https://doi.org/10.33307/entomon.v46i1.583
ENTOMON 46(1): 25-32 (2021)
Article No. ent. 46103

An appraisal of post flood dengue vector *Aedes albopictus* Skuse (Diptera: Culicidee) surveillance in a coastal district of Kerala, India

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ABSTRACT: Alappuzha coastal district was worst affected by floods due to the heavy rainfall in August 2018. *Aedes albopictus* survey carried out in the post flood/ disaster areas covering 1,140 households revealed maximum larval positivity in plastic/leather followed by metal and earthen containers. The House index ranged from 1.75 to 12.28 per cent whereas the container index ranged from 1.73 to 20.51 per cent. Breteau index ranged from 3.5 to14.3. As dengue is endemic in the district, there exists a potential outbreak of the vector borne disease.

KEY WORDS: Vector borne disease, *Stegomyia* indices, *Aedes*, container index

INTRODUCTION

Vector-borne diseases (VBDs) pose a significant global human threat today, with a number of old diseases resurging in recent decades alongside newly emerging infectious diseases (Smolinski *et al.*, 2003). Dengue is one of the most widespread mosquito-borne viral diseases worldwide. At present dengue is a major public health concern in 128 countries and is still expanding (WHO, 2012, 2020a). The incidence of dengue has grown drastically around the world in recent decades. One of the recent modeling estimates that 390 million dengue virus infections occur annually, with 96 million clinical manifestation and 5,00,000 hospitalization (Bhatt *et al.*, 2013). Southeast Asia is the most impacted region with highest incidence of dengue in the world (Undurraga *et al.,* 2013). Dengue is caused by a virus of the family Flaviviridae and there are four distinct, but closely related, serotypes of the virus that cause dengue (DENV-1, DENV-2, DENV-3 and DENV-4). Recovery from infection is considered to provide lifelong immunity against that serotype. But, cross-immunity to other serotypes after recovery is only partial, and temporary. Succeeding infections by other serotypes increase the risk of developing severe dengue. Dengue virus is mainly transmitted by female *Aedes aegypti* (L.) mosquitoes and to a lesser extent, *Aedes albopictus* Skuse. These

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mosquitoes are also vectors of chikungunya, yellow fever and zika viruses. *Aedes aegypti* mosquito is considered to be the major vector of DENV and it breeds mostly in man-made utensils and containers. *Ae. albopictus*, a secondary dengue vector is also known as Asian tiger mosquito and, is highly adaptive and its geographical spreads is largely due to its tolerance of colder conditions, as egg and adult (Romi *et al*., 2006).

Kerala experienced an abnormally high rainfall and received an excess of 96% rainfall during the period from 1st to 30th August 2018. During this period, Alappuzha district in Kerala received 608.2 mm rainfall which is 77% more than the normal rain fall (343.1 mm). The peak spell of rains that led to severe flood in Kerala began on 8th August 2018 and continued up to 17th August 2018. Floods can potentially increase the spread of water and mosquito-borne diseases. Floods may indirectly lead to an increase in VBDs especially mosquito-borne diseases due to the expansion of numerous mosquito breeding habitats. This enhances the possibility of getting exposure to vector mosquitoes in the flood-affected population and pave for the rapid spread of mosquito-borne diseases such as malaria, dengue (WHO, 2019). Dengue fever (DF) was first reported in Alappuzha district in 2003 and since then it is a major public health issue. In the district, dengue cases were reported throughout the year with more number during monsoon and post monsoon seasons. Even in extreme summer season, DF cases are reported in Alappuzha district due to summer rains. Every year hundreds of DF cases are reported and thus Alappuzha became an endemic area for dengue. As per the report of Integrated Disease Surveillance Project (IDSP-DSU, 2016-2018), Alappuzha, the number of DF cases reported in 2016 was 832 with no death; in 2017 it was 1375 with 08 deaths. The dengue fever cases reported in Alappuzha district in 2018 (flood year) was 149 with 1 death. The present surveillance work was done in post flood period in Alappuzha district, one of the coastal districts of Kerala, to determine the major breeding sites of vector mosquitoes and to identify high density vector infested areas so that appropriate and timely vector control activities could be initiated.

MATERIALS AND METHODS

Mosquito larval survey was done by house to house visit in rural and urban areas of Alappuzha district during the post flood period from1st to 30th September 2018. The survey was carried out in 22 rural Panchayaths spread over nine Community Development (CD) Blocks and two urban (Municipality) areas. *Aedes* larval survey was done in 22 Panchayath areas spread over 9 Community Development (CD) Blocks. The areas are Purakkad and Ambalappuzha North (Ambalappuzha Block), Mararikkulam South and Mannancherry (Aryad Block), Thakazhi, Champakkulam, Kainakary and Edatua (Chambakkulam Block), Budhanoor and Pandanad (Chenganoor Block), Cheruthana, Kumarapuram, Pallippad, Veeyapuram and Haripad (Haripad Block), Thaneermukkom and Kanjikuzhi (Kanjikuzhi Block), Vayalar and Ezhupunna(Pattanakkad Block), Thycattussery and Chennam-Pallippuram(Thycattussery Block) and Kavalam (Veliyanad Block). In addition to this the larval survey was also done in 2 urban areas namely Alappuzha and Cherthala Municipal areas. 50 houses each from 21 areas and 30 houses each from 3 areas were selected by random sampling. Thus a total of 1,140 houses were selected from 24 areas in Alappuzha district. For larval survey, house or premise was taken as the Basic Sampling Unit (BSU) and each house/premise was thoroughly searched for water holding containers. All the accessible water holding containers/habitats in and around the houses were checked for the presence of immature stages of mosquitoes and recorded. Larvae/pupae from each positive container were collected separately. The immature stages of mosquitoes from small containers (less than 10 litre capacity) were collected using appropriate Steiner. Larvae and pupae were collected from large containers using modified larval dipper. The larvae/ pupae collected from each container were kept in separate vials labeled with date of collection, name of the locality, house number and breeding source (container type/ habitat). The immature kept in separate vials were placed in rearing jars filled with 150ml freshwater and were covered with fine piece of mosquito net. All larvae were fed with larval diet (prepared by mixing 12.5 g of tuna meal, 9.0 g of bovine liver powder, and 3.5 g of Yeast, in 100 ml of distilled water). Larvae and pupae were reared until the emergence of adults and the mosquitoes were identified using standard key (WHO, 2020b). *Aedes* larval indices - House index (HI), Container index (CI), Breteau index (BI) and the Breeding Preference Ratio (BPR) of vector mosquitoes were analyzed.

RESULTS AND DISCUSSION

During the survey a total of 1,258 containers were checked for larval presence. In addition to this, fridges (12 nos.) and wells (15nos.) were inspected for mosquito larvae. None of the fridges have immature but mosquito larvae/ pupae could be collected from 13 % of the wells from the survey area (Fig. 1). Of the total 1,258 breeding sources examined, maximum positivity was found in plastic/ leather (39.03%), followed by metal containers (25.70%), earthen (mud pots, mud jars, flower pots) containers (17.80%) and glass bottles (6.12%).

In most of the houses in Kuttanad area, supply of water is only twice in a week. This forced the households to store the water in the available containers; most of them were without proper lid/ covering. This leads to breeding of *Aedes* mosquitoes in these containers. A total of 116 water stored containers without proper covering were checked for larval presence; 24 (20.68%) of them were having mosquito larvae. Many discarded/dry containers were seen scattered in the peridomestic area. House index ranged from 1.75- 12.28 percent. Container index (CI) ranged from 1.73 -20.51 percent. CI was minimum (1.73%) in Cherthala Municipal area (Ward No.13) and it was maximum in Ward No.4 of Ezhupunna Panchayath (20.51%). Breteau index (BI) noted was minimum in Ward No.1 of Kainakary Panchayath (3.5) while maximum (14.03) BI was noted in Ezhupunna Panchayath area (Fig. 2).

The larvae and pupae collected from each survey area were reared under laboratory conditions and the emerged mosquitoes were identified. Of the total 115 adult mosquitoes emerged, 85 (73.91%) were *Aedes albopictus*, 4 (3.48%) were *Aedes vittatus*, 15 (13.04%) were *Culex quinquefasciatus* and 11 (9.57%) were *Armigeres subalbatus* mosquitoes. Of the total *Aedes* mosquitoes emerged, 95.5% were *Ae.albopictus.* This indicates *Ae. albopictus* is the predominant *Aedes* mosquitoes prevalent in Alappuzha district.

The location and type of water holding containers seen scattered in the house premises may influence site selection of *Aedes* mosquitoes for oviposition. Study related to the breeding preference of *Ae. albopictus* mosquitoes in post flood situation is meager. Hence an analysis has been done to find out the most preferred breeding sources of *Ae. albopictus* in post flood situation in Alappuzha district (Fig.3). The Breeding Preference Ratio (BPR) was found to be more in cement tanks (5.0) and overhead tanks (5.0) followed by grinding stones (4.0) and tires (2.0).

Kerala received heavy monsoon rainfall in mid-August 2018 that resulted in severe flood in almost all districts. Floods are one of the natural disasters occurring worldwide which have a wide range of health impacts. Flood can increase the transmission of water borne and air borne diseases. In addition to this, flood can intensify the transmission of vector borne diseases such as West Nile Fever (WNF) and Dengue fever (Babaie *et al.,* 2015). Climate change scenario is coincided with the emergence and re-emergence of *Aedes* borne diseases such as dengue, chikungunya and zika. The rapid urbanization, travel, trade, demographic changes, globalization, global warming, and inadequate water supplies are key factors favoring the spread of *Ae. aegypti* and *Ae. albopictus* mosquitoes, the vectors of dengue.

Dengue is a major public health concern in Alappuzha since 2003. It has been found that among the *Aedes* mosquitoes, *Ae. albopictus* was the most predominant species prevalent in Alappuzha (Sheela Devi, 2011; Rajendran *et al*., 2020). After the flood, mosquito borne viral diseases such as dengue fever especially in endemic areas can increase. Standing water after overflow from different natural and man-made water sources could act as breeding sites of mosquitoes. Thus, one may naturally expect a sudden increase of mosquito borne diseases such as dengue in the flood affected areas of Alappuzha district.

The report of IDSP, Alappuzha showed that there was less number of dengue cases in 2018 in comparison to the number of cases reported in 2016 and 2017 in the district (IDSP-DSU, 2016-2018). This is possible because the flood had swept away most of the immature stages of mosquitoes. Many of the small and medium sized containers might have swept away due to heavy downpour. Of the 22 rural areas surveyed, nearly 45% of the areas were from Kuttanad region (Champakkulam, Haripad and Veliyanad Blocks) of Alappuzha district. Kuttanad is well known for its vast lowland, flooded and single crop seasonal paddy fields. The region has the lowest altitude in India, and is one of the few places in the world where agricultural farming is carried on in 4-10 feet lowland below mean sea level. This is a backwater area formed by confluence of four major rivers-Pampa, Meenachil, Achankovil and Manimala prior to final emptying in to the Arabian Sea. This area is unique with vast network of backwaters, the Vembanad Lake and lagoons criss-crossing the land.

Area wise data on communicable diseases in Alappuzha district during the last 10 years (IDSP-DSU, 2010-2019) indicates that the number of dengue fever cases in Kuttanad area were less when compared with other areas. This is mainly related to the attitude of the local inhabitants. Kuttanad being a water-logged area, most of the houses are on the bank of the river/canal. After cleaning the house premises, the households usually strew the things including the small and medium sized containers into the nearby water bodies. Hence the chance of mosquito breeding especially *Aedes* mosquitoes in these areas is very less. Because of this reason, in each year only very few dengue fever cases have been reporting from Kuttanad area. The team locating only on an average 1.04 containers per house in this area substantiates the aforesaid contention.

The traditional indicators of vector surveillance are House index (HI), Container index (CI) and Breteau index (BI) and continue to be the main surveillance tool to predict and prevent *Aedes*-borne diseases. The *Stegomyia* indices have been developed as quantitative indicators to predict the impending outbreak of dengue. However the reliability of these indices in assessing the epidemiological situation and vector control operations is still a debatable point. The HI has been most widely used for measuring the larval infestation level. But it does not give the number of positive containers per positive house. The CI provides information only on the proportion of water-holding containers that are positive. It does not take in to account the productivity of the containers (Focks, 2003). The BI establishes a relationship between positive containers and houses. Thus BI is considered to have some relevance in assessing the risk of dengue infection in an area. As the container productivity is not taken in to account, BI could not serve as a potential Risk Assessment Index (RAI) but remains only a Guiding index (GI).

In the present study, maximum *Aedes* larval positivity was found in plastic/leather (39.03%), followed by metal containers (25.70%), earthen containers (17.80%) and glass bottles (6.12%). In a study related to the post flood vector surveillance in Ernakulam district (Samuel *et al.*, 2019) reported a similar observation. However the vector borne disease surveillance in Malappuram district after 2018 flood, it has been found tires, plastic and earthen containers are the most preferred *Aedes* breeding habitats (Lalthazuali *et al*., 2020). The container positivity reflects only the number of containers positive in an area and it does not give the number of larvae/pupae in these containers. For instance, in some small water holding containers, there may be enough larvae, on the other hand in containers with more volume of water, the number of *Aedes* larvae may be less and vice versa. The field observations indicate that the most common containers are often not the most productive (Focks and Alexander, 2006).

In the post flood situation, due to severe disruption of ecosystem, the availability of breeding sources of mosquitoes may also differ. Sometimes due to lack of proper habitats in nearby resting places, the

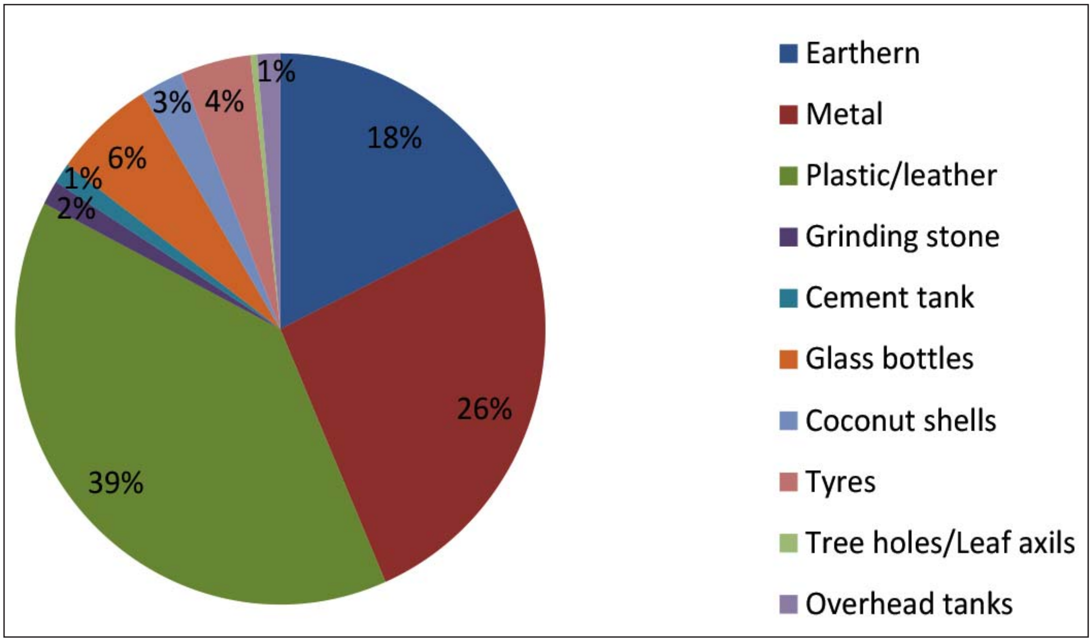

Fig. 1. Different types of containers/habitats checked in 24 localties (n = 1258) in Alappuzha District (%)

mosquitoes may force to fly in areas in search of suitable oviposition sites. In short, due to the changes in the environment, the behavior of the mosquitoes may also differ. Study related to the breeding preference of *Ae. albopictus*, the vector of dengue, in post flood situation is meager. Hence an analysis has been done to find out the most preferred breeding source of *Ae. albopictus* in post flood situation in Alappuzha district. The Breeding Preference Ratio (BPR) was found to be more in cement tanks and overhead tanks followed by grinding stones and tires. In an earlier study in Alappuzha district showed that the most preferred breeding sites of *Ae.albopictus* mosquitoes were tires followed by plastic containers (Rajendran *et al*., 2020). Due to unprecedented flood, almost all small and medium sized containers might have washed away. The cement tanks, overhead tanks and grinding stones remain as such. In the absence of most suitable breeding sites in the flood affected area, *Ae. albopictus* preferred to lay eggs in tanks and grinding stones. This is a classic example to illustrate the high adaptability of these mosquitoes. This also indicates that even breeding preference of *Ae. albopictus* may differ in tune with the changing environmental conditions. Therefore caution must be taken while referring breeding preference of *Aedes* mosquitoes in any locality.

Normally, in *Aedes* survey only those containers checked and positive for larvae/pupae are taken in to account leaving the actual number for calculating indices. The rate of emergence of adult mosquitoes from each type of container may likely to differ depending upon the number of immature stages of mosquitoes present. Hence for localities with similar larval indices and having different container profiles, the number of adult mosquito emergence may differ. This may create difficulty in assessing the transmission potential or epidemiological link of *Aedes* borne diseases.

The *Aedes* larval indices such as HI, CI and BI are commonly used to determine priority areas to determine vector control interventions. Generally, a HI greater than 5% and/or a BI greater than 20 for any locality are an indication that the locality is dengue sensitive. Earlier, *Aedes* larval indices were proposed to prevent outbreaks of yellow fever (YF). HI, 1% or less, BI, 5 or less has been considered to prevent dengue transmission because of the

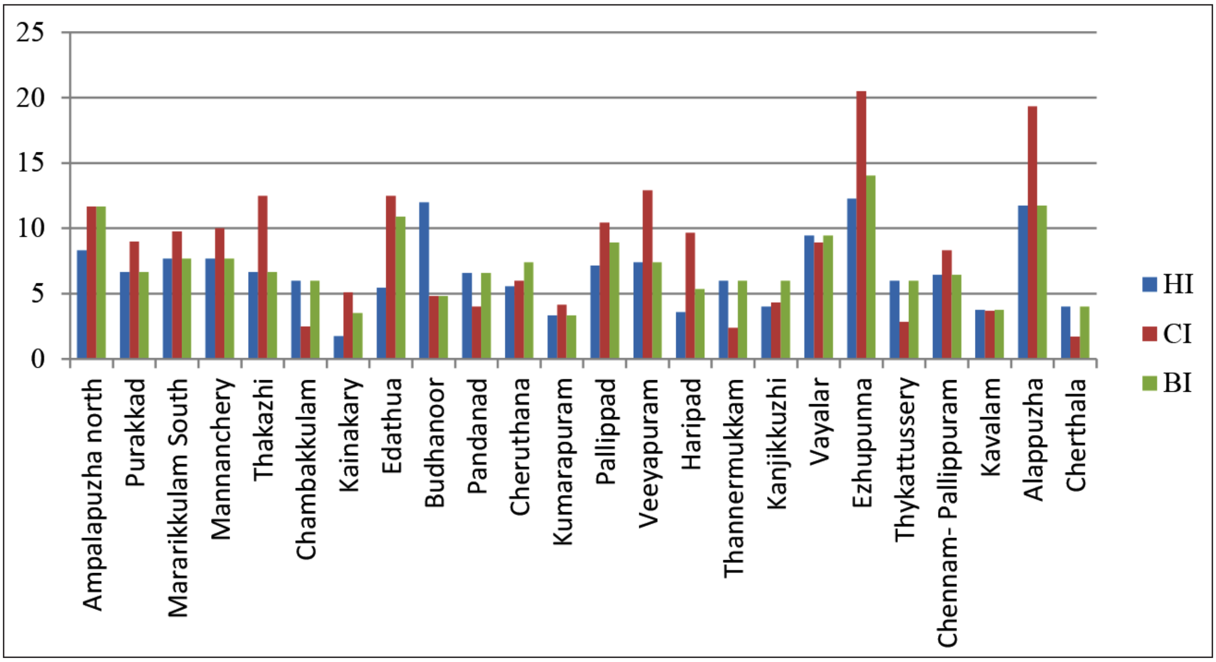

Fig. 2. Area-wise *Aedes* larval indices in Alappuzha district

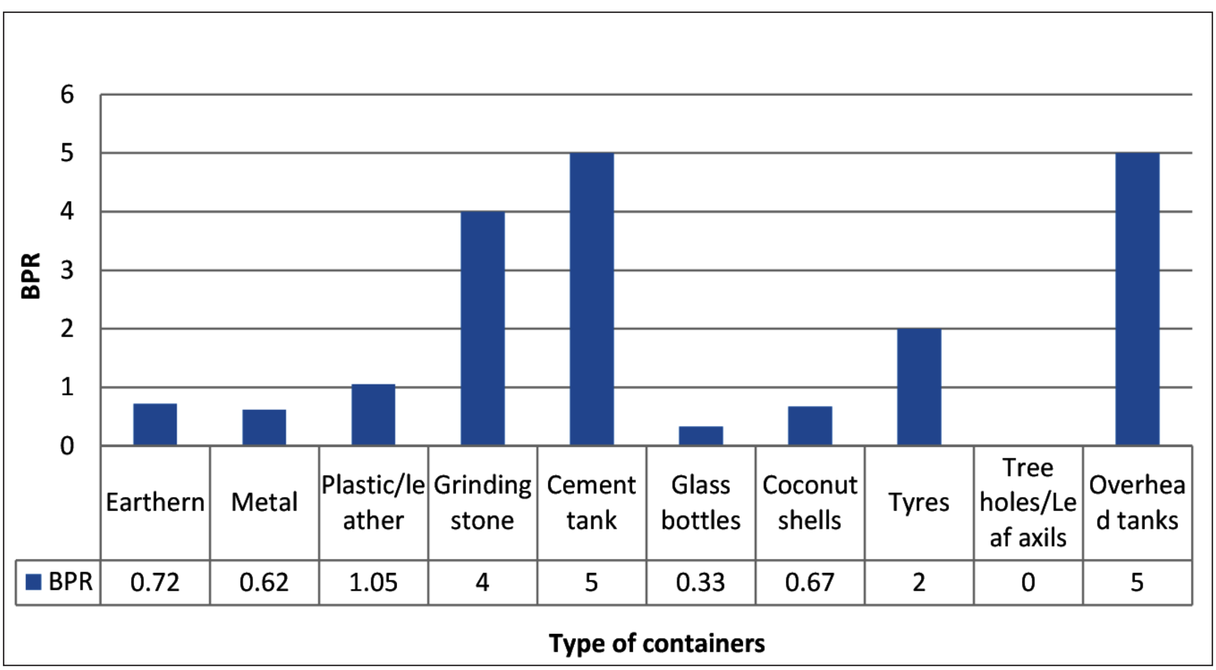

Fig. 3. Breeding Preference Ratio (BPR)

epidemiological similarities of both DF and YF (Kuno, 1995). But as per the Pan American Health Organization (1994), the dengue transmission can be assessed with the help of 3 levels of risk factors – low (HI<0.1%), medium (0.1% -0.5%) and high (HI >5%). The reliability and sensitivity of these indices in assessing *Aedes* borne diseases in different localities are yet to be ascertained (Cromwell *et al*., 2017; Garjito *et al*., 2020). Critical vector density as a risk factor in predicting dengue transmission is always a topic of much debate and conflicts.

In the present study, the predominant *Aedes* mosquitoes prevalent in Alappuzha district were noted as *Ae. albopictus*. As dengue is endemic in this district, there exists a potential threat of disease transmission. Normally one should expect an increase in vector-borne diseases such as dengue in flood affected areas. This is because of rapid increase in numerous mosquito breeding habitats. But the number of DF cases reported in Alappuzha district in the post flood period (September to December 2018) was 67. However in 2017, during the same period, the number of DF cases reported in the district was 246 ie, 3.7 times more than that of 2018. This clearly indicate that there was a significant reduction in dengue cases in 2018 post flood period when compared to the previous year. This is because of the devastating flood might have destroyed the immature and adult mosquitoes. Another major contributory factor for the reduction of dengue cases in post flood situation may be attributed to the vector control measures taken by the Local Self Governments (LSGs) and local health centers with the advice of central and state health teams.

ACKNOWLEDGEMENTS

We gratefully acknowledge the support received from Director General of Health Services (MOH&FW); Director (NCDC, Delhi); Director (AIIH&PH, Kolkata); Director (NIV, Pune); Director of Health Services (Kerala) and District Medical Officer (Health), Alappuzha.

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(Received February 02, 2021; revised ms accepted March 08, 2021; printed March 31, 2021)