Epidemiology and control of bluetongue disease in Israel

A. SHIMSHONY *, E. BARZILAI **, D. SAVIR * and M. DAVIDSON *

Summary: The history and epizootiology of bluetongue in Israel are described in detail. The disease has become endemic and strictly seasonal in the northern parts of the country. Exogenous breeds of sheep seem to be particularly susceptible. No clinical cases in bovines have been reported since 1973. There is no evidence of clinical disease in caprines. Five virus types, 2, 4, 6, 10 and 16, have been identified in Israel, all prior to 1974. Results of a recent survey, including serological and virological examinations, are presented. Seasonal and geographical distribution is discussed.

KEYWORDS: Bluetongue virus - Culicoides - Disease control - Diseases of ruminants - Epidemiology - Israel - Sheep - Vaccination.

INTRODUCTION

On 3 September 1950, A. Kimron and L. Goldsmit were called to a farm in Kefar Atta, near Haifa, where one cow of the fourteen on the farm was suspected to have "signs of foot and mouth disease". On another farm in the same district, without any history of contact with the first farm, one of twenty-eight cows showed similar symptoms. Within less than three months — until the end of November — sporadic cases were seen in 68 villages. A first case in sheep was reported on 13 October, followed by 16 additional outbreaks.

Since this outbreak, which was proved to be bluetongue, 38 years have elapsed. A disease which, as late as 1964, the FAO viewed as an emerging disease (Howell, 1964) is now regarded as endemic within an equatorial belt, the limits of which approximate 40°N and 35°S. The geographic situation of Israel, its intensive and susceptible livestock population and its centralised veterinary structure, have enabled the accumulation of epidemiological data on bluetongue which will be reviewed here.

Retrospective serological investigations, carried out by E. Barzilai in 1984, are also presented in this review.

HISTORY

Bluetongue (BT) in sheep was suspected in Israel for the first time in the winter of 1943-44. According to Goor (17), it affected some 20 flocks of sheep in the northern
districts of the country. The average morbidity was less than 10% (2-55%) and losses ranged from less than 1% to 8%. Symptoms and post-mortem lesions resembled those described previously in South Africa in cases of BT. At about the same time, a similar but more malignant disease made its appearance in Cyprus and proved to be BT. More or less simultaneously, the disease was recognised in Turkey and Syria. Some observers believe that the disease was present in the Middle East as early as 1924 (12, 19, 22).

The disease appeared again in Israel in the summer and autumn of 1950 and spring of 1951, affecting both sheep and cattle, as described by Komarov and Goldsmit (20) who isolated BT virus (BTV) which was later classified as type 4 (19).

The outbreak of 1950-51 primarily affected cattle imported from Europe and the USA several months before, and Sardinian sheep imported in October 1949. According to unofficial clinical reports, the first cases were observed at the beginning of August 1950. As most cases were concentrated in the coastal plain and northern valleys, the occurrence in particular districts appeared to be related to the presence of imported cattle. Fewer cases were seen in local breeds. Mortality was low and the incidence dropped towards the end of December.

According to the monthly bulletins of the Department of Veterinary Services in Jerusalem, sporadic clinical cases in sheep were reported during the following years: October-November 1951, April 1952, August 1953, August 1955 and May 1956; no virus isolations were attempted.

In the summer of 1963, a local veterinary practitioner in Yizreel district suspected BT in the Ta'anakh area. Scattered cases were reported among imported Merino sheep, with animals suffering from buccal and nasal oedema and some fatal cases. During the same period, in July 1963, numerous similar cases of a disease which was then suspected to be pasteurellosis, were observed in a large German Merino flock in the southern part of Israel (Mareisha), with approximately 15% mortality. No material was submitted for virological investigation. Retrospectively, one may be justified in regarding the incidents as forerunners of the BT epizootic of the following year.

This epizootic, involving 47 villages, caused a morbidity of 20.5% and mortality of 31.4% in the population of 12,000 exogenous and cross-bred sheep (10). The highest losses were encountered in the Ta'anakh area of the Yizreel district, where in seven villages, with 134 small flocks, 1,428 animals (39.5%) became affected, of which 652 (45.6%) succumbed (24). The BTV isolates were classified in the Kimron Veterinary Institute (KVI) as type 4, and confirmed by the Reference Laboratory at Onderstepoort as identical to the BTV type responsible for the 1950-51 epizootic (21).

During the 1964 epizootic no significant involvement of cattle could be observed.

Since 1964, the clinical and laboratory follow-up of BT in Israel has been intensified. Blood samples from each suspected case have been sent to the KVI for virus isolation and identification. In addition, entomological research, a serological survey in cattle, and infection trials in antelopes (Gazella gazella) and goats have been carried out. The present evaluation is a result of this work. Various data, accumulated until the end of 1983, have been summarised (7) and are updated now to include 1984-85.
THE DISEASE IN VARIOUS SPECIES

Sheep

During the outbreak of 1950-51, the disease occurred in its most severe form in Sardinian sheep which had been imported approx. ten months earlier, but local Awassi sheep were also reported as infected (20). Four forms of the disease were distinguished:

a) lameness alone;
b) lameness and hyperaemia of the buccal mucosa;
c) lameness, hyperaemia, necrosis and ulcerations in the mouth;
d) buccal lesions without lameness.

A number of the acute cases terminated fatally.

During the epizootic of 1964, these symptoms were observed in Merino sheep imported from Germany two to three years previously. In addition to the classical symptoms of ovine BT, some clinical observations may be mentioned: in a small number of cases, erosions were seen on the teats as well. The typical coronary linear haemorrhages were a constant feature, clearly demonstrable after a thorough washing of the hooves. The morbidity and mortality figures during the epizootic were very high (24).

During the following years, clinical cases in sheep were observed almost every autumn, caused by BTV types 2, 4, 6, 10 and 16 (Tables I and II). Most cases were seen in German Mutton Merinos, “Merino landschaf” sheep, East Friesians and Finnish landrace sheep. Less severe cases were observed in crosses with the local, resistant Awassi sheep. Some small-scale outbreaks, restricted to sporadic cases in a flock and mild clinical symptoms, have also been observed in Awassi sheep. Males seem to be more susceptible than females. No cases have been seen in lambs younger than 2 months, including the progeny of unvaccinated, susceptible ewes. Some clinical observations, though exceptional, may be described: in East Friesian rams, a pronounced cyanosis, hyperaemia and oedema of the sternal region, followed by local necrosis, were often seen.

Some peracute cases in Assaf (East Friesian × Awassi) and Awassi sheep were characterised by numerous petechiae which could be seen on the hairless parts of the body. The coronary changes in the sick animal, and the distinct haemorrhages in the base of the pulmonary artery in post-mortem examinations, represent very typical diagnostic lesions.

We had the impression that certain types of BTV tend to cause milder disease in sheep. This has yet to be confirmed experimentally.

Cattle

During the outbreak of 1950-51, Komarov and Goldsmit (20) described the symptoms in imported Austrian, American and French cattle. The majority of the confirmed cases were observed in bovines above the age of 6 months and none in calves less than 2 months old. Three forms of the disease were described:

a) typical changes in the oral cavity (haemorrhage, cyanosis, necrosis and ulceration), without dermatitis or lameness;
TABLE I

*BTV* types isolated from ovines and bovines in Israel from 1950-1986

<table>
<thead>
<tr>
<th>Year</th>
<th>2 Ovine</th>
<th>4 Ovine</th>
<th>6 Ovine</th>
<th>10 Ovine</th>
<th>16 Ovine</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950</td>
<td>+</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1964</td>
<td>+</td>
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<tr>
<td>1965</td>
<td>+</td>
<td></td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>1966</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
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<td>1967</td>
<td>+</td>
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<td></td>
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<td>1968</td>
<td>+</td>
<td>+</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>1969</td>
<td>+</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1970</td>
<td>+ (+)</td>
<td></td>
<td></td>
<td></td>
<td>(+)</td>
</tr>
<tr>
<td>1971</td>
<td>+ (+)</td>
<td></td>
<td></td>
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<tr>
<td>1982</td>
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<td>1983</td>
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<td>+</td>
<td></td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>1986</td>
<td>+</td>
<td></td>
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<td>+</td>
</tr>
</tbody>
</table>

(+) = *BTV* isolation from clinically healthy bovines.

*b)* dermatitis of the skin in the coronary region with lameness, and hyperaemia of the oral mucosa without necrosis or ulceration;

c) dermatitis and lameness, hyperaemia, necrosis and ulceration in the oral mucosa.

The disease initially and primarily affected imported cows, attacking sporadically one to three such animals in a herd, but occasionally it also affected local cattle in the same herds, with similar symptoms. There was no report of outbreaks in the indigenous Baladi cattle breed.

Very few cases in bovines have been reported since 1951, the last one in 1973 (Table I). All cases involved 6-12 month old animals of dairy breeds, manifesting
TABLE II

Monthly incidence of bluetongue cases in sheep, 1968-1986
(confirmed by virological examinations)

<table>
<thead>
<tr>
<th>Year</th>
<th>Jan</th>
<th>Feb-June</th>
<th>July</th>
<th>Aug</th>
<th>Sept</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Total</th>
<th>BT types isolated</th>
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<tbody>
<tr>
<td>1968</td>
<td>2</td>
<td>2</td>
<td>7</td>
<td>11</td>
<td>20</td>
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</tr>
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<td>2</td>
<td>4</td>
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<td></td>
<td></td>
<td>4, 16</td>
</tr>
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<td>2</td>
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<td>2</td>
<td>5</td>
<td>9</td>
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<td></td>
<td></td>
<td></td>
<td>4, 6</td>
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<td>1</td>
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<td>2</td>
<td>9</td>
<td>6</td>
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<td>1973</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>10</td>
<td>14</td>
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<td>32</td>
<td></td>
<td></td>
<td>4, 16</td>
</tr>
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<td>2</td>
<td>10</td>
<td>14</td>
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<td>32</td>
<td></td>
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<td>4, 16</td>
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<tr>
<td>1975</td>
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<td>1</td>
<td>2</td>
<td>9</td>
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<td>2, 4, 6, 10, 16</td>
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<td>4</td>
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<td>1981</td>
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<td>4</td>
<td>2</td>
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<td>17</td>
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<td></td>
<td>2, 6, 10, 16</td>
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<tr>
<td>1982</td>
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<td>1</td>
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<td>1983</td>
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<td>7</td>
<td>4</td>
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<td></td>
<td></td>
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<td>2, 6, 10, 16</td>
</tr>
<tr>
<td>1984</td>
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<td>1</td>
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<td>3</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
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<td>2, 6, 10, 16</td>
</tr>
<tr>
<td>1985</td>
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<td>1</td>
<td>2</td>
<td>3</td>
<td>2</td>
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<td></td>
<td></td>
<td></td>
<td>2, 6, 10, 16</td>
</tr>
<tr>
<td>1986</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2, 6, 10, 16</td>
</tr>
<tr>
<td>Total</td>
<td>2</td>
<td>8</td>
<td>12</td>
<td>17</td>
<td>61</td>
<td>72</td>
<td>18</td>
<td></td>
<td>190</td>
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<tr>
<td>%</td>
<td>1.05</td>
<td>4.21</td>
<td>6.32</td>
<td>8.95</td>
<td>32.11</td>
<td>37.89</td>
<td>9.47</td>
<td></td>
<td>100</td>
<td></td>
</tr>
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</table>

very mild symptoms of elevated temperature, hyperaemia and slight necrosis of the oral papillae, and coronitis.

Natural infection of pregnant heifers with BTV types 4 and 16 had no deleterious effect on their health, nor on their offspring (3).

Extensive serological surveillance has shown that a large proportion of cattle in Israel become infected with one or more BTV types during the months July-December (Tables III and IV) without any clinical signs. There is a yearly and geographical fluctuation in the infection rate, but in some years there is seroconversion in a high percentage of the bovines. In December 1982, for instance, 129 10-12 month old dairy calves were tested with the agar gel precipitation (AGP) test. It was found that 122 (95%) had converted to positive during the second half of 1982 in the northern coastal plain (Table IV).

The timing of infection in sero-converted cattle has been established several times by consecutive virus isolations, from previously sampled and preserved entire blood (Table III).

It may be claimed with almost complete certainty that the five local BTV types have not been found to affect the health of the Israeli-Holstein cow or bull during the last two decades.
### Table III

**A. Prevalence of neutralising antibodies in screened young cattle sampled at the end (December) of five seasons* (in percent)**

<table>
<thead>
<tr>
<th>Natural region</th>
<th>Year</th>
<th>BTV serotypes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>1. Jordan Valley</td>
<td>7</td>
<td>—</td>
</tr>
<tr>
<td>2. Yzreel</td>
<td>6</td>
<td>—</td>
</tr>
<tr>
<td>3. Coastal plain</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Akko</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Hedera</td>
<td>12</td>
<td>100</td>
</tr>
<tr>
<td>4. Judean foothills</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>5. Ashkelon-Beersheva</td>
<td>18</td>
<td>100</td>
</tr>
</tbody>
</table>

* Approx. 30 positive AGP sera from each natural district have been examined each year.

** Only 4 positive AGP tests in the screened cattle.
### TABLE III (contd.)

**B. BTV isolates during same period, with month of isolation**

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Origin</strong></td>
<td><strong>BTV serotypes</strong></td>
<td><strong>BTV serotypes</strong></td>
<td><strong>BTV serotypes</strong></td>
<td><strong>BTV serotypes</strong></td>
<td><strong>BTV serotypes</strong></td>
</tr>
<tr>
<td>Ovines — No. of clinical cases</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>10</td>
<td>16</td>
</tr>
<tr>
<td>BTV serotypes</td>
<td>(18)</td>
<td>(Oct, Nov)</td>
<td>(1)</td>
<td>(Oct)</td>
<td>(1)</td>
</tr>
<tr>
<td><strong>Culicoides</strong></td>
<td>+</td>
<td>(June, July)</td>
<td>+</td>
<td>(Sept)</td>
<td>+</td>
</tr>
<tr>
<td>Cattle (latent)</td>
<td>+</td>
<td>(July, Aug, Sept)</td>
<td>+</td>
<td>(Oct, Nov, Dec)</td>
<td>+</td>
</tr>
</tbody>
</table>
## TABLE IV

*BTV geographical distribution, 1982-1984*

<table>
<thead>
<tr>
<th>Year</th>
<th>1 Jordan Valley</th>
<th>2 Yizreel</th>
<th>3 Coastal plain</th>
<th>4 Judean foothills</th>
<th>5 Ashkelon-Beersheva</th>
<th>6 S. Arava*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1982</strong></td>
<td><strong>% AGP positive bovines</strong> (BTV types)***</td>
<td>75 (4, 2) (ND)</td>
<td>53 (4) (ND)</td>
<td>95 (4) (ND)</td>
<td>78 (4, 16, 2) (4)</td>
<td>26 (4, 16) (ND)</td>
</tr>
<tr>
<td>BTV types isolated from <em>C. imicola</em></td>
<td><strong>Number of clinical cases in sheep (BTV type)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>1983</strong></td>
<td><strong>% AGP positive bovines (BTV types)</strong></td>
<td>45 (6, 2) (ND)</td>
<td>25 (6, 2) (ND)</td>
<td>72 (6, 2) (ND)</td>
<td>74 (6, 2) (2, 6)</td>
<td>20 (2, 6) (ND)</td>
</tr>
<tr>
<td>BTV types isolated from <em>C. imicola</em></td>
<td><strong>Number of clinical cases in sheep (BTV type)</strong></td>
<td>1 (6)</td>
<td>0 (ND)</td>
<td>0 (ND)</td>
<td>0 (ND)</td>
<td>0 (ND)</td>
</tr>
<tr>
<td><strong>1984</strong></td>
<td><strong>% AGP positive bovines (BTV types)</strong></td>
<td>47 (4, 6) (ND)</td>
<td>29 (6, 4) (ND)</td>
<td>25 (6, 4) (ND)</td>
<td>32 (6, 2) (6)</td>
<td>40 (2, 6) (ND)</td>
</tr>
<tr>
<td>BTV types isolated from <em>C. imicola</em></td>
<td><strong>Number of clinical cases in sheep (BTV type)</strong></td>
<td>1 (4)</td>
<td>0 (ND)</td>
<td>0 (ND)</td>
<td>0 (ND)</td>
<td>0 (ND)</td>
</tr>
<tr>
<td><strong>Bovine population</strong></td>
<td><strong>Ovine population</strong></td>
<td>37,800</td>
<td>55,800</td>
<td>49,800</td>
<td>57,200</td>
<td>17,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15,000</td>
<td>38,600</td>
<td>13,600</td>
<td>16,200</td>
<td>104,600</td>
</tr>
</tbody>
</table>

* No positive sera have been detected in this region since the commencement of surveillance in 1977.
** Calves born Jan-Feb, sampled Dec.
*** BTV types analysed by micro-neutralisation tests in order of prevalence (details in Table III).
ND: Not done.
Goats

Contrary to the observations during the 1950-51 outbreak, no clinical cases of BT have been observed since. Except for a short and slight rise in temperature, no clinical symptoms were recorded in indigenous and cross-bred goats infected experimentally with BTV type 4 (4).

The BTV blood titre in goats was found to be 10-100 times lower than in sheep and cattle from day 2 to day 9 post-infection.

Gazelles (Mountain gazelle, Gazella gazella)

BTV (type 4) was isolated once from a naturally infected, symptomless mountain gazelle, and 10% of the examined sera were positive for BTV types 4 and 16 (6). Additional data were obtained during 1983, when 11 of 50 (22%) gazelles in Northern Israel were found positive by the AGP test (Barzilai, personal communication).

Experimental infection of the gazelles with BTV type 4 did not cause any clinical reactions (5). Virus was isolated from the blood up to 35 days post-infection. No recurrent viraemia could be induced by a corticosteroid injection 100 days post-infection. The virus multiplication curve resembled the one obtained in goats.

Camels

Serological evidence for possible BT infection in camels has been recorded by Barzilai (2). The sera were collected in Southern Israel over a three year period (1978-80). Eighteen sera were positive for BTV 4 (16), BTV 2 (1) and BTV 16 (1) by the micro-neutralisation test.

BTV TYPES

Since 1950, five BTV types have been isolated and identified in Israel (Tables I, II, III). All five types — 2, 4, 6, 10 and 16 — have been isolated from clinical cases in sheep, type 4 being the most prevalent in this species, followed by types 16, 2 and 6, and 10.

Types 4, 10 and 16 have been isolated also from clinically affected cattle. BTV type 6 was isolated recently from symptomless cattle. BTV type 2 has never been isolated from cattle, but there is serological evidence of its occurrence in this species, in some years and regions exceeding 50% of AGP-positive sera (e.g. 1981, 1983 and 1984).

The activity of the various BTV strains fluctuates from year to year. In 1973, all five types were isolated from sheep. In years such as 1980 and 1981, only one or two types were active, their presence being detected only by bovine seroconversion, or isolations from Culicoides (Table III). Thus, since 1977, type 16 has been “detected” in a significant number of bovine sera only in two southern regions in 1982. On the other hand, during the same period, serological evidence of BTV type 4 was found in four of the five years. Type 10 was absent during the last three years of the serological survey in cattle (1982-84).

Clearly, the absence of clinical cases in sheep does not necessarily indicate the absence of BTV in the particular region during that season.
Since 1973, when BTV type 2 was first recognised in Israel (Table I), no additional types have been found. Analysis of the data in Table III suggests that all AGP-positive sera reacted in neutralisation tests to at least one of the five known types in each year.

**SEASONAL INCIDENCE**

Data updated in the present review (Table II) confirm previous reports of the clear seasonality of BTV activity in Israel (25, 7). Seroconversions in cattle occur between July and December; clinical cases in sheep occur during the same period, but mainly in October (32.1%) and November (37.9%). Since 1970, no case of BT was reported during the period January-June.

During 1970 and 1971, 25 virus isolations from pregnant dairy heifers were carried out in the Yizreel region (3). Sixteen of these were of type 4, and 9 of type 16, as follows:

<table>
<thead>
<tr>
<th>September</th>
<th>October</th>
<th>November</th>
<th>December</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 4</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Type 16</td>
<td>-</td>
<td>-</td>
<td>2</td>
</tr>
</tbody>
</table>

Analysing the data on BTV isolations from ovines, bovines and Culicoides during the years 1980-84 (Table III), one could conclude that early infection in bovines and in Culicoides may precede clinical cases in ovines — as previously described by Du Toit (11) in South Africa.

It has been suggested (24) that rainier seasons in Israel may influence BT outbreaks. For the sake of completeness, the data on annual rainfalls in Northern Israel before BT vaccination commenced in 1965, may be cited from the Hebrew version of that paper (Table V).

**TABLE V**

*Mean annual rainfall, Northern Israel, 1938-1963*

<table>
<thead>
<tr>
<th>Winter:</th>
<th>38/9</th>
<th>39/40</th>
<th>40/1</th>
<th>41/9</th>
<th>42/3*</th>
<th>43/4</th>
<th>44/5</th>
<th>45/6</th>
<th>46/7</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm:</td>
<td>601</td>
<td>527</td>
<td>515</td>
<td>377</td>
<td>776</td>
<td>518</td>
<td>836</td>
<td>516</td>
<td>395</td>
</tr>
<tr>
<td>Winter:</td>
<td>47/8</td>
<td>48/9</td>
<td>49/50*</td>
<td>50/1</td>
<td>51/2</td>
<td>52/3</td>
<td>53/4</td>
<td>54/5</td>
<td>55/6</td>
</tr>
<tr>
<td>mm:</td>
<td>553</td>
<td>715</td>
<td>704</td>
<td>339−−−</td>
<td>690</td>
<td>619</td>
<td>619</td>
<td>410</td>
<td>618</td>
</tr>
<tr>
<td>Winter:</td>
<td>56/7</td>
<td>57/8</td>
<td>58/9</td>
<td>59/60</td>
<td>60/1</td>
<td>61/2</td>
<td>62/3</td>
<td>63/4*</td>
<td></td>
</tr>
<tr>
<td>mm:</td>
<td>530</td>
<td>551</td>
<td>367</td>
<td>437</td>
<td>526</td>
<td>608</td>
<td>496</td>
<td>636</td>
<td></td>
</tr>
</tbody>
</table>

* Rainy seasons preceding BT outbreaks

The rainy season in Israel runs from October to April, the coldest and rainiest months being December-February. There is usually no rainfall between May and August, and in most years, no rains before mid-October. In exceptional cases, there may be some rain in September and May.
GEOGRAPHICAL DISTRIBUTION

Since 1964, most susceptible sheep of exogenous breeds have been vaccinated annually. Consequently, the geographical distribution of clinical BT cases in sheep does not necessarily represent BTV activity. Between 1977 and 1984, extensive serological surveillance in bovines has been carried out, initially in 12-18 month old heifers, and later in 6-8 month old heifers which were serologically tested twice a year on selected dairy farms in twenty-three natural districts. For practical reasons, the said districts were later divided into six major natural regions where most dairy farms are concentrated (Fig. 1):

1. Jordan Valley, round the Sea of Tiberias and the Beth Shean valley.
2. Yizreel, the central northern valley and surroundings.
3. The coastal plain, including Akko and Hedera sub-regions.
4. The foothills of Judea, an inland plain south-east of Tel Aviv.
5. The Ashkelon-Beersheva district, a plateau with lower rainfall.
6. The Southern Arava region, an arid area (annual rainfall lower than 50 mm) with a recently developed dairy industry.

The data presented in Tables III and IV relate to young cattle on 47 farms sampled at the end of the seasons.

During the years 1977-84, 24,857 serum samples have been examined by the AGP method, with an overall positive ratio of 23.4%. During the last five years, however, the geographical distribution of positive bovines is significantly higher (p<0.001) in the northern coastal plain (703/2,120 = 33%) than in the southern Ashkelon-Beersheva area (308/1,562 = 19.7%).

The Southern Arava area (not included in Table III) has been found negative during each of the first five surveyed years 1977-81 (0/1,350). During the sixth year of surveillance, 1982, 66% (57/87) of the sera examined in December were found positive to BTV type 4. During the following three years, 1983-85, the results returned to the pre-1982 situation. No explanation for this phenomenon has been found. It seems that this arid area, with a population of approximately 3,700 bovines, and which is constantly uninfected, was subject to a solitary, probably windborne, introduction of infected Culicoides. Negative results during 1983, 1984 and 1985 indicate that the agent has not become endemic.

The yearly distribution of the various BTV types in the five infected natural regions, based upon unpublished data of Barzilai (1985) concerning seroconverted dairy calves, is presented in Table III. It seems that BTV type 16, which appeared in a significant number of sera only during autumn 1982 of the reviewed period, was confined to southern regions, with the exception of Southern Arava. Type 6 seems to have a countrywide distribution in years of its prevalence. Types 2 and 4 vary in their geographical distribution in various years. Type 10 was detected only during two of the five years under review, and then only in the coastal plain. Types 10 and 16 have not been detected in the two inland northern regions – Jordan Valley and Yizreel – since 1977.

The density of cattle and sheep populations in the various regions is presented in Table IV. It seems that regions 2 (Yizreel) and 4 (Judean foothills), in spite of a similar animal density, differ both in BTV activity rate as well as in the spectrum of BTV types in different years.
Fig. 1

Israel: Natural regions
VECTORS

Isolation attempts of BTV from Culicoides spp. were initiated in 1968 and the results until 1980 were reported by Braverman et al. (8) who described the isolation of BTV types 6, 16, 2 and 4. The results of further investigations carried out during the years 1981-83 in two permanent light-trapping stations, at Beit-Dagan and Kabri, have been published recently (9). All isolations were from pools of C. imicola, trapped during the months June-October, even though the suction light traps were operated throughout the entire year. In one case (October 1968) BTV type 16 was isolated from a pool consisting of both C. schultzei and C. imicola.

Kabri is situated at the northern part of the coastal plain. Beit-Dagan is situated at the northwestern part of the Judean foothills. The trap was operated in Kabri throughout 1982 and 1983, and in Beit-Dagan from 1980 to the end of 1984. The data presented in Tables III and IV show a clear correlation between BTV types prevalent in ovines and bovines (seroconversions and isolations) and the types isolated from Culicoides.

C. obsoletus was, during both 1981 and 1982, the dominant gnat caught in Kabri, concurrently with C. imicola, but did not yield BTV (9). The conclusions were:

1. C. imicola is the only species from which BTV (serotypes 2, 4, 6, 10) has so far been isolated in Israel.
2. Due to its prevalence around livestock, seasonality, geographical distribution and survival rate, C. imicola is the major vector of BTV in Israel. C. obsoletus has a lower survival rate and C. oxystoma has a shorter season compared to C. imicola.
3. C. imicola, due to its presence throughout the whole year, might serve also as an overwintering agent.
4. Of the three mammalian feeders tested, i.e. C. imicola, C. obsoletus and C. oxystoma, C. imicola has the strongest breeding site association with livestock.

PREVENTION

Following the outbreak in 1950, Komarov and Goldsmit (20) reported that South African vaccine did not offer sufficient protection against the isolated BTV type. In fact, vaccination against BT was not practised in Israel until 1964, when a polyvalent vaccine, incorporating BTV types 1-14, was imported from Onderstepoort. This vaccine gave very satisfactory results during the epizootic (10). Over 50% of the total consignment of vaccine was used in infected flocks. It was claimed that even in infected flocks the spread of the disease was generally arrested eight days after vaccination.

In May 1965, 9,800 exogenous and cross-bred sheep, over the age of six months, were vaccinated with a monovalent BTV 4 vaccine, which was prepared in liquid form by KVI from seed material supplied by Onderstepoort. A few months later, in the autumn of 1965, seven mild outbreaks were diagnosed in unvaccinated sheep. Since the virus isolate was classified as BTV 10, it was then decided to renew the annual use of the polyvalent, attenuated Onderstepoort vaccine.

In 1968, a few mild cases of BT were observed in vaccinated sheep and BTV 16 was identified. This was a new type, not included at the time in the South African vaccine.
In 1974, it was decided to discontinue the polyvalent vaccine and to use a quadrivalent vaccine comprising the four types identified in Israel and which were available as attenuated strains at Onderstepoort. Since 1974 this vaccine, including BTV 2, 4, 6 and 10 attenuated strains, has kindly been supplied by the Onderstepoort laboratory, and is used annually to vaccinate the susceptible sheep of exogenous breeds. Vaccination is carried out mostly in April-June.

In spite of the absence of BTV 16 in the vaccine, no isolations of this type have occurred from clinical cases in sheep since 1975. However, BTV 16 has been attenuated by approx. 100 intravenous (i.v.) egg passages and found, on trial in sheep, to be a suitable vaccine strain which may be added to the vaccine (Goldsmit and Barzilai, unpublished data, 1980).

In 1965 and 1966, Merino sheep were imported from Germany and vaccinated with the attenuated polyvalent vaccine on arrival in Israel. Following complaints about the fertility of these sheep, some of which were later found barren despite claims that they had been mated before shipment, the BT vaccination carried out on arrival in Israel was incriminated. To assess the actual risks of initial vaccination during pregnancy in imported sheep, studies were carried out during 1968-69 on susceptible primiparae Merino ewes imported from Germany and vaccinated during the sixth week of pregnancy (25). It was concluded that primary vaccination of susceptible sheep during the sixth week of pregnancy could cause foetal mortality in approximately 40% of the sheep. The lethal effect was not observed to be accompanied by significant CNS damage in the surviving lambs. The efficacy of the Onderstepoort polyvalent attenuated vaccine was demonstrated by seroneutralisation tests carried out 40-50 days post-vaccination.

In the second part of the trial, revaccination during the sixth week of pregnancy was not found to have the same deleterious effect upon the progeny. Based upon these findings, two decisions were then taken and are still in force:

1. Imported sheep should not be pregnant when arriving in Israel, if they are to be vaccinated on arrival.

2. No primary vaccinations against BT are carried out during pregnancy in susceptible sheep.

Since 1968, no clinical cases have been observed in vaccinated sheep. Approximately 40,000 sheep of the exogenous breeds are vaccinated annually.

A few cases of temporary testicular atrophy were observed in susceptible exogenous young rams following initial BT vaccination. It is recommended to vaccinate rams at least eight weeks prior to the breeding season, or preferably after termination of the season.

Insecticides and repellents are used when vaccination, for any reason, cannot be carried out in susceptible breeds. The efficacy of this common preventive measure has not been experimentally confirmed. During autumn 1984, serologically negative dairy breeding sheep were required for export purposes. A group of 379 lambs was sprayed twice a week for two months with a commercial repellent; 371 sheep (97.9%) remained negative, whereas 29% of untreated cattle in the same region seroconverted during the same period (BTV types 4 and 6). No clear conclusions could be drawn from this observation, however, since the attraction of the Culicoides to cattle may have been different from their attraction to unsprayed sheep.
LABORATORY METHODS

Goldsmit and Barzilai (13, 14) showed that chick embryos are 100 to 1,000 times more sensitive to BTV when inoculated by the intravenous rather than by the yolk-sac route.

Later, this method was compared to the inoculation of susceptible sheep. It was shown (16) that similar results were achieved by both methods. Consequently, the i.v. inoculation of embryonated chicken eggs (ECE) was advocated for the routine laboratory diagnosis of BT. The isolation and propagation of BTV in ECE was recently reviewed and discussed (15). BTV serotypes 2, 4, 6, 10 and 16 were isolated from C. imicola by the i.v. inoculation of ECE. Growth characteristics were different for the five local BTV serotypes.

The testing of bovine semen for the presence of BTV has been carried out on a large scale (Barzilai, unpublished data, 1984). The samples consisting of semen, blood and serum were collected twice a week during the months of BT absence (February, March). Blood was tested for BTV by i.v. inoculation of ECE; blood and semen were inoculated subcutaneously (s.c.) into susceptible sheep, which were serologically examined for a period of 41 days post-inoculation by the AGP and micro-neutralisation tests. The sheep were assayed for the presence of BTV, during 28 days post-inoculation, by inoculation of entire blood, sampled twice a week, into ECE.

AGP and micro-neutralisation tests were performed also on sera of bulls collected on the first day of semen collection and 42 days after the last semen collection.

This method enabled the certification of bovine semen for export to countries requiring such a procedure.

DISCUSSION

BTV may have been present in Israel long before its description in the fifties, its suspected diagnosis in the forties, and even its probably regional appearance in the twenties. Nomadic sheep and goats have penetrated into Israel for centuries. If the virus was present on the Asian or African continents, it could easily have been introduced to Israel either by the animals or by infected, airborne Culicoides. Most probably, its emergence as an epizootic clinical entity was due to intensified veterinary observations, the involvement of improved laboratory facilities and expertise, and above all, the introduction into the country of European sheep breeds which seem to be genetically far more susceptible than the local ones.

At present, the susceptible breeds are routinely protected by the available quadrivalent attenuated vaccine. The rate and length of induced immunity have not been measured, but field observations indicate that the vaccinated animals are well protected for at least a year. Effective and safe inactivated vaccines could enable the vaccination schedule to be adjusted to contemporary intensive husbandry methods such as multiple breeding seasons, etc.

The collected data helps in forming a clear picture of the BT situation in cattle. BTV was undoubtedly isolated from bovines during the 1950 outbreak. It is not possible to assess at this stage whether BTV was the only, or the main, aetiologic
factor in the described clinical disease. We now know that, in certain years and in

certain regions, almost every heifer goes through BT viraemia in September-November.

Nevertheless, it is at present clear that the five BTV types recognised during the last

20 years have not been found during this period to cause any detectable damage to

cattle in Israel, not even to young, susceptible, seronegative ones. The role of BT

in bovine reactions to alum-adjuvant, as recently mentioned (1), should receive special

consideration in Israel since annual FMD vaccination, including the alum-adjuvant,
is practised.

The most intriguing question, at present, is the interseasonal persistence of the

virus. There seems to exist an endemic situation in the northern regions of the country.

But the serologically detected absence of certain BTV types from the whole country in

certain years, and, in other years, the simultaneous appearance in all regions of

one single type, may indicate that windborne introduction and/or spread are possible.

This relates mainly to types 10 and 16, which seem to be the least locally prevalent

BT types, and to their absence in the northern inland valleys (Table III). The strikingly

clear seasonality, and the absence of virus isolations from any known source during

the first five months of each year, may also indicate airborne penetration as a factor

not to be excluded. Yet why have no additional BTV types been identified since 1973,
in spite of their reported serological identification in other Middle and Near Eastern

countries (18, 26)? Indeed, no importation of livestock from these countries is

permitted. Measures are also taken to prevent the introduction of exotic strains of

BT with imported animals from other parts of the world. But the wind does not

recognise import permits.

The Arava forms a specific, constantly uninfected region. Nonetheless, occasional

introduction of airborne infected Culicoides may occur, as was probably the case

in 1982. It seems that the arid conditions in this region do not enable the establishment

of an endemic situation, corresponding to zone “D”, as described by Sellers and

Taylor (23).

Analysing the abundant accumulated data of the serological tests, virus isolations,

clinical observations and entomological research carried out over the years in Israel,

it seems that sentinel-bovine-herd-serological-surveillance is the method of choice for

assessing the BT situation in a given region. Young, seronegative sentinel animals

should be sampled during several years, before and after their first exposure period.
The typing of the virus involved will enable us to decide upon vaccine strains to be

used.

In no case has constant viraemia in bovines, as reported in the USA, been

recognised in Israel. The local ruminants — ovines, bovines, caprines and gazelles —

may harbour the virus for short periods, bovines playing a more important role

than goats or gazelles as a reservoir of the virus. The role of camels, in which only

serological evidence for BT is available, has yet to be determined. However, due to

their small number (± 900 in 1985) and distribution (only in the southern regions),

they may be negligible as a virus reservoir. The situation is different regarding the

number and distribution of the other ruminants: bovines (± 300,000), ovines

(± 200,000), caprines (± 90,000) and even gazelles (± 10,000).

C. imicola is present in Israel throughout the year, and may thus serve as an

overwintering agent. Fluctuations in annual rainfall may play a role in its abundance.
Immunological studies of older animals, including the possibility of seasonal reactivation of latent viruses in vertebrates, might also be taken into consideration.

CONCLUSIONS

1. Bluetongue is endemic in the northern parts of Israel.
2. The disease is seasonal, restricted to the period July-December with peak occurrence during October-November, varying in prevalence rates from year to year.
3. Five types of the virus, namely 2, 4, 6, 10 and 16 have been identified in Israel, all prior to 1973. Type 4, which was isolated first, seems to be the most prevalent.
4. Exogenous European sheep breeds seem to be far more susceptible than indigenous ones.
5. Clinical symptoms in cattle are very uncommon and have not been recorded since 1973.
6. Viraemia in pregnant heifers, by types 4 and 16, was not found to cause any deleterious effect upon their progeny.
7. Quadrivalent, live-attenuated bluetongue vaccine comprising types 2, 4, 6 and 10, if applied annually, offers satisfactory protection for the susceptible sheep breeds. Primary vaccination is contra-indicated in susceptible sheep during pregnancy. It was experimentally found to cause approx. 40% foetal mortality.
8. The Arava region in Southern Israel seems to be free of bluetongue. In exceptional circumstances, temporary introduction of airborne infected Culicoides into the area may occur.
9. Bovines, and to a much lesser extent caprines and gazelles, may function as a virus reservoir in Israel. However, the interseasonal persistence of the virus has not yet been satisfactorily explained.
10. The serologically detected absence of certain BTV types from the whole country in certain years, along with the simultaneous appearance, in most regions, of one single type in other years, and the geographically-bound prevalence of certain types, may indicate that seasonal windborne introduction into Israel of infected Culicoides may play a significant role in the local epizootiology of bluetongue.
11. The study of BT epizootiology in the Middle East should be based upon coordinated surveillance activities including the Nile and Mesopotamia delta basins.
12. The sentinel-bovine-herd-serological-surveillance was found to be a reliable and accurate method of epizootiological assessment in given regions.

ACKNOWLEDGEMENTS

We thank the District Veterinary Officers and staff for their efforts in sampling cattle in sentinel herds, and Tami Sabbag for her excellent technical clerical assistance.

The BTV isolations and typing during 1985 were carried out by Dr M. Ianconescu, who is kindly acknowledged.
ÉPIDÉMIOLOGIE ET PROPHYLAXIE DE LA FIÈVRE CATARRHALE DU MOUTON EN ISRAËL. — A. Shimshony, E. Barzilai, D. Savir et M. Davidson.


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