# IMAGE INTENSIFICATION: A NEW METHOD OF STUDYING NOCTURNAL BIRD MIGRATION

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## ABSTRACT

This presentation will discuss a new technique of detecting, monitoring, and quantifying the density of nocturnal bird migration. The apparatus takes advantage of the latest developments in the field electro-optics and the system is composed of an image-intensifier (AN/TSV-5), a low-light level closed circuit television camera, a video tape deck. The image-intensifier amplifies incoming light by a factor of 50,000 and has a magnification of 6.3 power. In geographical areas with sufficient ground light, the apparatus may be directed skyward to detect migrating birds flying aloft and very dimly illuminated from the ground below. In areas without ground lighting, a narrow beam 300 watt spotlight can be directed vertically to provide sufficient illumination.

Initial tests indicate that the technique readily detects even small nocturnal migrants at considerable altitudes above ground level, and larger birds (e.g. waterfowl) can be observed migrating at even greater altitudes. Analysis of the migratory movements can be made directly and immediately from the television video monitor, or analysis can be completed at later time from the video tape. A brief 16-mm film made directly from the television monitor will demonstrate the capability and utility of the technique. Additional applications of this new technique will be discussed.

## INTRODUCTION

Ten years ago I published a paper on the use of a vertical ceilometer light beam to study low altitude nocturnal bird migration (Gauthreaux 1969), and the technique was further evaluated quantitatively in a later publication (Able and Gauthreaux 1975). Since 1969 several investigators have used the ceilometer technique (e.g., Hebrard 1971, Lindgren and Nilsson 1975, Avery, Springer, and Cassel 1976, and Balcomb 1977). In this paper I report on further developments in the basic ceilometer technique that markedly enhance its effectiveness as a research tool for studying nocturnal bird migration. These developments concern the use of an image intensifier ($I^2$), a low-light level closed circuit television camera (CCTV), a video tape recorder, and a high resolution television monitor.

## EQUIPMENT AND METHODS

The key component to the new ceilometer technique is an image intensifier, the AN/TVS-5, manufactured by Varo, Inc., Garland, Texas (Figure 1A). This instrument is on loan from the Night Vision Laboratory of the United States Army's Electronics Command, Fort Belvoir, Virginia. The AN/TVS-5 image intensifier is a second generation device that is 32.5 cm long and weighs 3.2 kilograms. It has a resolution (lines $mm^{-1}$) of 56 minimum and 64 average, and amplifies ambient light 37,000 times (minumum) and 50,000 times (average). The intensifier tube diameter is 25 mm (inverter tube-military model MX-9644). The intensifier is equipped with a catadioptric objective lens (focal length 155 mm) that gives a 6.3X magnification, and the instrument has very low distortion and has reduced blooming when a bright light is in the field of view. There is a manual video gain control that regulates the amount of light amplification. The field of view is approximately 9° without the television camera. The field is reduced to a minimum of 3.1° (vertical) when displayed on the television monitor. The unit is powered by two 2.7 volt batteries. The U.S. Government price for the AN/TVS-5 is approximately $4000.

The image intensifier is coupled to a closed circuit television camera, the Hitachi HV-17LU (AC117V 60 Ha 11 watts), that has an excellent response to low light levels (Figure 1B). A Macro-Switar, f 1.1, 26 mm lens is attached to the CCTV camera. The quality of

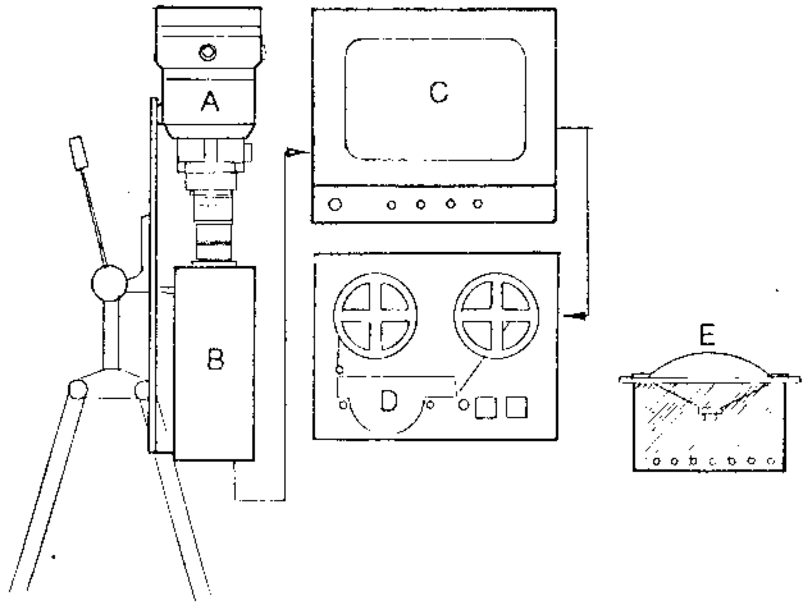


Figure 1. The image intensification-ceilometer system. A) AN/TVS image intensifier, B) video camera, C) video monitor, D) video tape recorder, E) very narrow spot light.

the image on the television monitor is adjusted by using the gain and focus on the image intensifier, the f stop and focus on the lens, and the intensity and contrast adjustments on the monitor. The monitor is a Hitachi Video Monitor, VM-126 AU (AC117V, 60 Hz, 37 watts), and has screen dimensions of 178 mm vertical and 240 mm horizontal (Figure 1C). The camera is connected to the monitor with a coaxial cable. The movements of birds aloft in the night sky can be monitored directly from the television screen or the video signal can be routed to a helical scan video tape recorder. I have used Sony AV-3600 Solid State Videocorder in my work (Figure 1D). The tape (V-30H) provides a continuous 30 minute record or a longer tape can be used for greater recording times.

Because of the cost of the ceilometer lamp bulb and transformer described in my original paper, a less expensive bulb (Sylvania 300 watt, 6.6 amp, PAR 64/3, visual approach slope indicator, mogul end prong, or the Sylvania 500 watt, PAR 64/VNSP, extended mogul end prong) is now being used (Figure 1E). These bulbs are superior to the old illumination system, because they can be used on line current

(125-160/60 AC) directly and they have higher wattage and longer life. During normal operation the vertical light beam is positioned about 20 m from the upright image intensifier. In geographical areas with sufficient ground lighting that reflects skyward (e.g., a city) the vertical light beam can be eliminated, because the undersides of the migrants aloft will receive sufficient illumination to be readily detected by the image intensifier.

On 26 occasions (10 spring, 16 fall), I was able to evaluate the performance of the image intensifier by moon watching (Lowery 1951) while gathering image intensification data. Because of the brightening of the sky when the moon in early overhead during full moon periods, comparisons were made only when the moon was between 30° and 45° elevation. However, on these occasions the sky was somewhat brighter than during other periods of the lunar cycle, and the contrast in the field of the image intensifier was reduced. When background contrast is reduced small, high-flying birds in the night sky are sometimes not detected.

## RESULTS

The image intensifier-ceilometer technique readily detects even small nocturnal migrants at considerable altitudes above ground level. Although visibility tests of known birds at various distances are presently being conducted, one can get some idea of the altitude of bird targets by examining wing beat frequency, speed, brightness, and size of the image on the television screen. The depth of field at sharp focus gives additional information on the altitude of the bird. On the television screen the minimum field of view is 5.4 m at 100 m altitude, 27 m at 500 m, 54 m at 100 m, and 81 m at 1500 m.

If one compares the image intensifier-ceilometer technique with moon watching, the results suggest that the technique is about as reliable as moon watching (Figure 2). In order to compute the number of birds crossing a statute mile of front (1.609 km) per hour one must apply a correction factor of 240 to each bird crossing before the disc of the moon directly overhead. To do the same for data gathered with the image intensifier, the correction factor is about 100. Thus by using the image intensifier one can express the amount of migration in terms of a migration traffic rate (birds mile of front$^{-1}$ hour$^{-1}$).

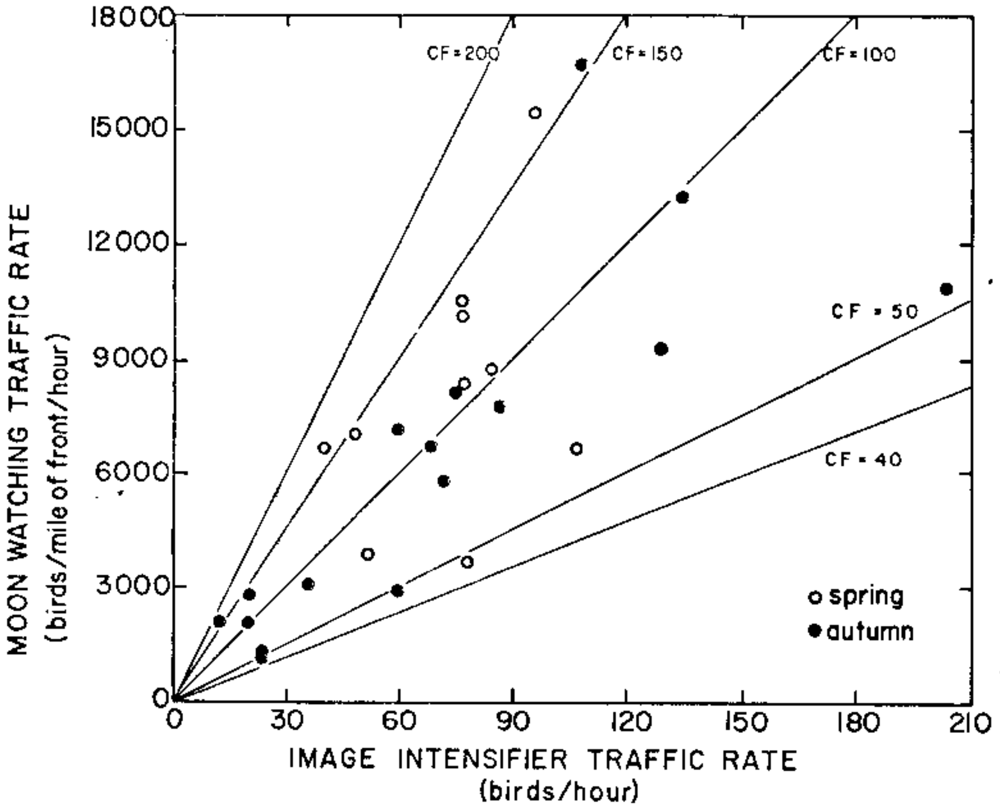


Figure 2. A graph showing the comparison of image intensifier traffic rates with simultaneous moon watching traffic rates. CF equals the correction factor applied to the image intensifier traffic rates to equal the moon watching traffic rates.

The direction of migratory movements can be determined directly from the television screen or in the event a more exact analysis is required, one can use the video tape recorder with stop action. By placing a transparent plastic sheet over the TV screen with a circle drawn so that its diameter equals the short dimension of the screen, one can use a wax pencil to precisely indicate the path of each bird. Once the sample is completed, the directions can be measured with a protractor and then statistically analyzed (Figure 3).

## DISCUSSION

The use of image intensification devices is not new to zoology (e.g., Swanson and Sargeant 1972), but their application to the study of nocturnal bird migration aloft is new. The technique provides quantitative data on the number of migrants aloft and yields results

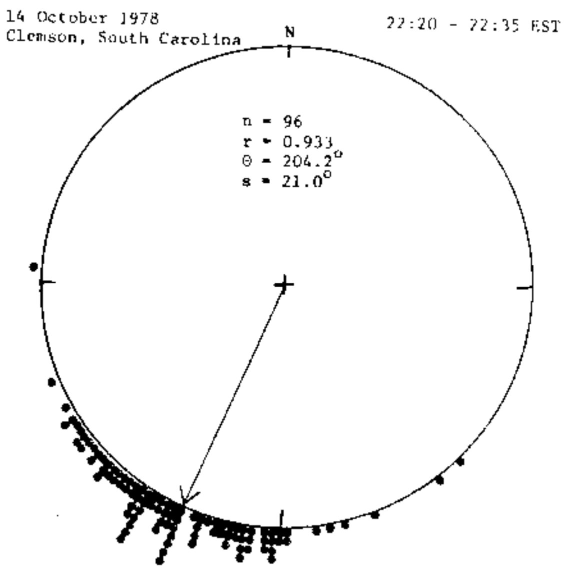


Figure 3. A plot of the flight directions of migrants aloft on 14 October 1978. n equals the number of birds, r equals the length of the resultant vector, Θ equals the resultant direction, and s equals the angular deviation.

quite comparable to those obtained by moon watching (Lowery 1951). Unlike the moon watching technique, the image intensifier-ceilometer technique can be used on any night and is not dependent on the presence of the moon and the lack of cloud cover.

One disadvantage of the image intensification system is a lack of exact altitudinal information on the birds detected aloft. If the image intensifier is used in conjunction with a small vertically pointing 3 cm radar (ship board navigation radar), it should be possible to measure exactly the altitudes of the migrants detected by the image intensifier. This approach is currently being developed at Clemson University. The image intensifier-ceilometer system can also be used to monitor the behavior of birds and mammals at night. Swanson and Sargeant (1972) have used this technique to study the nocturnal feeding behavior of ducks, and there are similar applications under way by numerous investigators.

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