Malaria and its Vectors in the Caribbean: The Continuing Challenge of the Disease Forty-Five Years after Eradication from the Islands

SC Rawlins[1], A Hinds[1], JM Rawlins[2]

ABSTRACT

Objectives: *Given the occurrence of autochthonous malaria in non-endemic island countries in the last 10 years, this study evaluates the risk factors for malaria transmission in the malaria "endemic and "non-endemic" countries of the Caribbean region.*

Design: *Data on imported and autochthonous malaria for the 27-year period (1980–2006) were gathered from surveillance units in the 21 Caribbean Epidemiology Centre (CAREC) Member Countries (CMCs) via the CAREC epidemiology unit. Anopheles mosquito data were also gathered from various sources. The vector and malaria data were correlated to determine the current risk of malaria transmission.*

Results: Imported cases. *For the 26-year period (1980–2005), there were 897 reported cases in the CMC islands. Jamaica (38.4%) > Trinidad and Tobago (19.5%) > Bahamas (15.8%) > Cayman Islands (12.5%) were mostly affected. Only the smallest CMCs eg Anguilla and British Virgin Islands reported no imported malaria.*

Indigenous malaria. *Over the same time period, malaria was seen mainly in the three mainland countries of Guyana (514 386 cases) > Suriname (275 361) > Belize (85 313). However, for the period 1995–2005, Belize and Guyana reported reduction in case numbers of 84% and 54% respectively. At the same time, Suriname reported a cyclical pattern of reported cases resulting in 77% increase in cases between 1995 and 2005.*

"Non-endemic" CMCs such as Trinidad and Tobago, and Bahamas, did report autochthonous malaria. In 2006/7, Jamaica reported 340 P falciparum *cases, coming just 1–2 years after a massive 505% increase in imported malaria in the region – 88% in Jamaica. Anopheles spp: There was a rich diversity of Anopheles mosquitoes – 29 spp. in CMCs. Mainland CMCs and nearby island countries had most spp. recorded. Smaller countries with limited ecological niches such as St Kitts, Anguilla, Turks and Caicos Islands (TCI) and Bermuda had little or no Anopheles spp. Two main Anopheles axes were identified –* An albimanus *in the northern CMCs and* An aquasalis *in the southern Caribbean.*

Conclusion: *All the essential malaria transmission conditions – vector, imported malaria organism and susceptible human host – now exist in most CMCs. A call is now made for enhanced surveillance, vector control and anti-malaria skills to be established in CMCs, in particular in:*

- *Recognizing the possible impact of climate change on the spread of anopheles and malaria transmission.*
- *Improving vector control skills for anopheles in CMCs.*
- *Strengthening malaria surveillance skills.*
- *Upgrading malaria therapy and prophylaxis.*
- *Emphasizing malaria prevention and education for all community and professional sectors.*

La Malaria y sus Vectores en el Caribe: el Continuo Desafío de la Enfermedad, Cuarenta y Cinco Años Después de su Erradicación de las Islas

SC Rawlins[1], A Hinds[1], JM Rawlins[2]

RESUMEN

From: [1]The Caribbean Epidemiology Centre, Federation Park, Port-of-Spain, Trinidad and Tobago, [2]Public Health Unit, The University of the West Indies, St Augustine, Trinidad and Tobago.

Correspondence: Dr SC Rawlins, The Caribbean Epidemiology Centre Federation Park, Port-of-Spain, Trinidad and Tobago. E-mail: rawlinsaiacc @ wow.net, rawlins@flowtrinidad.net.

Objetivos: *Dada la incidencia de la malaria autóctona en los países insulares no endémicos en los últimos 10 años, este estudio evalúa los factores de riesgo de la transmisión de la malaria en los países "endémicos" y "no endémicos" con respecto a esta enfermedad en la región del Caribe.*

Diseño: *Se recogieron datos sobre la malaria autóctona e importada correspondiente a un período de 27 años (1980–2006). Los datos provinieron de las unidades de vigilancia epidemiológica de los 21 CMCs, es decir, los países miembros del Centro de Epidemiología del Caribe (CAREC), a través de la unidad de epidemiología de este último. También se recogieron datos sobre el mosquito anófeles, a partir de varias fuentes. Se estableció una correlación entre los datos del vector y la malaria respectivamente, a fin de determinar el riesgo actual de transmisión de la malaria.*

Resultados: Casos importados. *En un periodo de 28 años (1980–2005), se reportaron 897 casos en las islas del CMC. Jamaica (38.4%) > Trinidad y Tobago (19.5%) > Bahamas (15.8%) > Islas Caimán (12.5%) fueron los más afectados. Sólo los países miembros más pequeños del CMCs, a saber, Anguila e Islas Vírgenes Británicas (IVB) no reportaron casos de malaria importada.* Malaria indígena. *En el mismo periodo de tiempo, se vieron casos de malaria principalmente en los 3 países del continente: Guyana (514 386 casos) > Surinam (275 361) > Belice (85 313). Sin embargo, para el periodo de 1995–2005, Belice y Guyana reportaron reducciones en el número de casos, de 84% y 54% respectivamente. Al mismo tiempo, Surinam reportó un patrón cíclico de casos reportados con el consiguiente aumento de un 77% de casos entre 1995 y 2005. De hecho, países "no endémicos" del CMCs, como Trinidad y Tobago, y Bahamas, reportaron malaria autóctona. En 2006/7, Jamaica reportó 340 casos de* P falciparum, *lo que se producía justamente 1–2 años luego de un masivo aumento de 505% de casos de malaria importada en la región, y un 88% en Jamaica.* Anófeles spp: *Había una gran diversidad de mosquitos anófeles: 29 spp. en los países del CMCs. Los países CMCs del continente y los países insulares tuvieron los registros más altos de spp. Los países más pequeños, tales como Saint Kitts, Anguila, Islas Turcas y Caicos, con nichos ecológicos limitados, tuvieron poco o ningún anófeles spp. Se identificaron dos ejes principales de anófeles –* an. albimanus *en los CMCs norteños y* an. aquasalis *en el Caribe sureño.*

Conclusion: *Todas las condiciones esenciales para la transmisión de la malaria – vector, organismos de malaria importada y huésped humano susceptible – se hallan actualmente presentes en la mayoría de los países del CMCs. Se esta haciendo un llamado a reforzar la vigilancia, aumentar el control de vectores, y desarrollar habilidades anti-malaria, en los países del CMCs, especialmente en cuanto a:*

- *Reconocer el posible impacto del cambio climático en la propagación del anófeles y la transmisión de la malaria.*
- *Mejorar las habilidades del CV para el anófeles en los países del CMCs.*
- *Fortalecer las habilidades de vigilancia de la malaria.*
- *Actualizar la terapia y la profilaxis en relación con la malaria.*
- *Poner énfasis en la prevención de la malaria y la educación de toda la comunidad y el sector profesional.*

West Indian Med J 2008; 57 (5): 463

INTRODUCTION

The recent – 2006/2007 – outbreak of *Plasmodium falciparum* malaria in Jamaica, in which there were recorded 340 autochthonous cases between November 2006 and June 2007 (1), must be a cause for concern for all Caribbean "malaria-free" countries in which there may exist the essential criteria for transmission of this disease:

- The presence of effective appropriate vectors (2, 3)
- A malaria-sensitive (naïve) population which has not experienced the disease for a whole generation or more
- A reservoir of infection through imported cases and the proximity of mainland endemic foci (4, 5).

Many Caribbean island countries may fall into this category, despite the successful elimination of transmission of the disease by the anti-malaria campaign of 1958/1962 in all island countries except Hispaniola (7). Indeed, in recent times, we have witnessed limited foci of autochthonous malaria in Caribbean countries which were previously known to be malaria-free. These included:

- The Cayman Islands, (*P falciparum, P vivax*), 1997.
- The Bahamas (New Providence*), (P falciparum*), 1998.
- Trinidad and Tobago (SW Trinidad, *(P vivax,* 1991); Eastern Trinidad [*P malariae,* 1994/5] (6, 8, 9).

Thus, because of the significant risk of the resumption of malaria transmission, resources from these countries, often with fragile tourist-dependent economies, must be spent either in continuous surveillance for this disease and/or in expensive control programmes to limit further transmission, once an active focus is detected.

However, with increasing challenges such as risk of insecticide resistance in some anopheles species coupled with a reluctance in some vector management authorities to use tried and proven but unpopular insecticides such as DDT, and with the absence of appropriate replacement insecticides, we are left at a significant risk of new outbreaks of the disease. Also, there is the emerging challenge of global warming, which could result in the extension of the natural boundaries of some vectors and thus their transmission zones as has been reported in E Africa (10), though this view has been challenged by other workers such as Hay *et al* (11). The current risk of resumption of malaria transmission could become even more acute.

It is thus important for us to record in detail the malaria situation in the Caribbean region, so that health decision-makers may be aware of how acute the situation really is, and how much emphasis should be rightly placed at preventing the re-occurrence of the disease in the region. In this paper, we are reviewing the most recent malaria data and the vector situation in endemic as well as non-endemic countries of the Caribbean region.

MATERIALS AND METHODS

Data on malaria cases in the 21-CAREC (Caribbean Epidemiology Centre) Member Countries (CMCs) were accessed from the Epidemiology Division at the CAREC. These data were submitted by CMCs surveillance units in the Ministries of Health to the CAREC on a monthly basis. The countries indicated to CAREC – based on the situation in the country and on the travel history of patients, whether the cases were:

- **Imported cases** – confirmed clinically and microscopically; these were mainly but not limited to non-malarious countries.
- **Autochthonous cases** – mainly from the three mainland countries – Guyana, Suriname and Belize – but not necessarily limited to these countries. These figures included confirmed (microscopy) and non-microscopically confirmed cases. From 2006 onwards, only microscopically-confirmed cases are being reported.

Anopheles (mosquito) data from CMCs and other Caribbean countries were based on:

- Publications in the scientific literature
- Non-published (grey) literature
- Reports to CAREC by CMCs and other public health authorities with confirmation of anopheles species at CAREC's laboratories or other reputable scientific facilities.

RESULTS

Data reported by CMCs to the CAREC over the last 27 years (1980–2006) indicate that 89% of CMCs have been exposed to the presence of malaria cases whether imported or autochthonous (Fig. 1; Table 1). By and large, most malaria cases from island CMCs have been imported, brought in by travellers from malaria-endemic countries. Only the smallest countries – Anguilla and British Virgins Islands – have been spared the importation of this disease (Table1). Of the 897 imported cases detected from 1980–2005, the larger CMCs – Jamaica (38.4%) and Trinidad and Tobago (19.5%) – have been the countries most greatly affected; these were followed by cases in countries, close to malaria-endemic Hispaniola such as The Bahamas (15.8%) and the Cayman Islands (12.5%).

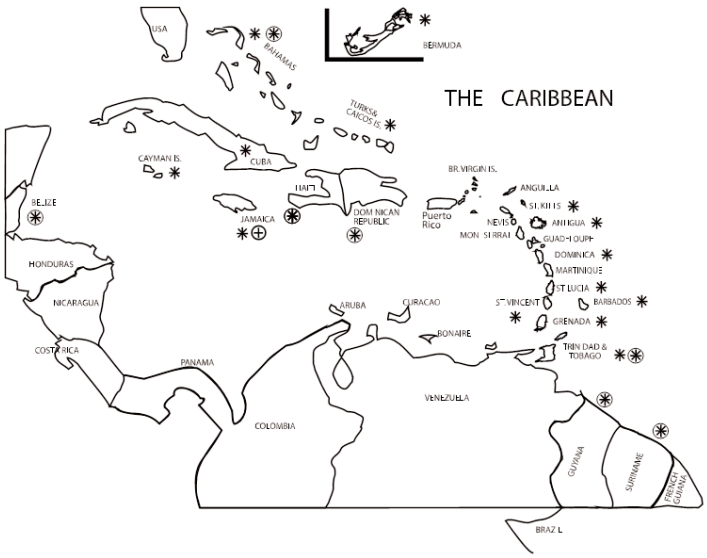

Fig. 1: Malaria in some Caribbean countries in the last 10 years.

Table 1: Summary of imported malaria cases in the Caribbean Islands, 1980–2005 as reported to the CAREC

Country	Population –2005	Total cases 1980–2005	% Total cases
Anguilla	12 874 (2006)	0	0
Antigua and Barbuda	81 526	12	1.3
Aruba*	102 149	1	0.1
Bahamas	325 200	141	15.8
Barbados	270 610	53	5.9
Bermuda	63 571	9	1
British Virgin Is.	22 053	0	0
Cayman Is.	45 980	112	12.5
Dominica	70 494	14	1.6
Grenada	104 149	5	0.6
Jamaica	2 660 723	343	38.6
Montserrat	4 681 (2004)	1	0.1
Netherlands Antilles	185 454	Na	
St Kitts and Nevis	48 720 (2004)	6	0.7
St Lucia	164 791	14	1.6
St Vincent and the Grenadines	106 253	6	0.7
Trinidad and Tobago	1 324 105	174	19.5
Turks and Caicos	NA	3	0.3

Source: Data submitted to CAREC

*Aruba data only from 2000; No data reported for Netherlands Antilles
NA – data not available

The recent pattern of imported cases into island CMCs (Fig 2a) tells an interesting story. From 1980–2003, the total

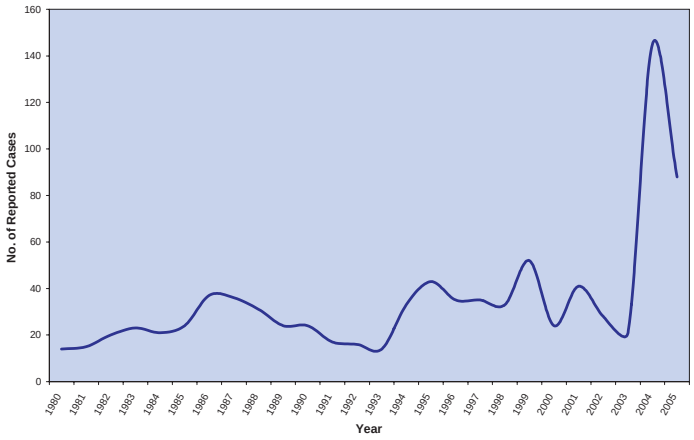

Fig. 2a: Confirmed cases of malaria (imported) by year, all CAREC member countries, 1980–2005.

number of imported cases in all the islands has hardly varied from a mean of 28.7 (14–52 cases/year). In 2004, this jumped to 145 cases (505%), 127 (88%) of which were reported from Jamaica.

Indigenous malaria was detected mainly in the three malarious mainland CMCs – Guyana (514 386 cases – 58.9%) > Suriname (275 361 cases – 31.5%) > Belize (83 513 cases – 9.56%), over the 1980–2005 period (Table 2). Over this same period, Trinidad and Tobago (13 cases)

Table 2: Summary of indigenous malaria in CMCs, 1980– 2005

Country	Total cases reported to – CAREC 1980 –2005	% Total cases
Bahamas	7	0
Belize	83 513	9.56
Guyana	514 386	58.9
Suriname	275 361	31.53
Trinidad and Tobago	13	0
Cayman Islands	NA	–

Source: Data submitted to CAREC

NA – no data available

Bahamas (7) and Barbados (3) reported small numbers of cases, believed to have been locally transmitted.

Overall, there appears to have been a major fall in the number of indigenous malaria cases (36%) over the 11-year period, 1995 – 2005, in the CMC region from 82 071 (1995) to 52 608 (2005). This fall has been observed in Belize and Guyana, but not so in Suriname (Fig. 3). In Belize, there was an 84% fall in reported annual cases – from 9417 (1995) to 1493 (2005). To a lesser extent, there was a 54% fall of reported case numbers in Guyana from 59 311 to 27 466 while in Suriname, there was a cyclical pattern of reported cases, resulting in a 77% increase from 13 343 to 23 646 cases (1995/2005). This pattern of a general fall in cases from 1995–2005 is shown for Belize and Guyana (Figs. 2b, 2c; 3). For Suriname there was a pattern of significant

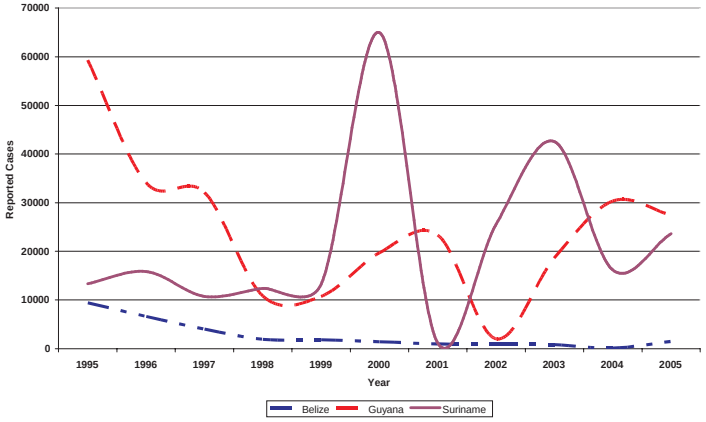

Fig. 2b: Patterns of reported malaria cases in three main malaria-endemic CMCs, 1995–2005.

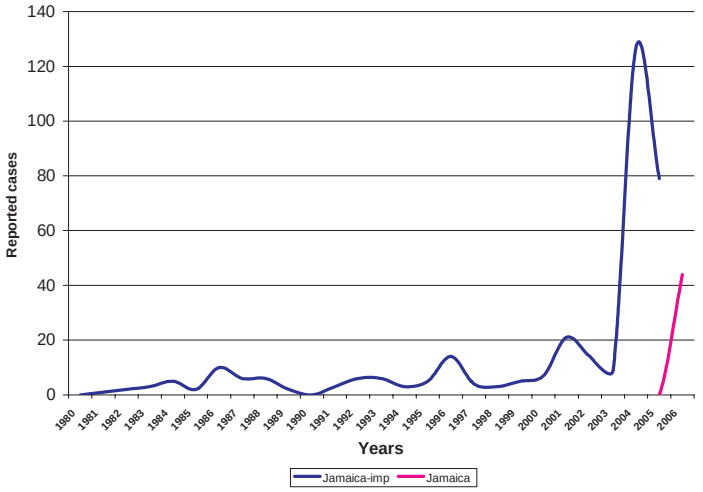

Fig. 2c: Reported cases of indigenous and imported malaria in Jamaica.

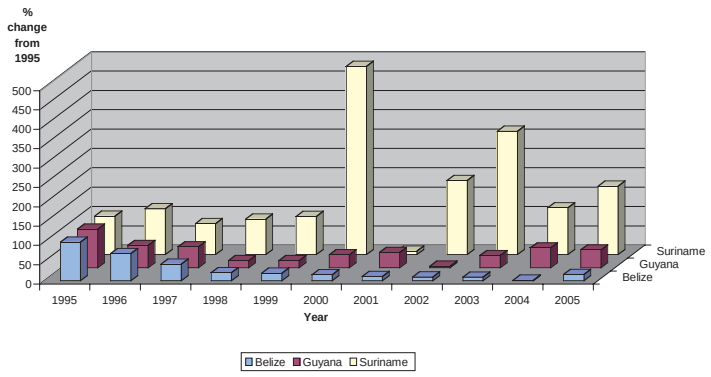

Fig. 3: Patterns of malaria trends in the three main malaria endemic CMCs – % of 1995 values: 1995–2005.

fluctuation in the number of reported cases in some of the 11 years. For example, in 2000 and 2003, there were increases of 487% and 319%, respectively, over the base year of 1995.

The reported confirmed cases of 2006 add a new dimension to the data. There were the cases from endemic countries – Guyana, Suriname and Belize and there were the smaller number of cases from non-endemic countries (Table 3). But for the first time in fifty years, Jamaica (211 cases) is

Table 3: Reported confirmed cases of malaria in CMCs in 2006

Countries	Endemic	Non-endemic	Number of cases
Antigua and Barbuda		Y	1
Bahamas		Y	48
Jamaica	Y	Y	211
Trinidad and Tobago		Y	4
St Kitts and Nevis		Y	1
Guyana	Y		20 553
Belize	Y		62
Suriname	Y		3407
Total			24 270

Source: Data submitted to CAREC

listed as both an endemic and a non-endemic country (CAREC, 2007). This is due to the outbreak that started late in 2006 in the Kingston and St Andrew part of the country and extended into February, 2007 (12).

Anopheles Species of the Caribbean

There is a rich diversity of anopheles mosquitoes in the Caribbean region. Of the 29 spp reported in the scientific literature (Table 4) to be endemic in the Caribbean, it is the mainland countries and adjacent islands which are more heavily colonized by these mosquitoes (Fig. 4). Thus, Guyana (16 spp) > Trinidad (11) > Belize (9) are the countries with most reported spp of anopheles (Table 5). While, the further north (from S America) and east (from C America) that the countries lie, there are fewer spp of this genus. Incidentally, the countries in which there were no anopheles spp detected – Anguilla, St Kitts, TCI and Bermuda, were also the smallest geographical land masses – with least ecological diversity (Fig. 4).

Anopheles species common in the Greater Antilles and Northern Caribbean included *An albimanus, An crucians, An vestitipennis and An grabhamii.* These could be grouped into the *An albimanus* axis (Fig. 5). In the S Caribbean, species such as *An aquasalis, An argyritarsis and An pseudopunctipennis* predominate. For this study, they were classed into *An aquasalis* axis group (Fig. 5).

These two axes overlap (Fig. 5) in the northern Windward and Leeward Islands but extend as far south as Barbados. The anopheles of Trinidad, though inclusive of the *An aquasalis* group, are also typically similar to those of the coastal S American spp, *eg* of Guyana, with a much richer variety of species. However, these do not include the well known significant malaria transmitter, *An darlingi*, which is common in the interior and savannah areas of S America.

To summarize, the mosquito data show that all countries of the Caribbean – except some of the smallest island nations – possess anopheles species which in theory are capable of transmitting malaria.

Table 4: Anopheles species of the Caribbean

Number	Species
1	Albimanus
2	Aquasalis
3	Argyritarsis
4	Crucians
5	Apimacula
6	Eisseni
7	neomaculipalpus
8	pseudopunctipennis
9	punctimacula
10	vestitipennis
11	atropos
12	grabhamii
13	walkeri
14	albitarsis
15	bellator
16	braziliensis
17	darlingi
18	evansai
19	intermedius
20	mediopunctatus
21	nimbus
22	oswaldoi
23	peryassui
24	shannoni
25	triannulatus
26	allopha
27	fluminensis
28	homunculus
29	triannulatus

References

Belkin, JN & Heinemann SJ (1973–76);
SJ & Belkin JN (1977–1980)

DISCUSSION

It is now over 45 years since the successful “eradication” of malaria from the islands of the Caribbean – with the exception of Hispaniola (7). However, as the most recent epidemic of 2006/2007 in Jamaica (1, 12) has shown malaria is still a significant threat to virtually all countries of the region – whether it is acknowledged to be endemic or non-endemic.

In the mainland CMCs – Belize, Guyana and Suriname – as well as the non-CMC island of Hispaniola, malaria and its transmission were never eliminated in 1961 – just suppressed. Thus, these countries remained potential sources of infection to travellers and thus the importation of malaria –

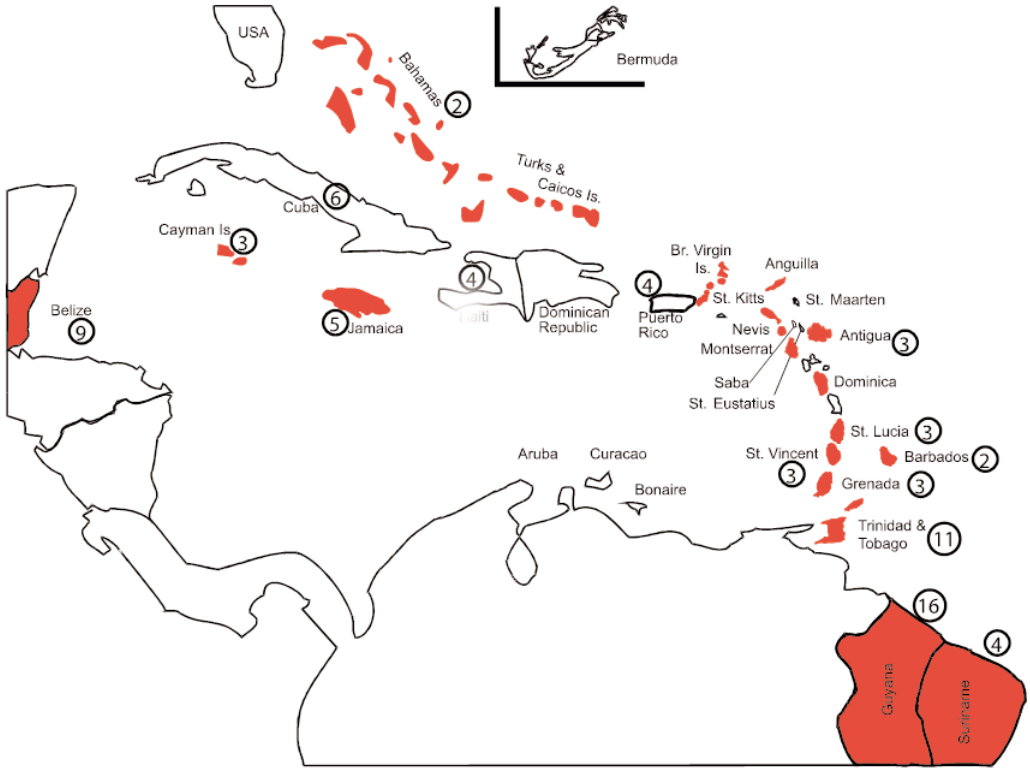

Fig. 4: Number of anopheles species in some Caribbean countries.

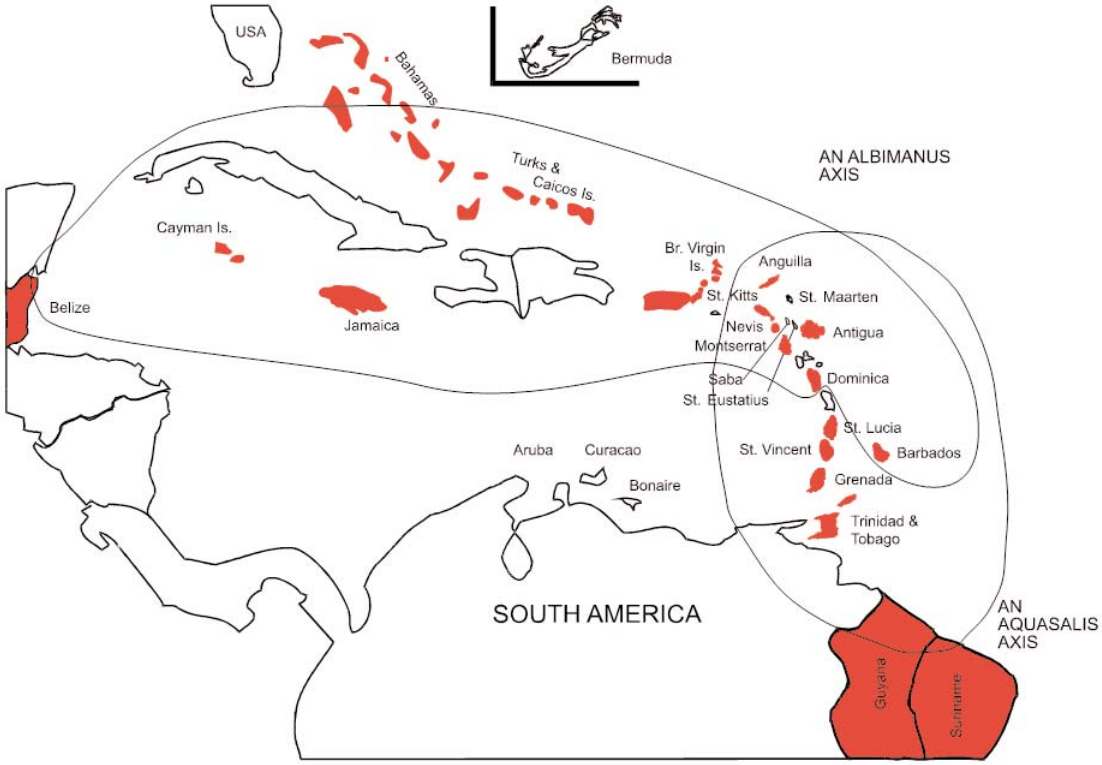

Fig. 5: Northern and southern axes of main Caribbean anopheles species.

Table 5: Anopheles species of the Caribbean and their distribution

Country	No. of Species	Species*
Anguilla	0	
Antigua and Barbuda	3	1, 2, 3
Bahamas	2	1, 4
Barbados	2	1, 2
Belize	9	1, 3–10
British Virgin Is.	0	–
Cayman Is.	3	1, 11, 12
Dominica	2	2, 3
Grenada	3	2, 3, 8
Belize	9	1, 3–10
Guadeloupe	3	1, 2, 3
Guyana	16	1–3, 5, 14–25
Haiti	4	1, 4, 10, 12
Dominican Republic	4	1, 4, 10, 12
Jamaica	5	1, 4, 10–12
Martinique	2	2, 3
Montserrat	3	1, 2, 3
Nevis	2	1, 2
St Kitts	0	–
St Lucia	3	1, 2, 3
St Vincent and the Grenadines	1	3
Tobago	3	2, 5, 7
Trinidad	11	2, 5–7, 15, 20–22, 26–28
Puerto Rico	4	1, 4, 10, 12
Suriname	4	2, 20, 21, 29
Turks and Caicos	0	–

Source: Data submitted to CAREC

* Species are listed in Table 4.

principally *P vivax and P falciparum* – into other Caribbean islands (4–6). Given the severity of the most recent malaria outbreak (2006/7) in Jamaica, it is therefore appropriate to review the present malaria transmission risk situation in the region since it may greatly impact adversely on means of livelihood. The hospitality sector (tourism) has become the main economic driver of the region, but it is also a very fickle industry. Any report of the presence of an infectious disease – much more a life-threatening one may cause visitors to seek an alternative holiday venue.

Imported malaria

Most of our 897 imported malaria cases in the last 26 years (1980–2005), occurred in the larger CMCs, Jamaica and Trinidad and Tobago, and in those physically close to the malaria-endemic Hispaniola such as The Bahamas and Cayman Islands. The significance of travellers and imported malaria should not be lost in these days of globalization and the freedom of movement within the CARICOM Single Market and Economy (CSME). The peak of imported cases in the CMC region in 2004 (505% increase over the previous average of 28.7 cases/year) in which 88% took place in Jamaica, may have lead to "silent" (undetected) cases in 2005 and a major outbreak of autochthonous malaria in 2006/7 (Fig. 2c). The presence of *An albimanus* and 4 other spp on the island have been shown already to be widespread on the island (9, 10) and these could have facilitated transmission to malaria-naïve human population. This risk factor exists in many island CMCs.

Indigenous malaria

This continues to be present in the three malaria-endemic CMCs – Belize, Guyana and Suriname. In the last 11 years, there has been a 36% downward trend in reported cases (1995–2005), with large reductions in Belize and Guyana (84% and 54% respectively). To some extent, the reported cases from Guyana showed a cyclical pattern over the 11-year period. But at the same time, to a much greater extent, there was a major cyclical pattern of the reported cases from Suriname. This resulted in a 77% increase in cases in 2005 over the base year of 1995. It is possible that this reported increase may have been due to improved (or sporadic) surveillance or reduction in the vector management situation. There was major fluctuation in the reported cases over the 11-year period.

A matter of serious concern for the CMC islands has been autochthonous malaria in traditionally non-malarious CMC: Trinidad and Tobago in 1991 (*P vivax*) in SW Trinidad – probably transmitted by *An aquasalis* – and *P malariae* in 1994/5 – probably transmitted by *An bellator* (4–6 8, 9); *P falciparum* in the Cayman Islands. (probably transmitted by *An. albimanus*), (4); *P falciparum* malaria in The Bahamas (1998), [*An albimanus*, suspected as the vector], (4–6); Jamaica (2006/7), 340 cases of *P falciparum* (1) with *An albimanus* as the suspected vector. These all necessitated prompt and extensive and expensive surveillance and control action in all these countries to put an end to these outbreaks. This too is a risk for most anopheles-infested countries.

The rich diversity of anopheles vector spp in the Caribbean, as summarized by Rawlins *et al*. (3) demonstrate and remind us that the "eradication" of malaria in the campaign of 1958/62 (Anon. 1965) did not eliminate the vectors. These 29 anopheles species remain in the CMC region. The greater number of anopheles species exist in mainland countries eg Guyana and Belize and the adjacent islands *eg* Trinidad. There seems to be a depletion of the number of spp with distance from the mainland – northwards from S America and eastward from C America. The countries in which there were no anopheles recorded – Anguilla, St Kitts, Bermuda and TCI were also the smallest land masses and further away from the mainland of South and Central America.

In the Caribbean islands, there appears to be two main axes of anopheles species dominated by *An albimanus* in the north and *An aquasalis* in the south. These two axes overlap in the northern Windward and Leeward Islands, but because of the smaller land masses resulting in paucity of ecotypes, these spp have not fared very well in this part of the region.

On the island of Trinidad – adjacent to South America – other spp such as *An bellator* – breeding in epiphytes in the canopy of trees – and *An homunculus* may have been im-

portant in recent malaria transmission (8, 9), and may have presented more challenges for vector control operations. On the mainland of South Aamerica, *An darlingi* is known to be an efficient malaria vector.

The bottom line is that all anopheles are capable of malaria transmission though some are more efficient than others. The presence of Anopheles species in all CMCs except Bermuda, St Kitts, Anguilla and TCI, mean that there is a risk for malaria transmission. At the same time, the absence of findings (9, 10) does not necessarily assure their absence. There is a need for vector surveillance to upgrade established vector data.

General

It has been established that in most CMCs the conditions for malaria transmission continues to exist, there being the vector, imported organism and a susceptible human host. Thus, there are conditions that require increased surveillance.

- Climate features must be taken into consideration. Warming conditions have been suggested to cause extension of anopheles species and malaria transmission in upland – previously malaria-free areas of Kenya (10, but this has been contested by other workers (11). It is possible that very efficient anopheles malaria vectors such as *An darlingi* could in theory and practice be introduced and colonize Caribbean islands and transmit malaria on a major scale.
- Vector control skills – specific for malaria – need to be enhanced to face this possible challenge of resurgence of malaria.
- Malaria surveillance skills need to be strengthened especially in island nations where cases are few and rare. New technologies for identification must be incorporated and added to the microscopy gold standard.
- Malaria therapy must be upgraded and stocks of appropriate medications must be maintained. Similarly, appropriate prophylaxes must be available, bearing in mind that the existing *P falciparum* and *P vivax* from S America may be resistant to chloroquine (14).
- Prevention strategies such as the use of insecticide-impregnated bed nets as well as air conditioning and meshed windows must be put in place pro-actively to reduce the human-mosquito contact.
- A programme of sensitization of all communities: professionals, locals and travellers – need to be made available to prevent importation and local transmission of malaria.

Limitations

The reliability of malaria data for CMCs must depend on the CMCs to accurately detect and report cases to the CAREC. The data should be shared by all CMCs.

ACKNOWLEDGEMENTS

We are grateful to all the CMC surveillance units and to CAREC for the access of the malaria data of the CMCs. We are also thankful to Ms Karen Lara for desktop publishing support. Thanks are also due to Ms Sara Quesnel, biostatistician of CAREC for appropriate advice.

REFERENCES

1. CAREC. Malaria in Jamaica (update July 9th 2007).
2. Belkin JN, Heinemann SJ, Page WA. The Culicidae of Jamaica. Bulletin of the Inst. Of Jamaica. 1970 Science Ser #20 458 pp.
3. Rawlins SC, Tikasingh ES, Martinez R. Catalogue of haematophagous arthropods in the Caribbean region. CAREC 1992 168 pp.
4. Rawlins SC. Emerging and re-emerging vector-borne diseases in the Caribbean region. West Indian Med J 1999; **48:** 252–3.
5. Rawlins SC. Vector control for public health in the Caribbean. Caribbean Health 2000; **3:** 22–5.
6. Rawlins SC. The continuing challenge of malaria in the Caribbean. West Indian Med J 2000; **49:** 254–6.
7. Anon. Register of malaria eradication in Jamaica. PAHO. WHO 1965.
8. Chadee DD, Le Maitre A, Tilluckdharry, CC. An epidemic outbreak of plasmodium vivax malaria in Trinidad. West Indian Med J 1993; **42 (Suppl 1):** 45–6.
9. Chadee DD, Beier JC, Doon R. A focus of Plasmodium malariae in Trinidad, West Indies. West Indian Med J 1998; **47 (Suppl 2):** 16.
10. Githeoka AI, Ndegwa W. Predicting malaria epidemics in Kenyan Highlands using climate data: a tool of decision makers. Glob. Change Hum. Health 2001. **2:** 54–63.
11. Hay SI et al. Climate change and the resurgence o f malaria in the E. African Highlands. Nature 2002; **415:** 905– 9.
12. Anon. Malaria in Jamaica. Jamaica Ministry of Health web page. 2007-02-09.
13. Rawlins SC, Figueroa P, Mundle M. Malaria – past scourge or continued threat. Jamaica Journal 1987; **22:** 46–8.
14. Baird JK, Tiwari T, Martin GJ, Tamminga CL, Prout TM, Tjaden, J et al. Chloroquine for the treatment of uncomplicated malaria in Guyana. Ann of Trop Med. Parasitol 2002; **96:** 339–48.