمعت من شواطئ الشريط الساحلي الشمالي لجزيرة سقطرى. هذه الأنواع تتبع في تصنيفها لـ 52 جنسا، 22 تحت عائلة، 35 عائلة، 16 فوق عائلة و 6 تحت رتبة. تم مناقشة الوضع التصنيفي لهذه الأنواع كما تمت مقارنة هذه الأنواع مع الأنواع النظامية لها ووصف الأنواع التي لم تتمكن من تعيين الوضع التصنيفي لها إلى مستوى النوع.



## Evaluation the Bioactivity of Some Medicinal Plants and Arabic perfumes Extracts on Selected Pathogenic Fungi

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### ABSTRACT

The antimicrobial effect of aqueous extracts of Six medicinal plants *Cinnamomum zylanicum* (Bark), *Dianthus caryophyllus* (Fruit), *Zingiber officinale*, *Allium sativum* (Fruit), *Curcuma longa* and *Elettaria cardamomum*), three kinds of musk (Red musk, China& Indian musk), Propriis and Teab were studied against four fungi namely, *Aspergillus flavus*, *Epidermophyton floccosum*, *Microsporium canis* and one yeast *Candida albicans* that are had a medicinal importance and cause skin infections. The inhibition zones were determined by using agar well diffusion method. The results revealed that *Dianthus caryophyllus* was had the best antimicrobial properties (Fruit), followed in order by *Allium sativum* (Fruit), *Cinnamomum zylanicum* (Bark), then Red musk and Teab. The minimum inhibitory concentration (MIC) for the aqueous extract was between (1:6) and (1:1) dilutions for fungi under study. The results therefore established a good support for the use of *Dianthus caryophyllus*, *Allium sativum* and *Cinnamomum zylanicum*, in traditional medicine

### INTRODUCTION

Plants have a great potential for producing new drugs of great benefit to mankind. There are many approaches to the search for new biologically active principles in higher plants (1). Many efforts have been done to discover new antimicrobial compounds from various kinds of sources such as soil, microorganisms, animals and plants (2). The active components of herbal remedies have the advantage of being combined with many other substances that appear to be inactive. However, these complementary components give the plant as a whole a safety and efficiency much superior to that of its isolated and pure active components (3).

In spite of the existence of potent antibiotic and antifungal agents, resistant strains are continuously appearing, so the antibiotic resistance has become a global concern (4). Imposing the need for a permanent search and development of new drugs (5). The screening of plant extracts and plant



products for antimicrobial activity has shown that higher plants represent a potential source of novel antibiotic prototypes (6). Numerous studies have identified compounds within herbal plants that are effective antibiotics (7). Traditional healing systems around the world that utilize herbal remedies are an important source for the discovery of new antibiotics (8). Some traditional remedies have already produced compounds that are effective against antibiotic-resistant strains of bacteria (9) others only use aquatic, alcoholic or organic extractions for the same purpose (10)

The aims of this study is to investigate the aqueous extracts of some natural compound and medicinal plants that may be used as therapeutic potential to control fungal diseases.

## MATERIAL AND METHODS

### Collection of Plants and other natural compound:

Six fresh or dried plant parts were collected randomly from Sana'a market, Yemen. Whole medicinal plants (*Cinnamomum zylanicum* (Bark), *Dianthus caryophyllus* (Fruit), *Zingiber officinale*, *Allium sativum* (Fruit), *Curcuma longa* and *Elettaria cardamomum*), in addition to three kinds of musk (Red musk, China musk & Indian musk), Propolis and Teab were taken for investigation of antimicrobial property. The Fresh plant material were washed under running by sterilized distilled water, air dried and then homogenized to fine powder and stored in airtight bottles.

### Preparation of extracts:

Aqueous extraction, 10 g of air-dried powder was added to 10 ml distilled water and extracted by shaking at room temperature, for 30 minute and stored at 4 °C (11).

### Microorganisms:

*In vitro* antimicrobial activity was examined for aqueous extracts from six medicinal plants and three natural products that used by traditional healers. The well identification microorganisms were obtained from Central Public Health Laboratory (CPHL) (20 specimens) and Modern International Laboratory (52 specimens), Sana'a, Yemen. Microorganisms were maintained at 4°C on Sabouraud dextrose agar.

### Antimicrobial assay:

The antimicrobial assay was performed by well diffusion method (12). The Sabouraud dextrose agar was inoculated with the 100 µl of the inoculum ( $1 \times 10^8$  Cfu) and poured into the Petri plate. With the help of a cork-borer (0.8cm). 100 µl of the extract was introduced into the well. The plates were incubated overnight at 37 °C. Control was maintained where pure sterile distilled were used instead of the extract. The result was obtained by measuring the inhibition zone diameter (mm). The experiment was done three times and the mean values are presented.

### Determination of minimum inhibition concentration (MIC).

Different concentration of the extracted antimicrobial agent were carried to obtain the lowest concentration that give antimicrobial effect. Dilution series was by using sterile distilled water (Gul, *et al.*, 2004). Seven fold dilutions were prepared in the water serially. One ml of each dilution was added in to

the holes of the seeded plates with target organisms. The MIC was determinate by agar well method; the inhibition zones that appeared around the wells determinate the effect of the extract. The highest dilution preventing the organism growth was represented as MIC (13; 14).

## RESULTS AND DISCUSSION

The data reported in Table (1) presents the antimicrobial activity of the aqueous extracts agonist *Candida albicans*. The results indicate that the extracts from the medicinal plant studied showed the largest inhibition zone around *Dianthus caryophyllus* (40mm), and the MIC was at (1:6), follows by *Cinnamomum zylanicum* (35mm ), and the MIC was at (1:4), *Allium sativum* (28mm), (see Fig 1), then *Red musk* and the MIC was at (1:2) dilution after one day. However the rest extracts were shown no effect.

Table (1): Antimicrobial activity of aqueous extracts at different dilutions on *Candida albicans*

| Extracts \ Dilutions         | Zone of inhibition (mm) |     |     |     |     |     |     |
|------------------------------|-------------------------|-----|-----|-----|-----|-----|-----|
|                              | 1:1                     | 1:2 | 1:3 | 1:4 | 1:5 | 1:6 | 1:7 |
| <i>Allium sativum</i>        | 28                      | 16  | 16  | 15  | -   | -   | -   |
| <i>Curcuma longa</i>         | -                       | -   | -   | -   | -   | -   | -   |
| <i>Cinnamomum zylanicum</i>  | 35                      | 20  | 17  | 16  | -   | 11  | -   |
| <i>Dianthus caryophyllus</i> | 40                      | 29  | 25  | 23  | 12  | 11  | -   |
| <i>Zingiber officinale</i>   | -                       | -   | -   | -   | -   | -   | -   |
| <i>Elettaria cardamomum</i>  | -                       | -   | -   | -   | -   | -   | -   |
| Teab                         | -                       | -   | -   | -   | -   | -   | -   |
| <i>Red musk</i>              | 18                      | 15  | -   | -   | -   | -   | -   |
| <i>China musk</i>            | -                       | -   | -   | -   | -   | -   | -   |
| <i>Indian musk</i>           | -                       | -   | -   | -   | -   | -   | -   |
| <i>Propriis</i>              | -                       | -   | -   | -   | -   | -   | -   |

Values are mean of three replicates; -: no inhibition zone; cork-borer diameter 8 mm, the extract diluted by sterile distilled water



Fig (1) Inhibition zones of *Allium sativum* (left) *Cinnamomum zylanicum*(mid) *Dianthus caryophyllus* (right) on *Candida albicans* at (1:2) dilution , after (1) day

Table (2) shows the antimicrobial activity of the aqueous extracts on *Aspergillus flavus*. The results of the medicinal plant extracts studied showed the largest inhibition zone around *Dianthus caryophyllus* (45mm), and the MIC was at (1:6), follows by *Cinnamomum zylanicum* (39mm), and the MIC was at (1:6), *Allium sativum* (28mm) , *Red musk* at (22mm) and the MIC was at (1:2), then Teab (19) and MIC was at (1:1) dilution after one day (Fig 2,3). Although the other extracts had no effect.

Table (2): Antimicrobial activity of aqueous extracts at different dilutions on *Aspergillus flavus*

| Extracts                     | Dilutions |     | Zone of inhibition (mm) |     |     |     |     |
|------------------------------|-----------|-----|-------------------------|-----|-----|-----|-----|
|                              | 1:1       | 1:2 | 1:3                     | 1:4 | 1:5 | 1:6 | 1:7 |
| <i>Allium sativum</i>        | 28        | 21  | 19                      | 17  | 14  | 14  | -   |
| <i>Curcuma longa</i>         | -         | 10  | -                       | -   | -   | -   | -   |
| <i>Cinnamomum zylanicum</i>  | 39        | 23  | 17                      | 16  | 15  | 15  | -   |
| <i>Dianthus caryophyllus</i> | 45        | 31  | 26                      | 15  | 13  | 10  | -   |
| <i>Zingiber officinale</i>   | -         | -   | -                       | -   | -   | -   | -   |
| <i>Elettaria cardamomum</i>  | -         | -   | -                       | -   | -   | -   | -   |
| Teab                         | 19        | -   | -                       | -   | -   | -   | -   |
| <i>Red musk</i>              | 22        | 15  | -                       | -   | -   | -   | -   |
| <i>China musk</i>            | -         | -   | -                       | -   | -   | -   | -   |
| <i>Indian musk</i>           | -         | -   | -                       | -   | -   | -   | -   |
| <i>Propris</i>               | -         | -   | -                       | -   | -   | -   | -   |

Values are mean of three replicates; -: no inhibition zone; cork-borer diameter 8 mm, the extract diluted by sterile distilled water

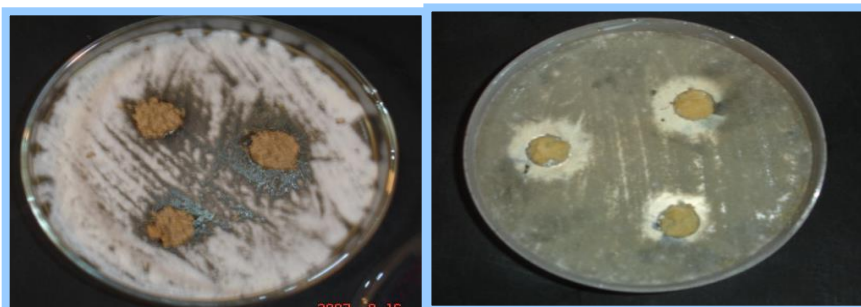


Fig (2) Inhibition zones of the teab (left) and Red musk (right) on *Aspergillus flavus* at (1:1) dilution, after (1) day

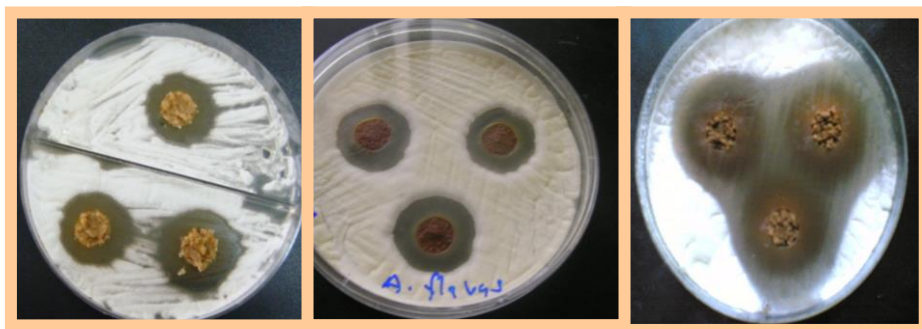


Fig (3): Inhibition zones of *Allium sativum* (left) *Cinnamomum zylanicum*(mid) *Dianthus caryophyllus* (right) on *Aspergillus flavus* at (1:2) dilution , after (1) day

All most all of studied extracts had no bioactivity on *Microsporum canis* except of the Teab aqueous extracts that shows in Fig (4), the inhibition zone was (17mm ) at (1:1) dilution



Fig (4): Inhibition zones of Teab on *Microsporum canis* at(1:1) dilution, after (10) days

Table (3): Antimicrobial activity of aqueous extracts at different dilutions on *Epidermophyton floccosum*

| Extracts \ Dilutions        | Zone of inhibition (mm) |     |     |     |     |     |     |
|-----------------------------|-------------------------|-----|-----|-----|-----|-----|-----|
|                             | 1:1                     | 1:2 | 1:3 | 1:4 | 1:5 | 1:6 | 1:7 |
| <i>Allium sativum</i>       | -                       | 35  | -   | -   | -   | -   | -   |
| <i>Curcuma longa</i>        | -                       | -   | -   | -   | -   | -   | -   |
| <i>Cinnamomum zylanicum</i> | -                       | 12  | -   | -   | -   | -   | --  |

|                              |    |    |    |   |   |   |   |
|------------------------------|----|----|----|---|---|---|---|
| <i>Dianthus caryophyllus</i> | CI | CI | CI |   |   |   | - |
| <i>Zingiber officinale</i>   | -  | -  | -  | - | - | - | - |
| <i>Elettaria cardamomum</i>  | -  | -  | -  | - | - | - | - |
| Teab                         | -  | -  | -  | - | - | - | - |
| Red musk                     | -  | -  | -  | - | - | - | - |
| China musk                   | -  | -  | -  | - | - | - | - |
| Indian musk                  | -  | -  | -  | - | - | - | - |
| Propriis                     | -  | -  | -  | - | - | - | - |

Values are mean of three replicates; - no inhibition zone; CI: Completely inhibited, cork-borer diameter 8 mm, extracts diluted by sterile distilled water

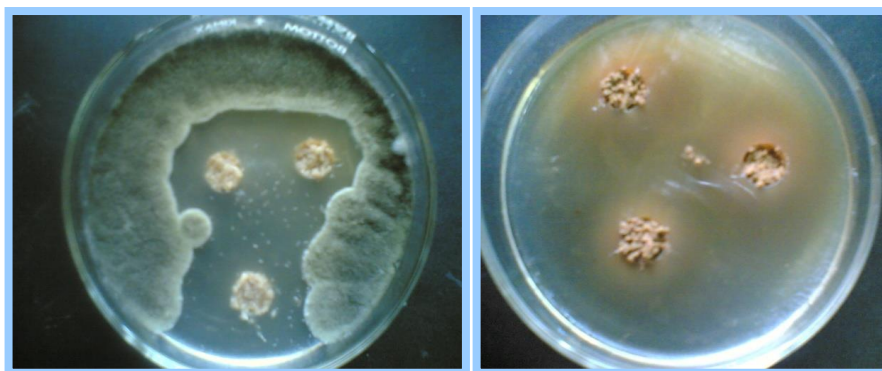


Fig (5): Inhibition zones of *Allium sativum* (left) *Dianthus caryophyllus* (right) on *Epidermophyton floccosum* at (1:2) dilution, after (5) days

The present study has shown that *Dianthus caryophyllus* (Fruit), *Allium sativum* (Fruit), *Cinnamomum zylanicum* (Bark) possesses remarkable fungi toxic activity against many human skin pathogens. Thus, there is a possibility of developing these plants sources of antifungal agent and further investigations are necessary to identify the bioactive principles. The antimicrobial effect of powerful extracts may be due to their characteristic, strongly aromatic taste, furthermore the effect of some essential oil and antimicrobial substances found in these plants. Afterward we can talk over researches that similar or related to our research, also had analogues result by similar or different microorganisms. Certain researches studied the antimicrobial agent *in vitro* or *in vivo*

*Dianthus caryophyllus* major chemical constituents is an essential oil, which is characterized by the presence of eugenol (60-95%), eugenol acetate (2-27%), and  $\alpha$ - and  $\beta$ -caryophyllene (5-10%) (15, 16, 17, 18, 19), and use in pharmacopoeias and in traditional systems as external or local applications for the treatment of toothache, and minor infections of the mouth and skin. Also used as an antiseptic for dressing of minor wounds, and, in the form of lozenges, for sore throats and coughs associated with the common cold. The essential oil (1-5%) is used in mouthwashes (20, 18, 21)

*In vitro* ethanol (95%) or aqueous extracts of Flos Caryophylli (*Dianthus caryophyllus*) inhibited the growth *Staphylococcus aureus* (21). The juice of the flower bud inhibited the growth of *Mycobacterium tuberculosis*

(minimal inhibitory concentration [MIC] 1:160) (22). The powdered crude drug inhibited the growth of *Yersinia enterocolitica* when added to the medium at a concentration of 1-3% (w/w) (23, 24). An aqueous extract of the flower buds inhibited the growth of *Bacillus subtilis* (25). A chloroform extract of the flower buds inhibited the growth of *Cladosporium werneckii* (26). A 50% ethanol extract of the flower buds inhibited the growth of *Aspergillus fumigatus*, *Aspergillus niger*, *Botrytis cinerea*, *Fusarium oxysporum*, *Penicillium digitatum*, *Rhizopus nigricans*, *Trichophyton mentagrophytes*, *Candida albicans* and *Saccharomyces pastorianus* at a concentration of 500mg/ml (27).

Eugenol, of *Dianthus caryophyllus* is one of the active constituents of the flower buds, inhibited the growth in vitro of *Staphylococcus aureus*, *Propionibacterium acnes* and *Pseudomonas aeruginosa*, with an MIC of 0.05, 0.05 and 0.80mg/ml, respectively (29, 28). In other studies, eugenol had a broad spectrum of antibacterial activity in vitro, inhibiting the growth of *Clostridium sporogenes*, *Enterobacter aerogenes*, *Escherichia coli*, *Klebsiella pneumoniae*, *Proteus vulgaris*, *Pseudomonas aeruginosa*, *Salmonella pullorum*, *Staphylococcus aureus*, *Streptococcus faecalis* and *Comamonas terrigena* at various concentrations (30, 31). Eugenol also had a broad spectrum of antifungal activity in vitro, inhibiting the growth of *Alternaria alternata*, *Aspergillus fumigatus*, *Aspergillus niger*, *Aspergillus flavus*, *Cladosporium werneckii*, *Cladosporium cucumerinum*, *Colletotrichum capsici*, *Helminthosporium oryzae*, *Microsporium canis*, *Penicillium expansum*, *Phytophthora parasitica*, *Rhizopus nodosus*, *Trichophyton mentagrophytes* and *T. rubum* at various concentrations (32-33).

An aqueous extract of *Dianthus caryophyllus* flower buds suppressed the replication of herpes simplex virus (HSV) in vitro at a concentration of 50µg/ml (34). An aqueous extract of the flower buds had antiviral activity against HSV-1 in vitro (IC<sub>50</sub> 60µg/ml), and in mice (250mg/kg body weight by gastric lavage) (35). A hot aqueous extract of the flower buds suppressed the replication of HSV-1, measles virus and poliovirus-1 in Vero cells in vitro at a concentration of 0.5mg/ml (36). Intra-gastric administration of a decoction of the flower buds (750mg/kg body weight) decreased HSV-1 genome titres and the severity of HSV infection in mice with recurring herpetic lesions induced by ultraviolet light (37). Eugenol at a concentration of 0.1-10µg/ml demonstrated antiviral activity against HSV and adenovirus-6 in vitro (38). Eugenol isolated from the flower buds exhibited anti-HSV-1 activity in mice (39).

In vitro studies, *Allium sativum* (garlic) has been found to have antibacterial, antiviral, and antifungal activity. However, these actions are less clear in vivo. It is also claimed to help prevent heart disease (including atherosclerosis, high cholesterol, and high blood pressure) and certain types of cancer, including stomach and colon cancers.(40)

Garlic cloves(*Allium sativum*) are used as an antiseptic to prevent gangrene during World War I and World War II.(41) More recently, it has been found from a clinical trial that a mouthwash containing 2.5% fresh garlic shows good antimicrobial activity, although the majority of the participants reported an unpleasant taste and halitosis.(42) and remedy for infections (especially chest problems), digestive disorders, and fungal infections such as thrush.(43) Garlic can be used as a disinfectant because of its bacteriostatic and bacteriocidal properties.(44) Likewise, has been used reasonably successfully in AIDS patients to treat *Cryptosporidium* in an uncontrolled study in China.(45) It has also been used by at least one AIDS patient to treat toxoplasmosis, another protozoal disease. (46)

When crushed, *Allium sativum* yields allicin, an antibiotic (47) and antifungal compound (phytoncide). Fresh or crushed garlic also affords the sulfur-containing compounds alliin, ajoene, diallyl polysulfides, vinyl dithiols, S-allylcysteine, and enzymes, B vitamins, proteins, minerals, saponins, flavonoids, and Maillard reaction products, which are not sulfur-containing compounds. Furthermore, a phytoalexin (allixin) was found, a nonsulfur compound with a  $\gamma$ -pyrone skeleton structure with antioxidant effects, antimicrobial effects, (48) antitumor promoting effects, inhibition of aflatoxin B2 DNA binding, and neurotrophic effects. Allixin showed an antitumor promoting effect in vivo, inhibiting skin tumor formation by TPA and DMBA initiated mice. Analogs of this compound have exhibited antitumor promoting effects in in vitro experimental conditions. Herein, allixin and/or its analogs may be expected useful compounds for cancer prevention or chemotherapy agents for other diseases.(49)

The researches of *Cinnamomum zylanicum*, had explained that; the external treated as a poultice can treat minor bacterial and fungal infections on the skin. Some of the plant constituents have proven value against bacteria and fungi, including the fungi that produce the carcinogenic aflatoxins. Its essential oil contains both antifungal and antibacterial principles that can be used to prevent food spoilage due to bacterial contamination. (50,51,52) Certain uses of cinnamon as a germicide, that used internally in typhoid fever and in the treatment of cancer and other microbial diseases. It is also said to be used as an antiseptic. Further studies with regard to cinnamon extracts against food borne pathogens and foliage microorganisms by Lopez, p, et al, (2009) has proven that the highest antibacterial activity was found for cloves and cinnamon against most of the bacterial cocktails and they have further concluded that use of cinnamon essential oil can provide an

adequate degree of protection against food borne pathogens to a certain extent due to its anti-bacterial quality(50,51)

A number of plants such as *Vitis vinifera* L. extract (Vitaceae) is used in conditions like burning sensations, hemorrhages, anemia, leprosy, skin diseases, syphilis, asthma, jaundice, bronchitis (Anjaria et al., 2002; Sriram et al., 2004). Similarly, an essential oil in the tubers has antibiotic activity and has been shown to arrest the growth of *Micrococcus pyrogenes* (53)

A similar study of screening the natural plant extracts against different fungal and bacterial pathogens was well recorded in literature (54,55). The systematic screening of plant species with the purpose of discovering new bioactive compounds is a routine activity in many laboratories. In particular, the search for components with antimicrobial activity has gained increasing importance in recent times, due to growing worldwide concern about the alarming increase in the rate of infection by antibiotic-resistant microorganisms (56).

Consequently plants are potent biochemists and have been components of phytomedicine since times immemorial; man is able to obtain from them a wondrous assortment of industrial chemicals. Plant based natural constituents can be derived from any part of the plant like bark, leaves, flowers, roots, fruits, seeds, etc (57) i.e. any part of the plant may contain active components. The beneficial medicinal effects of plant materials typically result from the combinations of secondary products present in the plant. The medicinal actions of plants are unique to particular plant species or groups are consistent with this concept as the combination of secondary products in a particular plant is taxonomically distinct. Since plants have co- evolved with pathogens, it is reasonable to expect a variety of such compounds with specific as well as general antifungal activity (58).

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## تقدير النشاط الحيوي للمستخلصات المائية لبعض النباتات الطبية وبعض الطيوب العربية على فطريات ممرضة منتقاة

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### ملخص

درس النشاط الضد ميكروبي للمستخلصات المائية لستة نباتات طبية بالإضافة الى المسك الهندي، الصيني والاحمر وكذلك الطيب على اربعة اجناس مختلفة من الفطريات ذات الاهمية الطبية والتي تسبب العدوي الجلدية وهذه الفطريات هي: *Aspergillus flavus*, *Epidermophyton floccosum*, *Microsporium canis* بالإضافة الى نوع واحد من الخمائر هو *Candida albicans*. و استخدمت طريقة الانتشار عبر الاجار المثقوب لتحديد منطقة التثبيط وكانت النتيجة ان القرنفل *Dianthus caryophyllus* حاز على اكبر منطقة تثبيط يليه الثوم *Allium sativum* ويأتي بعدهما نبات القرفة *Cinnamomum zylanicum* ويليه المسك الاحمر والطيب. وكان اقل تركيز مثبط يتراوح بين التخفيفات (1:6) و (1:1) للفطريات قيد الدراسة وهذه الدراسة تدعم استخدام هذه النباتات في الطب الشعبي .

## Study of 2-Amino-2-Methyl-1-Propanol Effect on Corrosion of Boiler Low Carbon Steel Pipes in Presence of Sodium Sulfite

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### ABSTRACT

This paper studies the effect of 2-Amino-2-methyl-1-propanol ( $C_3H_{11}NO$ ) on corrosion behavior of boiler steel pipes with low carbon content at sodium sulfite ( $Na_2SO_3$ ) in the additive mixtures form as oxygen scavengers in the boiler feed water.

Experiments were done at temperatures (100 - 150) °C and pressures (5 - 9) × 101.3 KN/m<sup>2</sup> in cylinder autoclave with 7.4 ppm dissolved oxygen in used water, then the corrosion rate is measured by weight loss technique and the concentration of dissolved oxygen in feed water was determined before and after the experiment by Winkler method (Titration).

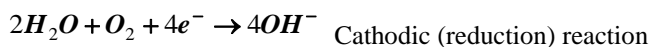
This analysis can provide valuable information for mixture scavengers and corrosion behavior on boiler steel pipes with range of used temperature and pressure. The better ratios found is 60 ppm for every one of amine and sulfite, with the best result in decreasing corrosion rate in acceptable way. The above mentioned ratio is optimal and recommended. This opens up the field for formulation synergetic packages of additives as O<sub>2</sub> scavengers .

*Keywords:* Oxygen Scavenger,  $Na_2SO_3$ ,  $C_3H_{11}NO$ , Boiler Steel Pipes, NA-Sulfite & 2-Amino-2-methyl-1-propanol Additive Package

### INTRODUCTION

The main use of water in industry is transferring of heat and the production of steam<sup>1</sup>. The steam boilers are constructed according to various designs, but they consist essentially of low carbon steel for water which is heating by hot gases<sup>2,3</sup>.

Appreciable corrosion of steel requires dissolved oxygen in neutral solution<sup>1</sup>. Therefore, the dissolved oxygen was the main cause of corrosion in neutral aqueous solution, because it is represented the main cathodic reaction which occurs in that cathodic areas<sup>4</sup>.



While the anodic reaction represent the oxidation of metal iron to its ions and transfer into the solution, which causes losing in the weight of metal<sup>5,6</sup>.



The oxygen is very energetic cathodic and depolarizer. With an increase of oxygen concentration in the water can expect an increase in the rate of corrosion of metals, particularly steel<sup>6,7</sup>. Therefore, any remained of dissolved oxygen in the water of boiler unites quantitatively with the metals of the boiler system and causing pitting of the boiler tubs and general attack elsewhere<sup>3,8,9,10</sup>. Stringent control of dissolved oxygen to absolute minimum levels is an obvious requirement to control corrosion in closed high temperature boiler system<sup>1</sup>.

Dissolved oxygen may be removed mechanically or chemically. Mechanical deaeration involves either heating or purging with a counter flow of gas to strip the oxygen from the water. Both heating and stripping may be accomplished with a counter flow of steam<sup>1,11</sup>. Chemical scavenging is usually necessary to reduce dissolved oxygen to levels acceptable for applications<sup>1,12,13</sup>.

Sodium sulfite has been used as oxygen scavenger<sup>12</sup>, which is very effectively in feedwater and neutral solution where oxygen reduction is the controlling corrosion cathodic reaction<sup>6</sup>. And amine components are well known in the boiler feed water. The selection one or more of amines must be based upon system pressure, temperature, Complexity types of equipments used and their ability to retard corrosion rate<sup>13,14,15</sup>. Typical of such amines are 2-amino-2-methyl-1-propanol<sup>13,14,15,16</sup>. In addition to that, mixtures of synergetic packages of amines and with other additives can be used<sup>14,16,17,18,19</sup>.

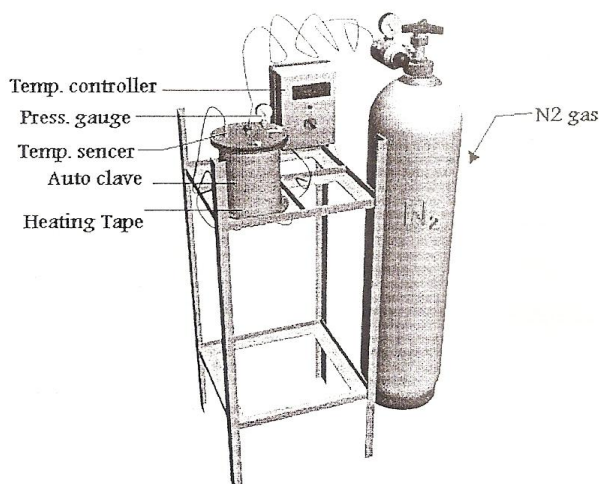
### Research Aim

The aim of this research is the control on corrosion behavior and the minimizing in corrosion rate of carbon steel through using optimum package of sodium sulfite and 2-amino-2-methyl-1-propanol in feed water of boiler system at different operation conditions (DOC).

## EXPERIMENTAL

Experiments were done at temperatures (100 - 150) °C and pressures (5 - 9) × 101.3 KN/m<sup>2</sup> in cylinder autoclave apparatus with a wall thickness of 12 mm, heating tape surrounded the outside of the autoclave, temperature controller and recorder, pressure gauge, N<sub>2</sub> gas cylinder, sensor record temperature and control valve to get rid of excess saturated steam. Maximum capacity of the autoclave is 1700 ml, as shown in figure 1.

The corrosion behavior of carbon steel in the investigation was carried out using weight loss technique under controlled condition of temperature, pressure & high efficiency amounts (20 - 60 ppm) for every one of amine<sup>13</sup> and sodium sulfite<sup>12</sup> as additive package of oxygen scavengers. Three rectangular specimens were used for measuring the corrosion rate of low carbon steel in gram per square meter per day (g/m<sup>2</sup>/d). The concentration of dissolved oxygen in feed-water was determined before and after the experiment by Winkler method (Titration) at atmospheric condition.



**Figure 1. Process Measurement Unit**

The chemical composition analysis of low carbon steel alloy specimen was made at the State Company of Geological Inspection- Iraq. It is shown in the Table 1.

Table 1. Chemical analysis of carbon steel alloy specimens

| Element | Percentage Content Wt% |
|---------|------------------------|
| C       | 0.085-0.1              |
| Mn      | 0.4-0.6                |
| S       | 0.05                   |
| P       | 0.04                   |
| Ni      | 0.017                  |
| Cr      | 0.014                  |
| Mo      | 0.061                  |
| Fe      | Remainder              |

## RESULTS AND DISCUSSION

Results of measurement of dissolved oxygen in feedwater by titration before and after experiment are given in table 2.

Figure 2 explains that the concentrations of dissolved oxygen before experiment is 7.4 ppm and after adding (0 , 20 , 40 , 60) ppm of amine on constant concentration of Na-Sulfite (20 ppm ) are (3.5 , 3.21 , 2.05 , 1.7) ppm respectively. But when the concentration of Na-sulfite is fixed 60ppm and the concentrations of amine are (0 , 20 , 40 , 60) the remaining concentrations of dissolved oxygen are about nil (0.05)ppm. This means that the increasing in concentration of 2-amino-2-methyl-1-propanol (20 , 40 , 60 ppm) on fixed amount of Na-sulfite (60 ppm) led to highest efficiency of scavenging oxygen, thus decreases the corrosion rate of boiler steel pipes.

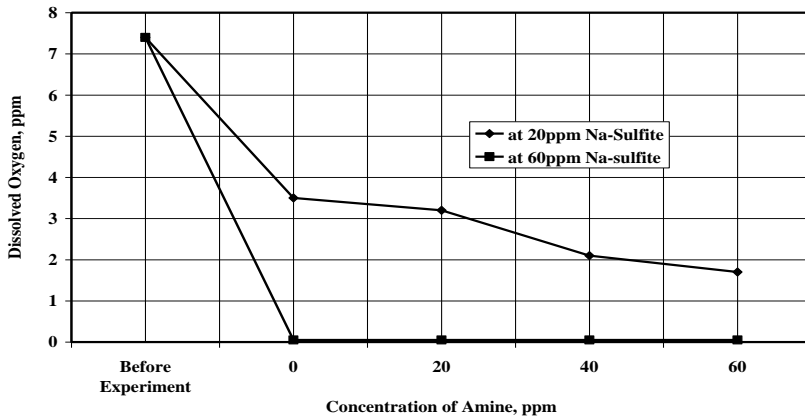


Figure (2): Effect of concentration of amine and sodium sulfite on consuming of oxygen in feed water

Results of effect of additions of the 2-amino-2-methyl-1-propanol on corrosion rate at 20 ppm of Na-sulfite and at different temperatures and constant pressure  $5 \times 101.3 \text{ KN/m}^2$  are given in figure 3.

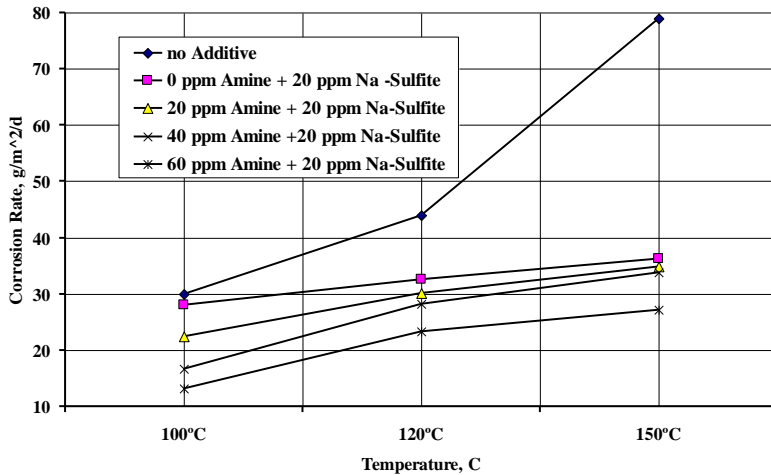


Figure (3): Effect of additions of the (Amine and sodium sulfite) on corrosion rate steel pipes at  $5 \times 101.3 \text{ KN/m}^2$  and different temperatures.

From figure 3. It is noted that at constant pressure ( $5 \times 101.3 \text{ KN/m}^2$ ) the corrosion rate increases up to high level (30 - 80  $\text{g/m}^2/\text{d}$ ) by increasing the operation temperature (100 – 150) °C in the closed system. This increasing is due to the dissolved oxygen, which accelerates corrosion. The oxygen is a strong and rapid oxidizing agent in cathodic reactions and this case is confirmed by references<sup>3, 4</sup>. When corrosion is controlled by diffusion of oxygen, the corrosion rate at given oxygen concentration (7.4ppm) approximately doubles from 43 to 80  $\text{g/m}^2/\text{d}$  for 30°C rise in temperature from 120 to 150

°C at constant pressure ( $5 \times 101.3 \text{ KN/m}^2$ ). However, in a closed system, oxygen can not escape and the corrosion rate continues to increase with temperature. And it is noted that the presence of inhibitor (Amine + Na-Sulfite) led to decreasing the corrosion rate up to lower levels ( $13 \text{ g/m}^2/\text{d}$ ). In addition, it is noted that when the temperature increases the corrosion rate increase for all additions of (2-amino-2-methyl-1-propanol + Na-Sulfite), but when adding the additive package (2-amino-2-methyl-1-propanol + Na-Sulfite) the starting point of corrosion rate was shifting down from 30 to  $13 \text{ g/m}^2/\text{d}$ . This case is due to the dissolved oxygen in feed water solution was approximately consumed with the increase of concentration of oxygen scavenger (2-amino-2-methyl-1-propanol + Na-Sulfite). The figure explains that the increasing in concentration of 2-amino-2-methyl-1-propanol (20, 40, 60 ppm) on fixed amount of Na-sulfite (20 ppm) led to high efficiency of scavenging oxygen and decrease the corrosion rate of boiler steel pipes specially at ratio (60:20) ppm of amine and sodium sulfite in feedwater solution.

Results of effect of additions of the 2-amino-2-methyl-1-propanol on corrosion rate at 60 ppm of Na-sulfite and at different temperatures and constant pressure  $5 \times 101.3 \text{ KN/m}^2$  are given in figure 4.

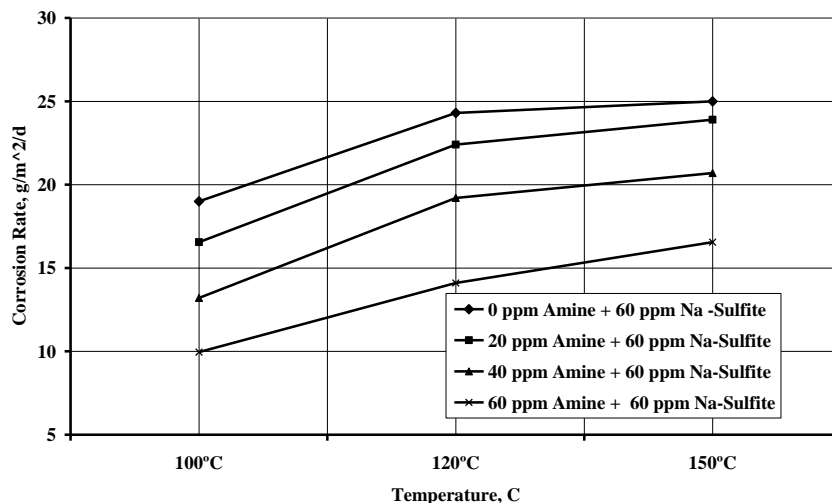


Figure (4): Effect of additions of the (Amine and sodium sulfite) on corrosion rate of boiler steel pipes at  $5 \times 101.3 \text{ KN/m}^2$  and different temperatures.

Figure 4 explains that the additions of 2-amino-2-methyl-1-propanol (20, 40, 60) ppm to the effective amount of Na-Sulfite (60 ppm) against corrosion rate of boiler steel pipes. This is according to reference Harharah and his group<sup>12</sup>. We noted that the efficiency again increases by the addition of 2-amino-2-methyl-1-propanol + Na-Sulfite from 19 to  $10 \text{ g/m}^2/\text{d}$ . The best ratio found is 60 ppm for every one of amine and Na-sulfite, with the best result in decreasing corrosion rate in acceptable way. Therefore, we well recommend this synergetic ratio of additive package (60 ppm amine + 60 ppm Na-sulfite) as oxygen

scavenger and decreases corrosion reaction in low carbon steel pipes of boilers . This is conformed by references Saad and Harharah<sup>13</sup> and Harharah et al<sup>12</sup> for individual compound, too.

Results of ratio (60ppm amine + 60ppm Na-sulfite) at different temperatures and pressures are given in figure 5.

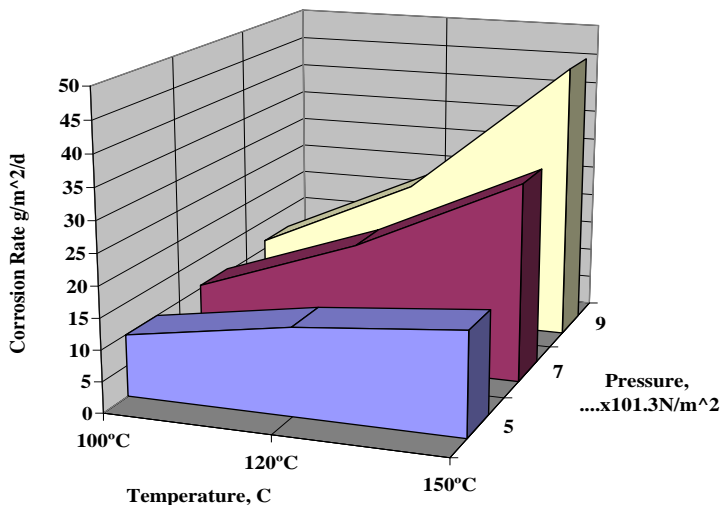


Figure (5): Effect of additions of the (60 ppm Amine + 60 ppm sodium sulfite) on corrosion rate boiler steel pipes at different operation conditions..

The figure 5 explains that influence of pressure changes (5 , 7 , 9) x101.3KN/m² on the corrosion rate at 100°C is lower than the influence of the same values of pressure on corrosion rate at 150°C. Therefore, at 100°C and the values of pressure are (5 , 7 , 9) x101.3KN/m² the corrosion rates are (10 , 10.5 , 11.4) g/m²/d respectively. And at 150°C and the values of pressure are (5 , 7 , 9) x101.3KN/m² the rates of corrosion are (16.55 , 32.12 , 45.5) g/m²/d respectively. Then that the increasing in the corrosion rate not depends only on the temperature, but also depends on the pressure. That increasing in corrosion rate with increasing in pressure may be for the reason of increasing the velocity of feed solution, which leads to increasing of the diffusion of the oxygen. With other words the increasing in temperature and pressure led to increasing in corrosion rate.

## CONCLUSIONS

This analysis can provide valuable information for mixture scavengers and corrosion behavior on boiler steel pipes with range of used temperature and pressure. The increasing in temperature and pressure led to increasing in corrosion rate, but when adding the additive package (2-amino-2-methyl-1-propanol + Na-Sulfite) the starting point of corrosion rate was shifting down. The better ratio found is 60 ppm for every one of amine

and sulfite in mixture, with the best result in decreasing corrosion rate in acceptable way. The above mentioned ratio is optimal and recommended. This opens up the field for formulation synergetic packages of additives as oxygen scavenger .

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## دراسة تأثير 2-أمينو-2-ميثيل-1-بروبانول على تآكل أنابيب الغلاية الفولاذية منخفضة الكربون في وجود الصوديوم سولفايت

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### ملخص

يدرس البحث تأثير مركب 2-أمينو-2-ميثيل-1-بروبانول  $C_3H_{11}NO$  على سلوك التآكل لأنابيب الغلاية الفولاذية ذات المحتوى الكربوني المنخفض في وجود مركب الصوديوم سولفايت  $Na_2SO_3$  في صيغة مخاليط بالإضافة الكيميائية ككاسح للأكسجين المذاب وسط لقيم ماء الغلاية. نفذت التجارب عند درجات حرارة (100 – 150) م° وضغوط (5 – 9)  $\times 101.3$  كيلو نيوتن/م<sup>2</sup> وسط أوتوكلاف اسطواني المعبأ بالماء الخالي من المعادن الحاوي على 7.4 جزء من المليون من الأكسجين الذائب، عندها يقاس معدل التآكل بواسطة تقنية فقد الوزن كما يعين تركيز الأكسجين الذائب بواسطة طريقة وينكلر (طريقة المعايرة) قبل وبعد التجربة. هذه الدراسة استطاعة أن تزودنا بمعلومات عن مخاليط الكاسح للأكسجين وكذلك سلوك التآكل على أنابيب الغلاية الفولاذية وسط المدى من درجات الحرارة والضغط المستخدمة. ووجدنا أن أفضل العلاقة الكمية هي 60 جزء من المليون لكل واحد من الأمين والسولفايت، حيث بواسطة هذا السياق وجدنا النتيجة المثلى في خفض معدل التآكل. وبهذا فإن النسبة المذكورة أعلاه هي الموصى بها. مما يفتح المجال لصياغة حزم جديدة من الإضافات الكيميائية ككواسح للأكسجين الذائب.

# Study The Effect of Substitution Ag on behavior of The High Temperature of $\text{YBa}_2\text{Cu}_{3-x}\text{Ag}_x\text{O}_{6.5+\delta}$ Superconductor

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## ABSTRACT

Solid state reaction used to prepared the high temperature superconductor of  $\text{YBa}_2\text{Cu}_{3-x}\text{Ag}_x\text{O}_{6.5+\delta}$  compounds, Ag was isovalent substitution Cu for ( $x=0.0, 0.15, 0.25, 0.35, 0.45$ ). Iodometric titration used to determine the oxygen content in the samples. The value of  $\text{O}_2$  was varies from sample to another .The result of titration exhibited value of  $\delta$  is increasing when increasing of concentration of Ag. The samples was analyzed by x-ray diffraction(XRD) patterns has been used to determine the purity of the used materials ,calculation of the lattice constants and determination of its phase .The study shows a high purity samples with an orthorhombic single phase ,resistivity measurement by four probe technique and morphological analysis by Scanning Electron Microscopy (SEM).These parameters are the forming pressure of the pellets , the sintering temperature was  $950^\circ\text{C}$  for sintering time (30hours) with the flow of oxygen gas of about (1.25)L/min. The maximum  $T_c$  value was 94.2K for  $\text{YBa}_2\text{Cu}_{5.5}\text{Ag}_{0.45}\text{O}_{6.5+\delta}$ , it is found  $T_c$  value increasing when increased  $x$  in the  $\text{YBa}_2\text{Cu}_{3-x}\text{Ag}_x\text{O}_{6.5+\delta}$  supercomputers.

## 1. INTRODUCTION

After the discovery of  $\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}$  (YBCO)superconductors, extensive studies have been made on the effect of Ag additions in YBCO system with a view to understanding the mechanism of superconductivity and to improve the current carrying capacity of these materials (1-5)it has been reported that silver addition is effective in improving mechanical properties of the brittle superconducting oxides  $\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}$ (Y123) (6-8)For examples studies on textured Ag doped Y123 samples showed that the Ag addition improved fractured toughness and the resistance to thermal.(9).At mesoscopic level, silver fills the intergranular spaces and increases plasticity and the resistance to crack formation(10).It has been found that Ag enhance the critical current density and magnetic –flux trapping (11,12).Also silver improves the grain



growth and helps to obtain a better grain orientation lowering the electrical resistance in the normal state.(13,14).In general manner. Silver addition to Y(123)clearly enhances the process dominated by the weak links (15).Silver can introduced into the samples by various ways ,such as by mixing with metallic Ag, by mixing with Ag<sub>2</sub>O or by electro chemical method (16,17).Due to its excellent chemical compatibility. The silver ion can by encountered into the Y-123grains (12,18).Yet as Copper and silver are from the same group of the periodic table .Ag atoms can substitute Cu(19).In the Y-123 grains and consequently many physical properties are affected by presence of microscopic granularity.(20). The samples were characterized by x-ray diffraction, electrical resistivity measurement and scanning electron microscopy.

## **2-EXPERIMENTAL**

A series of samples were prepared by a conventional solid state reaction method using high-purity powder of Y<sub>2</sub>O<sub>3</sub>, BaCO<sub>3</sub>, CuO, and Ag<sub>2</sub>O with 99.99% purity .The mixture to make the specimens was prepared by homogeneously mixing and grinding prescribed amounts of all powders, into a gate mortar. Appropriate amounts of these powders were mixed with alumina mortar and pestle for (3 hours) in 2- propanole and dried. The calcinations process performed at (930°C) for (20 hours) in order to remove the CO<sub>2</sub> amount from the mixture as gas and then crushed into fine powder. The calcinations and grinding procedure were repeated three times at least, that make insure the completely evolve of CO<sub>2</sub> –amount from the mixture. Measuring the weight of reactants with the required amounts using sensitive balance with (4-digitals), type (STATON) 462AL. The resulting powder then pressed into pellets.. The die has a stainless steel cylinder of 0.5 cm (13mm) diameter and (1.5-1.8) mm thick using manually hydraulic press RAKIN-EIMER, under a pressure of (0.6Gp).

The final step of sample preparation was high temperature treatment that causes particles of the materials to join together and gradually reduce the volume of pore space between them the powder is compacted into a pellet shape with a certain pressure then powder particles with then be in contact with one another at numerous sites, with significant amount of pore space between the particles.

In order to reduce the boundary energy, atoms diffuse to the boundaries, permitting the particles to be bound together and eventually causing the pores to shrink. If sintering is carried out for a long time the pores may be eliminated and the material becomes dense. The programming data for this process include, the rate of heating (60°C/hour) up to (950°C) for (30 hours) with the flow of oxygen gas of about (1.25)L/min and then with slow rate of cooling (30°C/hours) reached 550°C stopped for this temperature at 7 hours before it returned to room temperature. The significance of oxygen flow is to enhance the value of  $\delta$  to reach the content of oxygen atoms in the samples to about (6.88). X-ray diffraction (XRD) data were obtained by powder diffraction utilizing Co( $k\alpha$ ) radiation ,Scanning electron microscope, morphology of the crystalline grains in the samples prepared .The transition temperature of HTSC samples was determined using the four probe “resistive”.

## **3-RESULTS AND DISCUSSION**

The superconductivity of Ag substitution in Cu for  $\text{YBa}_2\text{Cu}_{3-x}\text{Ag}_x\text{O}_{6.5+\delta}$  samples for ( $x=0, 0.15, 0.25, 0.35, 0.45$ ) were studied using x-ray diffraction, temperature resistivity measurements and scanning electron microscopy.

### 3-1-X-ray diffraction studies

X-ray powder diffraction studies were carried out on  $\text{Ag}_2\text{O}$  added YBCO samples sintered at  $950^\circ\text{C}$  and cooled slowly to room temperature. Temperature at the rate of  $2^\circ\text{C}/\text{min}$  in flowing oxygen . Figure (1) represents the powder diffraction patterns of (YBCO) specimens with 0.0 to 4.5 wt % of Ag substitution type creating a  $\text{YBa}_2\text{Cu}_{3-x}\text{Ag}_x\text{O}_{6.5+\delta}$  .All samples showed an orthorhombic structure and no shift in the peak positions ,in the x-ray patterns of YBCO was observed because of Ag substitution. However in the doped samples , a few peaks were observed at  $2\theta = 36.875^\circ, 45.625^\circ$  and  $63.750^\circ$  apart from those of pure ( $\text{YBa}_2\text{Cu}_3\text{O}_{6.5+\delta}$ ).The intensities of these additional peaks were found to increase with the increase in levels of  $\text{Ag}_2\text{O}$  substitution in Cu for YBCO samples .The presence of these extra peaks in the diffraction pattern indicates the formation of a second phase in the system .This new phase could not be readily identified from the data a available in the joint committee on powder diffraction standards (JCPDS) file .X-ray diffraction pattern as shown in figure (1) taken into account with a presence of computational program to determine the lattice constants and to show the effect of substitution Ag on the structure comparable with the pure system (YBCO-compound).Table (1) showing orthorhombic phase with the lattice constants, exhibited some deviation in their value compared with pure ,this is the first data investigated and comparison with Kupper man et al( 21 ).who studied the effect of 15%Ag as additives to compound  $\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}$  .Also with Diko et al(22).They condensed their study on using 5wt%Ag with respect to compound  $\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}$  . Also with Pavund et al(23).Using of 10wt%Ag with respect to  $\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}$  .In other words, our studies confirmed by Taylor etal (24),who suggest that Ag play an important role due to the substitution as function of Cu site of  $\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}$  .The Ag atoms change the dimension of the unit cell ,because the Ag ion size is larger than that of the Cu ion .It is also reported Ag atoms saturates at nominal concentrations higher than 2.5wt% Ag (25) .

### 3-2Temperature Resistivity Measurements

The temperature resistivity measurements on  $\text{YBa}_2\text{Cu}_{3-x}\text{Ag}_x\text{O}_{6.5+\delta}$  samples cooled slowly to room temperature were carried out by the four –probe method (26) using digital Nanovoltmeter type ( KETHLY) model 180 with sensitivity of about( $\pm 0.1$  nanovolt) used to measured the voltage drop , and D-C power supply type (Electronic Veneta DV30/V3) and a KETHLY model 1221 current source after removing a substantial part of the surface layer of specimens by polishing . Silver paste was used for point contacts and the temperature was measured by a copper-constant thermocouple with an accuracy of  $\pm 0.2$  K. Figure (2) shows the temperature versus resistivity curves for  $\text{YBa}_2\text{Cu}_{3-x}\text{Ag}_x\text{O}_{6.5+\delta}$  for ( $x=0, 0.15, 0.25, 0.35, 0.45$ ) when the samples were slow cooled at a rate of  $2^\circ\text{C}/\text{min}$  in oxygen atom sphere .The transition temperature (  $T_c = 92.7$  K) for  $x=0$  and  $T_c= 92.8$  K for  $x= 0.15$  ,  $T_c= 93.2$  K for  $x= 0.25$ ,  $T_c=93.6$  K for  $x= 0.35$ ,and  $T_c= 94.2$  K for  $x= 0.45$ . These results indicated clearly that zero resistivity temperature is improved by excess substitution of Ag in Cu in the composition compared with pure compound.

**Table (1): INSERT CAPTION????**

| Samples name | $T_c(\text{K})$ | Lattice constant( $\text{A}^\circ$ ) | Volume( $\text{A}^3$ ) | $\delta$ |
|--------------|-----------------|--------------------------------------|------------------------|----------|
|--------------|-----------------|--------------------------------------|------------------------|----------|

|   |      |                                  |          |       |
|---|------|----------------------------------|----------|-------|
| $\text{YBa}_2\text{Cu}_3\text{O}_{6.5+\delta}$                      | 92.7 | a=3.820<br>b=3.8855<br>c=11.4835 | 170.4451 | 0.380 |
| $\text{YBa}_2\text{Cu}_{2.85}\text{Ag}_{0.15}\text{O}_{6.5+\delta}$ | 92.8 | a=3.820<br>b=3.8855<br>c=11.4835 | 170.4451 | 0.383 |
| $\text{YBa}_2\text{Cu}_{2.75}\text{Ag}_{0.25}\text{O}_{6.5+\delta}$ | 93.2 | a=3.820<br>b=3.8855<br>c=11.4834 | 170.4436 | 0.388 |
| $\text{YBa}_2\text{Cu}_{2.65}\text{Ag}_{0.35}\text{O}_{6.5+\delta}$ | 93.6 | a=3.820<br>b=3.8855<br>c=11.4834 | 170.4436 | 0.41  |
| $\text{YBa}_2\text{Cu}_{2.55}\text{Ag}_{0.45}\text{O}_{6.5+\delta}$ | 94.2 | a=3.820<br>b=3.8855<br>c=11.4835 | 170.4451 | 0.421 |

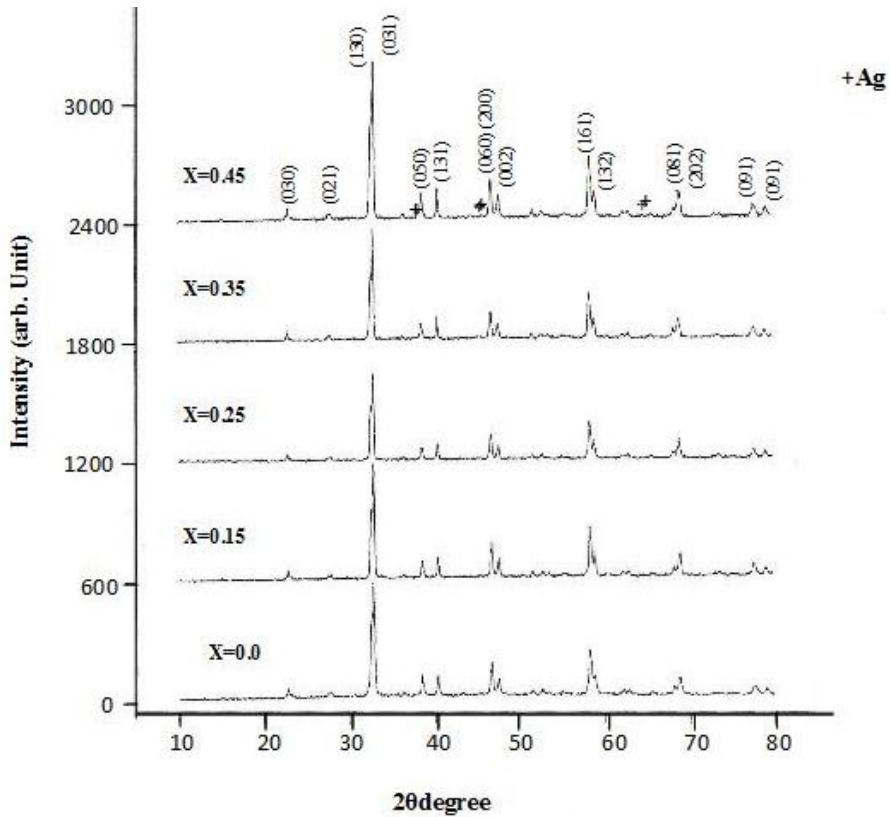


Figure (1) X-ray diffraction patterns for components  $\text{YBa}_2\text{Cu}_{3-x}\text{Ag}_x\text{O}_{6.5+\delta}$

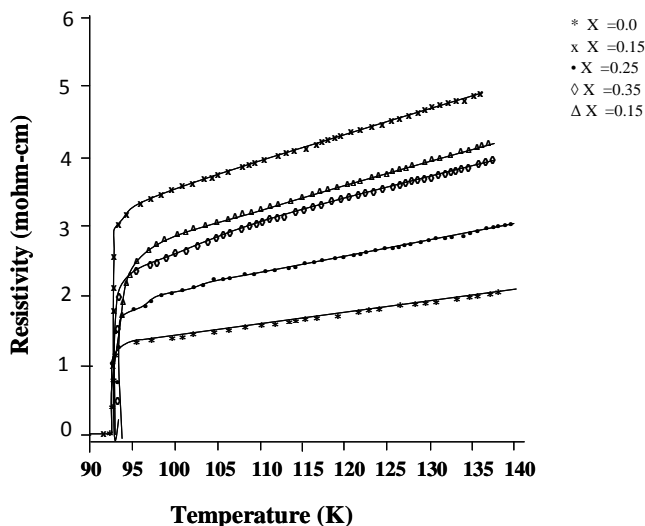


Figure (2): The resistivity veruse temperature for HTSC for  $\text{YBa}_2\text{Cu}_{3-x}\text{Ag}_x\text{O}_{6.5+\delta}$

### 3-3- Surface Morphology

To compare the microstructure of pure and Ag substitution on cu in the  $\text{YBa}_2\text{Cu}_{3-x}\text{Ag}_x\text{O}_{6.5+\delta}$  samples .SEM micrographs were taken by a JOEL JSM 4600 scanning electron microscope is used for studying the microstructure of the samples coating with metal and operated at 15KV. Figure (3) shows the microstructure of compound  $\text{YBa}_2\text{Cu}_{3-x}\text{Ag}_x\text{O}_{6.5+\delta}$  for ( $x=0, 0.15, 0.25, 0.35, 0.45$ ) cooled slowly after sintering at  $950^\circ\text{C}$  .The micrographs clearly show that the size of the plates shapes become is between  $(19.23-11.4) \mu\text{m}$  .It was found that the grain growth of plate .like increased rapidly with increasing Ag substitution and reaches to maximum size at the interior region of the fracture surface as shown in figure (3)E. The large homogeneity of the chemical species .This agree with stability of

### 3-4-Enhanced Oxygen absorption in $\text{YBa}_2\text{Cu}_{3-x}\text{Ag}_x\text{O}_{6.5+\delta}$ samples

The “Iodometrics titration “ method used to find oxygen content of oxide superconductor  $\text{YBa}_2\text{Cu}_3\text{O}_{6.5+\delta}$  ,the superconducting prosperities of YBCO are intimately connected with the tetragonal – orthorhombic phase transition (27,28) which in turn depends on the oxygen stoichiometry (29, 30) . Therefore processing atmosphere and annealing temperature are of great importance in obtaining high temperature superconductivity In the case of YBCO materials it has been extensively reported that slow cooling of the sintered  $\text{YBa}_2\text{Cu}_{3-x}\text{Ag}_x\text{O}_{6.5+\delta}$  samples in flowing oxygen or annealing between  $(500-550)^\circ\text{C}$  for several hours is an essential requirement for obtaining orthorhombic phase (31). As the tetragonal tp orthorhombic transformation takes place below  $700^\circ\text{C}$  by absorbing oxygen, samples quenched in liquid nitrogen from temperature above  $700^\circ\text{C}$  were always semiconducting and they did not show superconductivity (32). In our on the effect of Ag substitution in YBCO, we observed that the widely accepted procedure of slow cooling at  $2^\circ\text{C}/\text{min}$  or annealing at  $550^\circ\text{C}$  for several hours after high temperature sintering is not necessary to

obtain superconducting in YBCO samples. Table (1) showing the values ( $\delta$ ) of oxygen content for all samples.

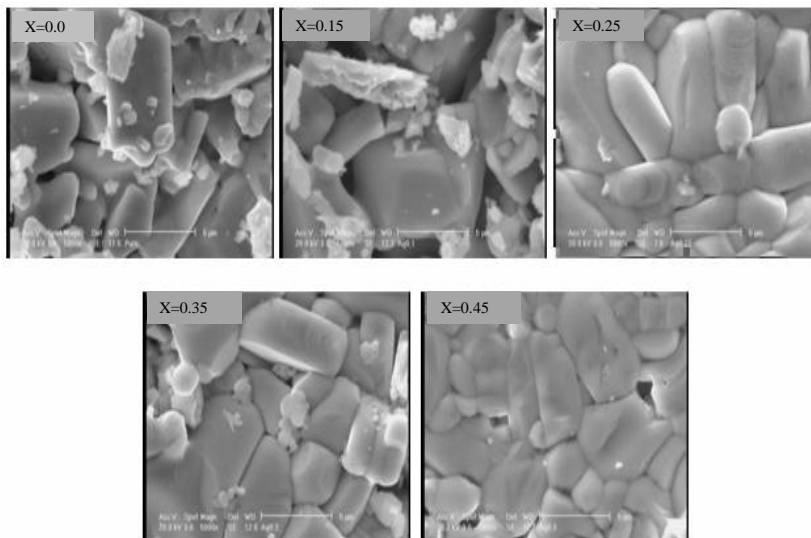


Figure (3): Morphology of fracture surface of compound  $\text{YBa}_2\text{Cu}_{3-x}\text{Ag}_x\text{O}_{6.5+\delta}$

#### 4-Discussion

The x-ray diffraction studies of all samples ( $\text{YBa}_2\text{Cu}_{3-x}\text{Ag}_x\text{O}_{6.5+\delta}$ ) showed that there is no structure change in superconducting YBCO compound due to Ag substitution. A few additional peaks at  $2\theta = 36.87, 45.625$  and  $63.75$  other than those of pure YBCO, indicate the presence of a second phase in the composite. It is found that the extensively used procedure of flow cooling or annealing at  $550^\circ\text{C}$  for several hours for oxygenation is not essential to obtain superconductivity in Ag substitution in Cu, superconducting transition was obtained by quenching Ag substitution in Cu directly from a sintering temperature  $950^\circ\text{C}$ . In the present study one may suspect that tetragonal to orthorhombic phase transformation temperature has been raised to a higher temperature ( $950^\circ\text{C}$ ), due to  $\text{Ag}_2\text{O}$  additional resulting in an orthorhombic structure on quenching the sample to room temperature. If that is true then sample quenching in liquid nitrogen should also have shown orthorhombic structure. All the electrical measurements were taken on samples after polishing and removing the outer surface layers. X-ray diffraction patterns were also taken on powdered samples which again confirms that the observed effect in quenched samples is a bulk property. Indicating that the rate of oxygen absorption has been tremendously increased by the addition of a small amount of  $\text{Ag}_2\text{O}$  in YBCO and the materials become superconducting by air quenching. However, it is not clear that the enhanced oxygen absorption is due to the second phase formed, it is likely that the second phase ( $\text{YBa}_2\text{Cu}_{3-x}\text{Ag}_x\text{O}_{6.5+\delta}$ ) may be acting as a catalyst for the oxidation of YBCO materials. Appearance of texture in SEM images for all samples under study such as plate-like accompanied the formation of superconducting phase.

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## دراسة تأثير التعويض الجزئي للفضة على النحاس في المركب الفائق التوصيل ( $YBa_2Cu_{3-x}Ag_xO_{6.5+\delta}$ )

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### ملخص

تم تحضير نماذج من ( $YBa_2Cu_{3-x}Ag_xO_{6.5+\delta}$ ) الفائق التوصيل عند درجات الحرارة العالية بطريقة تفاعل الحالة الصلبة. اظهرت الدراسة تراكيب النماذج باستخدام تقنية حيود الاشعة السينية والمحضرة عند درجة حرارة تلييد 950 درجة مئوية ، انها في طور معيني القائم (Orthorhombic). كما تم دراسة التعويض الجزئي ل ( $x$ ) على التركيب والخواص الكهربائية ل  $YBa_2Cu_{3-x}Ag_xO_{6.5+}$  واستخدمت عدة قيم ( $x=0.0,0.15,0.25,0.35,0.45$ ) ولابعد وحدة الخلية اعتمدت طريقة قياس المقاومة الكهربائية لاجاد قيم درجات الحرارة الحرجة ( $T_c$ ) لهذه النماذج وذلك باستخدام منظومة تبريد تعمل بالننتيروجين السائل وكانت اعلى قيمة عند ( $x=0.45$ ) حيث كانت قيمة درجة الحرارة الحرجة تزداد بازدياد قيم ( $x$ ). تم فحص النماذج باستخدام المجهر الالكتروني الماسح (SEM).

# Floating Point Genetic Algorithm Approach for Optimizing Unstructured Meshes

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## ABSTRACT

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This paper presents a method for optimizing unstructured triangular meshes using a floating-point genetic algorithm. A mesh generation algorithm based on a modified advancing front method and sets of heuristic rules are used to generate the initial non-smooth triangular meshes for complex shapes. The developed mesh is then smoothed using a floating-point genetic algorithm that is more flexible than the usual binary genetic algorithms, and can handle non-smooth regions containing several local extrema. Three approaches are used in selecting the fitness function to be optimized in the genetic algorithm, namely, the triangle aspect ratio, the maximum angle at each node of the triangular mesh, and a weighted linear combination of both functions. The genetic algorithm has been tested and validated for a number of test cases covering a wide range of complex geometry applications. The results have shown a high degree of improvement in the quality of the smoothed meshes and an ability to handle non-convex regions.

Key Words: Genetic algorithms, mesh generation, unstructured meshes.

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## 1. INTRODUCTION

The development of sufficiently smooth unstructured surface meshes (grids) plays an important role in the geometry processing of real world objects. In most application the term unstructured meshes refer to triangular and tetrahedral meshes in two and three dimension respectively. A primary application of unstructured meshes concerns the geometric modeling of complex real world objects, soft tissue modeling, and multi-resolution representation of complex shapes. Additionally unstructured meshes play a pivotal role in the numerical simulation of many physical problems in solid mechanics, geo-mechanics, and fluid dynamics.

Mesh generation has a huge literature and there are excellent references on structured and unstructured mesh generation [1-5], most grid generation techniques currently in use can fit into one of the three basic methods; Delaunay [6], Quadtree [7-8], and Advancing front method [5].



### 1.1 Grid optimization and smoothing

It is rare that any grid generation algorithm will be able to define a grid that is optimal without some form of post-processing to improve the overall quality of the grid. Most smoothing procedures [9-13] involve some form of iterative process that repositions individual vertices to improve the local quality of triangular grids.

The often used quality criteria for triangular grids are small aspect ratio and no angles very close to 0 or to 180. However, there is a variety of other optimization problems such as maximizing the minimum angle, minimizing the maximum angle, minimizing the maximum aspect ratio, minimizing the maximum circumradius and the radius of the containing circle of the incident triangles. Smoothing, averaging, and optimization-based methods are also used to improve the quality of triangular grids. Grid smoothing adjusts the locations of grid vertices in order to improve element shapes and overall grid quality. In grid smoothing, the topology of the grid remains invariant.

Laplacian smoothing is the most commonly used smoothing technique. Laplacian [14-16] smoothing is computationally inexpensive and fairly effective, but it does not guarantee improvement in grid quality. Similar to Laplacian smoothing, there are a variety of other averaging/smoothing techniques, which iteratively reposition nodes based on a weighted average of the geometric properties of the surrounding grid points (nodes). Canann [11] provides an overview of some of the common methods in use.

Optimization-based smoothing techniques measure the quality of the surrounding elements to a node and attempt to optimize by computing then local gradient of the element quality with respect to the node location. The grid vertices are moved so as to minimize a given distortion metric.

Some of the developments in this area include [11,12]. Parthasarathy [13] developed an optimization-based technique by solving a nonlinear, constrained, global optimization problem with the aspect ratio being the objective function to be minimized. Canann [11] presents optimization-based smoothing algorithm and recommends a combined Laplacian/optimization-based approach. An approach developed by Freitag [16] work to maximize the minimum angle in triangular grids by using an analogue of the steepest decent method for smooth functions. Amenta [9] presents theoretical results showing how some local triangle shape optimization be solved using generalized linear programming. Other efficient algorithms are presented and many distortion metrics are discussed and various optimization techniques are compared. Other optimization based methods include the works of [13] that is based on making use of posteriori error estimates, and [14] that

is based on the use of distortion metrics. The selection of good distortion metrics is also discussed in [15].

Recently, methods based on artificial intelligence concept have been used in grid generation and optimization. In [17] Neural Networks concepts have been used in finite element grid generations. Holder [18] presents a binary genetic algorithm for smoothing grids used in finite element analysis. A distortion metric is used to quantify the goodness of quadrilateral grid elements and serves as the fitness function for the genetic algorithm.

The objective of the paper is to:

- Develop an unstructured two-dimensional grid generation algorithm capable of triangulating complex geometrical shapes.
- Develop and apply a genetic algorithm for smoothing and optimization of triangular grids.

## 2. PROPOSED METHOD

The present method consists of a mesh generation algorithm based on the advancing front method for the generation of the initial grid to be smoothed, and a genetic algorithm to smooth the generated triangular mesh.

### 2.1 Grid Generation Algorithm

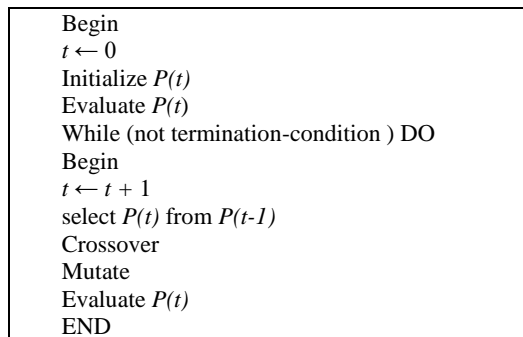
The algorithm is based on the advancing front method and a number of heuristic rules to ensure proper triangulation of arbitrary and simply connected regions into quality triangles. Several tests have been included into the algorithm to handle overlapping, edge crossing, and degenerate edges that may occur during the grid generation process. An efficient algorithm is also developed to generate the grid connectivity information needed during the grid generation process.

### 2.2 Grid Smoothing

The developed grids normally contain poorly shaped triangles that may affect the generated grid when used in any specific application. The developed smoothing process is affected in two steps; first a diagonal swapping algorithm is first implemented followed by a floating-point genetic algorithm.

#### 2.2.1 Genetic Algorithms

The genetic algorithm starts from a set of chromosomes (assumed solutions) and evolves different but better sets of chromosomes (sets of solutions) over a sequence of iterations. In each generation (iteration) the fitness-measuring criterion (objective function) determines the suitability of each chromosome and, based on these values, some of them are selected for reproduction. The number of copies reproduced by an individual parent is expected to be directly proportional to its fitness value, thereby embodying the natural selection procedure, to some extent. The procedure thus selects more fit solutions; and less fit solutions are eliminated. The structure of a simple genetic algorithm is shown in Figure 1.



**Figure 1:** Structure of a simple genetic algorithm.

During iteration  $t$ , a genetic algorithm maintains a population of potential solutions (chromosomes, vectors)

$$P(t) = \{x^1, x^2, \dots, x^n\}.$$

Each solution is evaluated to give some measure of its “fitness”, then, a new population (iteration  $t+1$ ) is formed to establish new solutions. Crossover combines the feature of two parent chromosomes to form two similar offspring by swapping corresponding segments of the parents. Mutation arbitrary alters one or more genes of a selected chromosome, by a random change with a probability equal to the mutation rate.

The present genetic algorithm uses proportional selection, elitist model, one point crossover and uniform mutation. A geometrical procedure that will produce an object function for optimization works in the following manner.

### 2.2.2 Genetic Algorithm parameters

- *Population size*

Population size is one of the parameters affecting the algorithm's convergence. The larger, more diverse population takes longer to converge on a solution, but is more likely to find a solution because of its diverse gene pool. For every internal node in the grid, 50 generation of populations are generated and every population contains 100 chromosomes (nodes).

Creating a population of chromosomes initializes the process. Each chromosome contains two floating random numbers, the first for x-coordinate and the second for y-coordinate.

Each member of every chromosome is generated using random number generator.

- *Evaluation function*

For every random node (chromosome) generated the summation of areas for all triangles around that node are computed and it must be equal the summation of areas  $A$  for all triangles around that initial node  $N$  (to be moved to optimum location).The fitness function for every node is described later.

- *Selection Process*

For the selection process (selection of a new population with respect to the probability distribution based on fitness values), a roulette wheel with slots sized according to fitness is used.

A roulette wheel is constructed as follows:

1. Calculate the fitness value  $fivalu(N_i)$  for each chromosome (node  $N_i$ ) ( $i=1,2,\dots, Pop\_Size$ ).
2. Find the total fitness of population (  $i$  ) \_  

$$1 \Sigma = = pop\ size$$

$$i F fivalu N.$$
3. Calculate the probability of a selection  $p_i$  for each chromosome (node  $N_i$ ) ( $i=1,2,\dots, Pop\_Size$ ):  $p_i = fivalu(N_i) / F$
4. Calculate a cumulative probability  $q_i$  for each chromosome (node  $N_i$ ) ( $i=1,2,\dots, Pop\_Size$ ):  

$$q_i = \sum_{j=1}^i P_j$$
5. Calculate a cumulative fitness
6. Finally select survivors using cumulative fitness probability and based on elitist model :  
 -Generate a random (float) number  $r$  between  $[0..1]$ ,for each chromosome i.e.  $Pop\_Size$  times; each time( for every chromosome ) if  $r < q_1$  then select the first chromosome ( $N_1$ );  
 -Otherwise select the  $i$ -th chromosome  $N_i$  ( $2 \leq i \leq Pop\_Size$ ) such that  $q_{i-1} < r < q_i$ .

- *Crossover Probability:*

Crossover probability usually ranges from 0.01 to 1.0. Crossover reflects the likelihood that future population of nodes will contain a mix of information from the previous generation

of nodes. A rate of 0.5 means that a child node will contain about 50% of its location from one parent node and the rest from the second parent node. A rate of 1.0 means that no crossover will occur, or only clones of the parents will be evaluated. A crossover probability of 0.8 is used in the current algorithm.

- *Mutation rate*

The mutation rate can vary from 0.0 to 1.0. The higher the mutation rate, the more likely future nodal chromosomes will contain some random values. Since mutation occurs after crossover, a mutation rate that is too high will prevent crossover from having much if any effect. A random uniform mutation with a probability of 0.15 is used in the present algorithm.

- *Evaluation (fitness) function*

Three approaches are used in selecting the function to be optimized in the genetic algorithm, namely, the least square error of the variation of angles, the average of the aspect ratio of triangles at each node of the triangular grid, and a linear combination of both approaches. In this method evaluation function is in a composite form, made up of the least square error of the angles and average of aspect ratio for the triangles. Numerical experimentation indicates that the third approach is the best criteria for the selection of the fitness function.

The fitness function is computed at every selected node. In every iteration, the absolute value of the change of the fitness function  $F$  and its maximum value is computed. The process is repeated for every iteration until convergence is achieved. A fixed value of 0.01 is set for the differences in the fitness function as criteria for convergence.

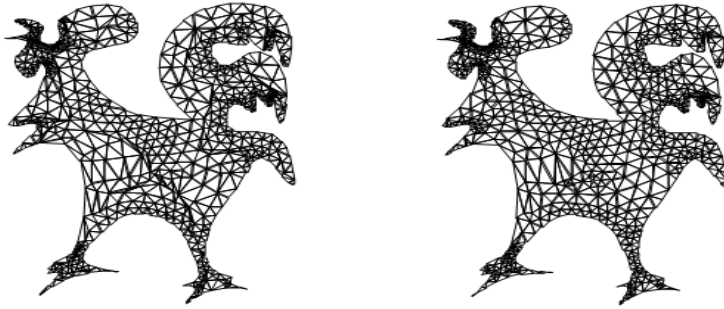
### 3. RESULTS

The optimization algorithm is implemented for complex geometrical shapes and the results are shown in Figures 2 through 9. The optimization algorithm selectively moves the nodes of the poorly shaped triangles based on the fitness function which results in a marked improvement in the grid quality. The results clearly show that the improvement in the triangles quality from the initial grid to the optimum.

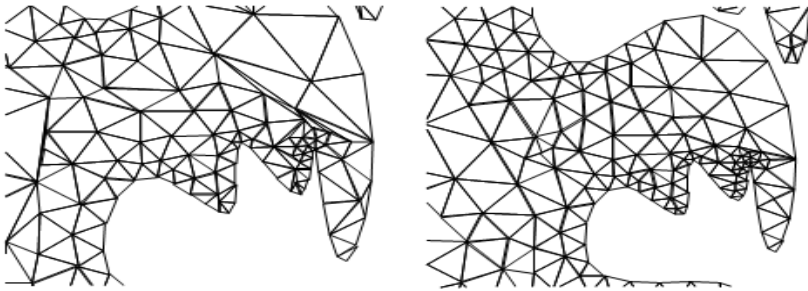
Figures 7 through 9 compares the variation of the fitness function before and after optimization for nodes of the poorly shaped triangles.  $\alpha=0.8$  and  $\beta=0.2$ . for the case of the cartoon-type rooster shape The curves of figure 8 show that the optimization using the genetic algorithm has resulted in improved values of the fitness function. The fitness values for most nodes ranges from 0.5 to 0.85, after smoothing the fitness values improved to a range of 0.85 to 0.94.

The analysis of the curves in figure 1-6 shows that the fitness values of the initial grid for most nodes are in range 0.5 to 0.85. But after optimization with diagonal swapping the range improved to a range of 0.88 to 0.97. The results shown in figures 7-9 show that smoothing using the genetic algorithm have made a marked enhancement of the triangles quality.

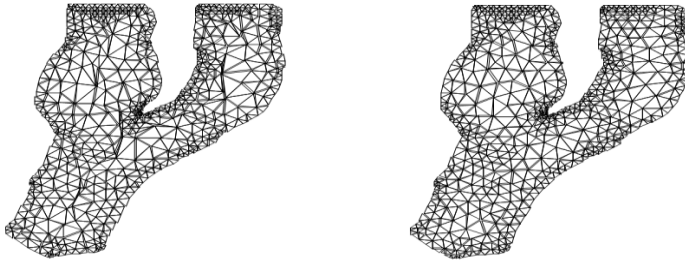
The triangles quality have improved and the range of the quality of the most triangles is improved from (0.11 – 0.92) to (0.91 – 0.97).



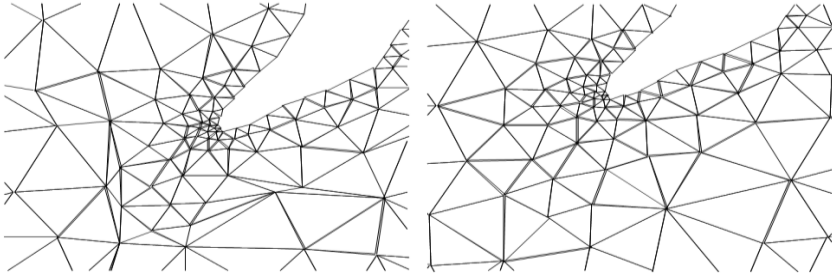
**Figure 2:** Initial and smoothed grids of cartoon-type rooster shape.



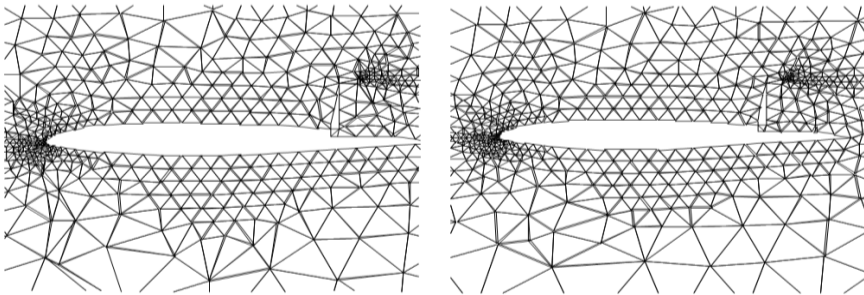
**Figure 3:** Enlarged region of initial and smoothed grids of cartoon-type rooster shape.



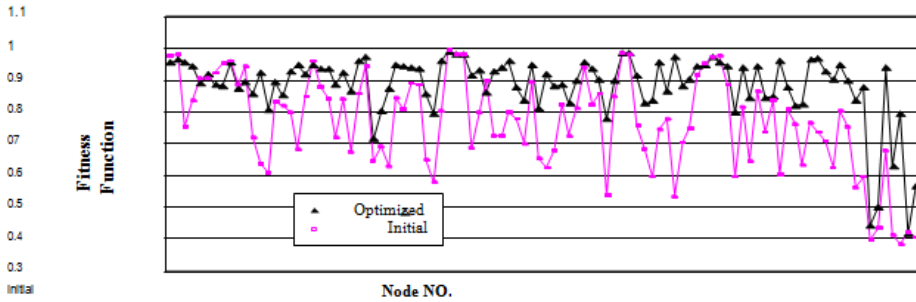
**Figure 4:** Initial and smoothed grids of an artificial heart model section



**Figure 5:** Enlarged region of Initial and optimum grid of an artificial heart section



**Figure 6:** Enlarged region of Initial and optimum grid of an airfoil with a spoiler



**Figure 7:** Curves of initial and optimum fitness function for cartoon-type rooster shape.

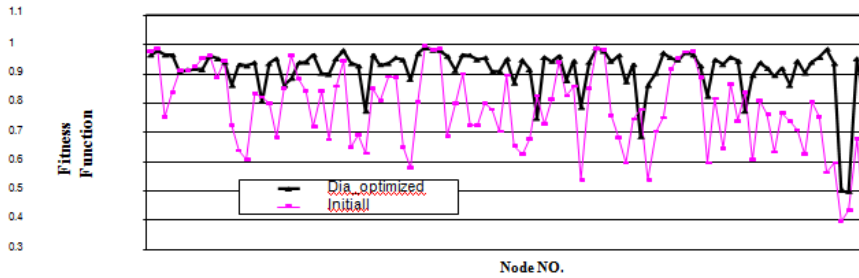


Figure 8: Curves of initial and optimum fitness function for cartoon-type rooster shape

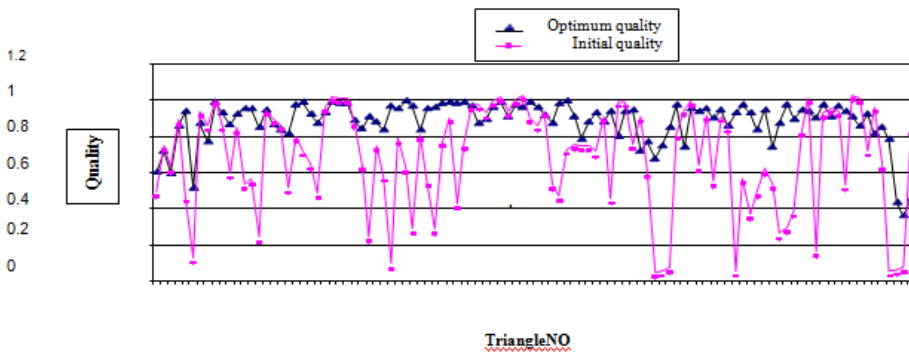


Figure 9: Curves of initial and optimum triangles quality for Cartoon-type rooster shape.

### 4. Conclusions

In this paper an unstructured triangular grid generation and smoothing algorithm is developed for arbitrary two-dimensional regions. The grid generation algorithm is based on a modified advancing front method and a set of heuristic rules to guarantee the efficient triangulation of complex regions. The developed algorithm gives a high priority for the smallest angle between any two adjacent segments during the triangulation process. The developed heuristics rules are designed to avoid many of the problems encountered during triangulation; such as, front overlapping and intersection, close proximity of neighboring triangles.

Additionally, the algorithm uses an efficient branching strategy for triangle construction and selection. The grid generation algorithm also includes an efficient fast permutation algorithm to establish the connectivity of the triangular grid that is needed for the advancing front algorithm and for post-processing the developed grids. The results show that the grid generation algorithm is capable of generating high quality triangles for any complex two dimensional region. A smoothing algorithm is then developed to optimize the quality of the developed grid. The optimization process is implemented in two steps.

First, diagonal swapping is implemented, followed by the floating-point genetic algorithm. Diagonal swapping is used according to a triangle quality that is based on the

aspect ratio. The second step in the optimization process employs a floating-point genetic algorithm that is more flexible than the usual binary genetic algorithms. Three approaches are used in selecting the function to be optimized in the genetic algorithm, namely, the least square error of the variation of angles, the average of the aspect ratio of triangles at each node of the triangular grid, and a linear combination of both approaches. The results clearly show the marked improvement in the quality of the optimized grids and the ability of floating point genetic algorithm to handle non-convex regions.

Future research work may include the extension of the present method to the more difficult case of three dimensions to establish smooth tetrahedral grids for 3D regions.

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## الخوارزمية الوراثة (الجينية) لتحقيق الأمثلية (الوصول الأمثل) للشبكات الغير بنيوية

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### ملخص

هذه الورقة تقدم طريقة للوصول الأمثل إلى الشبكات الثلاثية الغير بنيوية باستخدام خوارزمية النقطة العائمة الوراثة. لقد تم استخدام خوارزمية لتوليد الشبكة الابتدائية الثلاثية الغير مستوية (ناعمة) بالاعتماد على طريقة الواجهة المتقدمة المعدلة وكذا مجموعات القوانين التجريبية. الشبكة المتولدة تم تنعيمها باستخدام خوارزمية النقطة العائمة الوراثة التي تعتبر مرونة من الخوارزمية الثنائية الوراثة، والتي تستطيع التعامل مع المناطق الغير مستوية (ناعمة) والتي تحتوي على عدة نهايات محلية (نتوءات محلية) تم استخدام ثلاث طرق لاختيار الدالة الملائمة والتي سيتم تحقيق الأمثلية لها باستخدام الخوارزمية الوراثة وهذه الطرق هي: نسبة أبعاد المثلث، الزاوية العظمى لكل عقده من الشبكة الثلاثية، ومركب خطي وموزون من الدالتين. الخوارزمية الوراثة تم فحصها والتأكد من صلاحيتها باستخدام عدد من حالات الاختبار والتي تغطي مجموعة واسعة من تطبيقات الأشكال الهندسية المعقدة. دلت النتائج على درجة عالية من التحسن في وجود الشبكة المنعمة والقدرة على التعامل مع مناطق النتوءات الغير محدبة.



## Zeta Function for Commuting Matrix Shift of Finite Type

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### ABSTRACT

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In this paper we show two-dimensional shifts of finite type whose transition matrices commutes and such that the entries of their product also consist of 0's and 1's. In particular, the form of associated zeta function of the two-dimensional shift was obtained. Unlike in the one-dimensional shifts of finite type; we gather that zeta functions for them have not closed form. This result derived by obtaining a formula for the number of periodic points of the subshift of finite type. This formula is then incorporated in the corresponding zeta function.

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### 1. INTRODUCTION

There has been great deal of interest has been concerning theoretical issues on a class of dynamical systems known as the higher-dimensional subshifts of finite type. In part to in the one-dimensional analogue of the aforementioned systems example(Johnson et al.,1998) and (schmidt,2000). It is well-known that each subshift of finite type can be defined via their corresponding transition matrices. And probably one of the first papers to exploit this situation, as far as higher-dimensional subshift of finite type is concerned,(markley et al.,1981)and Al-Refaei.2011). In this paper, we shall also assume that the associated transition matrices commutes but with the extra assumption that the product of these matrices also have 0-1 entries, (Noorani,M.1996)and Al-Refaei,A.2011). Our main goal is to study the form of an associated zeta function. In this paper, it shown that, unlike in the one-dimensional case, the corresponding function for the higher-dimensional analogue of this dynamical system may not have a closed form. To arrive at this conclusion we shall present a formula for the number of the periodic points of these subshifts, (Noorani,M.2002). We shall then invoke the zeta function introduced by (Lind,D.1995).where the aforementioned formula is then incorporated. Along the way we also recover some of the results proposed in (Lind,D.1995). To fix ideas, we shall concentrate entirely in the two-dimensional case.



## 2. PERIODIC POINTS

We are interested in counting the number of beriodic points for a given matrix subshifts. It is convenient to introduce the following notation which is due to (Lind,D. 1995). Let  $S = \{0,1,\dots,k-1\}$  for some fix positive integer  $k$  and  $H, V$  is two  $k \times k$  0-1 matrices, Also let  $X$  be the set

$$X = \left\{ x = (x_n) \in S^{\mathbb{Z}^2} : H(x_n, x_{n+e_1}) = V(x_n, x_{n+e_2}) = 1, \forall n \in \mathbb{Z}^2 \right\}$$

Where  $e_i$  's  $i = 1, 2$  are the standard basis vectors for  $\mathbb{Z}^2$ .

The set  $X$  together with the shift map  $\sigma_n : X \rightarrow X$  defined by  $(\sigma_n(x))_a = x_{n+a}$   $a, n \in \mathbb{Z}^2$  is called the subshift of finite type with respect to the transition matrices  $H$  and  $V$ .

We are interested in counting the number of periodic points for a given matrix subshifts.

It is convenient to introduce the following notions which are due to Lind .Let the set of all finite-index subgroups of  $\mathbb{Z}^2$  by  $\mathfrak{S}_2$  .For  $L \in \mathfrak{S}_2$ , let  $Fix_L = card \{ x \in X : \sigma_n(x) = x \forall n \in L \}$ , denote the number of points in  $X$  which are fixed by elements of  $L$ . As is in (Lind,D.1995). We are need the following classical result from the theory of integer matrices,(Manning,1971).

### Proposition 1

Every finite-index subgroup of  $\mathbb{Z}^d$  can be uniquely represented as the image of  $\mathbb{Z}^d$  under a matrix having the form

$$\begin{pmatrix} r_1 & q_{12} & q_{13} & \dots & q_{1d} \\ 0 & r_2 & q_{23} & \dots & q_{2d} \\ 0 & 0 & r_3 & \dots & q_{3d} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & 0 & 0 & r_d \end{pmatrix}$$

Where  $r_i \geq 1 \forall i = 1, 2, \dots, d$  &  $0 \leq q_{ij} \leq r_i - 1, \forall i + 1 \leq j \leq d$ .

From the above general result we have the following parameterization  $\mathfrak{S}_2^*$  of  $\mathfrak{S}_2$ ,

$$\mathfrak{S}_2^* = \left\{ \begin{pmatrix} r_1 & q \\ 0 & r_2 \end{pmatrix} \mathbb{Z}^2 : r_1, r_2 \geq 1, 0 \leq q \leq r_1 - 1 \right\}.$$

From this parameterization, we have the following proposition.

### Proposition 2

Let  $X$  be a 2-dimentional matrix subshift with transitions matrices  $H, V$  such that  $HV = VH$  and  $HV$  is a 0-1matrix. Then for each  $L \in \mathfrak{S}_2^*$  where

$$L = \begin{pmatrix} r_1 & q \\ 0 & r_2 \end{pmatrix} \mathbb{Z}^2, \text{ we have}$$

$$Fix_L = Trace(H^q V^{r_2}).$$

### 3 .ZETA FUNCTIONS

The following was introduced by (Lind,D. 1995). The zeta function associated with a 2-dimensional subshift of finite type is given as

$$\zeta(z) = \exp\left(\sum_L \frac{Fix_L}{[L]} z^{[L]}\right)$$

Where the sum is taken over all subgroups  $L$  of  $\mathbb{Z}^2$  with finite index and  $[L]$  denotes the index of  $L$ . One recovers the 1-dimensional zeta function of (Artin,M.1965) when one considers finite-index subgroups of  $\mathbb{Z}^2$ , which are given by the cosets  $\{nz : n \geq 1\}$ . Of course the above definition also holds for arbitrary  $d$ -dimensional subshift of finite type. The zeta function is clearly conjugacy invariant because the number of point of each period is preserved. For  $A \in GL(d, \mathbb{Z})$ , then  $\mathbb{Z}^2$ -shift of finite type  $\sigma^A$  can be defined as

$$(\sigma^A)^n = \sigma^{An}.$$

**Proposition 3**

Let  $\sigma$  be a  $\mathbb{Z}^2$ -shift of finite type and  $A \in GL(d, \mathbb{Z})$ . Then  $\zeta_{\sigma^A}(z) = \zeta_{\sigma}(z)$ .

Proof:

$$\text{For } L \in \mathfrak{S}_d \text{ let } AL = \{A_n : n \in L\}$$

The  $L \leftrightarrow AL$  is a bijection by  $g : L \leftrightarrow AL$  &  $g(n)=An$ ,

$$\forall n \in L, A \in GL(d, \mathbb{Z}) \Rightarrow [L] = \left| \mathbb{Z}^2 / L \right| = \left| \mathbb{Z}^2 / AL \right| = [AL]$$

$$\text{Also } x \in \{x \in X : \sigma_n(x) = x \forall n \in L\}$$

Iff  $\sigma_n(x) = x \forall n \in L$ , and  $x$  is fixed point of  $\sigma_n$  in  $X$  and

$$x \in \{x \in X : \sigma^{An}(x) = x \forall An \in AL\}$$

$$\Rightarrow \left| \{x \in X : \sigma^n(x) = x \forall n \in L\} \right| = \left| \{x \in X : (\sigma^A)^n(x) = x \forall An \in AL\} \right|$$

$$\Rightarrow P_{AL}(\sigma) = P_L(\sigma^A) = P_L(\sigma). \text{ Then}$$

$$\zeta_{\sigma^A}(z) = \exp\left(\sum_{L \in \mathfrak{S}_d} \frac{P_L(\sigma^A)}{[AL]} z^{[AL]}\right) = \exp\left(\sum_{L \in \mathfrak{S}_d} \frac{P_L(\sigma)}{[L]} z^{[L]}\right) = \zeta_{\sigma}(z).$$

The following examples will illustrate how to calculate the zeta functions when we get the periodic point.

**Example 1**

Let  $\sigma$  be  $\sigma$ -invariant of finite type on single point  $X = \{x\}$

Then  $X$  is compact space, and  $\sigma_n(x) = x \forall n \in \mathbb{L} \& P_L(\sigma) = 1 \forall L \in \mathfrak{S}_2$

In  $\mathbb{Z}^2$  let  $\mathfrak{S}_2^* = \left\{ \begin{pmatrix} r_1 & q \\ 0 & r_2 \end{pmatrix} \mathbb{Z}^2 : r_1, r_2 \geq 1, 0 \leq q \leq r_1 - 1 \right\}$ . Then the zeta function of  $\sigma$  is

$$\begin{aligned} \zeta_\sigma(z) &= \exp\left( \sum_{L \in \mathfrak{S}_2^*} \frac{P_L(\sigma)}{[L]} z^{[L]} \right) = \exp\left( \sum_{L \in \mathfrak{S}_2^*} \frac{1}{r_1 r_2} z^{r_1 r_2} \right) \\ &= \exp\left( \sum_{r_1=1}^{\infty} \sum_{r_2=1}^{\infty} \sum_{q=0}^{\infty} \frac{1}{r_1 r_2} z^{r_1 r_2} \right) = \exp\left( \sum_{r_1=1}^{\infty} \sum_{r_2=1}^{\infty} \frac{1}{r_1 r_2} z^{r_1 r_2} ((r_1 - 1) - 0 + 1) \right) \\ &= \exp\left( \sum_{r_1=1}^{\infty} \sum_{r_2=1}^{\infty} \frac{1}{r_1 r_2} z^{r_1 r_2} \right) = \exp\left( \sum_{r_1=1}^{\infty} \sum_{r_2=1}^{\infty} \frac{(z^{r_1})^{r_2}}{r_2} \right) \\ &= \exp\left( \sum_{r_1=1}^{\infty} -\log(1 - z^{r_1}) \right) = \exp\left( \sum_{r_1=1}^{\infty} \log\left( \frac{1}{1 - z^{r_1}} \right) \right) \\ &= \prod_{r_1=1}^{\infty} \left( \exp\left( \log\left( \frac{1}{1 - z^{r_1}} \right) \right) \right) = \prod_{r_1=1}^{\infty} \frac{1}{1 - z^{r_1}}. \end{aligned}$$

**Example 2**

Let  $\sigma$  be the full  $\mathbb{Z}^2$   $k$ -shift, then

$$\left( X = \{0, 1, \dots, k-1\}^{\mathbb{Z}^2}, (\sigma^n(x))_a = x_{a+n} \forall x \in X \forall n, a \in \mathbb{L} \right)$$

Then  $\forall L \in \mathfrak{S}_2 \& P_L(\sigma) = K^{[L]} = K^{r_1 r_2}$

So the zeta function is  $\exp\left( \sum_{L \in \mathfrak{S}_2} \frac{K^{[L]}}{[L]} z^{[L]} \right)$

$$\begin{aligned} &= \exp\left( \sum_{r_1=1}^{\infty} \sum_{r_2=1}^{\infty} \sum_{q=0}^{\infty} \frac{K^{r_1 r_2}}{r_1 r_2} z^{r_1 r_2} \right) = \exp\left( \sum_{r_1=1}^{\infty} \sum_{r_2=1}^{\infty} \frac{((Kz)^{r_1})^{r_2}}{r_2} \right) \\ &= \exp\left( \sum_{r_1=1}^{\infty} -\log(1 - (Kz)^{r_1}) \right) = \prod_{r_1=1}^{\infty} \frac{1}{1 - (Kz)^{r_1}}. \end{aligned}$$

**4. RESULTS**

From the above propositions, examples and by (Al-Refaei,A.2011) we get this Theorem which will be help us to get the zeta function for any periodic point that we jet it by transition matrix.

**Theorem**

Let  $X=X(H,V)$  be a 2-dimensional matrix subshift such that  $HV=VH$  and  $HV$  is a 0-1 matrix. Then the zeta function of  $X$  is formally given by

$$\zeta(z) = \prod_{i=1}^2 \prod_{j=1}^{\infty} (1 - \mu_i z^j)^{-\lambda_i^j} \text{ where } \lambda_i^j = \frac{(\lambda_i + \lambda_i^2 + \dots + \lambda_i^j)}{j} \text{ and } \lambda_i, \mu_{i,i=1,2} \text{ are the}$$

eigenvalue of  $H$  and  $V$  respectively .

Proof :

Since  $H$  and  $V$  commutes, one can simultaneously 'diagonals' them via a non-singular matrix  $R$  (see, for e.g, (Jacobson 1953)) so that

$$\begin{aligned} \text{Fix}_L &= \text{Trace} (H^q V^{r_2}) = \text{Trace} (R H^q R^{-1} R V^{r_2} R^{-1}) \\ &= \text{Trace} (diag (\lambda_1^q, \lambda_2^q)) (diag (\mu_1^{r_2}, \mu_2^{r_2})) \\ &= \text{Trace} (diag (\lambda_1^q \mu_1^{r_2}, \lambda_2^q \mu_2^{r_2})) = \lambda_1^q \mu_1^{r_2} + \lambda_2^q \mu_2^{r_2} \end{aligned}$$

Hence

$$\begin{aligned} \left( \exp \sum_L \frac{\text{Fix}_L}{[L]} \right) &= \exp \left( \sum_{r_1=1}^{\infty} \sum_{r_2=1}^{\infty} \sum_{q=1}^{r_1-1} \frac{\text{Trace} (H^q V^{r_2})}{r_1 r_2} z^{r_1 r_2} \right) \\ &= \exp \left( \sum_{i=1}^2 \sum_{r_1=1}^{\infty} \sum_{r_2=1}^{\infty} \sum_{q=1}^{r_1-1} \frac{\lambda_i^q \mu_i^{r_2}}{r_1 r_2} z^{r_1 r_2} \right) \end{aligned}$$

we see that

$$\sum_{r_2=1}^{\infty} \sum_{q=1}^{r_1-1} \frac{\lambda_i^q \mu_i^{r_2}}{r_1 r_2} z^{r_1 r_2} = -\lambda_i^{r_1} \log (1 - \mu_i z^{r_1})$$

Therefore,

$$\begin{aligned} \left( \sum_L \frac{\text{Fix}_L}{[L]} \right) &= \exp \left( \sum_{i=1}^2 \sum_{r_1=1}^{\infty} \sum_{r_2=1}^{\infty} \sum_{q=1}^{r_1-1} \frac{\lambda_i^q \mu_i^{r_2}}{r_1 r_2} z^{r_1 r_2} \right) = \exp \sum_{i=1}^2 \sum_{r_1=1}^{\infty} \log (1 - \mu_i z^{r_1})^{-\lambda_i^{r_1}} \\ &= \prod_{i=1}^2 \prod_{r_1=1}^{\infty} (1 - \mu_i z^{r_1})^{-\lambda_i^{r_1}} \end{aligned}$$

In particular, we have

$$\zeta(z) = \exp \left( \sum_L \frac{\text{Fix}_L}{L} z^{[L]} \right) = \exp \left( \log \prod_{i=1}^2 \prod_{r_1=1}^{\infty} (1 - \mu_i z^{r_1})^{-\lambda_i^{r_1}} \right) = \prod_{i=1}^2 \prod_{r_1=1}^{\infty} (1 - \mu_i z^{r_1})^{-\lambda_i^{r_1}} .$$

**5. CONCLUSIONS**

This papers focused on properties for shift of finite type exactly zeta function for subshift in dimension two, to present various method to calculate periodic point and zeta function for two-shift of finite type using subgroup and transition matrix .

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## إستخدام دالة الزيتا لحساب عمليات نقل المصفوفة من النوع المحدود

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### ملخص

في هذه الورقة نعرض ثنائية الأبعاد تحولات من نوع محدود والتي تمر بمرحلة انتقالية للمصفوفات المحولة ومثل هذه الإدخالات من ناتجها تتألف من الأرقام 0 و 1. على وجه الخصوص، تم الحصول عليها على شكل دالة زيتا يرتبط بها من التحول ثنائية الأبعاد. وخلافا للتحولات ذات بعد واحد من نوع محدد، ان تجتمع دالة زيتا بالنسبة لها ليس لها شكل مغلق. هذه النتيجة التي نحصل عليها للحصول على صيغة لعدد من النقاط الدورية للتحول من نوع محدد. ثم أدرج هذه الصيغة في دالة زيتا المقابلة.



## Classic Spline Functions for Approximate Solution of System of Non-Linear Volterra Integral Equations of the Second Kind

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### ABSTRACT

In this paper we consider non-linear system of Volterra integral equations of the second kind (NSVIEK2), Three different kinds of classic spline functions (Linear, quadratic and cubic) have been modified and applied for the first time to treat the above system, A comparison between approximate and exact results for two numerical examples depending on the least-square error are given to show the accuracy of the results obtained by using this method, Programs are written in matlab program version 7.0.

Keywords: Three different kinds of classic spline function (Linear, quadratic and cubic), system of nonlinear Volterra integral equations.

### 1. INTRODUCTION

Splines are functions that are mathematically equivalent to physical spline used by draughtsman, A physical spline is a thin flexible rod held fixed at certain points but is free to move between them, and subject of course to laws of physics [8, 10].

Mathematical spline are piecewise polynomial, where pieces correspond to interval between points that hold physical spline fixed, a set of knots defines the intervals.

Al-Salhi; find numerical solution of non-linear Volterra integral equations of the second kind [3], Al-Kahachi; Approximate method for solving Volterra integral equations of the first kind [2], Abd-Al-Hammeed; Numerical solution of Fredholm integro-differential equations using spline functions [1].

### 2- CLASSIC SPLINE FUNCTIONS: [9]

Generally, impose a subdivision of the interval  $[a, b]$  as;  $\Delta: a=x_0 < x_1 < \dots < x_n$ ,  
 $x_{n+1}=b$ ,

And use a linear polynomial on each subinterval  $[x_i, x_{i+1}]$ ;  $i=0, 1, \dots, n-1$ ,

Let  $\Delta x_i = x_{i+1} - x_i$ , then  $|\Delta| = \max\{\Delta x_i\}$ , we control accuracy by choosing  $|\Delta|$  as small as is needed, thus ; under the assumption that the local error is mainly



concentrated where the grid points are most distant, this of course; is not the entire story, as it also depends on the spectrum of the data itself,

We will define a class of functions;  $S_m^k(\Delta) = \{s : s \in C^k[a, b], s_{[x_{i-1}, x_i]} \in P_m, i = 1, 2, \dots, n-1\} \dots(1)$ ,

Where  $m, k \geq 0$  and  $S_m^k(\Delta)$  “**classic spline functions of degree m and smoothness class k**” relative to the subdivision  $\Delta$ , so  $S_m^k(\Delta)$  has differentiable structure of  $C^k$ ,

The continuity assumption of (1) is that  $k^{th}$ , derivative of  $s$  is continuous everywhere on  $[a, b]$ , and in particular; at the grid points  $x_i, i=0, 1, \dots, n-1$  of  $\Delta$ ,

If  $k=m$ , then  $s = S_m^m$  consist of polynomial of degree  $m$  and whole interval  $[a, b]$ , we don't want this, so  $k < m$ ,

Three types of classic spline functions has been considered, they are in following;

**2.1 Linear Classic Spline  $S^1(x)$ : [6]**

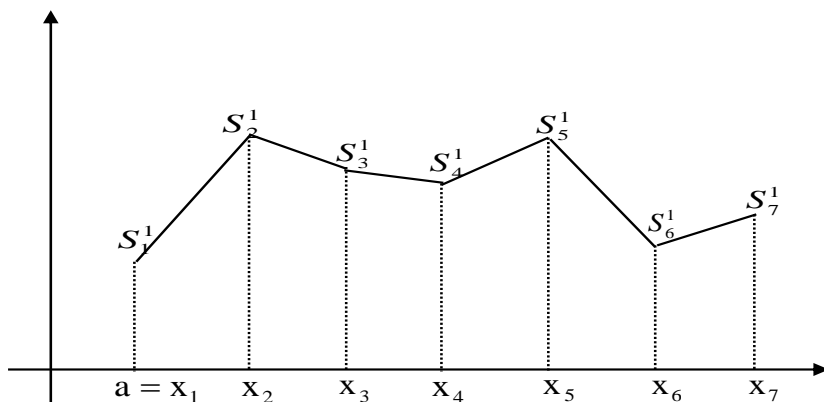
Now; we want  $s \in S_1^0(\Delta)$ , s. t. for  $f$  on  $[a, b]$ ;  $S(x_i) = S_i^1$  where  $S_i^1 \in S^1(x_i), i = 1, 2, \dots, n$ ,

It will be assumed that the interpolation points concede with grid locations  $x_i$ , though that is

not necessary, so we take;  $S^1(x) = S_i^1 + (x - x_i) \frac{(S_{i-1}^1 - S_i^1)}{(x_{i-1} - x_i)}$ ,

Therefore;  $S^1(x) = \left(\frac{x_{i+1} - x}{h}\right) S_i^1 + \left(\frac{x - x_i}{h}\right) S_{i+1}^1$ , for  $x_i \leq x_{i+1} \leq x, i = 1, 2, \dots, n-1, \dots (2)$ ,

This shown schematically in figure (1);



**figure (1): Discretization of domain**

**2.2 Quadratic Classic Spline  $S^2(x)$ : [9]**

Quadratic classic Spline is continuously differentiable piecewise quadratic function which consists of  $n$  separated polynomial over each subinterval  $[x_i, x_{i+1}]$ , i.e.  $s \in S_2^1(\Delta)$ , s. t. for  $f$  on  $[a, b]$ ;  $S(x_i) = S_i^2$  where  $S_i^2 \in S^2(x_i), i = 1, 2, \dots, n$ ,

Now; it is assumed that  $S_i^2(x) = a_i x^2 + b_i x + c_i$ , where  $S^2(x)$  is piecewise quadratic function which is continuously differentiable on each subinterval  $[x_i, x_{i+1}]$ ,  $0 \leq I \leq n-1$ ,

The formula for  $S_i^2(x)$  on  $[x_i, x_{i+1}]$  taken from some polynomials  $P_i$  of order 3, the  $i^{\text{th}}$  polynomial piece made to satisfy condition;  $P_i(x_i) = f_i(x_i)$ ,  $P_i(x_{i+1}) = f_i(x_{i+1})$  and  $P_i'(x_i) = f_i'(x_i)$ , in order to compute coefficient of  $i^{\text{th}}$  polynomial piece  $P_i$ , Newton form used as;  $P_i = P_i(x_i) + (x-x_i)[x_i, x_{i+1}]P_i' + (x-x_i)^2[x_i, x_i, x_{i+1}]P_i \dots$  (3), And divided difference table for  $P_i$  given as;

|       | $P_i(x_i)$     | $[x_i, x_{i+1}]P_i$                  | $[x_i, x_i, x_{i+1}]P_i$   |
|-------|----------------|--------------------------------------|--|
| $x_i$ | $f_i(x_i)$     | $P_i'(x_i) = \frac{dS_i^2(x_i)}{dx}$ | $\frac{[x_i, x_{i+1}]P_i - \frac{dS_i^2(x_i)}{dx}}{(x_{i+1} - x_i)}$ |
| $x_i$ | $f_i(x_i)$     |                                      |  |
| $x_i$ | $f_i(x_{i+1})$ | $[x_i, x_{i+1}]P_i$                  |  |

For above; if the table substituting in (3), yields;

$$S^2(x) = \left[ 1 - \left( \frac{x-x_i}{h} \right)^2 \right] S_i^2(x_i) + \left( \frac{x-x_i}{h} \right)^2 \left( \frac{x-x_i}{h} \right) S_i^2(x_{i+1}) + \frac{(x-x_i)(x_{i+1}-x)}{h} \frac{dS_i^2(x_i)}{dx} \dots$$
 (4)

Since  $s \in S_2^1(\Delta)$ , that is  $s \in C^1[a, b]$ , then we have;  $S_2^1(x_{i+1}) = f(x_{i+1})$ ,  $i = 0, 1, \dots, n-1$ ,

Differentiating (4) w. r. t.  $x$ , gives;  $\frac{d}{dx} S^2(x) = \frac{-2(x-x_i)}{h^2} S_i^2(x_i) + \frac{2(x-x_i)}{h^2} S_i^2(x_{i+1}) + \frac{-(x-x_i) + (x_{i+1}-x)}{h} \frac{dS_i^2(x_i)}{dx}$ ,

Putting  $x=x_{i+1}$ , yields;  $\frac{d}{dx} S^2(x_{i+1}) = \frac{d}{dx} S_i^2(x_i) + 2 \frac{(S_i^2(x_{i+1}) - S_i^2(x_i))}{h}$ , i. e.  $\frac{dS_{i+1}^2}{dx} = \frac{dS_i^2}{dx} + 2 \frac{(S_{i+1}^2 - S_i^2)}{h} \dots$  (5)

### 2.3 Cubic Classic Spline $S^3(x)$ : [8]

Cubic classic Spline are the lowest order polynomial endowed with inflection points, and it is a pricewise technique, which is very popular.

To find a cubic Spline  $S^3(x)$  for which  $S^3(x) = y_i$ ,  $i=0, 1, \dots, n, \dots$  (6),

We begin by investigating how many degrees of freedom are left in the choice of  $S^3(x)$ , once it satisfies (6), the technique used will not lead directly to practical means for calculating  $S^3(x)$ , but will furnish additional insight,

Write;  $S_i^2(x) = a_i + b_i x + c_i x^2 + d_i x^3$ ,  $x_{i-1} \leq x \leq x_i$ ,  $i=1, 2, \dots, n, \dots$  (7),

There are  $4n$  unknown coefficients  $\{a_i, b_i, c_i, d_i\}$ , the constraints are (6) and continuity restrictions, thus;  $\frac{d^j}{dx^j} S^3(x_i+0) = \frac{d^j}{dx^j} S^3(x_i-0) \dots$  (8), together gives;  $n+1+3(n-1)=4n-2$ ,

Constraints; as compared with  $4n$  unknowns, thus there are at least two degrees of freedom in choosing the coefficient of (7),

Note that nothing has been said about value of  $S^3(x)$  on  $[x_0, x_n]$ , it is easy to construct an extension to  $(-\infty, \infty)$ , although it will not be unique,

Now we give method for constructing  $S^3(x)$ , Introduce notation  $M_i = \frac{d^2}{dx^2} S^3(x_i)$ ,  $i=0,1,\dots,n$ ,

Since;  $S^3(x)$  is cubic on  $[x_i, x_{i+1}]$ ,  $\frac{d^2}{dx^2} S^3(x_i)$  is linear and thus;

$$M_i = \frac{d^2}{dx^2} S^3(x_i) = \frac{(x_{i+1}-x)M_i + (x-x_i)M_{i+1}}{h_i}, \quad i=0,1,\dots,n-1, \dots \quad (9), \text{ where } h_i=x_{i+1}-x_i,$$

with this formula  $\frac{d^2}{dx^2} S^3(x)$  is continuous on  $[x_0, x_n]$ ,

$$\text{Integrate twice to get; } S^3(x) = \frac{(x_{i+1}-x)^3 M_i + (x-x_i)M_{i+1}}{6h_i} + C(x_{i+1}-x) + D(x-x_i), \text{ with } C, D$$

arbitrary,

The interpolating condition (6) implies;  $C = \frac{y_i}{h_i} - \frac{h_i M_i}{6}$ ,  $D = \frac{y_{i+1}}{h_i} - \frac{h_i M_{i+1}}{6}$ , and so;

$$S^3(x) = \frac{(x_{i+1}-x)^3 M_i + (x-x_i)M_{i+1}}{6h_i} + \frac{(x_{i+1}-x)y_i + (x-x_i)y_{i+1}}{h_i} - \frac{h_i}{6} \left[ (x_{i+1}-x)^3 M_i + (x-x_i)M_{i+1} \right], \quad x_i \leq x \leq x_{i+1}, \quad 0 \leq i \leq n-1, \dots \quad (10)$$

Thus (10) implies continuity of  $S^3(x)$  on  $[a, b]$ , as well as interpolating condition (6), To determine  $M_0, M_1, \dots, M_n$  we require  $\frac{d^2}{dx^2} S^3(x)$  to be continuous at  $x_1, x_2, \dots, x_{n-1}$ ,

$$\lim_{x \rightarrow x_i^-} \frac{d^2}{dx^2} S^3(x) = \lim_{x \rightarrow x_i^+} \frac{d^2}{dx^2} S^3(x), \quad i=1,2,\dots,n-1, \dots \quad (11),$$

$$\text{on } [x_i, x_{i+1}]; \quad \frac{d}{dx} S^3(x) = \frac{-(x_{i+1}-x)^2 M_i + (x-x_i)^2 M_{i+1}}{2h_i} + \frac{y_{i+1}-y_i}{h_i} - \frac{h_i}{6} [M_{i+1} - M_i],$$

$$\text{and on } [x_{i-1}, x_i]; \quad \frac{d}{dx} S^3(x) = \frac{-(x_i-x)^2 M_{i-1} + (x-x_{i-1})^2 M_i}{2h_{i-1}} + \frac{y_i - y_{i-1}}{h_{i-1}} - \frac{h_{i-1}}{6} [M_i - M_{i-1}],$$

$$\text{Using (11) and some manipulation, yield; } \frac{h_{i-1}}{6} M_{i-1} + \frac{h_i + h_{i-1}}{3} M_i + \frac{h_i}{6} M_{i+1} = \frac{y_{i+1}-y_i}{h_i} - \frac{y_i - y_{i-1}}{h_{i-1}}, \dots \quad (12),$$

For  $i=1, 2, \dots, n-1$ , this gives  $n-1$  equations for  $n+1$  unknowns  $M_0, M_1, \dots, M_n$ , we generally specify an endpoint condition at  $x_0, x_n$ , to remove two degrees freedom as in (12),

**Case1:** "The cubic natural interpolating spline",

$$\text{One particular choice of endpoint condition is to use; } M_0=M_n=0 \dots \quad (13),$$

This may appear, but it is based on the solution of following important problem, Among all functions  $g(x)$ , which are twice continuously differentiable on  $[a, b]$ , and satisfy;  $g(x_i)=y_i$ ,

$$i=0, 1, \dots, n, \dots \quad (14), \text{ Choose } g \text{ minimizes integral; } \int_a^b [g''(x)]^2 dx,$$

The solution of problem above will be an interpolating function to the data in (14), And it should contain a minimum of oscillatory behavior  $g''(x)$  because is small,

The solution is cubic spline  $S^n(x)$ , which satisfies (12) and (13),

$$\text{The condition } \frac{d^2 S^3(x_0)}{dx^2} = \frac{d^2 S^3(x_n)}{dx^2} = 0, \text{ has interpolation that } S^3(x) \text{ is linear on } (-\infty, x_0), (x_n, \infty),$$

This can be given additional physical meaning by using theory of small deformation of thin beam of an elastic material,

With the choice of (13) we have the system of equations;  $AM = D \dots$  (15), S. t;

$$A = \begin{bmatrix} \frac{h_0 + h_1}{3} & \frac{h_2}{6} & 0 & \dots & 0 \\ \frac{h_1}{6} & \frac{h_1 + h_2}{3} & \frac{h_2}{6} & \dots & 0 \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ 0 & \dots & \frac{h_{n-2}}{6} & \frac{h_{n-1} + h_{n-2}}{3} & \cdot \end{bmatrix}, M = \begin{bmatrix} M_1 \\ M_2 \\ \cdot \\ \cdot \\ M_{n-1} \end{bmatrix},$$

$$\text{and } D = \begin{bmatrix} \frac{h_2 - h_1}{h_1} - \frac{h_1 - h_0}{h_0}, \dots, \frac{h_n - h_{n-1}}{h_{n-1}} - \frac{h_{n-1} - h_{n-2}}{h_{n-2}} \end{bmatrix}'$$

This matrix is symmetric, positive definite and diagonally dominant, also the associated linear system (15) can be easily and rapidly solved,

**Case1:** “Endpoint derivative conditions”,

To specify  $M_0, M_n$  implicitly, impose condition  $\frac{d}{dx}S^3(x)$  at endpoints;

$$\frac{d}{dx}S^3(x_0) = y_0', \frac{d}{dx}S^3(x_n) = y_n' \dots (16),$$

this leads to additional equations;

$$\frac{h_0}{3}M_0 + \frac{h_0}{6}M_1 = \frac{y_1 - y_0}{h_0} - y_0', \frac{h_{n-1}}{6}M_{n-1} + \frac{h_{n-1}}{3}M_n = y_n' - \frac{y_n - y_{n-1}}{h_{n-1}} \dots (17),$$

The system composed of (13) and (17) is of order  $n+1$ , and it has exactly the same properties as the earlier matrix  $A$  in (15) of case1.

### 3- THE ERRORS OF CLASSIC SPLINE FUNCTIONS

#### 3-1 Theorem:

Let  $x_0, x_1, \dots, x_n$ , be distinct real numbers, and  $f$  be given real-value function of  $C^{n+1}$ , i. e.  $f$  has  $n+1$ -derivative on interval  $I = \mathbb{S}\{t, x_0, x_1, \dots, x_n\}$ , with  $t$

some given real number, then there exist  $\xi \in I$ , s. t.  $f(t) - p_n(t) = \frac{(t - x_0) \dots (t - x_n)}{(n + 1)!} f^{n+1}(\xi)$ ,

Where  $p_n(t) = \sum_{j=0}^n f(x_j)l_j(t)$ , and that  $l_j(t) = \prod_{i \neq j} \left( \frac{t - x_i}{x_j - x_i} \right)$ ,  $j = 0, 1, \dots, n$ ,

#### Proof:

Note that result is trivially true if  $t$  is any node point, since then both sides of (18) are zero,

Assume  $t$  does not equal node point, define;  $E(x) = f(x) - p_n(x)$ ,  $G(x) = E(x) \cdot \frac{\psi(x)}{\psi(t)}$ ,  $\forall x \in I$ ,

With  $\psi(x) = (x - x_0)(x - x_1) \dots (x - x_n)$ , so  $G(x)$  is  $n+1$ time differentiable on  $I$ , as  $E(x)$ ,  $\psi(x)$  are,

Also  $G(x_i) = E(x_i) - \frac{\psi(x_i)}{\psi(t)} E(t)$ ,  $i = 0, 1, \dots, n$  and  $G(t) = E(t) - E(t) = 0$ , thus  $G$  has  $n+2$  distinct zero in  $I$ ,

when one uses the mean value theorem,  $G'$  has  $n+2$  distinct zero, inductively  $G^{(j)}(x)$  has  $n+2-j$  zero in  $I$ , for  $j=0, 1, \dots, n+1$ ,

Let  $\xi$  be the zero of  $G^{(n+1)}(x)$ ,  $G^{(n+1)}(\xi) = 0$ , since  $E^{(n+1)}(x) = f^{(n+1)}(x)$ ,  $\psi^{(n+1)}(x) = (n+1)!$ , we obtain;  $\psi^{(n+1)}(x) = f^{(n+1)}(x) \cdot \frac{(n+1)!}{\psi(t)} E(t)$ , substituting  $x = \xi$  and solving for

$E(t)$ ,  $E(t) = \frac{\psi(t)}{(n+1)!} f^{(n+1)}(\xi)$ , give the desired result, and this may seem a tricky derivation, but

it is commonly used technique for obtaining some error formulas,

#### 4- SOLUTION OF SYSTEM OF NON-LINEAR VIE'S USING CLASSIC SPLINE FUNCTIONS

In this section, we use classic Spline functions “quadratic and cubic” to find the numerical solution of system of non-linear VIE's of the form;

$$u_i(x) = f_i(x) + \sum_{j=1}^m \int_0^x K_{ij}(x, t, u_j(t)) dt, \quad x \in I = [a, b] \dots (19), \text{ where } m \in N, f_i \text{ s. t. } i=1, 2, \dots, n, \text{ assumed}$$

to be continuous on  $I$ , and  $K_{ij}$  s. t.  $i, j=1, 2, \dots, m$ , denotes given continuous functions,

##### 4-1 Using Linear Classic Spline Function $S^1(t)$ :

A linear interpolation  $S^1(t)$  with knots  $t_0, t_1, \dots, t_n$ , in interval  $[t_i, t_{i+1}]$  is given by;

$$S^1(t) = A_i(t)S_i^1 + B_i(t)S_{i+1}^1 \dots (20), \text{ where } A_i(t) = \frac{t_{i+1} - t}{h} \text{ and } B_i(t) = \frac{t - t_i}{h}, \text{ substituting}$$

equation (20) into (19) gives;  $S_i^1$ ,  $i = 1, 2, \dots, n$ , with  $t = t_r$  and  $r = 1, 2, \dots, n$ , so we get;

$$S_{ir}^1 = f_{ir} + \sum_{j=1}^m \sum_{z=0}^{r-1} \left( \int_{x_z}^{x_{z+1}} K_{ij}(x_r, t [A_z(t)S_{jz}^1 + B_z(t)S_{j,z+1}^1]) dt \right) \quad i = 1, 2, \dots, m \text{ and } r = 1, 2, \dots, n, \dots (21)$$

Where  $S_{ir}^1 = S_i^1(t_r)$  and  $f_{ir} = f_i(t_r)$  and the iterated integral above are calculated using Trapezoidal rule, the following algorithm is considered as solve a system of non-linear VIE's using linear classic Spline function as follows;

##### The algorithm (NSVIELSP);

###### Step1:

- a- Assume  $h = \frac{b}{n}$ ,  $n \in N$ ,
- b- Set  $S_{i0}^1 = f_{i0}$ ,  $i = 1, 2, \dots, m$ ,

###### Step2:

To compute  $S_{r1}^1$ ,  $i = 1, 2, \dots, m$  we use step1, put  $r=1$  in (21) and using algorithm (NLVIETRP),

**Step3:** In same way as in step2, and using (21) we compute  $S_{1r}^1, S_{2r}^1, \dots, S_{mr}^1$ ,  $r = 2, 3, \dots, n$ ,

**4-2 Using Quadratic Classic Spline Function  $S^2(t)$ :**

Quadratic Classic Spline  $S^2(t)$  with knots  $t_0, t_1, \dots, t_n$ , in  $[t_i, t_{i+1}]$  can be written as;

$$S^2(t) = A_i(t)S_i^2 + B_i(t)S_{i+1}^2 + D_i(t)\frac{dS_i^2}{dt} \quad (22),$$

where;  $A_i(t) = 1 - \left(\frac{t-t_i}{h}\right)^2$ ,  $B_i(t) = 1$  and  $D_i(t) = \frac{(t-t_i)(t_{i+1}-t)}{h}$ ,

Putting (22) into (19) gives;  $u_i; i=1,2,\dots,n$ , with  $t=t_r, r=1,2,\dots,n$ , we get;

$$S_{ir}^2 = f_{ir} + \sum_{j=1}^m \sum_{z=0}^{r-2} \left\{ \int_{x_z}^{x_{z+1}} K_{ij} \left( x_r, t [A_z(t)S_{jz}^2 + B_z(t)S_{j,z+1}^2 + D_z(t)\frac{dS_{jz}^2}{dt}] dt \right) \right\} \dots(23),$$

$$+ \sum_{j=1}^m \left\{ \int_{x_{r-1}}^{x_r} K_{ij} \left( x_r, t [A_{r-1}(t)S_{j,r-1}^2 + B_{r-1}(t)S_{j,r}^2 + D_r(t)\frac{dS_{j,r-1}^2}{dt}] dt \right) \right\} i = 1,2,\dots,m,$$

Where  $S_{ir}^2 = S_i^2(t_r)$  and  $f_{ir} = f_i(t_r)$ ,  $i = 1,2,\dots,m$ ,

Now for  $r=1$  we need to calculate  $\frac{dS_{j0}^2}{dt}$ ,  $j=1,2,\dots,m$ , we can find this value by differentiating (19) one-time w. r. t.  $x$ , so we get;

$$u_i'(x) = f_i'(x) + \sum_{j=1}^m \int_0^x \frac{dK_{ij}(x, t, u_j(t))}{dx} dt + \sum_{j=1}^m K_{ij}(x, x, u_j(x)), j = 1,2,\dots,m, \text{ putting } t=a, \text{ we obtain;}$$

$$u_{i0}' = f_{i0}' + \sum_{j=1}^m K_{ij}(a, a, u_{j0}), j = 1,2,\dots,m, \dots (24),$$

But for  $r=2,3,\dots,n$  we calculate  $\frac{dS_{jr}^2}{dt}$  by;  $\frac{dS_{jr}^2}{dt} = \frac{dS_{j,r-1}^2}{dt} + \frac{2(S_{jr}^2 - S_{j,r-1}^2)}{h}$ ,  $j = 1,2,\dots,n \dots (25)$ ,

The following algorithm is considered to solve a system of non-linear VIE's using quadratic classic Spline functions,

**The algorithm (NSVIEQSP);**

**Step1:**

- a- Assume  $h = \frac{b}{n}$ ,  $n \in N$ ,
- b- Set  $S_{i0}^2 = f_{i0}$ ,  $i = 1,2,\dots,m$ ,

**Step2:**

- a- To calculate  $\frac{dS_{j0}^2}{dt}$  we use step1, with equation (24),
- b- To compute  $S_{i1}^2$ ,  $i = 1,2,\dots,m$  we use step1 and step2-a, put  $r=1$  in (23) and using algorithm (NLVIETRP),

**Step3:**

a- Using step1, step2, to find  $\frac{dS_{j1}^2}{dt}$ , by putting  $i=0$  in (25),

b- Putting  $r=2$  in (23) to find  $S_{i2}^2, i = 1,2,\dots,m$ , and using algorithm (NLVIETRP),

**Step4:**

In same way as in step3, and using (21, 25) we compute;

$$\frac{dS_{j2}^2}{dt}, S_{j3}^2, \frac{dS_{j3}^2}{dt}, S_{j4}^2, \dots \text{and so on, } j = 1,2,\dots,m,$$

**4-3 Using Cubic Classic Spline Function  $S^3(t)$ :**

A cubic Classic Spline  $S^3(t)$  with knots  $t_0, t_1, \dots, t_n$ , in  $[t_i, t_{i+1}]$  can be written as;

$$S^3(t) = A_i(t)S_i^3 + B_i(t)S_{i+1}^3 + C_i(t)\frac{dS_i^3}{dt} + D_i(t)\frac{dS_{i+1}^3}{dt} \dots (26), \text{ where;}$$

$$A_i(t) = 1 - 3\left(\frac{t-t_i}{h}\right)^2 + 2\left(\frac{t-t_i}{h}\right)^3, B_i(t) = 1 - A_i(t), C_i(t) = (t-t_i)\left(\frac{t-t_{i+1}}{h}\right)^2 \text{ and } D_i(t) = (t-t_{i+1})\left(\frac{t-t_i}{h}\right)^2,$$

Substituting (26) in (19) gives;  $u_i; i=1,2,\dots,n$ , with  $t=t_r, r=1,2,\dots,n$ , we get;

$$S_{ir}^3 = f_{ir} + \sum_{j=1}^m \sum_{z=0}^{r-2} \left\{ \int_{x_z}^{x_{z+1}} K_{ij} \left( x_r, t [A_z(t)S_{jz}^3 + B_z(t)S_{j,z+1}^3 + C_z(t)\frac{dS_{jz}^3}{dt} + D_z(t)\frac{dS_{j,z+1}^3}{dt}] dt \right) \right\} \dots(27)$$

$$+ \sum_{j=1}^m \left\{ \int_{x_{r-1}}^{x_r} K_{ij} \left( x_r, t [A_{r-1}(t)S_{j,r-1}^3 + B_{r-1}(t)S_{j,r}^3 + C_r(t)\frac{dS_{j,r-1}^3}{dt} + D_r(t)\frac{dS_{j,r}^3}{dt}] dt \right) \right\} i = 1,2,\dots,m,$$

Where  $S_{ir}^3 = S_i^3(t_r)$  and  $f_{ir} = f_i(t_r), i = 1,2,\dots,m$ , we calculate  $\frac{dS_{jr}^3}{dt}, j = 1,2,\dots,m$ , by equation;

$$\frac{dS_{j,r+1}^3}{dt} = -\frac{dS_{j,r-1}^3}{dt} - 4\frac{dS_{jr}^3}{dt} + \frac{3(S_{j,r+1}^3 - S_{j,r-1}^3)}{h}, j = 1,2,\dots,n \dots (28),$$

The following algorithm is considered to solve a system of non-linear VIE's using Cubic classic Spline functions,

**The algorithm (NSVIECSP);**

**Step1:**

Assume  $h = \frac{b}{n}, n \in N$ , and set  $S_{i0}^3 = f_{i0}, i = 1,2,\dots,m$ ,

**Step2:**

a- To calculate  $\frac{dS_{j0}^3}{dt}$  we use step1, with equation (24),

b- To compute  $S_{i1}^3, i = 1,2,\dots,m$ , use step1, 2-a, put  $r=1$  in (27) and use (NLVIETRP),

**Step3:**

a- Using step1, step2, to find  $\frac{dS_{j1}^3}{dt}$ , by putting  $i=0$  in (28),

b- Putting  $r=2$  in (21) to find  $S_{i2}^3, i = 1, 2, \dots, m$ , and using algorithm (NLVIETRP),

**Step4:**

In same way as in step3, and using (27, 28) we compute;

$$\frac{dS_{j2}^3}{dt}, S_{j3}^3, \frac{dS_{j3}^3}{dt}, S_{j4}^3, \dots \text{and so on, } j = 1, 2, \dots, m,$$

**5- NUMERICAL EXAMPLES**

**5-1 Example:**

Consider problem;  $u_1(x) = \frac{1}{4}(1 - e^{2x}) + \int_0^x (x-t)(u_2(t))^2 dt$  and  $u_2(x) = -(x e^x - 2e^{2x} + 1) + \int_0^x t e^{-2u_1(t)} dt$ ,

Which is system of two non-linear VIE's with;  $u_1(x) = -\frac{1}{2}x, u_2(x) = e^x$ ,

Tables (1, 2), present comparison between exact and numerical solution using classic Spline ‘‘Quadratic and Cubic’’, for respectively depending on last square error and running time with  $h=0.1$ ,

**Table(1),**

| X   | Exact1       | LSP          | QSP          | CSP          |
|-----|--------------|--------------|--------------|--------------|
| 0.0 | 0            | 0            | 0            | 0            |
| 0.1 | -5.0000e-002 | -5.2151e-002 | -5.2151e-002 | -5.0351e-002 |
| 0.2 | -1.0000e-001 | -1.0356e-001 | -1.0294e-001 | -1.0074e-001 |
| 0.3 | -1.5000e-001 | -1.5456e-001 | -1.5384e-001 | -1.5117e-001 |
| 0.4 | -2.0000e-001 | -2.0642e-001 | -2.0503e-001 | -2.0165e-001 |
| 0.5 | -2.5000e-001 | -2.5827e-001 | -2.5638e-001 | -2.5216e-001 |
| 0.6 | -3.0000e-001 | -3.0903e-001 | -3.0832e-001 | -3.0285e-001 |
| 0.7 | -3.5000e-001 | -3.6983e-001 | -3.6043e-001 | -3.5315e-001 |
| 0.8 | -4.0000e-001 | -4.4377e-001 | -4.1377e-001 | -4.0558e-001 |
| 0.9 | -4.5000e-001 | -4.6974e-001 | -4.6712e-001 | -4.6108e-001 |
| 1.0 | -5.0000e-001 | -5.4390e-001 | -5.2290e-001 | -5.0261e-001 |
|     | L. S. E.     | 6.2481e-002  | 1.2791e-003  | 1.8818e-004  |
|     | R. T.        | 0.118000     | 0.141000     | 0.156000     |

**Table(2),**

| X   | Exact2      | LSP         | QSP         | CSP         |
|-----|-------------|-------------|-------------|-------------|
| 0.0 | 1.0000e+000 | 1.0000e+000 | 1.0000e+000 | 1.0000e+000 |
| 0.1 | 1.1052e+000 | 1.1053e+000 | 1.1053e+000 | 1.1053e+000 |
| 0.2 | 1.2214e+000 | 1.2207e+000 | 1.2207e+000 | 1.2218e+000 |
| 0.3 | 1.3499e+000 | 1.3484e+000 | 1.3484e+000 | 1.3504e+000 |

|     |             |             |              |             |
|-----|-------------|-------------|--------------|-------------|
| 0.4 | 1.4918e+000 | 1.4889e+000 | 1.48893e+000 | 1.4925e+000 |
| 0.5 | 1.6487e+000 | 1.6449e+000 | 1.6449e+000  | 1.6494e+000 |
| 0.6 | 1.8221e+000 | 1.8159e+000 | 1.8159e+000  | 1.8227e+000 |
| 0.7 | 2.0138e+000 | 2.0067e+000 | 2.0067e+000  | 2.0135e+000 |
| 0.8 | 2.2255e+000 | 2.2154e+000 | 2.2154e+000  | 2.2261e+000 |
| 0.9 | 2.4596e+000 | 2.4488e+000 | 2.4488e+000  | 2.4662e+000 |
| 1.0 | 2.7183e+000 | 2.7052e+000 | 2.7052e+000  | 2.7108e+000 |
|     | L. S. E.    | 7.1242e-002 | 5.0352e-003  | 1.0218e-004 |
|     | R. T.       | 0.118000    | 0.141000     | 0.156000    |

Tables (3), presents the error and running time for Cubic classic Spline when  $h$  is changing and initial value is fixed,

|       |             |             |             |          |
|-------|-------------|-------------|-------------|----------|
|       | H=0.1       | H=0.05      | H=0.02      | H=0.01   |
| CSP   | 1.8818e-004 | 2.0280e+919 | 8.3653e+067 | NaN      |
|       | 1.0218e-004 | 8.8485e+006 | 2.1605e+003 | NaN      |
| R. T. | 0.156000    | 0.421000    | 2.235000    | 9.047000 |

Tables (4), presents the error and running time for Cubic classic Spline when initial value is changing and  $h$  is fixed,

| I.V.  | $u_1$       | $u_2$       | R.T.     |
|-------|-------------|-------------|----------|
| 0.0   | 1.8818e-004 | 1.0218e-004 | 0.156000 |
| 0.001 | 3.0520e-004 | 3.4644e-005 | 0.141000 |
| 0.01  | 2.5423e-003 | 1.2761e-002 | 0.140000 |
| 0.1   | 1.8072e-001 | 9.7074e+001 | 0.156000 |
| 0.5   | 3.2369e+003 | 5.4064e+002 | 0.157000 |

**5-2 Example:**

Consider problem;  $u_1(x) = (x - x^2) + \int_0^x (u_1(t) + u_2(t))dt$  and  $u_2(x) = (x - \frac{x^2}{2} - \frac{x^3}{3}) + \int_0^x (u_1^2(t) + u_2(t))dt$ ,

Which is system of two non-linear VIE's with;  $u_1(x) = x$ ,  $u_2(x) = x$ ,

Tables (5, 6), present comparison between exact and numerical solution using classic Spline functions "Quadratic and Cubic", for  $u_1(t)$  and  $u_2(t)$  respectively, depending on last square error and running time with  $h=0.1$ ,

**Table(5),**

| $t$ | Exact1      | LSP         | QSP         | CSP         |
|-----|-------------|-------------|-------------|-------------|
| 0.0 | 0           | 0           | 0           | 0           |
| 0.1 | 1.0000e-001 | 5.4933e-002 | 7.9233e-002 | 9.9233e-002 |
| 0.2 | 2.0000e-001 | 0.9345e-001 | 1.8245e-001 | 1.9985e-001 |

|          |             |             |             |             |
|----------|-------------|-------------|-------------|-------------|
| 0.3      | 3.5000e-001 | 2.4384e-001 | 2.6754e-001 | 2.9985e-001 |
| 0.4      | 4.0000e-001 | 3.5818e-001 | 3.7858e-001 | 3.9978e-001 |
| 0.5      | 5.5000e-001 | 4.3855e-001 | 4.5185e-001 | 4.9990e-001 |
| 0.6      | 6.0000e-001 | 5.6667e-001 | 5.7617e-001 | 5.9930e-001 |
| 0.7      | 7.5000e-001 | 6.0101e-001 | 6.2291e-001 | 7.0134e-001 |
| 0.8      | 8.0000e-001 | 7.5892e-001 | 7.8202e-001 | 7.9354e-001 |
| 0.9      | 9.5000e-001 | 7.6116e-001 | 7.6346e-001 | 8.7086e-001 |
| 1.0      | 1.0000e+000 | 1.0294e+000 | 1.0200e+000 | 1.0054e+000 |
| L. S. E. |             | 2.1189e-001 | 3.0450e-002 | 9.2268e-004 |
| R. T.    |             | 0.097000    | 0.109000    | 0.141000    |

**Table(6),**

| $t$      | Exact2      | LSP         | QSP         | CSP         |
|----------|-------------|-------------|-------------|-------------|
| 0.0      | 0           | 0           | 0           | 0           |
| 0.1      | 1.0000e-001 | 8.1805e-002 | 9.1805e-002 | 9.9805e-002 |
| 0.2      | 2.0000e-001 | 0.9999e-001 | 1.9027e-001 | 2.0025e-001 |
| 0.3      | 3.0000e-001 | 2.1821e-001 | 2.8477e-001 | 3.0042e-001 |
| 0.4      | 4.0000e-001 | 3.5679e-001 | 3.8472e-001 | 4.0052e-001 |
| 0.5      | 5.0000e-001 | 4.6881e-001 | 4.7021e-001 | 5.0081e-001 |
| 0.6      | 6.0000e-001 | 5.7678e-001 | 5.8190e-001 | 6.0038e-001 |
| 0.7      | 7.0000e-001 | 6.2789e-001 | 6.4163e-001 | 7.0259e-001 |
| 0.8      | 8.0000e-001 | 7.8119e-001 | 7.9791e-001 | 7.9489e-001 |
| 0.9      | 9.0000e-001 | 7.7821e-001 | 7.8992e-001 | 8.7128e-001 |
| 1.0      | 1.0000e+000 | 1.1981e+000 | 1.1935e+000 | 1.0046e+000 |
| L. S. E. |             | 7.5391e-001 | 2.8080e-002 | 8.8035e-004 |
| R. T.    |             | 0.97000     | 0.109000    | 0.141000    |

Tables (7), presents the error and running time for Cubic classic Spline when  $h$  is changing and initial value is fixed,

|       | H=0.1       | H=0.05      | H=0.02   | H=0.01   |
|-------|-------------|-------------|----------|----------|
| CSP   | 9.2268e-004 | 1.0507e-005 | NaN      | NaN      |
|       | 8.8035e-004 | 7.2419e-006 | NaN      | NaN      |
| R. T. | 0.141000    | 0.359000    | 1.875000 | 7.485000 |

Tables (8), presents the error and running time for Cubic classic Spline when initial value is changing and  $h$  is fixed,

| I.V. | $u_1$       | $u_2$       | R.T.     |
|------|-------------|-------------|----------|
| 0.0  | 9.2268e-004 | 8.8035e-004 | 0.141000 |

|       |             |             |          |
|-------|-------------|-------------|----------|
| 0.001 | 9.2269e-003 | 8.8488e-003 | 0.141000 |
| 0.01  | 5.7983e-001 | 2.7313e-000 | 0.141000 |
| 0.1   | 6.2564e-002 | 5.8120e+004 | 0.140000 |
| 0.5   | 4.5803e+004 | 3.8322e+007 | 0.141000 |

## 6- DISCUSSION

This Paper; introduce numerical methods for approximation solution of system of non-linear VIE's, which are classic Spline "Linear classic Spline, Quadratic classic Spline, Cube classic Spline", we have tried to emphasize some important ideas while maintaining a reasonable level of complexity, for one thing; we have always used a uniform step size, This method for solving a system of non-linear VIE's has some advantages and disadvantages, the following remarks are concluded;

- The cube classic Spline gives better accuracy than Quadratic classic Spline,
- The quadratic classic Spline gives better accuracy than Linear classic Spline,
- The running time of quadratic classic Spline is less than running time of cubic classic Spline,

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## دراسة منظومة معادلات فولتيرا التكاملية اللاخطية من النوع الثاني

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### ملخص

في هذا العمل تم دراسة منظومة معادلات فولتيرا التكاملية اللاخطية من النوع الثاني، كما تم تطوير واستخدام ثلاث أنواع مختلفة من دوال الثلمة التقليدية "الخطية، التربيعية، التكعيبية"، حيث طورت وطبقت في منحى غير مسبوق لمعالجة المنظومة أعلاه، إضافة للمقارنات بين الحلول التقريبية والمضبوطة من خلال الاعتماد على أخطاء التربيغات الصغرى، وهو ما يمثل تعزيز للناتج التي تم التوصل إليها باستخدام تلك الطريقة، مع استخدام برنامج " Matlab Version 7.0" لكتابة البرامج الخاصة بهذه الطريقة.



## On A Class of Locally Convex Involution Algebras

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### ABSTRACT

In this paper we introduced a class of locally convex involution algebras called MBG\*-algebras as generalized of GB\*-algebras was introduced by Allan. We obtain some results on this class and established a necessary and sufficient conditions for a commutative MGB\*-algebra to be symmetric.

*Mathematics Subject Classifications:* 46A03, 46K05, 46H05.

*Keywords:* Locally convex \*-algebras; GB\*-algebras; symmetric \*-algebras; hermitian algebras.

### 1. INTRODUCTION

Since the theory of Banach algebras has undergone considerable development, the concepts of locally convex \*-algebras and pseudo-complete locally convex \*-algebras (PL\*-algebras) was introduced by Allan [1] and as generalizations of normed \*-algebras and in particular Banach \*-algebras. In [2], Allan defined a class of locally convex \*-algebras called GB\*-algebras as a generalization of B\*-algebras. In this paper we introduced a new class of locally convex \*-algebras called MGB\*-algebras (definition (3.3)) as a modification of GB\*-algebras. This class is more general of the definition of GB\*-algebras introduced by Allan [2]. The required definitions and results from books and research papers (cited in the bibliography) are listed in §2.

In §3 we obtain some results on locally convex MBG\*-algebras and establish a necessary and sufficient conditions for a commutative MGB\*-algebra to be symmetric, Theorem (3.11).

### 2. LOCALLY CONVEX\*-ALGEBRAS

We shall use the basic terminologies of definitions and results of this section from books and research papers cited in the bibliography.

**DEFINITION 2.1** [7] A \*-algebra is an associative linear algebra  $A$  over the complex field  $\mathbb{C}$  with an involution  $*$  satisfying the usual axioms

- (i)  $(\lambda x + \mu y)^* = \bar{\lambda}x^* + \bar{\mu}y^*$  ( $x, y \in A; \lambda, \mu \in \mathbb{C}$ );
- (ii)  $(xy)^* = y^*x^*$  ( $x, y \in A$ );



$$(iii) \ x^{**} = x \quad (x \in A).$$

An element  $x \in A$  will be called hermitian if  $x^* = x$  and normal if  $x^*x = xx^*$ . The set of all hermitian elements of  $A$  will be denoted by  $A_h$ .

**DEFINITION 2.2** [1] A locally convex algebra is an associative linear algebra  $A$  over the complex field  $\mathbb{C}$  equipped with a topology  $\tau$  such that

(i)  $(A, \tau)$  is a Hausdorff locally convex topological vector space ;

(ii) for any element  $x_0 \in A$  the maps  $x \rightarrow x_0 x$  and  $x \rightarrow xx_0$  of  $A$  into itself are continuous.

**DEFINITION 2.3** [1] Let  $E$  be a locally convex space. A subset  $B$  of  $E$  is said to be bounded if for each neighborhood  $V$  of the origin, there is  $\lambda > 0$  such that  $B \subseteq \lambda V$ .

**DEFINITION 2.4**[1] Let  $A$  be a locally convex algebra. An element  $x \in A$  is bounded if and only if for some non-zero  $\lambda \in \mathbb{C}$  the set  $\{(\lambda x)^n : n = 1, 2, \dots\}$  is a bounded subset of  $A$ . The set of all bounded elements of  $A$  will be denoted by  $A_0$ .

**REMARK 2.5** Every element of a normed algebra is bounded so for each normed algebra  $A$ ,  $A = A_0$ .

**NOTATION 2.6** If  $A$  is a locally convex algebra, then  $\mathcal{B}_1$  will denote the collection of all subsets  $B$  of  $A$  such that

(i)  $B$  is absolutely convex and  $B^2 \subseteq B$ ,

(ii)  $B$  is bounded and closed.

For each  $B \in \mathcal{B}_1$ , let  $A(B)$  denote the sub-algebra of  $A$  generated by  $B$ . Then from (i) and (ii)

$$A(B) = \{\lambda x : \lambda \in \mathbb{C}, x \in B\}.$$

And the Minkowski functional

$$\|x\|_B = \inf\{\lambda > 0 : x \in \lambda B\} \quad (x \in A(B)),$$

defines a norm on  $A(B)$ , which make  $A(B)$  a normed algebra. Unless mention is made to the contrary, it will always be assumed that  $A(B)$  carries the topology induced by this norm.

**DEFINITION 2.7**[1] The locally convex algebra  $A$  is called pseudo-complete algebra if and only if each normed algebra  $A(B)$  ( $B \in \mathcal{B}_1$ ) is complete (Banach algebra) and denoted by PL-algebra.

**DEFINITION 2.8** A subcollection  $\mathcal{B}_2$  of  $\mathcal{B}_1$  is said to be basic in  $\mathcal{B}_1$  if for every  $B_1$  in  $\mathcal{B}_1$  there is some  $B_2$  in  $\mathcal{B}_2$  such that  $B_1 \subseteq B_2$ .

**PROPOSITION 2.9** Let  $A$  be a locally convex algebra and let  $\mathcal{B}_2$  be any basic subcollection in  $\mathcal{B}_1$ . Then

$$A_0 = \cup \{A(B) : B \in \mathcal{B}_2\}.$$

*Proof.* See [1] Proposition(2.4).

**PROPOSITION 2.10** Let  $A$  be a locally convex algebra. If  $A$  is sequentially complete then  $A$  is pseudo-complete but not conversely.

*Proof.* See [1] Proposition(2.6) and example1.

**DEFINITION 2.11** If  $A$  is a locally convex algebra, then the radius of boundedness,  $\beta(x)$ , of  $x$  is defined by

$$\beta(x) = \inf\{\lambda > 0: \{(\lambda^{-1}x)^n: n = 1, 2, \dots\} \text{ is bounded}\}$$

with the convention  $\inf \emptyset = +\infty$ .

**DEFINITION 2.12** (i) Let  $A$  be a locally convex algebra with identity  $e$  and let  $x \in A$ .

The *spectrum* of  $x$  in  $A$  denoted by  $\sigma_A(x)$  (or just  $\sigma(x)$ ), is that subset of  $\mathbb{C}^*$  (The extended of  $\mathbb{C}$ ) defined as follows

(a) for  $\lambda \neq \infty, \lambda \in \sigma(x)$  if and only if  $\lambda e - x$  has no inverse belonging to  $A_0$  (i.e. has no bounded inverse),

(b)  $\infty \in \sigma(x)$  if and only if  $x \notin A_0$ .

(ii) If  $A$  has no identity, we define  $\sigma_A(x) = \sigma_{A_e}(x)$ ,

where  $A_e$  is the unit adjoint. By [1]  $A$  is PL-algebra if and only if  $A_e$  is PL-algebra.

**DEFINITION 2.13** Let  $A$  be a locally convex algebra with identity  $e$  and let  $x \in A$ .

Then the *spectral radius* of  $x$  in  $A$  denoted by  $r_A(x)$  (or just  $r(x)$ ) will be defined by

$$r_A(x) = \sup\{|\lambda|: \lambda \in \sigma(x)\}.$$

**THEOREM 2.14** Let  $A$  be a locally convex algebra and let  $x \in A$ . Then

$\beta(x) \leq r(x)$  and if  $A$  is PL-algebra then  $\beta(x) = r(x)$ .

*Proof.* See [1] Theorem(3.12).

**DEFINITION 2.15** A locally convex  $*$ -algebra is a locally convex algebra with a continuous involution. And a pseudo-complete locally convex  $*$ -algebra (PL $*$ -algebra) is a PL-algebra with a continuous involution.

**PROPOSITION 2.16** A closed subalgebra of pseudo-complete algebra (resp.  $*$ -algebra) is itself pseudo-complete algebra (resp.  $*$ -algebra).

*Proof.* See [1] Proposition(2.8).

**PROPOSITION 2.17** If  $A$  is a commutative pseudo-complete algebra (resp.  $*$ -algebra) then  $A_0$  is a subalgebra (resp.  $*$ -algebra) of  $A$ .

*Proof.* See Corollary(2.11) in [1].

**DEFINITION 2.18** Let  $A$  be a locally convex  $*$ -algebra. The involution in  $A$  is said to be hermitian if for each  $h \in A_h, \sigma_A(h)$  is real.

**PROPOSITION 2.19** Let  $A$  be a PL $*$ -algebra with identity  $e$ . If  $x \in A$  such that  $\beta(x) < 1$  then there exists  $y \in A$  such that  $2y - y^2 = x$ , furthermore if  $x \in A_h$  then also  $y \in A_h$ .

*Proof.* See [6] Lemma1.

**REMARK 2.20** If  $A$  is a complex  $*$ -algebra then every element has a unique representation in the form  $x=h+ik$  where  $h$  and  $k$  are hermitian. In fact  $h = \frac{x+x^*}{2}$  and  $k = \frac{x-x^*}{2i}$ .

**THEOREM 2.21** Let  $A$  be a real or complex algebra and let  $P(x)$  be any polynomial with coefficients in the field of the scalars of  $A$  and with constant term zero in case  $A$  does not have an identity. Then, for every  $x \in A, P(x) \in A$  and  $P(\sigma_A(x)) = \sigma_A(P(x))$ .

*Proof.* See [7] Theorem(1.6.10).

**PROPOSITION 2.22** Let  $A$  be a locally convex algebra. Then

- (i) Any subset or any scalar multiple of a bounded set is bounded,
- (ii) Any finite union or sum of bounded sets is bounded,

- (iii) The image by a continuous linear mapping of a bounded set is bounded,
- (iv) The closure, convex envelope and absolutely convex envelope of a bounded set are bounded.

**Note:** The following propositions (Proposition 2.23 and Proposition 2.24) were obtained in another work (as a paper) and we need them in this paper, so we also give their proofs here.

**PROPOSITION 2.23** If  $A$  is a locally convex\*-algebra with identity  $e$ . Then

- (i) If  $x \in A_0$ , then  $x^2$  and  $x - x^2 \in A_0$ ,
- (ii) If  $x^2 \in A_0$ , then  $x \in A_0$ .

**Proof.** (i) let  $x \in A_0$ , then there exists  $\lambda \neq 0$  such that

$$S_1 = \{(\lambda x)^n : n = 1, 2, \dots\}$$

is a bounded set in  $A$  and  $S_1 \subseteq A_0$ . Let

$$S_2 = \{(\lambda^2 x^2)^n : n = 1, 2, \dots\}$$

It is clear that  $S_2 \subseteq S_1$ . Since every subset of a bounded set is bounded, then  $S_2$  is a bounded set and thus  $x^2 \in A_0$ . Also  $\lambda^{-1}S_1$  and  $\lambda^{-2}S_2$  are bounded sets, then by Proposition(2.22)  $\lambda^{-1}S_1 - \lambda^{-2}S_2$  is a bounded set. Since  $x - x^2 \in \lambda^{-1}S_1 - \lambda^{-2}S_2$ , then  $x - x^2 \in A_0$ .

- (ii) Suppose  $x^2 \in A_0$ . Then there exists  $\lambda \neq 0$  such that the set

$$S_1 = \{(\lambda^2 x^2)^n : n = 1, 2, \dots\}$$

is bounded. Let  $S_2 = S_1 \cup \lambda x S_1 \cup \{\lambda x\}$ . Since  $A$  is a locally convex\*-algebra then for each  $y \in A$  the function

$$f_y : A \rightarrow A, \quad f_y(x) = yx$$

is a continuous function. Since  $S_1$  and  $\{e\}$  are bounded sets in  $A$  and by Proposition(2.22) the image by a continuous function of a bounded set is bounded, and since

$$f_e(S_1) = S_1, f_{\lambda x}(S_1) = \lambda x S_1, \text{ and } f_{\lambda x}(\{e\}) = \{\lambda x\}.$$

then  $S_1, \lambda x S_1$  and  $\{\lambda x\}$  are bounded sets in  $A$ . Since any finite union of bounded sets is a bounded set, therefore  $S_2 = S_1 \cup \lambda x S_1 \cup \{\lambda x\}$  is a bounded set in  $A$ . since

$$\{(\lambda x)^n : n = 1, 2, \dots\} \subseteq S_2.$$

Then the set

$\{(\lambda x)^n : n = 1, 2, \dots\}$  is a bounded set. Therefore  $x \in A_0$ .  $\square$

**PROPOSITION 2.24** Let  $A$  be a locally convex\*-algebra with identity  $e$ . If the involution in  $A$  is hermitian then for every  $h \in A_h, e + h^2$  has a bounded inverse. Further, the element  $h(e + h^2)^{-1}$  is also bounded.

**Proof.** Assume that the involution in  $A$  is hermitian and let  $h \in A_h$ , then  $\sigma_A(h)$  is real and by Theorem(2.21),  $\sigma_A(h^2) = (\sigma_A(h))^2$ . Then  $\sigma_A(h^2)$  is non-negative real and hence  $-1 \notin \sigma_A(h^2)$ . Thus  $e + h^2$  has a bounded inverse. Put  $u = h(e + h^2)^{-1}$ . Then  $u^2 = h^2(e + h^2)^{-2} = (e + h^2)^{-1} - (e + h^2)^{-2}$ . Since  $(e + h^2)^{-1} \in A_0$  then by Proposition(2.23)  $u^2$  and then  $u \in A_0$ .

### 3. MGB \*-ALGEBRAS

In this section we introduced a new class of locally convex algebras with an involution so-called MGB\*-algebras, as a modification of GB\*-algebras was introduced in [2] by Allan, and show that each commutative MGB\*-algebra is symmetric if and only if the involution is hermitian.

**Notation 3.1** (a) If  $A$  is a locally convex \*-algebra with identity  $e$ , as [2] then  $\mathcal{B}$  will denote the collection of subsets  $B$  of  $A$  satisfying:

- (i)  $B$  is absolutely convex, closed and bounded;
- (ii)  $e \in B, B^2 \subseteq B$  and  $B^* = B$ .

And write  $\mathcal{B}^* = \{B \in \mathcal{B} : B = B^*\}$ .

(b) If  $A$  is a topological \*-algebra with identity  $e$ , as [4] then  $\mathcal{B}^*$  will denote the collection of subsets  $B$  of  $A$  satisfying:

- (i)  $B$  is closed and bounded;
- (ii)  $e \in B, B^2 \subseteq B$  and  $B^* = B$ .

Allan[2] defined a GB\*-algebra as follows

**DEFINITION 3.2** [2] A GB\*-algebra is a locally convex \*-algebra  $A$  with identity  $e$  such that

- (i)  $\mathcal{B}^*$  has a greatest member  $B_0$ ,
- (ii)  $A$  is symmetric,
- (iii)  $A(B)$  is a Banach \*-algebra for each  $B$  in  $\mathcal{B}^*$ .

Dixon in [4] modified Allan's definition of GB\*-algebras by defining it as follows:

A GB\*-algebra is a topological \*-algebra  $A$  such that

- (i)  $\mathcal{B}^*$  has a greatest member  $B_0$  and  $B_0$  is absolutely convex,
- (ii)  $A$  is symmetric,
- (iii)  $A(B_0)$  is a Banach \*-algebra.

We now come to the definition of the class of algebra so-called MGB\*-algebras which is more general than the GB\*-algebras (Allan's[2] definition).

**DEFINITION 3.3** A MGB\*-algebra is a locally convex \*-algebra  $A$  with identity  $e$  such that

- (i)  $\mathcal{B}^*$  has a greatest member  $B_0$  and  $B_0$  is absolutely convex,
- (ii)  $A(B_0)$  is a Banach \*-algebra.

**REMARK 3.4** Every GB\*-algebra (as in [2]) is a MGB\*-algebra but not conversely. It is clear that each GB\*-algebra is a MGB\*-algebra. To show that the converse is not true in general, consider the \*-algebra  $A$  of all complex polynomials,  $p$ ; endowed with the topology  $\tau$  of uniform convergence on compact subsets of the positive real line. It is easy to see that  $A_0$  consists just of the constant functions and that  $\mathcal{B}^*$  has a greatest member  $B_0$ , namely the set of all constant functions not exceeding unity in absolute value and  $A(B_0)$  is a Banach \*-algebra. Thus  $A$  is a MGB\*-algebra. Now let  $p \in A$  defined by  $p(x) = x^2$  and let  $q = I + pp^*$  where  $I$  is the identity map then  $q(x) = x + x^2$ . It is clear that  $q \in A$  has not a bounded inverse in  $A$ . Thus  $A$  is not symmetric. Therefore  $A$  is not a GB\*-algebra.

**PROPOSITION 3.5** Let  $A$  be a MGB\*-algebra. Then the subspace  $A(B_0)$  contains all hermitian elements of  $A_0$ .

*Proof.* Let  $h$  be a hermitian element of  $A_0$  then there exists a real  $\lambda \neq 0$  such that  $S = \{(\lambda h)^n : n = 1, 2, \dots\}$  is a bounded set. Therefore  $B = \overline{S \cup \{e\}}$  is bounded (where  $\overline{\phantom{x}}$  denote the closure in  $A$ ). Thus  $B$  is closed,  $e \in B, B^2 \subseteq B$  and  $B^* = B$ . Hence  $B \subseteq B_0$ . Since  $\lambda h \in B$  then  $\lambda h \in B_0$ . Therefore  $h \in A(B_0)$ .  $\square$

**COROLLARY 3.6** If  $A$  be a symmetric MGB\*-algebra, then for each  $x \in A$ ,  $(e + x^*x)^{-1} \in A(B_0)$ .

*Proof.* Let  $x \in A$ . Since  $A$  is symmetric then  $(e + x^*x)^{-1} \in A_0$ . Since  $(e + x^*x)^{-1}$  is hermitian element of  $A_0$  then by Proposition (3.5),  $(e + x^*x)^{-1} \in A(B_0)$ .  $\square$

**PROPOSITION 3.7** If  $A$  be a symmetric MGB\*-algebra, then for each  $x \in A$ ,  $x^*x(e + x^*x)^{-1} \in A(B_0)$ .

*Proof.* Let  $x \in A$ . Since  $A$  is symmetric then by Corollary (3.6),  $(e + x^*x)^{-1} \in A(B_0)$ . Let  $u = x^*x(e + x^*x)^{-1} = e - (e + x^*x)^{-1}$ . Since both  $e$  and  $(e + x^*x)^{-1}$  are elements of  $A(B_0)$  and since  $A(B_0)$  is a \*-subalgebra then  $e - (e + x^*x)^{-1} \in A(B_0)$ .

Hence  $x^*x(e + x^*x)^{-1} \in A(B_0)$ .  $\square$

**PROPOSITION 3.8** Let  $A$  be a MGB\*-algebra and let  $x$  be any element of  $A_h$  such that  $\beta(x) < +\infty$ , then there exists an element  $v \in A_h$  such that  $v^2 = x$ .

*Proof.* Let  $x \in A_h$  such that  $\beta(x) < +\infty$ , then  $x \in A_h \cap A_0$  and then there exists a real  $\lambda \neq 0$  such that  $S = \{(\lambda x)^n : n = 1, 2, \dots\}$  is a bounded set. Let  $B = \overline{S \cup \{e\}}$  then  $B$  is bounded, closed,  $e \in B, B^2 \subseteq B$  and  $B^* = B$ . Hence  $B \subseteq B_0$ . Since  $\lambda x \in B$  then  $\lambda x \in B_0$ .

Therefore  $x \in A(B_0) \subseteq A_0$ . Since  $A(B_0)$  is a Banach \*-algebra then by Proposition (2.19) and by [7] Lemma(4.7.2), there exists  $v \in A_h$  such that  $v^2 = x$ .  $\square$

**PROPOSITION 3.9** Let  $A$  be a commutative MGB\*-algebra and hermitian involution. Then  $A$  is symmetric.

*Proof.* Suppose that the involution on  $A$  is hermitian and let  $x \in A$ , then by Remark(2.20)  $x$  has the form  $x = h + ik$  where  $h, k \in A_h$  then  $x^*x = h^2 + k^2 \in A_h$  and then by Proposition(2.24) and Proposition(3.5),  $(e + h^2)^{-1}, (e + k^2)^{-1}, h(e + h^2)^{-1}$  and  $k(e + k^2)^{-1}$  are hermitian elements of  $A_0$  and then of  $A(B_0)$ .

Let

$$h_1 = h(e + h^2)^{-1}(e + k^2)^{-1}$$

$$k_1 = k(e + k^2)^{-1}(e + h^2)^{-1}$$

Clearly  $h_1, k_1 \in A(B_0) \subseteq A_0$  and  $h_1, k_1 \in A_h$ . Since

$h_1^2 + k_1^2 \in A(B_0) \cap A_h$  then by Proposition (3.8) there exists  $v_1 \in A_h$  such that  $h_1^2 + k_1^2 = v_1^2$ . Then

$$h^2 + k^2 = v_1^2(e + h^2)^2(e + k^2)^2 = v^2,$$

where  $v = v_1(e + h^2)(e + k^2) \in A_h$ . Thus

$$e + x^*x = e + h^2 + k^2 = e + v^2 \in A_h.$$

Since the involution on  $A$  is hermitian and  $e + x^*x = e + v^2 \in A_h$  then by Proposition(2.24)  $e + v^2$  and then  $e + x^*x$  has a bounded inverse. Therefore  $A$  is symmetric.  $\square$

**PROPOSITION 3.10** Let  $A$  be a locally convex\*-algebra with identity  $e$ . If  $A$  is symmetric then the envolution on  $A$  is hermitian.

*Proof.* Suppose that  $A$  is symmetric and let  $h \in A_h$ . We claim that that  $\sigma_A(h)$  is real if this is not true then there is  $h \in A_h$  such that  $\sigma_A(h)$  contains a complex number

$a + ib$ , where  $a, b \in \mathbb{R}$  and  $b \neq 0$ . Define

$$k = \frac{ah^2 + (b^2 - a^2)h}{b(b^2 + a^2)}.$$

Then  $k \in A_h$  and by Theorem (2.21),

$$\sigma_A(k) = \frac{a(\sigma_A(h))^2 + (b^2 - a^2)\sigma_A(h)}{b(b^2 + a^2)}.$$

Since  $a + ib \in \sigma_A(h)$  then

$$\frac{a(a + ib)^2 + (b^2 - a^2)(a + ib)}{b(b^2 + a^2)} \in \sigma_A(k) \Rightarrow -1 \in \sigma_A(k^2),$$

which implies that  $e + k^2$  has no bounded inverse in  $A$ , which is a contradiction with the hypothesis. Therefore the involution on  $A$  is hermitian.  $\square$

**THEOREM 3.11** Let  $A$  be a commutative MGB\*-algebra. Then  $A$  is symmetric if and only if the involution is hermitian.

*Proof.* Since each MGB\*-algebra is a locally convex\*-algebra. Then the result follows from Proposition(3.9) and Proposition (3.10).  $\square$

**COROLLARY 3.12** Let  $A$  be a commutative PL\*-algebra with identity. Then  $A$  is symmetric if and only if the involution is hermitian.

*Proof.* Since each commutative PL \*-algebra  $A$  with identity is a commutative MGB \*-algebra. Then by Theorem (3.11)  $A$  is symmetric if and only if the involution is hermitian.  $\square$

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## حول صنف جبور ملتفة محدبة موضعياً

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### ملخص

في هذا البحث قدمنا صنف من الجبر الملتف المحدب موضعياً رمزنا له بالرمز \*MGB كتعميم للجبر \*GB المقدم من Allan. أحرزنا بعض النتائج في هذا الصنف كما حصلنا على الشروط الضرورية والكافية لأن يكون الجبر \*MGB جبراً متناظراً.





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## **Bayesian Smoothing of Dynamic linear model – Step model**

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### **Abstract:**

Smoothing is a kind of estimation of a parameter or a state variable. It is also called data smoothing. In this paper, the Bayesian smoothing for the dynamic linear model (step model) has been considered. The use of Bayesian smoothing means the reconsideration of new data for better enhancement and error reduction. Implementing any new data in the estimation process is a type of backward filtering to get a more precise estimation of the model parameters (state variable). In this paper, the mathematical content is highlighted to obtain a practical application as soon as real data are provided.

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$$m_t(-h) = m_{t-h} + a_t(-h) \sum_{j=1}^h d^{-1}(j) (y_{t-j+1} - m_{t-h}) \quad (18)$$

ومن المعادلات ( 14 ) ، ( 15 ) ، ( 16 ) نتوصل إلى التوزيع التمهيدي  $P(\mu_{t-h} \setminus D_t, \sigma^2)$  لنموذج التدرج . و الذي يمكن أن نعبر عنه وصفا كالتالي :

$$(\mu_{t-h} \setminus D_t, \sigma^2) \sim N(m_t(-h), \sigma^2 a_t(-h))$$

يطلق على المعادلة (18) بمقدر تمهيد بيز (Bayesian Smoothing Estimate) بالنسبة إلى المعلمة  $\mu_{t-h}$  عند الزمن t-h ، و التي من خلالها ستتم عملية التحسين و التعديل بإعادة النظر في عملية التقدير، وهذا ما يتبين عند مقارنتها مع مرشح كالمن الذي تمت دراسته سابقا وفق المشاهدات المتوافرة لدينا . ويمكننا إجراء تطبيق عملي بأخذ بيانات حقيقية و استخدام نموذج التدرج الموضحة صيغته في المعادلتين ( 2 ) ، ( 3 ) . و الهدف الأساسي يكمن في معالجة البيانات المرشحة أو التي يتم تقديرها بواسطة مقدر مرشح كالمن لتخليصها من التشويش الذي قد تحتويه فيها نتيجة أسباب عدة في عملية القياس او يكون متبقيا فيها بشكل واضح . و الترشيح الذي سيجري على بيانات حقيقية عن طريق مقدر مرشح كالمن يمثل الخطوة الأولى في المعالجة معتمدين للحصول عليه على برنامج حاسوبي يعد لهذا الغرض ، حيث يتم تقليلها بنسبة من التشويش الذي تحتويه لنبدأ عملينا بتقدير تمهيد بيز للبيانات المرشحة من خلال إعادة النظر بعملية التقدير ليتم التدقيق و التعديل على البيانات المقدر سابقا ( البيانات المرشحة ) لتقليل ما تبقى من تشويش في عملية الترشيح لتكون البيانات المعالجة أكثر دقة . ويمكن توضيح ذلك بأشكال بيانية تمثل المقارنة بين التمهيد و الترشيح (  $m_t$  ،  $m_t(-h)$  ) وكذا المقارنة بين التمهيد و البيانات المشوشة التي تعتبر عملية التمهيد بمثابة الترشيح العكسي في ضوء البيانات الحديثة ويمكن ملاحظه التعديل أو المعالجة بدقة بأخذ مقطع من الشكل العام الذي يظهر المعالجة بين عمليتي تمهيد بيز ومرشح كالمن عند المقارنة ، فضلا عن البيانات المشوشة التي تمثل البيانات الحقيقيه قبل أي معالجة .

#### 4 الاستنتاجات:

نستنتج أن عملية التمهيد هي العملية العكسية للترشيح و التي تجري على البيانات مرتين أو مرحلتين متعاقبتين لتوصلنا إلى تقدير أدق وذلك بالاعتماد على مشاهدات أو بيانات جديدة أي قراءة جديدة تساعدنا على عملية المعالجة لكي نخلصنا من الأخطاء التي تظهر فيها نتيجة أسباب عدة لنحصل على قراءة أكثر دقة عما هو عليه مسبقا . ونوصي بعمل برنامج حاسوبي تتم من خلاله المعالجات الموضحة في هذا البحث وإبرازها بأشكال بيانية وذلك حال توافر بيانات حقيقية .

$$\begin{aligned}
&= \sum_{j=1}^h \text{var} \left( \delta_{\mu_{t-h+1}} \setminus \mu_{t-h}, \sigma^2 \right) + \text{var} \left( \varepsilon_{t-h+1} \setminus \mu_{t-h}, \sigma^2 \right) \\
&= \sigma^2 r + \sigma^2 r + \dots + \sigma^2 r + \sigma^2 \\
&= \sigma^2 (r + r + \dots + r + 1) \\
&= \sigma^2 (hr + 1) \\
&= \sigma^2 d(h) \tag{14}
\end{aligned}$$

وذلك بوضع :

$$\begin{aligned}
d(h) &= r + r + \dots + r + 1 \\
&= hr + 1
\end{aligned}$$

وبالتالي من المعادلتين (13) و(14) نستنتج أن:

$$(y_{t-h+1} \setminus \mu_{t-h}, \sigma^2) \sim N(\mu_{t-h}, \sigma^2 d(h)) \tag{15}$$

وبالتعويض عن كل من المعادلة (12)، (15) في المعادلة (1) نحصل على التوزيع التمهيدي  $P(\mu_{t-h} \setminus D_t, \sigma^2)$  بالنسبة إلى المعلمة  $\mu_{t-h}$  ومن خلالها نحصل على مقدر تمهيد بيز التالي :

$$\begin{aligned}
P(\mu_{t-h} \setminus D_t, \sigma^2) &\propto \text{Exp} \left\{ -\frac{1}{2\sigma^2} \left[ \sum_{j=1}^h \frac{1}{d(j)} (y_{t-j+1} - \mu_{t-h})^2 + \frac{1}{a_{t-h}} (\mu_{t-h} - m_{t-h})^2 \right] \right\} \\
&\text{وعند إتباع نفس الأسلوب الرياضي الذي قمنا به من أجل التوصل إلى المعادلة التي تمثل مرشح كالم، فإننا نحصل على توزيع الاحتمال التمهيدي أعلاه بالصورة :} \\
P(\mu_{t-h} \setminus D_t, \sigma^2) &\propto \text{Exp} \left\{ -\frac{1}{2\sigma^2} \left( \frac{1}{d(h)} + \frac{1}{a_{t-h}} \right) (\mu_{t-h} - m_t(-h))^2 \right\} \tag{16}
\end{aligned}$$

حيث أن :

$$\begin{aligned}
\text{var}(\mu_{t-h} \setminus D_t, \sigma^2) &= \sigma^2 \cdot \left( \frac{1}{d(h)} + \frac{1}{a_{t-h}} \right)^{-1} \\
&= \sigma^2 a_t(-h) \tag{17}
\end{aligned}$$

$$a_t(-h) = \left( \frac{1}{d(h)} + \frac{1}{a_{t-h}} \right)^{-1}$$

وذلك بوضع :

وكذلك :

حيث أن  $a_{t-1}$  ،  $m_{t-h}$  ذوات بعد واحد عند الزمن  $t-h$  .  
 بعد إيجاد الاحتمال اللاحق في المعادلة ( 12 ) نسعى إلى الحصول على دالة التوزيع  
 $P(y_{t-h+1} \mid \mu_{t-h}, \sigma^2)$  ، التي تتسلسل مع تغير قيمة  $h$  لتكتمل عمليتنا في إيجاد التوزيع  
 التمهيدي وذلك من خلال إدخال التوقع و التباين على  $(y_{t-h+1} \mid \mu_{t-h}, \sigma^2)$  ووفق نموذج  
 التدرج لمعادلة المشاهدة ( 4 ) وكالتالي:

$$\begin{aligned} E(y_{t-h+1} \mid \mu_{t-h}, \sigma^2) &= E(\mu_{t-h+1} + \varepsilon_{t-h+1} \mid \mu_{t-h}, \sigma^2) \\ &= E(\mu_{t-h+1} \mid \mu_{t-h}, \sigma^2) + E(\varepsilon_{t-h+1} \mid \mu_{t-h}, \sigma^2) \\ &= E(\mu_{t-h+1} \mid \mu_{t-h}, \sigma^2) \end{aligned}$$

وعند تعويض قيمة  $h$  حيث  $(h = 1, 2, \dots, t-1)$  بشكل متعاقب في معادلة النظام رقم (3) نحصل  
 على :

$$\begin{aligned} E(y_{t-h+1} \mid \mu_{t-h}, \sigma^2) &= E(\mu_{t-h+1} \mid \mu_{t-h}, \sigma^2) \\ &= E(\mu_{t-h} \mid \mu_{t-h}, \sigma^2) + \sum_{j=1}^h E(\delta_{\mu_{t-h+j}} \mid \mu_{t-h}, \sigma^2) \\ &= \mu_{t-h} \end{aligned} \quad (13)$$

$$\begin{aligned} \text{var}(y_{t-h+1} \mid \mu_{t-h}, \sigma^2) &= \text{var}(\mu_{t-h+1} + \varepsilon_{t-h+1} \mid \mu_{t-h}, \sigma^2) \\ &= \text{var}(\mu_{t-h+1} \mid \mu_{t-h}, \sigma^2) + \text{var}(\varepsilon_{t-h+1} \mid \mu_{t-h}, \sigma^2) \end{aligned}$$

بالمثل عند التعويض بقيمة  $h$  بشكل متعاقب في معادلة النظام (3) نحصل على :

$$\begin{aligned} \text{var}(y_{t-h+1} \mid \mu_{t-h}, \sigma^2) &= \text{var}\left(\mu_{t-h} \mid \mu_{t-h}, \sigma^2 + \sum_{j=1}^h \text{var}(\delta_{\mu_{t-h+j}} \mid \mu_{t-h}, \sigma^2)\right) \\ &\quad + \text{var}(\varepsilon_{t-h+1} \mid \mu_{t-h}, \sigma^2) \end{aligned}$$

$$C_t = \frac{\sigma^2 r_t}{\sigma^2 + r_t} \quad \text{وتباين } m_t \text{ يمثل توزيعا احتماليا طبيعيا ذو وسط } m_t \text{ أي أن } P(\mu_t \setminus D_t)$$

$$= \sigma^2 a_t$$

$$a_t = \frac{r_t}{\sigma^2 + r_t} \quad \text{وذلك بوضع :}$$

كما يمكن التعبير عن  $m_t$  بالشكل الأتي :

$$m_t = \frac{r_t y_t + \sigma^2 m_{t-1}}{\sigma^2 + r_t}$$

$$= \frac{\sigma^2}{\sigma^2 + r_t} m_{t-1} + \frac{r_t}{\sigma^2 + r_t} y_t$$

$$= (1 - a_t) m_{t-1} + a_t y_t$$

$$= m_{t-1} - a_t m_{t-1} + a_t y_t$$

$$= m_{t-1} + a_t (y_t - m_{t-1})$$

$$= m_{t-1} + K_t (y_t - m_{t-1}) \quad (9)$$

وذلك بوضع :

$$K_t = a_t$$

$$K_t = \frac{r_t}{\sigma^2 + r_t} \quad (10)$$

ونعبر رياضيا عن التوزيع الاحتمالي اللاحق للمعلمة  $\mu_t$  عند الزمن  $t$  كالتالي :

$$(\mu_t \setminus D_t) \sim N(m_t, \sigma^2 a_t) \quad (11)$$

المعادلة (9) تدعى بترشيح كالمن و  $K_t$  في المعادلة (10) تدعى بمعامل كالمن أو ربحية الترشيح (filter gain). ومن العلاقة (11) التي تمثل مرشح كالمن لهذا النموذج الذي سيصبح توزيعا أساسيا للتمهيد, لهذا الغرض نعتبر عنه حسب تسلسل قيمة  $h$  كما يلي :

$$(\mu_{t-h} \setminus D_{t-h}, \sigma^2) \sim N(m_{t-h}, \sigma^2 a_{t-h}) \quad (12)$$

$$\begin{aligned}
 &= \left( \frac{1}{\sigma^2} + \frac{1}{r_t} \right) \left[ \mu_t^2 - 2\mu_t \left( \frac{\frac{1}{\sigma^2} y_t + \frac{1}{r_t} m_{t-1}}{\frac{1}{\sigma^2} + \frac{1}{r_t}} \right) + \left( \frac{\frac{1}{\sigma^2} y_t^2 + \frac{1}{r_t} m_{t-1}^2}{\frac{1}{\sigma^2} + \frac{1}{r_t}} \right) \cdot \frac{\frac{1}{\sigma^2} + \frac{1}{r_t}}{\frac{1}{\sigma^2} + \frac{1}{r_t}} \right] \\
 &= \left( \frac{1}{\sigma^2} + \frac{1}{r_t} \right) \left[ \mu_t^2 - 2\mu_t \left( \frac{\frac{1}{\sigma^2} y_t + \frac{1}{r_t} m_{t-1}}{\frac{1}{\sigma^2} + \frac{1}{r_t}} \right) + \left( \frac{\left( \frac{1}{\sigma^2} \right)^2 y_t^2 + \frac{2}{\sigma^2 r_t} y_t m_{t-1} + \left( \frac{1}{r_t} \right)^2 m_{t-1}^2}{\left( \frac{1}{\sigma^2} + \frac{1}{r_t} \right)^2} \right) \right] \\
 &\quad - \frac{1}{\sigma^2 r_t \left( \frac{1}{\sigma^2} + \frac{1}{r_t} \right)} (y_t^2 - 2y_t m_{t-1} + m_{t-1}^2) \\
 &= \left( \frac{1}{\sigma^2} + \frac{1}{r_t} \right) \left\{ \mu_t^2 - 2\mu_t \left( \frac{\frac{1}{\sigma^2} y_t + \frac{1}{r_t} m_{t-1}}{\frac{1}{\sigma^2} + \frac{1}{r_t}} \right) + \left( \frac{\frac{1}{\sigma^2} y_t + \frac{1}{r_t} m_{t-1}}{\frac{1}{\sigma^2} + \frac{1}{r_t}} \right)^2 \right\} + \frac{1}{\sigma^2 + r_t} (y_t - m_{t-1})^2 \\
 &= \left( \frac{1}{\sigma^2} + \frac{1}{r_t} \right) \left\{ \mu_t^2 - 2\mu_t m_t + m_t^2 \right\} + \frac{1}{\sigma^2 + r_t} (y_t - m_{t-1})^2 \\
 &= \left( \frac{1}{\sigma^2} + \frac{1}{r_t} \right) (\mu_t - m_t)^2 + \frac{1}{\sigma^2 + r_t} (y_t - m_{t-1})^2
 \end{aligned}$$

وذلك بوضع:

$$m_t = \frac{\frac{1}{\sigma^2} y_t + \frac{1}{r_t} m_{t-1}}{\frac{1}{\sigma^2} + \frac{1}{r_t}}$$

وعليه فان :

$$P(\mu_t \in D_t) \propto \text{Exp} \left\{ -\frac{1}{2} \left( \frac{1}{\sigma^2} + \frac{1}{r_t} \right) (\mu_t - m_t)^2 \right\}$$

حيث أن الحد  $\text{Exp} \left[ -\frac{1}{2} \left( \frac{1}{\sigma^2 + r_t} \right) (y_t - m_{t-1})^2 \right]$  ثابت.

وصفياً نعبر عن الاحتمال الأولي  $P(\mu_t \setminus D_{t-1})$  كالآتي :

$$(\mu_t \setminus D_{t-1}) \sim N(m_{t-1}, r_t)$$

بالتعويض في المعادلة ( 8 ) عن  $P(\mu_t \setminus D_{t-1}), P(y_t \setminus \mu_t)$  نحصل على التوزيع الاحتمالي اللاحق للمعلمة  $\mu_t$  عند الزمن  $t$  كالآتي :

$$P(\mu_t \setminus D_t) \propto \text{Exp} \left\{ \frac{-1}{2} \left[ \frac{1}{\sigma^2} (y_t - \mu_t)^2 + \frac{1}{r_t} (\mu_t - m_{t-1})^2 \right] \right\}$$

بوضع:

$$I = \frac{1}{\sigma^2} (y_t - \mu_t)^2 + \frac{1}{r_t} (\mu_t - m_{t-1})^2$$

نجد أن :

$$I = \frac{1}{\sigma^2} (y_t^2 - 2 y_t \mu_t + \mu_t^2) + \frac{1}{r_t} (\mu_t^2 - 2 \mu_t m_{t-1} + m_{t-1}^2)$$

$$+ \frac{1}{r_t} \mu_t^2 + \frac{1}{r_t} m_{t-1}^2 - 2 \cdot \frac{1}{r_t} \mu_t m_{t-1}$$

$$= \frac{1}{\sigma^2} y_t^2 + \frac{1}{\sigma^2} \mu_t^2 - 2 \cdot \frac{1}{\sigma^2} y_t \mu_t$$

$$+ \left( \frac{1}{\sigma^2} y_t^2 + \frac{1}{r_t} m_{t-1}^2 \right) = \left( \frac{1}{\sigma^2} + \frac{1}{r_t} \right) \mu_t^2 - 2 \mu_t \left( \frac{1}{\sigma^2} y_t + \frac{1}{r_t} m_{t-1} \right)$$

$$P(\mu_t \setminus D_t) \propto P(y_t \setminus \mu_t) \cdot P(\mu_t \setminus D_{t-1}) \quad (8)$$

نقوم الآن بإيجاد كل من دالة الترجيح  $P(y_t \setminus \mu_t)$  و الاحتمال الأولي قبل المشاهدة  $y_t$  وهو  $P(\mu_t \setminus D_{t-1})$ ، وذلك باستخدام المعادلتين (2)، (3) و التوزيع الاحتمالي (7).  
ولنبدأ بإيجاد دالة الترجيح كالآتي :  
من المعادلة (2)

$$\begin{aligned} E(y_t \setminus \mu_t) &= E(\mu_t + \varepsilon_t \setminus \mu_t) \\ &= E(\mu_t \setminus \mu_t) + E(\varepsilon_t \setminus \mu_t) \\ &= \mu_t + 0 \\ &= \mu_t \\ \text{var}(y_t \setminus \mu_t) &= \text{var}(\mu_t + \varepsilon_t \setminus \mu_t) \\ &= \text{var}(\mu_t \setminus \mu_t) + \text{var}(\varepsilon_t \setminus \mu_t) \\ &= 0 + \sigma^2 \end{aligned}$$

ووصفياً نعبر عن دالة الترجيح كالآتي :

$$(y_t \setminus \mu_t) \sim N(\mu_t, \sigma^2)$$

أما التوزيع الأولي للمعلمة  $\mu_t$  عند الزمن  $t$  (قبل المشاهدة  $y_t$ ) نحصل عليه من المعادلة (3) و التوزيع الاحتمالي (7) كالآتي :

$$\begin{aligned} E(\mu_t \setminus D_{t-1}) &= E(\mu_{t-1} + \delta_{\mu} \setminus D_{t-1}) \\ &= E(\mu_{t-1} \setminus D_{t-1}) + E(\delta_{\mu} \setminus D_{t-1}) \\ &= m_{t-1} \end{aligned}$$

$$\begin{aligned} \text{var}(\mu_t \setminus D_{t-1}) &= \text{var}(\mu_{t-1} + \delta_{\mu} \setminus D_{t-1}) \\ &= \text{var}(\mu_{t-1} \setminus D_{t-1}) + \text{var}(\delta_{\mu} \setminus D_{t-1}) \\ &= C_{t-1} + \sigma^2 r \\ &= r_t \end{aligned}$$

وذلك بوضع:  $r_t = C_{t-1} + \sigma^2 r$

### 3 تمهيد بيز لنموذج التدرج : Bayesian smoothing of step model

يمكن التعبير عن النموذج عند الزمن ( t-h+1 ) كما يلي :

$$y_{t-h+1} = \mu_{t-h+1} + \varepsilon_{t-h+1}, \quad \varepsilon_{t-h+1} \sim N(0, \sigma^2) \quad (4)$$

$$\mu_{t-h+1} = \mu_{t-h} + \delta_{\mu-h+1}, \quad \delta_{\mu-h+1} \sim N(0, \sigma^2 r) \quad (5)$$

حيث أن :

r : تمثل معامل القياس وهذا ثابت نفرض له قيمة معلومة .

h : تمثل دليل التمهيد إذا أن : ( h=1,2,3,...,t-1 ) .

للحصول على تمهيد بيز بالنسبة إلى المعلمة  $\mu_{t-h}$  عند الزمن ( t-h ) ، يمكننا أولا إيجاد التوزيع اللاحق (posterior Distribution) للمعلمة  $\mu_t$  التي تمثل مرشح كالمن بحسب نظرية بيز و تحليله المتسلسل عند توافر المعلومات  $D_t$  وكما يلي :

من خلال المعادلتين ( 2 ) ، ( 3 ) و الوصف الإحصائي السابق لبعض مكونات النموذج ، و المعلومات المؤشرة حوله ، يمكن تكوين مرشح كالمن له كما يلي :  
الإجراء التكراري للمرشح يبدأ عند الزمن صفر( زمن ما قبل أخذ المشاهدة الأولى ) وعنده تكمن المعلومات الأولية المتوافرة قبل بدء الترشيح ، هنا سوف نعبر عن معلوماتنا الأولية وصفا كالآتي :

$$\mu_0 \sim N(m_0, C_0) \quad (6)$$

وتقرأ معلوماتنا الأولية  $\mu_0$  تخضع لتوزيع طبيعي بتوقع أولي  $m_0$  وتباين أولي  $C_0$  .  
وعند الزمن ( t-1 ) يكون التوزيع اللاحق للمعلمة  $\mu_{t-1}$  توزيعا طبيعيا أيضا ويعبر عنه وصفا كالآتي :

$$(\mu_{t-1} \setminus D_{t-1}) \sim N(m_{t-1}, C_{t-1}) \quad (7)$$

ويمثل توزيعا أوليا (prior Distribution) للمعلمة  $\mu_t$  عند الزمن t ، حيث أن  $D_{t-1}$  يمثل المعلومات المتوافرة لغاية الزمن t-1 وهي :

$$D_{t-1} = \{y^t, \sigma^2, \sigma^2 r\} = \{y_1, y_2, \dots, y_{t-1}, \sigma^2, \sigma^2 r\}$$

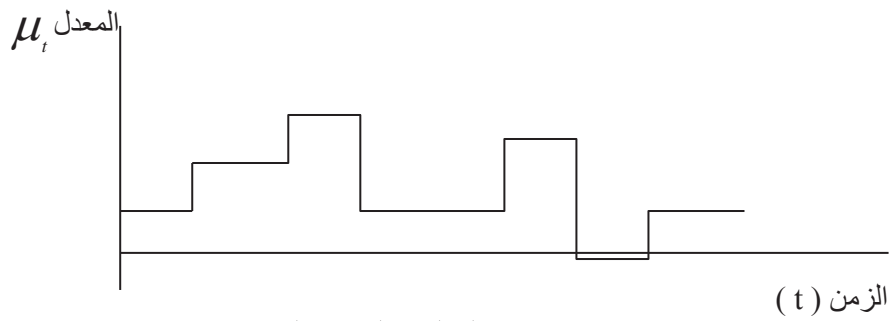
هدفنا الآن هو إيجاد التوزيع اللاحق للمعلمة  $\mu_t$  عند الزمن الذي يعين عن طريق معرفتنا بأنة

يضم جميع البيانات المتوافرة بوجود المعلومات  $D_t$  حيث أن :  
 $D_t = \{D_{t-1}, y_t\}$   
باستخدام نظرية بيز وأسلوب التحليل المتسلسل نحصل على الصيغة للتوزيع الاحتمالي اللاحق للمعلمة  $\mu_t$  عند الزمن t كالآتي :

المشاهدات في كل مرحلة نبدى بها في عملية التقدير ، أما الترشيح فإنه عملية مستقرة وتعاد بعد اخذ كل مشاهدة في عملية التحليل المتسلسل أو بعد كل عينة تعاد العملية الحسابية الخاصة بالتقدير .

## 2 نموذج التدرج : Step Model

قبل الدخول في تفصيل تمهيد بيز لنموذج التدرج ، نتناول نموذج التدرج وتعريفه باعتباره احد النماذج الحركية الخطية ، يستخدم هذا النموذج في الحالات التي يكون فيها مستوى العملية مستقر لفترة قصيرة الأمد ثم يتغير إلى مستوى آخر ، ويدعى هذا التغير بالقفز (Jump) ثم يرجع إلى الاستقرار .. وهكذا .  
يدعى النموذج بنموذج التدرج لان سلسلة التحولات من مستوى إلى آخر تكون بشكل درج انظر الشكل (1) أدناه:



شكل(1): يوضح معادلة النظام لنموذج التدرج

لنموذج التدرج تطبيقات في مجالات شتى كالتنبؤ و السيطرة النوعية ويمكن التعبير عن هذا النموذج كالآتي :

$$\text{معادلة المشاهدة} \quad y_t = \mu_t + \varepsilon_t \quad , \varepsilon_t \sim N(0, \sigma^2) \quad (2)$$

$$\text{معادلة النظام} \quad \mu_t = \mu_{t-1} + \delta_{\mu} \quad , \delta_{\mu} \sim N(0, \sigma^2 r) \quad (3)$$

حيث أن  $(\delta_{\mu}, \varepsilon_t)$  مستقلان عن بعضهما ، وأن  $\mu_t$  يطلق عليها غالبا ( مستوى العملية ) عند الزمن t و r ثابت .

ويلاحظ في النموذج أن كل من  $\mu_t, y_t$  أحادي البعد (One Dimensional) .

يتعلق بالمعلمة غير المعلومة  $\theta_s$  نستدل عليها من المشاهدات:  $(y_1, y_2, \dots, y_t)$  ، فإذا كانت :

( 1 )  $s = t$  فالحالة تعرف بالترشيح ( filtering ) وفيه يكون الهدف إيجاد :

$$p(\theta_t \setminus y_1, y_2, \dots, y_t)$$

( 2 )  $s > t$  فالحالة تعرف بالتنبؤ ( prediction ) وفيه يكون الهدف إيجاد :

$$p(\theta_{t+h} \setminus y_1, y_2, \dots, y_t), h = 1, 2, \dots$$

( 3 )  $s < t$  تعرف الحالة بالتسوية ( التمهيد ) (Smoothing) وهي عملية تقدير المعلمة  $\theta_{t-h}$  وذلك بتوظيف المشاهدات الجديدة في إعادة النظر بالتقدير الترشحي ويعبر عنه كميًا بإيجاد التوزيع الاحتمالي اللاحق :  $h=1, 2, \dots, t-1$  ،  $p(\theta_{t-h} \setminus y_1, y_2, \dots, y_t)$  وهذه الحالة سوف نبني دراستنا عليها ، وفي هذا البحث سوف نستخدم أسلوب بيز مع نموذج حركي خطي ( Dynamic linear model ) هو نموذج التدرج المقدم من قبل

( Harrison and Stevens , 1971 , 1976 ) و ( Harrison and west , 1997 ) ، بالإضافة إلى الأبحاث التي استخدمت هذا النموذج ومن هذه الأبحاث البحث الذي قدمه ( Gamerman and Migon , 1993 ) والذي تطرق فيه إلى حالة التمهيد مع النماذج الحركية الخطية، وكذلك البحث الذي قدمه ( West 1995 ) معتمداً فيه على هذه النماذج ودراسة التنبؤ .

وسوف تكون انطلاقتنا في هذا البحث من حساب مرشح كالمن (Kalman Filter) رياضيًا والذي يكون حالة أساسية (أولية) لعملية التمهيد، ولكي نتوصل إلى علاقة تعايقية (Recursive Relation) في تمهيد بيز ، سوف نعتمد على قاعدة السلسلة (Chain rule) المبينة من قبل ( Talib,s 1999 ) وبالاعتماد على نظرية بيز والتحليل المتسلسل وفق الخاصية الماركوفية (Markovian property) لتكون مفتاحاً أساسياً يوصلنا إلى الهدف المطلوب ضمن دوال أساسية محددة و يمكن توضيحها بالخاصية التعايقية لقانون قاعدة السلسلة عند أخذنا لمشاهدات عشوائية لغاية الزمن  $t$  ، وبالاعتماد على النماذج الحركية الخطية ، يمكن أن نعبر عنها كالآتي :

$$p(\theta_{t-h} \setminus D_t, \sigma^2) \alpha p(y_t \setminus \theta_{t-h}, \sigma^2) p(y_{t-1} \setminus \theta_{t-h}, \sigma^2) \dots p(y_{t-h+1} \setminus \theta_{t-h}, \sigma^2) p(\theta_{t-h} \setminus D_{t-h}, \sigma^2) \quad (1)$$

حيث أن :

$h$  : عدد صحيح موجب ( $h > 0$ ) ، وان  $D_t = \{y_t, y_{t-1}, \dots, y_1\}$  تمثل المشاهدات منذ أول مشاهدة . وان  $\alpha$  علامة التناسب و  $\sigma^2$  التباين.

ومن خلال العلاقة ( 1 ) يتحقق حساب التمهيد العكسي على التوالي من أول مشاهدة مأخوذة عند  $t = 1$  حتى آخر مشاهدة بشكلها المتعاقب حسب قيمة  $h$  وباستخدام التحليل المتسلسل في اخذ

## تمهيد بيز لنموذج خطي حركي - نموذج التدرج

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### ملخص

التمهيد (smoothing) نوع من حالات التقدير لمعلمة أو متغير الحالة (state variable)، ويطلق عليه أيضا (Data \_ smoothing). ففي هذا البحث تم الاهتمام بتمهيد بيز (Bayesian Smoothing) لنموذج حركي خطي هو نموذج التدرج، واستخدام أسلوب بيز في التمهيد يعني إعادة النظر في التقدير الترشيجي (Filtering Estimation) في ضوء بيانات جديدة وذلك لتحسين التقدير (Enhancement) وتقليل نسبة الخطأ. وتوظيف أي بيانات جديدة في عملية التقدير هو نوع من الترشيج العكسي (Backward filtering) للحصول على تقدير أدق لمعلمة النموذج (متغير الحالة). وقمنا في هذا البحث بإبراز المحتوى الرياضي بصورة واضحة تمكن القارئ من التطبيق العملي حال توافر بيانات حقيقية.

### 1 مفهوم التمهيد : Meaning of Smoothing

أن التمهيد يقصد به التنعيم أو الصقل أو التعديل الذي يجري على القيم ذات التعرجات الناتجة من التشويش الموجود أو المتبقي فيها، وهو نوع من عملية التقدير، ويعتبر التمهيد إحدى الحالات المهمة في مجال الاستدلال الإحصائي وكذلك في مجالات متعددة في العلوم الأخرى منها هندسة الاتصالات، حيث برز دورها في عملية المعالجة أو التدقيق من خلال دراسة الظواهر التي تتغير مع الزمن وذلك باستعادة الماضي.

في هذا البحث نقوم بدراسة التمهيد من خلال تقدير المعلمة أو إعادة التقدير في ضوء توافر بيانات جديدة، وهذا يعني أن التمهيد نوع من الترشيج العكسي (Backward Filtering) لتوصلنا إلى تقدير أدق. وهناك ثلاث تقديرات وردت في أدبيات الاستدلال حول الحالة أو المعلمة التي تكون غير معلومة حيث بينها لأول مرة الباحث (kalman, 1960) وسميت بقيم التقديرات ل  $\theta$  وهي الترشيج والتنبؤ والتمهيد معتمدا على البيانات المعطاة لغاية الزمن  $t$ . وعند افتراض أن هناك معلمة مهمة بالنسبة لنا والتي لا نعرف قيمتها بشكل تام، نأخذ بيانات للحالة تحت الدراسة وبواسطتها نقدر المعلمة المهمة المطلوبة، إلا أن هذه المشاهدات تكون مشوبة (غير خالية) من الخطأ. وفيما





## **Evaluation of the inpatient satisfaction in public and private hospitals in Sana'a about the services provided to them**

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### **ABSTRACT**

To determine the level of the patients' satisfaction in Sana'a hospitals, We did a cross-sectional study on patients who spent 3 or more days in 6 of the largest hospitals (public and private), who are above 15 years old, during the period from Aug. 2007 to July 2009. They were 1045 patients. The level of satisfaction was high for doctors, nurses, hygiene, calm, visit, equipments and nutrition. The level of the satisfaction about the calm and the equipments was higher among rural. While The medical patients were more satisfied with the admission procedures, the nurses and the time taken by the physician; the surgical patients showed more satisfaction with the explanation of the physician for their complains, the availability of the investigations, and hygiene. In contrast, the satisfaction level for the cost of service was low, especially in the private hospitals, which just care about money according to the patients. However, most of the participants still advised the others to the same hospital. So we recommend the hospitals to apply a suitable interventions which increase the level of patients' satisfaction and to do a regular evaluations about patients' satisfaction and assessing the role of those interventions.

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يسرع من إجراءات دخولهم، أما تأثير الحالة الاقتصادية على اختيارهم للمستشفى فمرده انه كلما كانت حالة المريض أفضل كلما اهتم بالخدمة الجيدة، وكلما كانت حالته أسوأ يعدل من أولوياته فيبحث ذوو الحالة المتدنية عن مستشفيات أقل كلفة وبالتالي كانوا أكثر اختياراً للمستشفيات العامة، مع مراعاة أن زيادة كلفة الخدمات الصحية ليس بالضرورة أن يصاحبها زيادة جودتها لكن الانخفاض الشديد في كلفة الخدمات الصحية غالباً ما يصاحبه تدني في مستوى الجودة<sup>(31)</sup>.

ومع أن حياة المدينة تتصف بالضجيج بخلاف حياة الريف التي تتصف بالهدوء، ولكن ضجيج المدينة لم يكن سبباً لسخط أهل الريف، فزيادة رضا أهل الريف عن الهدوء في المستشفى وبفارق ذي دلالة إحصائية يمكن أن يعزى إلى أن الريفيين يرتبطون في المدينة بالأماكن الأكثر إزعاجاً كالأماكن العامة والأسواق فهم لا يعرفون هدوء المدينة وبالتالي ربما يقارنون الهدوء داخل المستشفى بخارجه، خلافاً لأهل المدينة الذين يشعرون بالهدوء في منازلهم أكثر من المستشفى، أما زيادة رضا الريفيين عن تجهيزات الغرفة وبدلالة إحصائية فهو أمر متوقع ويرتبط باختلاف نوعية السكن بين الحياة الريفية والمدينة المحاطة بالتجهيزات.

زيادة مستوى رضا مرضى الباطنية عن إجراءات الدخول قد يعزى إلى أن مرضى الجراحة بحاجة لدفع كلف العمليات مسبقاً بخلاف مرضى الباطنية فالكلفة لا تكون محددة بدقة، كما أن مرضى الجراحة يتم تأخيرهم في القطاع العام حتى إيجاد أماكن لهم مما قد يؤخرهم لأيام، وفي المقابل فإن زيادة رضا مرضى الحالات الجراحية عن توضيح حالتهم المرضية من قبل الطبيب لأنهم لا يتم ترقيدهم غالباً إلا بعد تشخيص حالتهم بوضوح، كما أن أي عملية جراحية تجرى بعد موافقة مكتوبة ولا يتم ذلك إلا بعد شرح الطبيب عن العملية، وقد يفسر ذلك أن نسبة رضا المرضى عن توضيح الطبيب لحالتهم المرضية كانت أعلى من الدراسة السعودية السالف ذكرها للحالات الجراحية لكنها أدنى منها للحالات الباطنية<sup>(10)</sup>. وفي المقابل نجد أن مرضى الجراحة أقل رضا عن منح الأطباء لهم الوقت الكافي مقارنة بالباطنية، ويمكن أن يعزى ذلك أن طبيب الباطنية يمر يومياً لتقييم حالة المريض بخلاف مرضى الجراحة فقد لا يمر الطبيب بنفسه ويكل ذلك لأحد مساعديه للمتابعة بل إن من الشائع في اليمن أن بعض الجراحين يجرون العمليات ولا يعودون لمريضهم بعد ذلك أبداً، أما تدني الرضا عن التمريض من مرضى الجراحة فيمكن تفسيره لحساسية حالتهم خاصة في الأيام التي تلي العملية مما يسهم في تدميرهم من الممرضين لأنهم يسببون لهم ألماً عند التعامل مع جراحهم، أما رضاهم عن توفر الفحوصات فقد يعود إلى أن الفحوصات المطلوبة لهم معتادة ومكررة وتوفرها كافة المستشفيات، بخلاف مرضى الباطنية فإن الفحوصات المطلوبة لهم تتطور من الروتينية إلى الأكثر دقة. كما أن زيادة نسبة الرضا عن النظافة لدى مرضى الجراحة مقارنة بالباطنية قد يعود إلى أن أقسام الجراحة غالباً ما يعنى فيها بالنظافة والتعقيم.

## الاستنتاج

كان مستوى الرضا عالياً عن الأطباء والتمريض والنظافة والهدوء والزيارة وتجهيزات الغرف والغذاء مقابل تدنيه عن كلفة الخدمة خصوصاً في القطاع الخاص، مع وجود قناعة بتغليب الجانب المادي على الإنساني، وكان الريفيون أعلى رضا عن الهدوء وتجهيزات الغرف، ومرضى حالات الباطنية أكثر رضا عن إجراءات الدخول وعن التمريض وعن الوقت الممنوح من الطبيب، بينما كان مرضى الحالات الجراحية أكثر رضا عن توضيح الطبيب لحالتهم المرضية، وعن توفر الفحوصات، وعن النظافة، وقد كان واقع الخدمة أسوأ من توقعات معظم المرضى، ومع ذلك فإن أكثر المرضى ينصحون غيرهم بنفس المستشفى.

نسبة الرضا عن الوجبات في المستشفيات الخاصة يمكن أن يعزى إلى عدم الاهتمام في المستشفيات العامة بمستوى التغذية كما أن الكثيرين معتادون على أصناف معينة كجزء من ثقافتهم والمستشفيات العامة لا تراعي ذلك بل وتمنع إحضار الغذاء من خارج المستشفى، بينما الأمر أكثر مرونة في القطاع الخاص، كما هو الحال أيضاً في مرونة تنظيم آلية الزيارة وتوقيتها الأمر الذي يفسر زيادة مستوى الرضا عن أوقات الزيارة في القطاع الخاص فضلاً عن محدودية عدد المرضى في الغرفة الواحدة، بخلاف المستشفيات العامة فإن الوقت المتاح للزيارة فيها أقل وعدد المرضى أكثر، وهذا يتفق مع الدراسة الكويتية التي أظهرت مستوى أعلى من الرضا عن الخدمات المعاونة (من هدوء وراحة وكمية ونوع الغذاء ومواعيد الزيارة والنظافة) في القطاع الخاص عن العام، بل انفتحت الدراسات في تفوق القطاع الخاص عن العام في التقييم العام للرضا، وهذا متوقع كون دوافع القطاع الخاص للمحافظة على المريض أعلى من القطاع العام في أي مكان، مع الفارق في نسب الرضا فقد كانت نسبة الرضا في القطاعين (العام والخاص) في الكويت 80.3% و 91.8%<sup>(15)</sup> عالية بالمقارنة بنتائج الدراسة، وقد يعود ذلك للفارق الكبير في الإمكانيات والتجهيزات والكوادر.

وتدني مستوى الخدمة في المستشفيات دون ما يتوقعه المرضى يتفق مع دراسات عربية أخرى في السعودية والأردن كانت الخدمات فيها أسوأ من توقعات المرضى<sup>(16,29)</sup>، وذلك لأن توقعات المرضى أقرب إلى المثالية فتوقعات معظمهم لا تبنى على تجارب سابقة باعتبار أن معظمهم يرددون في المستشفى للمرة الأولى، ومع ذلك فإن الكثيرين سينصحون غيرهم بالمستشفى لقناعتهم بأنه ربما أفضل المتاح، وذلك مع تدني رضا المرضى عن تكلفة الخدمة وخصوصاً في المستشفيات الخاصة والذي يعززه قناعة أغلب المرضى عن وجود تغليب للجوانب المالية على الإنسانية، كون المريض غالباً لا يجد أي تعاون عند عجزه عن دفع كلفة أي خدمة ولاسيما في المستشفيات الخاصة، وقد اتضح أن المريض يفصل بين الرؤية المادية وبين الطبيب والذي هو صاحب القرار (وأحياناً صاحب المنفعة أيضاً) في استحداث أي خدمة، فالمرضى يركزون خصومتهم مع إدارات المستشفيات وليس مع الأطباء الذين يعتبرونهم يمثلون الجانب الإنساني ولذلك كان مستوى الرضا عنهم عالياً وبالذات في القطاع الخاص المتهم باستهدافه الربح المادي.

وقد يعود ارتفاع الرضا في الفئة العمرية المتوسطة عن توضيح الحالة المرضية لأن هذه الفئة ضمن مرحلة النضج الفكري مما يسهل عليهم فهمها، بينما كان الرضا أدنى للأصغر سناً كونهم أقل خبرة وأحياناً أكثر قلقاً من تأثير حالتهم المرضية على صحتهم المستقبلية باعتبارهم في مقتبل العمر، ونلاحظ أن الدراسة اختلفت عن كثير من الدراسات<sup>(2,5,10)</sup> في أن كبار السن لم يكونوا أعلى رضا عن معظم الخدمات وقد يعود ذلك لتداخل عوامل ومتغيرات أخرى متعلقة بالمجتمع اليمني مثل كون معظم كبار السن من الأميين ومن محدودي الدخل وبالتالي فالعائق المالي يؤثر على مستوى الرضا على الجوانب الأخرى، وخلافاً للمتوقع بأن المتعلمين يطلبون خدمات ذات جودة أعلى ولكن عدم وجود أثر ذي دلالة إحصائية للتعليم باستثناء التناسب العكسي مع الرضا عن الغذاء قد يوحي بمحدودية أثر التعليم في تغيير الثقافات والقناعات في اليمن بما يكفي، ويتمشى هذا مع الدراسة الكويتية التي لم تجد أي أثر للمستوى التعليمي على رضا المرضى في المستشفيات الخاصة وبالمثل في المستشفيات العامة لم يتأثر الرضا باستثناء وجود تناسب عكسي بين المستوى التعليمي والخدمات المعاونة<sup>(15)</sup>.

وعدم وجود دلالة إحصائية لتأثير جنس المريض يتفق مع دراسة مصرية أظهرت عدم تأثر مستوى الرضا عن الخدمات الصحية بجنس المريض<sup>(30)</sup>، وبشكل عام يوجد تناقض بين الدراسات في هذا الشأن<sup>(1,316)</sup>، أما عن وجود تناسب طردي بين الحالة الاقتصادية والرضا عن إجراءات الدخول فيمكن تفسيره بأن ذوي الحالة الاقتصادية الجيدة هم أقدر على دفع الرسوم المطلوبة مما

ورضاً مما ينعكس على أدائه لعمله، فضلاً عن أن الإشراف على المريض في القطاع الخاص يكون غالباً من الطبيب الاختصاصي، أما في القطاع العام فالإشراف يكون من عدد من الاختصاصيين في نفس المجال والذين يعملون معاً كفريق معالجة، مع أن دراسات متعلقة بالرضا تربط بين العمل كفريق وزيادة الرضا<sup>(21)</sup> ولعل المعول عليه هو أسلوب عمل فريق العمل وقناعة المريض به، كما يمكن أن نعزو الأمر إلى أن المستشفيات العامة جميعها مستشفيات تعليمية وكثيراً ما يعنى الأطباء عند مرورهم بتدريب الطلاب وكثيراً ما يؤثر هذا على الوقت الممنوح لسماع شكوى المريض، أضف إلى ذلك أن المريض غالباً ما يختار طبيبه في القطاع الخاص بينما في القطاع العام فإنه كثيراً ما يرتضي أن يعالجه أي طبيب يجده، فضلاً عن زيادة عدد المرضى في القطاع العام والدراسات تشير أن الأطباء الذين لديهم عدد أكبر من المرضى يصبحون أقل اهتماماً بالعلاقة مع المريض وبالتالي يصبح رضاهم أقل<sup>(1)</sup>.

ونسبة الرضا العالية عن التمريض يعود لكونهم أكثر التصاقاً بالمريض، وزيادة الرضا في القطاع الخاص قد يعود لما أوردناه من فارق في الامتيازات والتي لها الأثر الأكبر على مستوى رضا الكادر والذي يؤثر بدوره على مستوى الخدمة المقدمة كما أوضحت ذلك الدراسات المتعلقة بالرضا الوظيفي<sup>(22-25)</sup> فضلاً عن توفر وسائل النداء بعكس الحال في المستشفيات العامة التي يضطر المريض فيها أن يرسل مرافقه، أو يذهب بنفسه أو يصيح بأعلى صوته، أو يصبر على معاناته، وهذا يفسر تدني الرضا عن استجابة التمريض في القطاع العام مقارنة بالخاص.

أما تدني مستوى الرضا عن الكادر الأجنبي فقد يعود لصعوبة تعامل المريض مع الكادر الأجنبي لعائق اللغة، وخصوصاً أن معظم المرضى من الأميين أو ذوي تعليم متدني، كما أن المرض اليمني أقرب لهم وأعرف بنفسيتهم وثقافتهم مما يجعله أكثر قدرة على التعامل معهم وفهم احتياجاتهم وهذا يتفق مع دراسة سعودية جعلت من أسباب تدني رضا المرضى مشكلة الاتصال بين المرضى والمرضات<sup>(26)</sup>، كما يتفق مع دراسات أوضحت زيادة الرضا عندما يكون الطبيب والمريض من نفس البلد؛ وتم تفسير ذلك في دراسة سعودية لسهولة التعامل وغياب حاجز اللغة<sup>(27,28)</sup>، وربما يفسر ذلك بان الكادر اليمني أكفأ من الكادر الأجنبي؛ وهذا لأن المستشفيات عند استقدامها للكادر الأجنبية ولأسباب مالية غالباً لا تستهدف ذوي الكفاءات المتميزة.

وارتفاع نسبة الرضا عن توفر الفحوصات الطبية في القطاع الخاص يعود لحرصه على توفير الإمكانيات التي تدر للمستشفى دخلاً بينما في القطاع العام قد تستمر أجهزة معطلة لأسابيع لأن الإصلاح يتطلب إجراءات عديدة، أما تدني نسبة الرضا عن كلفة الخدمة حتى في المستشفيات العامة على الرغم من أن تكلفة الخدمة فيها أقل من الخاصة فقد يرجع لاعتقاد المرضى أن الخدمات المقدمة في المستشفيات العامة يجب أن تكون مجانية كونها مدعومة من الدولة وهذا يتماشى مع دراسة كويتية أوضحت أن ثلاثة أرباع المرضى غير مستعدين لدفع أية رسوم مقابل الخدمات الصحية في القطاع العام<sup>(15)</sup>، كما أن الكثير من مرتادي المستشفيات العامة من محدودي الدخل وهؤلاء مهما تدنت الكلفة فهي لازالت عالية بالنسبة لهم، ومع ذلك فيبقى عدم الرضا عن الكلفة أعلى في المستشفيات الخاصة لارتفاع الكلفة فيها، وهذا لم يمنع وجود نسبة من المرضى راضين عن الكلفة وذلك لرضاهم عن الخدمة المقدمة لهم ولمعقولية التكاليف في اليمن إذا ما قورنت بكلفة الخدمات الصحية خارجها.

ارتفاع نسبة الرضا عن الهدوء في المستشفيات الخاصة قد يعود لقلّة عدد المرضى في الغرفة وليس لموقعها لأن معظم المستشفيات لم يراعى في اختيار موقعها أن يتصف بالهدوء فجميعها على شوارع رئيسية مزدحمة لكنها تبقى أكثر اهتماماً بتجهيزات الغرفة ونظافتها مما انعكس على رضا المرضى بخلاف القطاع العام الذي يتدنى فيها مستوى النظافة لضعف الرقابة، وبالمثل فإن ارتفاع

وعند تصنيف إجابات المرضى بحسب فئاتهم العمرية لم يكن لذلك دلالة إحصائية إلا في جانبين اثنين أولهما ارتفاع الرضا في الفئة العمرية ما بين 31-45 سنة عن توضيح الحالة المرضية من قبل الطبيب، وكانت نسبة الرضا هي الأدنى في الفئة ما بين 15-30 سنة، والجانب الثاني أن كبار السن لم يكونوا أعلى رضا عن معظم الخدمات. كما أن المستوى التعليمي لم يكن له أثر ذو دلالة إحصائية باستثناء وجود تناسب عكسي مع الرضا عن الغذاء فكلما ارتفعت الحالة التعليمية قل الرضا عن الغذاء المقدم كمّاً ونوعاً وكذلك لم نجد تأثيراً ذا دلالة إحصائية لجنس المريض أو حالته الاجتماعية على مستوى الرضا.

جدول رقم (3): تأثير الحالة المرضية على رضا المرضى بشأن عدد من الخدمات المقدمة :

| الحالات الباطنية |       |          | الحالات الجراحية |       |          | نوع الحالة المرضية                     |
|------------------|-------|----------|------------------|-------|----------|--|
| متوسط            | راضي  | غير راضي | متوسط            | راضي  | غير راضي | مستوى الرضا عن الخدمات المحددة أدناه   |
| 20.5%            | 54.4% | 25.1%    | 21.1%            | 46.1% | 32.8%    | الرضا عن سهولة إجراءات الدخول          |
| 14.8%            | 59%   | 26.2%    | 8.1%             | 76.6% | 15.4%    | توضيح الحالة للمريض من قبل الطبيب      |
| 22.5%            | 67.5% | 10%      | 19.6%            | 63.7% | 16.7%    | منح المريض الوقت الكافي أثناء المتابعة |
| 16.6%            | 75.9% | 7.4%     | 16%              | 71.7% | 12.3%    | رضا المريض عن التمريض                  |
| 17.1%            | 55.5% | 27.4%    | 13.1%            | 63.7% | 23.2%    | الرضا عن توفر الفحوصات الطبية          |
| 21.5%            | 60.1% | 18.4%    | 17.5%            | 69.4% | 13.1%    | رضا المرضى عن النظافة                  |

## المناقشة

كانت الحالة الاقتصادية لمعظم المرضى متوسطة أو متدنية لأنهم السواد الأعظم في المجتمع، وذو الدخل المتدني يفضلون القطاع العام لتدني كلفته ولكن أكثر من ربع مرضى القطاع الخاص كانوا أيضاً من ذوي الدخل المتدني؛ ويمكن أن يعزى ذلك للزحام الشديد في القطاع العام ولتفشي ظاهرة لدى كثير من الأطباء وهي تحويل المرضى من القطاع العام ليعالجوهم في القطاع الخاص كون القوانين اليمنية تسمح للطبيب بالجمع بين العمل في القطاع العام والخاص.

وعند المقارنة بين المستشفيات العامة والخاصة نجد أن تدني نسبة الرضا عن إجراءات الدخول في المستشفيات العامة ناتج عن الصعوبات التي يواجهها المرضى بسبب الزحام وقلة اهتمام موظفي الدخول مع عدم وجود مكان واضح للاستقبال، مما جعل الوقت المستغرق لإتمام إجراءات الدخول طويلاً بخلاف المستشفيات الخاصة فقد كانت نسبة الرضا أعلى والوقت أقل لسهولة الإجراءات ووجود مكاتب مختصة بإجراءات الدخول فالمستشفيات الخاصة تحاول كسب المرضى وتسريع دخولهم قبل تحويلهم إلى مستشفيات أخرى، ومع ذلك فإن حدوث عدم رضا عن إجراءات الدخول في المستشفيات الخاصة معظمه يعزى للحاجة لدفع مبالغ لا يتم الإدخال إلا باستيفائها.

ونسبة الرضا العالية عن الأطباء تتفق مع دراسات أخرى تجعل أعلى مستويات الرضا عن الأطباء ثم عن التمريض<sup>(1)</sup>، وزيادة الرضا عن الأطباء في القطاع الخاص يمكن أن نعزوه إلى أن وضع الأطباء فيه أفضل من ناحية الرواتب والحوافز مما يجعل الطبيب أكثر تفرغاً وإخلاصاً

تقييم رضا المرضى المرقدين في المستشفيات الحكومية والخاصة بمدينة صنعاء عن الخدمات المقدمة لهم عادل أحمد العماد

جدول رقم (2): تقييم رضا المرضى عن الخدمات المقدمة لهم في مستشفيات القطاعين

| غير راضي |       | متوسط |       | راضي  |       | مستوى الرضا                                  |
|----------|-------|-------|-------|-------|-------|--|
| الخاص    | العام | الخاص | العام | الخاص | العام | معياري التقييم                               |
| %7.2     | %36   | %17.6 | %21.6 | %75.2 | %42.4 | مستوى الرضا عن سهولة إجراءات الدخول          |
| %17.1    | %42.1 | %17.1 | %13.2 | %65.8 | %44.7 | مستوى الرضا عن الوقت المستغرق للدخول         |
| %7.7     | %13.2 | %11.7 | %19.1 | %80.6 | %67.7 | مستوى الرضا عن الاستماع لشكوى المريض         |
| %6.8     | %15.6 | %22.5 | %19.9 | %70.7 | %64.5 | مستوى الرضا عن منح المريض الوقت الكافي       |
| %9.9     | %23   | %14.9 | %10   | %75.2 | %67   | مستوى الرضا عن توضيح الحالة للمريض           |
| %37.4    | %42.5 | %12.2 | %11.2 | %50.4 | %46.3 | طريقة استخدام الدواء والأعراض الجانبية       |
| %15.3    | %27.4 | %12.2 | %14   | %72.5 | %58.6 | إشراك المريض لتحديد وسيلة العلاج             |
| %3.2     | %12.2 | %9.5  | %18.5 | %87.3 | %69.3 | مستوى الرضا عن الكادر التمريضي               |
| %45.3    | %48.9 | %18.7 | %13.8 | %36   | %37.3 | الرضا عن التمريض الأجنبي مقارنة باليمني      |
| %5.5     | %32.1 | %9.1  | %16.6 | %85.4 | %51.3 | مستوى الرضا عن توفر الفحوصات الطبية          |
| %7.2     | %33.1 | %21.3 | %21.9 | %71.5 | %45   | سهولة إجراء الفحوصات الطبية                  |
| %57.2    | %34.4 | %26.1 | %32.4 | %16.7 | %33.2 | مستوى الرضا عن كلفة الخدمة                   |
| %11.0    | %27.7 | %17.4 | %24.0 | %71.6 | %48.3 | مستوى الرضا عن الهدوء والراحة                |
| %9.5     | %19.4 | %19.9 | %23.4 | %70.6 | %57.2 | مستوى الرضا عن تجهيزات الغرف                 |
| %7.7     | %19.5 | %10.4 | %21.8 | %81.9 | %58.7 | مستوى الرضا عن النظافة                       |
| %5.0     | %20.4 | %9.6  | %14.4 | %85.4 | %65.2 | مستوى الرضا عن الزيارة                       |
| %23.3    | %33.3 | %17.2 | %22   | %59.5 | %44.7 | مستوى الرضا عن كمية الوجبات المقدمة          |
| %23      | %31   | %19.4 | %21.8 | %57.6 | %47.2 | مستوى الرضا عن نوعية الوجبات المقدمة         |
| %27.0    | %34.9 | %22.3 | %18.5 | %50.7 | %46.6 | القناعة بتغليب الجوانب المالية على الإنسانية |
| %44.6    | %45.2 | %15.8 | %21.6 | %39.6 | %33.2 | مدى تطابق خدمات المستشفى مع ما توقعت         |
| %14.3    | %17.0 | %15.2 | %17.1 | %70.5 | %65.9 | نصيحة الآخرين بهذا المستشفى                  |

جدول رقم (1): توزيع المرضى حسب العمر والجنس والحالة التعليمية والحالة المرضية في القطاعين :

| المجموع  |      | مستشفيات القطاع الخاص |     | مستشفيات القطاع العام |     | المتغير                   |
|--|------|-----------------------|-----|-----------------------|-----|---------------------------|
| %100.00  | 1045 | %21.20                | 222 | %78.80                | 823 | إجمالي المرضى المشمولين   |
| توزيع المرضى من حيث العمر :                                  |      |                       |     |                       |     |                           |
| %33.88   | 354  | %33.78                | 75  | %33.90                | 279 | 15 - 30 سنة               |
| %23.35   | 244  | %25.23                | 56  | %22.84                | 188 | 31 - 45 سنة               |
| %25.45   | 266  | %22.07                | 49  | %26.37                | 217 | 46 - 60 سنة               |
| %17.32   | 181  | %18.92                | 42  | %16.89                | 139 | أكثر من 60 سنة            |
| توزيع المرضى من حيث المستوى التعليمي :                       |      |                       |     |                       |     |                           |
| %40.96   | 428  | %23.42                | 52  | %45.69                | 376 | أمي                       |
| %33.30   | 348  | %29.28                | 65  | %34.39                | 283 | يقرأ ويكتب                |
| %17.22   | 180  | %31.08                | 69  | %13.49                | 111 | تعليم متوسط (دون الجامعة) |
| %8.52  | 89   | %16.22                | 36  | %6.44                 | 53  | تعليم عالي                |
| توزيع المرضى من حيث الجنس والحالة الاجتماعية :               |      |                       |     |                       |     |                           |
| %63.35   | 662  | %76.13                | 169 | %59.90                | 493 | ذكر                       |
| %36.65   | 383  | %23.87                | 53  | %40.10                | 330 | أنثى                      |
| %16.75   | 175  | %15.32                | 34  | %17.13                | 141 | أعزب                      |
| %72.44   | 757  | %78.83                | 175 | %70.72                | 582 | متزوج                     |
| %2.58  | 27   | %0.90                 | 2   | %3.04                 | 25  | مطلق                      |
| %8.23  | 86   | %4.95                 | 11  | %9.11                 | 75  | أرمل                      |
| توزيع المرضى من حيث الحالة الاقتصادية ومكان الإقامة الدائم : |      |                       |     |                       |     |                           |
| %44.02   | 460  | %48.20                | 107 | %42.89                | 353 | سكان المدينة              |
| %55.98   | 585  | %51.80                | 115 | %57.11                | 470 | سكان الريف                |
| %10.81   | 113  | %17.57                | 39  | %8.99                 | 74  | حالة اقتصادية جيدة        |
| %48.52   | 507  | %54.50                | 121 | %46.90                | 386 | حالة اقتصادية متوسطة      |
| %40.67   | 425  | %27.93                | 62  | %44.11                | 363 | حالة اقتصادية متدنية      |
| توزيع المرضى من حيث نوع الحالة المرضية :                     |      |                       |     |                       |     |                           |
| %53.49   | 559  | %66.67                | 148 | %49.94                | 411 | حالات جراحية              |
| %46.51   | 486  | %33.33                | 74  | %50.06                | 412 | حالات باطنية              |
| توزيع المرضى من حيث فترة الرقود                              |      |                       |     |                       |     |                           |
| %32.92   | 344  | %48.65                | 108 | %28.68                | 236 | 3-4 أيام                  |
| %34.35   | 359  | %25.23                | 56  | %36.82                | 303 | 5-7 أيام                  |
| %20.67   | 216  | %20.27                | 45  | %20.78                | 171 | 8-14 يوم                  |
| %12.06   | 126  | %5.86                 | 13  | %13.73                | 113 | أكثر من 14 يوم            |

المبدئي المحدد لها؛ وذلك لقلّة عدد من تنطبق عليهم الشروط في المستشفيات الخاصة كون الأغلبية العظمى للمرضى يبقون يوماً أو يومين فقط.

## النتائج

يبين الجدول رقم (1) أن المرضى الذين انطبقت عليهم شروط العينة أكثرهم كانوا في المستشفيات العامة، ومثّل الأميون نسبة أعلى في القطاع العام، والحالة الاقتصادية للأغلبية كانت متوسطة أو متدنية، مع وجود عزوف لذوي الدخل المتدني عن القطاع الخاص مقارنةً بذوي الدخل الأعلى، وكان الذكور أكثر من الإناث، وأكثر من ثلثي المرضى متزوجون وأكثر من نصفهم ريفيون وذلك في القطاعين، وكان عدد حالات الباطنية متساوياً تقريباً مع الجراحية في المستشفيات العامة بينما في المستشفيات الخاصة كانت ثلثا الحالات جراحية، وكانت فترة البقاء في مستشفيات القطاع الخاص أقل منها في العام، كما أوضحت النتائج أن قرابة ثلثي المرضى رقدوا لأول مرة.

ويبين الجدول رقم 2 أن نسبة الرضا عن سهولة وسرعة إجراءات الدخول كانت أعلى في المستشفيات الخاصة مقارنةً بالعامة حيث تجاوز الوقت المستغرق للدخول في المستشفيات العامة الساعة لدى 56.9% من المرضى، مقابل أقل من ساعة في المستشفيات الخاصة لدى أكثر من 80%، وأظهرت النتائج نسبة رضا عالية عن الأطباء من حيث استماعهم لشكوى المريض ومنحهم الوقت الكافي وتوضيح الحالة لهم وإشراكهم في اتخاذ القرار، وكذلك كان الرضا عالياً عن التمريض وخصوصاً في المستشفيات الخاصة لكن الرضا عن الكادر الأجنبي كان أقل، وكانت نسبة الرضا عالية عن توفر الفحوصات وسهولة إجراءاتها وعن الهدوء وتجهيزات الغرف ونظافتها وعن الزيارة والغذاء كما ونوعاً وخصوصاً في القطاع الخاص، وفي المقابل كان مستوى الرضا عن كلفة الخدمة متدنياً ولاسيما في المستشفيات الخاصة (16.5%)، لفتاعة معظم المرضى أن هناك تغليباً للجوانب المالية على الإنسانية، وقناعتهم أن واقع الخدمة أسوأ من توقعاتهم، ومع ذلك فقد نصح أكثر المرضى غيرهم بنفس المستشفى.

وتبقي أسباب اختيار المستشفى اتضح أنه كلما كانت الحالة الاقتصادية أفضل كلما بحث المرضى عن مستشفى أفضل فمثّل الذين يبحثون عن المستشفى الأفضل كميّار مقدم على الكلفة 78% من ذوي الحالة الجيدة، و50.2% من ذوي الحالة البسيطة، وفي المقابل فضل 32% من محدودي الدخل اختيار مستشفى أقل كلفة مقابل 6.4% من ذوي الحال الأفضل، وكلما كانت حالة المريض الاقتصادية أفضل كان الرضا أكثر (57.8%) عن إجراءات الدخول مقارنةً بذوي الدخل الأقل (42.2%). وأوضحت النتائج أن مستوى الرضا عن الكلفة يقل بتدني الحالة الاقتصادية 34.4% للجيدة و29.6% للمتوسطة و23.8% للمتدنية، وكلما كانت الحالة الاقتصادية جيدة كلما زاد الرضا عموماً ولكن لم تكن الفروق ذات دلالة إحصائية باستثناء الرضا عن إجراءات التسجيل والدخول، بوجود تناسب طردي بين الحالة الاقتصادية والرضا عن إجراءات التسجيل والدخول.

نسبة الرضا عن الهدوء داخل المستشفى وعن تجهيزات الغرف كان أعلى وبفارق ذي دلالة إحصائية لدى من يسكنون الريف 58.6% و64.4% مقارنةً بسكان المدن 46.2% و54.5% على التوالي، وأظهر تأثير الحالة المرضية وجود فروق متفاوتة ولكنها كانت ذا دلالة إحصائية وبمستوى متفاوت في عدة جوانب بعضها كان فيه مستوى الرضا أعلى لدى مرضى الباطنية حيث كانوا أكثر رضاً عن إجراءات الدخول والتمريض وعن الوقت الذي يمنحه لهم الأطباء، وفي بعضها الآخر كان فيه مستوى الرضا أعلى لدى مرضى الجراحة حيث كانوا أكثر رضاً عن توضيح حالتهم المرضية لهم، وعن توفر الفحوصات، وعن نظافة المستشفيات (جدول رقم 3).

ومحلياً أجريت دراسة لتقصي جودة الخدمات الصحية من وجهة نظر المرضى، وشملت 183 مريضاً وأظهرت الحاجة الماسة لإجراء مسوحات أشمل<sup>(17)</sup>، ودراسة أخرى قام بها باحثون من جامعات ماليزية عام 2005 درست رضا المرضى في المستشفيات الخاصة اليمينية وولأهم لها وقد اتضح أن النساء أكثر ولاءً مع اتضاح عدم وجود علاقة بين الولاء ومستوى الخدمة والاستجابة<sup>(18)</sup>. ونظراً لشحة الدراسات المحلية حول رضا المرضى وغياب الدراسات المقارنة بين الرضا في المستشفيات العامة والخاصة ومحدداتها فقد هدفت هذه الدراسة لتقييم رضا المرضى عن الخدمات المقدمة لهم ومقارنة مستوى الرضا بين المستشفيات العامة والخاصة في أمانة العاصمة ، مع تحديد تأثير بعض المتغيرات التي قد تؤثر على رضا المرضى.

## المنهجية

دراسة وصفية مقطعية أجريت في كبرى مستشفيات صنعاء، منها 3 مستشفيات حكومية (الثورة العام، الجمهوري التعليمي، الكويت الجامعي) و3 مستشفيات خاصة (العلوم والتكنولوجيا، السعودي الألماني، أزال). وشملت الدراسة جميع المرضى اليمنيين المرقدين في المستشفيات المختارة في قسيمي الباطنية والجراحة خلال الفترة من أغسطس 2007 إلى يوليو 2009، من الذين أمضوا 3 أيام رقاد فأكثر (حتى يكونوا أقدر على التقييم بموضوعية) وأعمارهم فوق 15 سنة، وحالتهم مستقرة ويحملون نفقتهم بأنفسهم وأجابوا على جميع الأسئلة، وقد بلغ إجمالي المرضى الذين شملتهم الدراسة 1045 مريضاً.

ومن خلال استبانة أعدت بالاستفادة من دراسات مرجعية ذات صلة والتي تؤكد أن الاستبانة المكتوبة لازالت من أفضل وأدق الوسائل لقياس الرضا<sup>(11،19،20)</sup>، وقد تم السؤال عن معلومات تعريفية بالمرضى، وعن رأيهم بشأن الخدمة المقدمة وكلفتها وعن تعامل الكادر الطبي وعن الخدمات التي ثبتت علاقتها بالرضا، وقد تم الاكتفاء بتصنيف من 3 مستويات وهي (راضي) لمن لديهم انطباع إيجابي تجاه موضوع السؤال، و(غير راض) لمن لديهم انطباع سلبي، و(متوسط)، لمن ليس لديهم انطباع محدد؛ وقد تم الاكتفاء بالمستويات الثلاثة تبسيطاً للمرضى فلا مجال لتطبيق استبانة من مستويين (راضي وغير راض) لأن أدبيات منظمة الصحة العالمية المتعلقة بتقييم رضا المرضى حذرت من ذلك وأكدت أن الأسلوب المستخدم وتفصيله تعتمد على طبيعة الفئة المستهدفة<sup>(11)</sup>؛ ولذلك وتماشياً مع نصوص الأدبيات لم نكتفي بتسليم الاستبانة للمرضى وإنما عبئنا بالمقابلة المباشرة من خلال فريق محايد دربه الباحث بشكل كافي وذلك مراعاةً لتدني المستوى الثقافي لمعظم المرضى.

وقد أجريت في البداية دراسة تجريبية لاستبانة من 5 مستويات وكان مستوى الاعتمادية والثبات فيها ضعيفاً عند تكرار الأسئلة لنفس المرضى، بعكس الاستبانة ذات المستويات الثلاث فقد أظهرت مستوى أعلى من الثبات.

وقد وجهنا رسائل رسمية من كلية الطب بجامعة صنعاء لمدراء المستشفيات، وتعهدنا بالتعامل مع المستشفيات العامة ككل دون تحديد وكذلك الخاصة؛ وذلك محافظة على سمعة وخصوصية كل مستشفى.

وكان من معوقات الدراسة تدني ثقافة معظم المرضى، وأمياً بعضهم وتحاشي المصادقية أحياناً خوفاً من أن ينعكس ذلك على الخدمة المقدمة لهم، مع أنه تم الشرح لهم بعدم كتابتنا للأسماء وأن الاستبانة تعباً لأغراض بحثية ولا ترتبط بإدارة المستشفى، وقد تطلبت الدراسة ضعف الوقت

أكبر من الرضا<sup>(12،45)</sup>، وأن الرجال أقل رضا عن الخدمة ، ومنها ما يختص بحالته الصحية والاقتصادية والتعليمية حيث تشير الدراسات أن محدودى الدخل وذوي الثقافة المتدنية هم أقل رضا عن الخدمة<sup>(61)</sup> غير أن دراسات أخرى كانت تخالف ذلك<sup>(3)</sup>، كما تختلف الدراسات في تقييم أثر هذه العوامل ففي الوقت الذي تعتبرها بعض الدراسات محدودة الأثر تعدها أخرى ذات أهمية بالغة، وتشير الدراسات أن الطبيب يعد أهم عامل مؤثر على الرضا وخصوصاً ما يتعلق بتعامله وتواصله مع مرضاه ومنحهم الوقت الكافي بما في ذلك الوقت الذي يمضيه لشرح خطة العلاج لهم، بل يتأثر الرضا بابتسامه الطبيب وتعبيرات وجهه وبهينته وبملاسه أيضاً، ويمدى إيضاحه لأسلوب العلاج ونتائج المعالجة<sup>(9،7،2،1)</sup>، في دراسة سعودية كان معظم المرضى راضين عن الإيضاح المقدم لهم<sup>(10)</sup>، كما يتأثر الرضا بالتمريض وسرعة استجابته لمتطلبات المريض وبالجو المحيط وتجهيزات ونظافة الغرفة، وجودة الطعام ونوعه، وبكلفة الخدمة، وبموقع المستشفى وتصميمه وحجمه؛ الأمر الذي أدى لبروز فرع هندسي يعنى بتصميم المستشفيات بالتركيز على رضا المرضى<sup>(5)</sup>.

وتؤكد أدبيات منظمة الصحة العالمية على دور تقييم رضا المرضى في قياس فاعلية الخدمات المقدمة ومدى استجابتها لحاجات وتوقعات المرضى، ومع أن رضا المريض يعتبر مؤشراً لجودة الخدمة ولكن رضا العميل ليس أمراً مرادفاً للجودة ولا يكفي منفرداً لإثباتها، وذلك أن رضا العميل تحكمه توقعاته وتجاربه واحتياجاته وتفضيلاته وظروفه، فالمرضى الذي ليس له مرجعية ذهنية أو تجارب سابقة قد يكون راضياً عن خدمات رديئة، وفي المقابل فقد يكون عدم الرضا عن خدمات جيدة ناتجاً عن توقعات غير منطقية<sup>(11)</sup>؛ ولذا تشير الدراسات أن الأطباء عليهم العناية الشديدة بمعرفة توقعات المريض فذلك لا يزيد من رضا المرضى فحسب وإنما رضا الأطباء أيضاً<sup>(1)</sup>، ولا تعنى دراسات رضا المرضى بتقييم كفاءة الأطباء فالمرضى لا يمكنهم الحكم على ذلك بدقة؛ ولهذا لا تتحرى الدراسات أن تسأل عن كفاءة الطبيب<sup>(12،2،1)</sup>، وبالرغم من ذلك فإن بعض الدراسات ربطت بين تدني مستوى الرضا والممارسات الطبية الخاطئة<sup>(13)</sup>، ودراسات أخرى أوضحت أن المرضى يفضلون الطبيب القادر على التشخيص والعلاج السليم أكثر من اهتمامهم بأسلوب تعامله<sup>(1)</sup>، بل أوضحت بعض الدراسات أنه يمكن تقصي مهارات وقدرات الأطباء من خلال رضا المرضى إذا تم إعدادهم للقيام بذلك<sup>(14)</sup>.

ومع كثرة الدراسات المتعلقة برضا المرضى لكن المنشور منها في الدول العربية معظمها اهتم برضا المراجعين للعيادات أما الدراسات التي عنيت بالمرضى المنومين أو التي قارنت بين القطاع العام والخاص فهي محدودة ومنها دراسة كويتية على 400 مريض في 5 مستشفيات عامة و4 خاصة أوضحت نسبة رضا 91.8% في المستشفيات الخاصة مقابل 80.3% في المستشفيات العامة، ولم تظهر الدراسة وجود تأثير للخصائص الشخصية للمرضى على مستوى الرضا باستثناء تدني الرضا عن الخدمات المساندة مع ارتفاع المؤهل العلمي وزيادة رضا المتزوجين في القطاع العام وكذلك زيادة الرضا بين الذكور في المستشفيات الخاصة<sup>(15)</sup>، كما أجريت دراسة سعودية أجريت على 500 مريض في 7 مستشفيات (5 مستشفيات خاصة ومستشفيان تابعان لوزارة الصحة في مدينة الرياض) وأوضحت الدراسة أن الخدمة المقدمة كانت أقل من المتوقع في المستشفيات العامة والخاصة<sup>(16)</sup>، كما أن دراسة سعودية أخرى درست مستوى الرضا عن الأطباء لدى 400 مريض وجدت أن الرضا أعلى بين النساء والمتزوجين وكبار السن والأقل دخلاً وثقافة ، أما التواصل والسؤال عن رأي المرضى في جودة الخدمة ومشكلاتها فقد حاز أقل قدر من الرضا<sup>(3)</sup>.

## تقييم رضا المرضى المرقدين في المستشفيات الحكومية والخاصة بمدينة صنعاء عن الخدمات المقدمة لهم

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### ملخص

تنامى الاهتمام بتقييم رضا المرضى عالمياً منذ بداية الثمانينات مع حدة التنافس بين المؤسسات الصحية. وقد أجريت هذه الدراسة المقطعية بهدف تقييم مستوى رضا المرضى في مستشفيات صنعاء تم سؤال المرضى الذين أمضوا 3 أيام فأكثر في 6 من أكبر المستشفيات (حكومية وخاصة) ممن تجاوزوا 15 سنة وحالتهم مستقرة ويتحملون نفقتهم خلال الفترة من أغسطس 2007 إلى يوليو 2009 ومثّلوا 1045 مريضاً ومريضة، وكان مستوى الرضا عالياً عن الأطباء والتمريض والنظافة والهدوء والزيارة وتجهيزات الغرف والغذاء، كما كان مستوى الرضا عن الهدوء وتجهيزات الغرف أعلى بين الريفيين، وكان مرضى الحالات الباطنية أكثر رضا عن إجراءات الدخول وعن التمريض والوقت الممنوح من الطبيب، كان مرضى الحالات الجراحية أكثر رضا عن توضيح الطبيب لحالتهم المرضية، وعن توفر الفحوصات، وعن النظافة، وفي المقابل كان مستوى الرضا عن كلفة الخدمة متدنياً وخصوصاً في القطاع الخاص، مع وجود قناعة بتغليب الجانب المادي على الإنساني ومع ذلك فأكثر المرضى ينصحون غيرهم بنفس المستشفى، لذا نوصي المستشفيات باتخاذ التدخلات المناسبة لرفع مستوى الرضا وإجراء تقييم دوري حول رضا المرضى وقياس أثر تلك التدخلات.

### المقدمة

تنامى الاهتمام بتقييم رضا المرضى عالمياً منذ بداية الثمانينات مع حدة التنافس بين المؤسسات الصحية<sup>(1)</sup>، وأجريت العديد من الدراسات ركز بعضها على جوانب محددة سواء للمقارنة بين مجتمع وآخر أو لدى عمر معين أو للمصابين بمرض ما أو لدى مقدم خدمة محدد أو لخدمات معينة أو نحو أسلوب محدد للمعالجة وغيرها<sup>(2)</sup>، وتهدف المؤسسات الصحية إلى تحسين مستويات الرضا، لا للحفاظ على قاعدة مرضاها وتوسيعها فحسب بل ولتحسين مستوى الخدمة؛ كونه يمكن على ضوء معرفة مواطن القصور اتخاذ التدابير والتدخلات المناسبة لإصلاحها<sup>(3)</sup>.  
ورضا المرضى بحاجة لتقييم من وقت لآخر فما يرضي المريض حالياً قد لا يرضيه مستقبلاً، كما أن تشكيل القناعة يتأثر بعوامل ومتغيرات عدة منها ما يختص بالمرضى كجنسه وعرقه وعمره حيث رجحت الدراسات أن كبار السن لديهم مستوى



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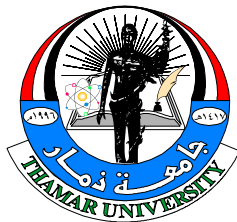
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