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TECHNICAL NOTE

PATHOLOGY/BIOLOGY

Aidan P. Johnson,[1] *B.Sc. (Hons); James F. Wallman,*[1] *Ph.D.; and Melanie S. Archer,*[2] *Ph.D.*

Experimental and Casework Validation of Ambient Temperature Corrections in Forensic Entomology*,†

ABSTRACT: This paper expands on Archer (J Forensic Sci 49, 2004, 553), examining additional factors affecting ambient temperature correction of weather station data in forensic entomology. Sixteen hypothetical body discovery sites (BDSs) in Victoria and New South Wales (Australia), both in autumn and in summer, were compared to test whether the accuracy of correlation was affected by (i) length of correlation period; (ii) distance between BDS and weather station; and (iii) periodicity of ambient temperature measurements. The accuracy of correlations in data sets from real Victorian and NSW forensic entomology cases was also examined. Correlations increased weather data accuracy in all experiments, but significant differences in accuracy were found only between periodicity treatments. We found that a >5°C difference between average values of body *in situ* and correlation period weather station data was predictive of correlations that decreased the accuracy of ambient temperatures estimated using correlation. Practitioners should inspect their weather data sets for such differences.

KEYWORDS: forensic science, forensic entomology, ambient temperature correction, validation, correlation

Estimating ambient temperature at death scenes is an ongoing challenge for forensic entomologists. Maggot growth rates are thermally driven, and along with maggot mass thermogenesis, ambient temperature has a major influence on development (1–4). Understanding and being able to accurately estimate the development of flies is important because it is one of the main sources of evidence in forensic entomology (5). To estimate death scene temperatures, geographical separation between the death scene and the nearest weather station necessitates ambient temperature correction (6). A remote temperature logger is placed at the body discovery site (BDS) for a number of days, and a regression equation is constructed to compare temperatures at the BDS with those measured simultaneously at the nearest weather station. The equation is then used to retrospectively "correct" ambient temperatures measured at the nearest weather station during the period the body is thought to have lain *in situ.*

It is not known whether the accuracy of retrospective correction is affected by the length of the correlation period. A period of 10 days, with 3-hourly temperature measurements, was used by Archer (6). Ten days of 1- to 3-hourly measurements are standard in casework in Victoria and New South Wales (Australia), but this is an arbitrary period chosen because its length is considered to provide sufficient temperature measurements for a robust correlation. If a shorter period, such as 5 or even 2 days, could be used, this would provide a considerable time advantage in a fast-moving investigation and hasten the return of access of a domestic crime scene to the owners of the property. It would also reduce the chance of logger theft or loss from the site of body discovery, which has occurred several times in the authors' experience.

Distance between the weather station and BDS may also affect the accuracy of ambient temperature correction. A weather station that is more distant from the BDS is expected to experience more differences in weather patterns that could be manifested by decreased accuracy of correction. However, this variable cannot be controlled in casework, so it is important to determine whether the accuracy of the *in situ* temperature estimate is affected by distance between the death scene and weather station. This is an especially important problem in Australia where weather stations, especially those that are automated, are sometimes sparsely distributed.

Periodicity with which ambient temperature is measured may also affect the accuracy of ambient temperature corrections. Weather stations in southeastern Australia may measure ambient temperature every 30 min, every 3 h, or twice daily (9:00 and 15:00 h). More frequent measurements could provide greater accuracy in correlation because they more fully describe the 24-h pattern of ambient temperature variation. However, the benefit should be demonstrated empirically given that working with a greater number of observations is more labor intensive. Also, it must be ensured that less frequent ambient temperature measurements can still provide robust ambient temperature corrections, even if these models are less accurate than those using frequent measurements. This is because the entomologist may have no

[1]Institute for Conservation Biology and Environmental Management, School of Biological Sciences, University of Wollongong, NSW 2522, Australia.

[2]Department of Forensic Medicine, Monash University, 57-83 Kavanagh St., Southbank, Vic. 3006, Australia.

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option but to use low-periodicity temperature data. For example, manually operated Bureau of Meteorology (BoM) stations in Australia, which may be the closest to the BDS, only collect twice-daily meteorological data.

Archer (6) established a series of hypothetical death scenes to test the accuracy of retrospective temperature correction. Retrospective correction improved the accuracy of *in situ* period estimation in 22 of 24 correlations. The level of accuracy decreased significantly with an increase in the difference between weather station temperatures measured during (i) the body *in situ* period (hereafter referred to as the "*in situ* period") and (ii) the correlation period. It would be useful to define how large this difference can become before the level of accuracy is compromised and the error involved outweighs the benefit of correlation. In other words, at a certain point, the application of retrospective correction is inappropriate and the forensic entomologist would obtain a better result using raw weather station data than carrying out a correlation.

This study aimed to expand on the work of Archer (6) by estimating temperatures at larger numbers of new hypothetical death scenes in both New South Wales (Sydney, Southern Highlands, and Wollongong) and Victoria (Melbourne). We investigated the effect on retrospective correction accuracy of length of the correlation period, distance between the BDS and weather station, and periodicity of weather station ambient temperature measurements. We also examined the effect of differences between weather station average temperatures during the *in situ* and correlation periods on the accuracy of correlation.

Methods

Collection of Ambient Temperature Data

A total of 16 hypothetical BDSs (after [6]) were established around Sydney, the Southern Highlands, Wollongong, and Melbourne (Fig. 1). Each group of sites surrounded one of the four BoM weather stations in various compass directions, and no site was more than 15 km from the weather station (Fig. 1, Table 1). Although weather stations may be farther than 15 km from death scenes in actual cases, around 75% are <15 km away in the authors' experience of southeast Australian casework. Temperature data at each site were recorded continuously for at least 30 days on two occasions; once in autumn 2006 and again in summer 2006/07 (Table 1).

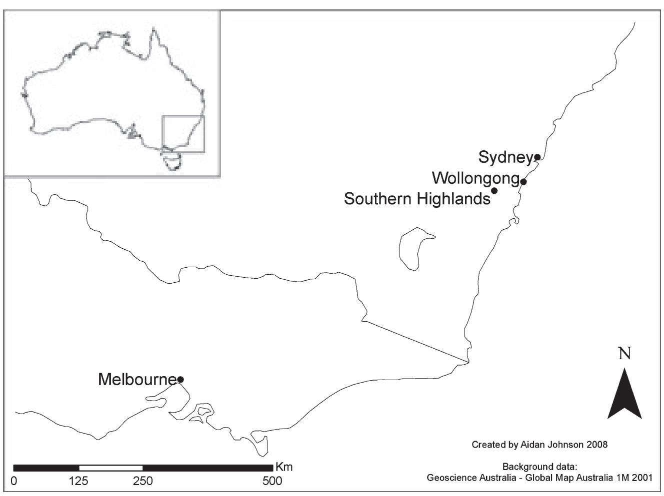

FIG. 1—*Map of localities.*

The temperature data were collected with Thermotag™ temperature loggers (Thermodata, South Yarra, VIC, Australia), which are used in forensic entomology casework in both Victoria and New South Wales. These loggers consist of an iButton™ temperature recorder (Dallas Semiconductor, Dallas, TX) mounted on a small plastic fob measuring 55×21 mm. The Thermotags™ used here measure temperatures between −10°C and +85°C. At each site, the logger was left undisturbed, in a constantly shaded position beneath vegetation and away from heat sources, for the full period of data collection. Uniformity of logger placement was important because of the possible effects of microclimate (7).

Linear regression to correlate death scene and weather station temperatures relies on matching simultaneous logger and BoM readings (6). The Thermotag™ logging interval was 30 min. BoM weather stations logged temperature every 30 min for all weather stations, except Moss Vale, where readings were taken hourly. Thermotag™ observations were therefore taken closest to each simultaneous BoM observation. The greatest time difference between the site and station measurement time was 8 min.

Experiment 1: Length of the Correlation Period

This experiment tested whether the length of the correlation period after body removal affected the accuracy of retrospective weather data correction. Ambient temperature was logged for a 5-day *in situ* period at each of the 16 sites, which represented the time between death and body discovery in each hypothetical case. These temperatures were then compared with ambient temperature estimates derived for each site using correlation to assess whether there is any significant difference in the accuracy of estimates produced by 2-, 5-, or 10-day correlation periods.

Correlation periods within sites were nonoverlapping to avoid the pseudo-replication that would occur with the comparison of overlapping data sets (Fig. 2). In many cases, *in situ* periods overlapped with correlation periods other than their own (e.g., Fig. 2: the 2-day *in situ* period overlaps with the 5-day correlation period); however, this had no statistical effect because these data sets were not being compared. Length of time between removal of a hypothetical body and the commencement of correlation significantly affects the accuracy of ambient temperature estimation (6). Each correlation period therefore immediately followed its hypothetical *in situ* period (Fig. 2). The order of 2-, 5-, and 10-day correlation periods was also randomized between sites.

Correlation period temperatures and corresponding BoM station temperatures were used to produce linear regression equations for each of the 2-, 5-, and 10-day correlation periods at the 16 sites in both autumn and summer (96 equations). Temperatures for the *in situ* period for each site were then retrospectively predicted by correcting BoM weather data recorded during the *in situ* period. The accuracy of these estimates was assessed by calculating the absolute difference between the mean of the estimated temperatures and the mean of the actual temperatures from the *in situ* period. Absolute differences were also calculated between the mean of BoM data for the *in situ* period to assess whether there is any difference in the level of improvement made to raw weather station data when using 2-, 5-, and 10-day correlation periods.

Experiment 2: Distance Between Death Scenes and Weather Stations

Assessment was made of whether distance between the weather station and BDS affects the accuracy of ambient temperature correction. The same 16 sites were used as for the analysis of

TABLE 1—*Hypothetical body discovery sites (BDSs) established around four weather stations in NSW and Victoria.*

Logger	Site	BoM Station	Distance from BoM Station (km)	Direction from BoM Station	Collection Period for Session 1 (2006)	Collection Period for Session 2 (2006/07)
B1	Backyard	Bellambi (NSW)	3.6	NW	9 April–5 May	17 December–7 January
B2	Backyard	Bellambi (NSW)	3.4	W	5 April–7 May	6 January–27 January
B5	Backyard	Bellambi (NSW)	6.2	N	15 April–10 May	17 December–7 January
K1	Coastal scrub	Sydney Airport (NSW)	11.4	S	26 March–20 April	22 December–12 January
K2	Coastal scrub	Sydney Airport (NSW)	7.8	SE	25 March–17 April	22 December–12 January
K3	Roadside bush	Sydney Airport (NSW)	14.7	S	26 March–20 April	22 December–12 January
K4	Roadside bush	Sydney Airport (NSW)	3.4	SE	25 March–20 April	22 December–12 January
K5	Park	Sydney Airport (NSW)	6.1	SW	25 March–20 April	22 December–12 January
K6	Roadside bush	Sydney Airport (NSW)	9.5	S	26 March–18 April	22 December–12 January
M1	Institution grounds	Melbourne Regional Office (Vic)	2	S	20 March–21 April	15 December–27 January
M3	Backyard	Melbourne Regional Office (Vic)	8.3	SE	23 March–24 April	9 January–21 February
MV1	Backyard	Moss Vale (NSW)	8.9	NW	26 March–27 April	21 January–12 February
MV2	Backyard	Moss Vale (NSW)	3	N	28 March–28 April	14 January–4 February
MV3	Backyard	Moss Vale (NSW)	8.3	N	27 March–28 April	13 January–3 February
MV5	Backyard	Moss Vale (NSW)	3.8	N	26 March–27 April	13 January–3 February
MV6	Backyard	Moss Vale (NSW)	3.2	SW	26 March–27 April	13 January–3 February

BoM, Bureau of Meteorology.

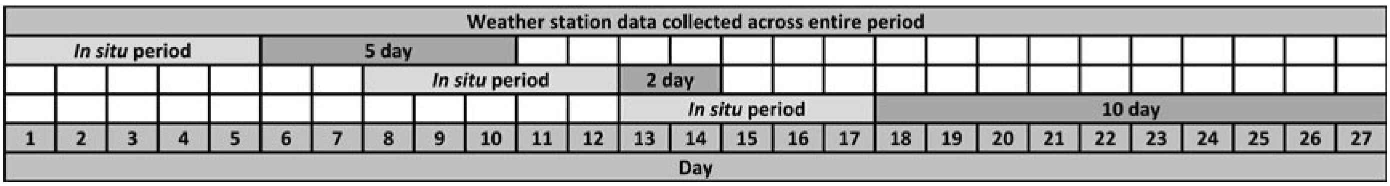

FIG. 2—*Experimental design used for comparing variable and nonoverlapping correlation period lengths (2, 5, and 10 days). One site is shown here as an example, although 16 sites were used in total.*

correlation period length (Table 1), but only the 2-day correlation period replicates (for both the autumn and summer logging periods pooled) were included in this analysis based on the findings of Experiment 1. There were three treatments describing distance between the hypothetical death scene and the weather station: (i) 0–4 km, (ii) 4–8 km, and (iii) 8–15 km. Accuracy of ambient temperature corrections was compared between treatments. Accuracy was measured by calculating absolute differences between the mean ambient temperature predicted for each BDS and the actual mean temperature for each BDS during the *in situ* period (as in Experiment 1).

Experiment 3: Periodicity of Ambient Temperature Measurements

This experiment investigated potential effects on correlation accuracy of the frequency (periodicity) of ambient temperature measurement at weather stations. Three ambient temperature measurement frequencies were compared: (i) every 30 min, (ii) every 3 h, and (iii) bi-daily measurements at 09:00 and 15:00 h. The same 16 sites were used as for the analysis of correlation period length (Table 1), but only the 2-day correlation period replicates (for both the autumn and summer logging periods) were included in this analysis, based on the findings of Experiment 1. Accuracy of ambient temperature corrections was compared between treatments. Accuracy was measured by calculating absolute differences between the mean ambient temperature predicted for each BDS and the actual mean temperature for each BDS during the *in situ* period (as for Experiments 1 and 2).

Experiment 4: Assessing Correlation Accuracy in Casework Scenarios

The final stage of this study applied the results of the first three experiments to temperatures collected at actual BDSs and nearby weather stations. We aimed to test the accuracy of correlations in previous casework to help refine the recommendations resulting from this project. Data sets (Table 2) were derived from some correlations made as part of forensic entomology investigations conducted since the introduction of the technique in NSW and Victoria in 2002 ($n = 27$). They therefore encompassed a realistic spread of differences between temperatures measured at BDSs and weather stations. These data were collected under a variety of situations in which bodies were found, including in houses, sheds, and fields (Table 2). We used these data sets in the same manner as the hypothetical death scene data by extracting the periods where we had simultaneous BDS and weather station data. We then selected 5 days at the beginning of this period to represent a hypothetical body *in situ* period (as for the experimental data), and the following 2 days were selected to represent the correlation period. Correlations were then performed and their accuracy calculated as in Experiment 1, by calculation of absolute differences between actual and estimated *in situ* period temperatures and between actual and weather station *in situ* period temperatures.

Preliminary results indicated that estimated *in situ* temperatures from correlations were closer to actual temperatures than uncorrected weather station data in 16 of 27 cases. However, this posed a problem for the remaining 11 cases where the estimated temperatures were less representative of the actual *in situ* temperature

TABLE 2—*Details of real forensic case data used in Experiment 4.*

Case	BDS	Weather Station	Notes	R^2 of Correlation Equation	Accuracy of Correlation Estimates °C (X)	Accuracy of Uncorrected Weather Station Data °C (Y)	"Improvement" Scale °C (Y−X)	Absolute Mean Difference Between Body *In Situ* and Correlation Weather Station Data °C
1	Bairnsdale, Vic	Bairnsdale Airport AWS 85279	Outside location, open field next to a drainage ditch	0.87	1.41	0.95	−0.46	0.28
2	Doncaster, Vic	Viewbank AWS 86068	Indoor location, apartment, unheated with blinds drawn	0.65	0.43	2.15	1.72	4.37
3	Dickson, ACT	Canberra Airport AWS 70014	Indoor location, unheated apartment	0.24	4.79	3.68	−1.11	5.45
4	Kew, Vic	Melbourne Regional Office 86071	Indoor location, unheated room in boarding house with window open	0.13	0.71	3.64	2.93	0.87
5	Tarwin Lower, Vic	Wonthaggi AWS 86127	Outdoor location, roadside	0.77	0.63	1.44	0.81	1.21
6	Fitzroy, Vic	Melbourne Regional Office 86071	Indoor location, unheated room in boarding house	0.92	0.56	2.32	1.76	0.55
7	Dandenong, Vic	Scoresby AWS 86104	Outdoor location, suburban garden (side passage)	0.62	0.11	8.30	8.19	1.20
8	Springvale, Vic	Moorabin Airport AWS 86077	Outdoor location, suburban front garden, next to wall of house	0.85	0.14	0.34	0.20	1.46
9	Pt Henry, Vic	Pt Wilson AWS 87166	Outdoor location, coastal heathland	0.86	0.02	0.90	0.88	4.07
10	Moe, Vic	LaTrobe Valley Airport AWS 85280	Indoor location, partially demolished house	0.36	0.13	0.49	0.36	0.28
11	Mildura, Vic	Mildura Airport AWS 76031	Indoor location, shed	0.45	0.60	2.44	1.84	1.53
12	Pakenham, Vic	Cranbourne AWS 86372	Indoor location, garage	0.05	2.04	6.26	4.22	7.50
13	Yarra Glen, Vic	Coldstream Airport AWS 86383	Outdoor location, exposed hillside	0.78	0.82	3.92	3.10	3.14
14	Frankston, Vic	Frankston AWS 86371	Indoor location, unheated house	0.43	7.62	3.68	−3.94	5.87
15	Shepparton, Vic	Shepparton AWS 81125	Outdoor location, roadside	0.96	1.33	1.02	−0.31	4.51
16	Park Orchards, Vic	Viewbank AWS 86068	Outdoor location, roadside	0.96	0.07	0.61	0.54	1.82
17	Queen's Park, NSW	Observatory Hill AWS 66062	Indoor location, storeroom beneath block of units	0.00	0.57	0.30	−0.27	0.94
18	Lismore, NSW	Lismore AWS 58214	Outdoor location, beneath shrubs	0.94	0.02	1.39	1.37	2.94
19	Maroota, NSW	Richmond RAAF AWS 67105	Indoor location, room inside house where female victim was found—same case as 20	0.56	1.38	2.71	1.33	6.07
20	Maroota, NSW	Richmond RAAF AWS 67105	Indoor location, room inside house where male victim was found—same case as 19	0.38	0.43	2.39	1.96	2.78
21	Bilpin, NSW	Mount Boyce AWS 63292	Outdoor location, on open ground—same case as 22	0.65	7.09	5.19	−1.90	8.97
22	Bilpin, NSW	Richmond RAAF AWS 67105	Outdoor location on open ground—same case as 21	0.77	0.70	0.34	−0.36	5.26
23	Kempsey, NSW	Kempsey Airport AWS 59007	Outdoor location, in forest	0.79	1.02	0.24	−0.78	3.40
24	Engadine, NSW	Holsworthy AWS 67117	Outdoor location, in forest	0.85	0.59	0.39	−0.20	3.52
25	Schofields, NSW	Richmond RAAF AWS 67105	Indoor location, room inside house	0.49	0.41	0.12	−0.29	0.14
26	Katoomba, NSW	Mount Boyce AWS 63292	Outdoor location, in forest at high elevation—same case as 27	0.36	1.65	1.33	−0.32	2.76
27	Katoomba, NSW	Mount Boyce AWS 63292	Outdoor location, in forest at high elevation—same case as 26	0.01	2.46	2.50	0.04	2.60

than uncorrected weather station values. We therefore investigated the hypothesis of Archer (6) that large differences between uncorrected weather station data from the *in situ* and correlation periods are what drive the generation of these errors. Emphasis is placed on differences between weather station data sets because the forensic entomologist will have these data in hand for each case and can inspect for these large differences before performing a correlation.

The accuracy (as defined earlier) of the estimated *in situ* average was subtracted from the accuracy of the uncorrected weather station *in situ* average. This provided an "improvement" scale ranging from negative values (estimated values do not improve on raw weather data) to positive values (estimated values improve on raw weather data). The difference between the average temperature of the uncorrected weather station data for the *in situ* period and the average temperature of the uncorrected weather station data for the correlation period was tabulated against the "improvement" scale (Table 3). We then identified the absolute mean difference, between body *in situ* and correlation weather station data, above which estimated values become inferior to raw weather data.

Data Analysis

Data were analyzed using SAS 9.1 (Cary, NC). Data in Experiments 1–3 were subjected to two-way repeated measures analysis of variance after being inspected for normality. Differences between treatments were identified using the difference of mean squares test. Data in Experiment 4 subjected to linear regression were first inspected for linearity.

Results

Experiment 1: Length of the Correlation Period

Correlation gave significant improvement over raw weather data regardless of the correlation length (Fig. 3). There was a significant interaction between treatment and season with regard to differences in correlation accuracy between 2-, 5-, and 10-day correlation periods ($F_{5,15} = 3.09$, $p = 0.041$). Significant treatment differences lay only between raw weather data and each of the 2-day correlation ($t_{15,0.05} = 3.08$, $p = 0.008$), 5-day correlation ($t_{15,0.05} = 2.47$, $p = 0.026$), and 10-day correlation ($t_{15,0.05} = 2.15$, $p < 0.048$) periods.

Correlation improved the accuracy of death scene temperature estimation by more than 1 (±0.5)°C in 92 of 96 correlations (96%). This means that, in only four cases, it would have been better to have used weather station data and not to have attempted correlation. The reason for this was investigated further in Experiment 4.

Experiment 2: Distance Between Death Scenes and Weather Stations

We found no effect of distance (up to the 15 km limit tested here) on the accuracy of correlations for either experimental season (Fig. 4). There was no significant difference between treatments in accuracy of correlations produced at different distances from the weather station ($F_{2,3} = 0.26$, $p = 0.786$), or in different seasons ($F_{1,3} = 1.3$, $p = 0.336$). There was also no significant interaction between season and distance from the weather station ($F_{2,3} = 0.53$, $p = 0.635$).

Experiment 3: Periodicity of Ambient Temperature Measurements

Analysis of these results suggests that 30-min and 3-hourly temperature measurements provide improvement over raw weather data, whereas bi-daily data will not (Fig. 5). There was a significant interaction between periodicity and season ($F_{5,11} = 6.79$, $p = 0.004$). Furthermore, there were significant differences in accuracy between raw data and measurements taken every 30 min ($t_{11,0.05} = 3.46$, $p = 0.005$) and every 3 h ($t_{11,0.05} = 2.58$,

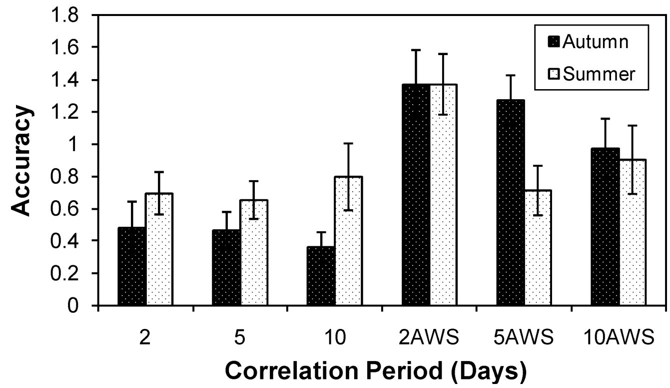

FIG. 3—*Mean accuracy (±SE) of corrected weather data with 2-, 5-, and 10-day correlation periods versus uncorrected (AWS) data with 2-, 5-, and 10-day correlation periods for autumn and summer. Smaller mean accuracy scores indicate that estimates are close to actual temperatures.*

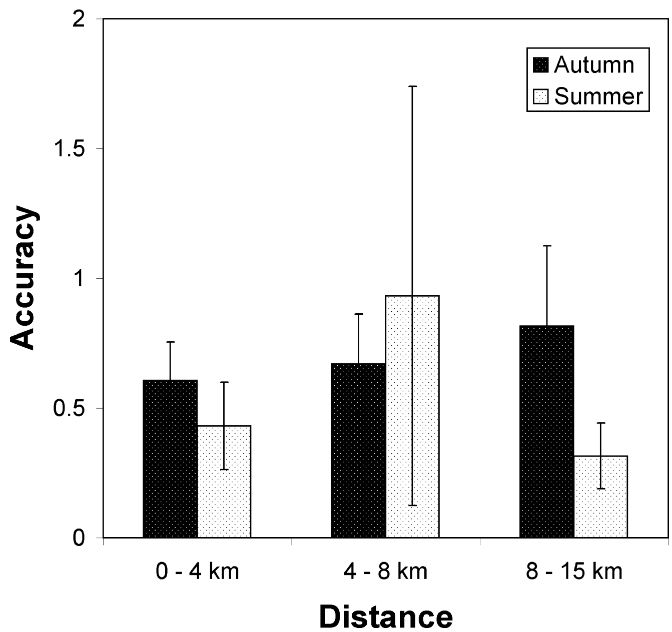

FIG. 4—*Mean accuracy (±SE) of corrected weather data of sites at varying distances from the weather station. All correlations are carried out using a 2-day correlation periods for both autumn and summer. Smaller mean accuracy scores indicate estimates are close to actual temperatures.*

TABLE 3—*Corrected values for real casework after extending the correlation period to 5 days.*

Case	Accuracy of Correlation Estimates °C (X)	Accuracy of Uncorrected Weather Station data °C (Y)	"Improvement" Scale °C (Y−X)	Absolute Mean Difference Between Body *In Situ* and Correlation Weather Station Data °C
3	3.91	3.68	−0.23	3.95
12	2.03	6.26	4.23	2.78
14	5.81	3.68	−2.13	5.89
19	0.84	2.71	1.87	1.65
21	2.20	5.19	2.99	4.35
22	1.10	0.34	−0.76	2.23

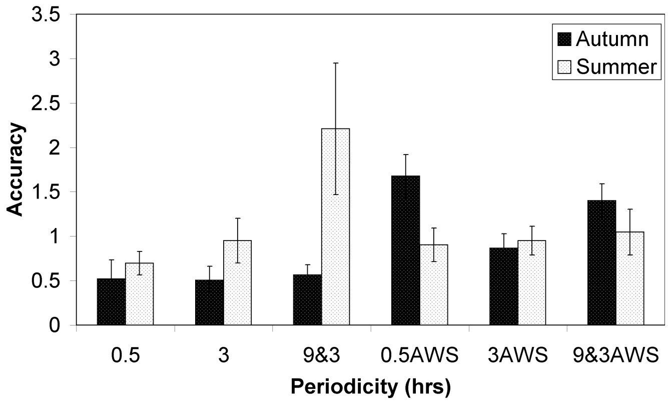

FIG. 5—*Mean accuracy (±SE) of corrected weather data with 2-day correlation periods for autumn and summer. Correlations used data collected every 0.5, every 3 h, or at 9 AM and 3 PM each day, these were then compared with the uncorrected data (AWS) for the same periods Small mean accuracy scores indicate estimates produced are close to actual temperatures.*

p = 0.026), while there was no significant difference between raw data and bi-daily measurements ($t_{11,0.05}$ = 0.51, p = 0.621).

The data also strongly suggest that 30-min and 3-hourly weather data are superior to bi-daily and raw weather data. There were significant differences in accuracy between bi-daily data and measurements taken every 30 min ($t_{11,0.05}$ = 3.09, p = 0.010) and every 3 h ($t_{11,0.05}$ = 3.17, p = 0.001), but not between 30-min and 3-hourly data ($t_{11,0.05}$ = 0.08, p = 0.940).

Experiment 4: Assessing Correlation Accuracy in Casework Scenarios

As predicted, the higher the difference between the average weather station temperatures for the *in situ* period and the average weather station temperatures for the correlation period, the higher the "improvement" scale value (Table 2). Of the 11 cases that were less representative of actual temperatures than uncorrected weather data, nine were not considered to be of concern because they were worse by <1 (±0.5)°C. However, two cases (Table 2: case numbers 14 and 21) were of concern because they were less representative of actual temperatures than uncorrected weather data by >1 (±0.5)°C and may make a difference to larval growth rate estimates for most species. R^2 values did not provide any indication of accuracy (Table 2). We therefore tabulated the absolute mean difference between *in situ* and correlation weather station data against the "improvement" scale (Table 2). This revealed that an absolute mean difference between *in situ* and correlation weather station data above 5°C yielded corrected weather data that were less representative of *in situ* data than uncorrected weather station data. However, three other cases (Table 2: case numbers 12, 19, and 22) with satisfactory improvement scale scores (>−1 [±0.5]°C) also had differences >5°C between weather station data sets. The other 22 cases with differences <5°C all had improvement scales >−1 (±0.5)°C (as mentioned previously, an error of <1 [±0.5]°C is considered acceptable).

To try to reduce the excessive (>5°C) mean weather station data differences of cases 12, 14, 19, 21, and 22, the correlation period was extended from 2 to 5 days and the weather station data difference recalculated (Table 3). In four cases, encapsulation of a greater range of temperature by extending the correlation period to 5 days both reduced the mean weather station temperature difference below 5°C and increased the "improvement" scale to values >−1 (±0.5)°C (Table 3). In one instance (case 14), failure to reduce the gap between weather station data sets below 5°C resulted in corresponding failure to achieve a positive "improvement" scale value (Table 3).

Discussion

The findings of this study show that retrospective ambient temperature correction of weather station temperature is a robust technique. We conducted the analysis with data collected in two different states at 16 sites, in two different seasons, and across a variety of BDSs encountered since 2002 by two different forensic entomologists. Accuracy of correction was not significantly affected by season, the length of the correlation period, or distances up to 15 km between the site of body discovery and the weather station. However, the study revealed an important caveat: corrected weather data can actually be made less representative of actual BDS temperatures if correlation is attempted when there is a temperature difference >5°C between weather station *in situ* and correlation data.

Errors because of >5°C differences between weather station data sets were produced here in correlations generated from real case data. However, this does not mean that Archer and Wallman generated errors in their original cases because the data subsets analyzed in this study were not the same excerpts from the entire set that were used in the original cases. Indeed, a file review showed that for cases where >1 (±0.5)°C errors were generated in this study (cases 14 and 21), there was a <5°C difference between weather station *in situ* and correlation data. Furthermore, Archer has been routinely checking in casework the magnitude of difference between weather station *in situ* and correlation data sets since it first became apparent that differences >6°C could produce errors (6). Differences >4°C have not been encountered since then. Prior to 2004, one case (case 7) had a >8°C difference between weather station sets. However, although the correlation must now be regarded as suspect, maximal larval growth rates were employed in this case, meaning that the temperature estimate had no bearing on the minimum postmortem interval estimate.

It is strongly recommended that all practitioners performing retrospective weather station data correction henceforth check that the difference between the weather station *in situ* and correlation periods does not exceed 5°C. In this study, 50% of corrections made when there was >5°C between *in situ* and correlation weather data did not actually result in error. However, to omit this check incurs a substantial risk of making corrected weather station data much less representative of actual temperatures than uncorrected weather station values. The results show that it is not helpful to inspect the R^2 value as this had no relationship with correlation accuracy in our study, which also accords with the findings of Archer (6).

If practitioners encounter a >5°C difference between average *in situ* and correlation period weather station temperatures, they do not necessarily have to abandon correlation. We were able to correct the error in our correlations in every case where we were able to reduce the difference between averages below 5°C. This was done simply by extending the length of the correlation period from 2 to 5 days, thus including a greater range of temperatures and reducing the risk of bias inherent in selection of a 2-day stretch of temperature readings. Importantly, in the cases where there was a gap in weather data sets of >5°C, but no corresponding error (cases 12, 19, and 22), reduction in the gap further improved the accuracy and did not produce an error.

We recommend the collection of 10 days' worth of correlation data wherever possible so that the practitioner is able, if necessary, to extend the length of the correlation period to try and correct any difference exceeding 5°C between weather station *in situ* and correlation average temperatures. The importance of being able to do this increases with temporal distance between the *in situ* and the correlation period, because correlation accuracy reduces as this factor increases, probably mainly because of changes in macro-weather patterns (6). If the difference between data sets cannot be corrected by extension of the correlation period to 5 or 10 days, then the correlation should be abandoned. Accuracy of correlation periods beyond 10 days has not been tested, so we are unable to comment on their value.

Another important finding of this study is that the accuracy of retrospective weather station data correction was linked to the periodicity of measurements when only a 2-day correlation period was used. Measurements need to be taken at least every 3 h to improve on raw weather data if a correlation period as short as 2 days is used. This is to be expected because the fewer the number of measurements taken during the correlation period, the fewer the data that will be available to the practitioner to build a representative scene versus weather station temperature model.

There was a significant difference between the seasonal results for the periodicity experiment. The results show that accuracy can be unpredictable, even though most of the differences between corrected and uncorrected data amount to <1°C in this experiment. It is clear from Fig. 5, however, that the temperature measurements taken every 30 min or every 3 h were consistently reliable and that the bi-daily and AWS data displayed unexplained fluctuation.

The findings of this study provide increased confidence in the validity of retrospective weather station ambient temperature corrections. We have shown that the technique is robust over the range of conditions we have examined, provided that the practitioner is prepared to follow two simple rules:

- Ensure that there is a <5°C difference between the average temperatures of the weather station data sets recorded during the *in situ* and correlation periods.
- Use correlation data with a high periodicity. If using a 2-day correlation period, the periodicity in this study had to be every 3 h or less to ensure an improvement of accuracy when correlating.

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Additional information and reprint request:
Melanie Archer, Ph.D.
Department of Forensic Medicine
Monash University
57-83 Kavanagh St.
Southbank, Vic. 3006
Australia
E-mail: melanie.archer@vifm.org